Saskatoon Freeway Functional Planning Study

Phase 2 Functional Design Report

Saskatchewan Ministry of Highways

July 5, 2023

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Executive Summary

The Government of Saskatchewan, through the Ministry of Highways (Ministry), is completing a functional planning study which will determine how the Saskatoon Freeway will look and operate. The study was originally planned to be completed in three phases. This report; Saskatoon Freeway-Phase 2 Functional Design Report, describes the activities and functional design recommendations for the Saskatoon Freeway in Phase 2. The Phase 1 report was finalized and submitted to the Ministry on November 30, 2021. Phase 3 was removed from the scope of the original study and will be completed in the future. A final project report will be completed which will tie the Phase 1 and Phase 2 reports together as well as address functional design items that overlap both phases including intelligent transportation system concepts, over dimension routing, and project staging opportunities.

The Saskatoon Freeway will ultimately be a minimum four-lane divided uninterrupted flow freeway, which is approximately 56-kilometres in length. It begins at Highway 11 south of the City of Saskatoon (CoS) just south of Floral Road and then passes around the east, north, and west sides of the city ending at the Highway 7/Highway 60 junction. The Saskatoon Freeway Functional Planning Study (SFFPS) considers the placement of 17 interchanges, 5 railway overpasses, 4 flyovers (plus consideration for other future flyovers), and a new bridge crossing the South Saskatchewan River. The Phase 1 study was completed in 2021 and the Phase 2 study is scheduled to be completed in 2022. Currently, there is no timetable for completion of Phase 3 of the functional study nor is there a final decision regarding the timing for the freeway's construction.

The SFFPS has been divided into three phases. The second phase of the SFFPS is focused on the segment extending from the connection with Highway 11 south of the CoS, around the east side of the CoS and connecting to and including the South Saskatchewan River bridge crossing. The river crossing functional design work is a continuation of the work started in Phase 1. Phase 2 crosses critical environmentally sensitive areas at the Small Swale and Northeast Swale. This phase also directly impacts numerous existing landowner's and access for future residential developments. Particularly noteworthy are the University of Saskatchewan lands and Federal lands used for agricultural research. Refining the property requirements through the functional planning study process will enable development to proceed with certainty of the freeway right of way. Phase 2 is approximately 27 km in length and includes a new interchange at Highway 11 south, at Floral Road east, at the Zimmerman Road extension, at Highway 16, at 8th Street East, at Highway 5, at Highway 41 east with a new alignment of Highway 41, at Blackley Road, and includes a new interchange for the extension of Central Avenue.

This Phase 2 report elaborates on previous general location studies completed by the Ministry and provides functional plans that can be used either as a "Reference Concept" for alternate delivery models, such as a Design/Build model or can be used as the basis for proceeding with a detailed design using a traditional Design/Bid/Build delivery model.

The following key technical functional planning study elements for Phase 2 are described in this report:

› An update of the regional Travel Demand Model (TDM) using a design and planning year of 2063 (CoS and Saskatoon Census Metropolitan Area (CMA) populations of 748,000 and 831,000, respectively);

- Functional design criteria and level-of-service targets for the freeway, interchange, and bridge structures components;
- Three-dimension conceptual alignment and laning designs for the freeway and interchanges;
- Environmental and Heritage Studies used to guide functional designs;
- Stakeholder engagement processes and events;
- Multiple Account Evaluation (MAE) processes and out comes for crossing the Small Swale and Northeast Swale and for interchange locations and configurations;
- Drainage data and schemes to maintain existing drainage patterns; and
- Right-of-way property requirements including potential Transportation Utility Corridors.

The following are key highlights/recommendations/outcomes of this functional planning study phase:

- Focused consultation sessions with environmental experts and stakeholders followed by an environmental workshop led to a proposed freeway route through the Small Swale and Northeast Swale area. This route was outside the general location corridor previously established by shifting the freeway to the north in an effort to minimize environmental impacts;
- It is proposed to realign Highway 41 starting from a point near the intersection of Bergheim Road (Township Road 374) westward to a proposed interchange at Blackley Road. This realignment better served some of the travel patterns between Highway 41 and the north side of the CoS employment/development area. Existing Highway 41 will still connect to Highway 5 at the existing intersection west of the Saskatoon Freeway alignment via a flyover;
- Integrating the realigned Highway 41/Blackley Road interchange allowed for adequate separation between the Highway 5 interchange and the Highway 41/Blackley Road interchange. This also better serves travel patterns;
- The Highway 5 interchange is configured to account for the Highway 5 four-lane improvements currently being planned by the Ministry;
- The 8th Street interchange incorporates some higher speed ramps recognizing the rural nature of the location until development encompasses the areas;
- The Highway 16 interchange does not include all movements (turns) recognizing the proximity of the Zimmerman Road interchange and travel patterns to and from Circle Drive. Future interchanges located at the Zimmerman Road/Circle Drive intersection and at the Highway 16/Floral Road east intersection were conceptualized to ensure compatibility with the proposed Highway 16/Saskatoon Freeway interchange configuration;
- Patience Lake Road is proposed to pass over the Saskatoon Freeway along its current alignment. It is recognized that future development plans may alter the location of Patience Lake Road and its connection to Zimmerman Road at Costco;
- An interchange was added at Floral Road west near Grasswood. This was required to better serve the travel patterns to and from the Grasswood business development area; and
- A noise study was completed to assess the extent of noise levels. The CoS noise thresholds were used to determine locations where mitigation may be needed based on current development.

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1 Introduction

The Government of Saskatchewan, through the Ministry of Highways (Ministry), is engaging in a functional planning study which will determine how the Saskatoon Freeway will look and operate. The Saskatoon Freeway will ultimately be a minimum four-lane divided uninterrupted flow freeway, which is approximately 56-kilometres in total length. It begins at Highway 11 south of the City of Saskatoon (CoS) just south of Floral Road and then passes around the east, north, and west sides of the city ending at the Highway 7/Highway 60 junction. The three phases of the Saskatoon Freeway Functional Planning Study (SFFPS) will consider the placement of 17 interchanges, 5 railway overpasses, 4 flyovers plus consideration for other future flyovers, and a new bridge crossing at the South Saskatchewan River.

The SFFPS was originally planned to be completed in three phases. This report; Saskatoon Freeway-Phase 2 Functional Design Report, describes the activities and functional design recommendations for Phase 2 of the SFFPS. The Phase 1 report was finalized and submitted to the Ministry on November 30, 2021. A final project report will be completed which will tie the Phase 1 and Phase 2 reports together as well as address functional design items that overlap both phases including intelligent transportation system concepts, over dimension routing, and project staging opportunities.

The current study scope will be completed in 2022 with endorsement of the Phase 1 and Phase 2 study reports and the Final project report. Phase 3 was removed from the project scope of the SFFPS and currently there is no timetable for completion of Phase 3 of the functional study nor is there a final decision regarding the timing for the freeway's construction.

The Ministry identified significant traffic delays and safety issues with provincial highway traffic entering the CoS and destined for other provincial highway routes exiting the CoS. The CoS and the Saskatoon Census Metropolitan Area (CMA) are experiencing population growth, resulting in an increase to congestion and safety problems. The traffic problems will be most prevalent with large trucks, some hauling dangerous goods using intra-city travel routes. The Saskatoon Freeway will alleviate congestion on intra-city travel routes and will improve the safety for all road users. The Saskatoon Freeway will also provide a high mobility route for trucks to move goods across, to, and from Saskatchewan.

General location studies (Saskatchewan Ministry of Highways and Infrastructure, November 2017; UMA, June 2005; and UMA, August 2007) were completed and established a 500 meter corridor in which the freeway would be located. The purpose of the SFFPS is to determine the conceptual design for the North, East, and West segments within the general location corridor, to identify property requirements thereby reducing the extents of current property restrictions, and to provide a reference concept for future phases of detailed design and construction. Completion of the functional designs for Phase 1 and Phase 2 includes property lines required for the freeway and interchanges.

This Phase 2 Functional Design Report includes a description of previous studies completed to date, including details of the general location plan which is the base location reference for this study. Existing conditions are also discussed including identified environmental and geotechnical constraints, as well as constraints imposed by existing infrastructure (utilities, railway, roadways, etc.). Stakeholder Engagement and Communication activities are discussed including details on engagement activities, consulted stakeholder groups, and summaries of stakeholder input. Transportation planning was undertaken by updating the traffic demand model (TDM) for Phase 2. This update did not impact any of the outcomes determined in Phase 1. Background traffic volumes and studies were reviewed, and stakeholders consulted on current CoS and surrounding community development plans. The Functional Plan portion of the report details design criteria, access plans, horizontal and vertical alignments, and the functional design of the South Saskatchewan River bridge. The Multiple Account Evaluation (MAE) processes used in the selection of the preferred routing through the Small Swale and Northeast Swale section and the selection of interchange concepts is detailed. Multiphase supporting information is also discussed including utility plans and conflicts, geotechnical details, and intelligent transportation systems. A road safety audit was not completed as part of the functional design but should be completed closer to time of construction. Recommendations are also provided for Phase 2. Information on staging will be provided in the final summary report.

Key deliverables for SFFPS include:

1. **Functional Plan**, incorporating previous planning activities since 2001, setting the alignment of the freeway and developing interchange concepts (including bridges) which will be used as a reference concept for future procurement options;
2. **Public and Stakeholder Engagement Plan**, which will be followed to gain endorsement from major stakeholders and allow the Ministry to be open and transparent throughout the planning phases;
3. **Bridge Concept(s)** for crossing the South Saskatchewan River; and
4. **Accurate property line and boundaries** for the freeway alignment, interchanges, service roads, and realigned cross roads which are based on the functional design concepts.

Key functional planning activities that will elaborate on the general location and preceding reports are:

- Update and regionalize the regional travel demand model using a design and planning year of 2063;
- Develop functional design criteria and establish level-of-service targets for the freeway and interchange components;
- Develop a three-dimension conceptual alignment and laning for the freeway;
- Develop three-dimension concept plans for interchanges (including bridges) and flyovers including laning;
- Incorporate environmental and heritage study data to reduce environmental impact;
- Incorporate drainage data;
- Assess possible staging options;
- Develop right-of-way property requirements; and
- Develop the South Saskatchewan River crossing bridge concept(s).

1.1 Study Area

The SFFPS is focused on the 500 m corridor developed in previous studies as illustrated in **Figure 1.1**. Freeway mainline alignment options were generally retained within the general location corridor; however, there are a few locations in Phase 2 where the alignment has shifted outside the corridor aimed at reducing environmental impacts and to facilitate environmental mitigation measures. There are interchanges and intersecting roads which extended beyond the corridor to facilitate acceptable geometric design and operational characteristics. In addition, access concepts were developed for municipal roads that were intersected by the freeway.

Figure 1.1: Saskatoon Freeway Functional Planning Study corridor

1.2 Phases of Work

The SFFPS has been divided into three phases as illustrated in **Figure 1.2**. The first phase of the SFFPS is focused on the segment extending from the east side of the South Saskatchewan River to a point just south of Highway 16 on the northwest side of the CoS. This phase encompasses critical commercial development areas with lands restricted to protect the outcome of the SFFPS. Refining the property requirements through the functional planning study process will enable development to proceed. Phase 1 is approximately 10 km in length and intersects Wanuskewin/Highway 11, Highway 12, and Highway 16.

Phase 1 includes details of a bridge option study for the river crossing**.** Both shortlisted bridge types have been caried forward in this Phase 2 Functional Design Report; a Steel Girder bridge type and a Cable Stayed bridge type using concrete towers.

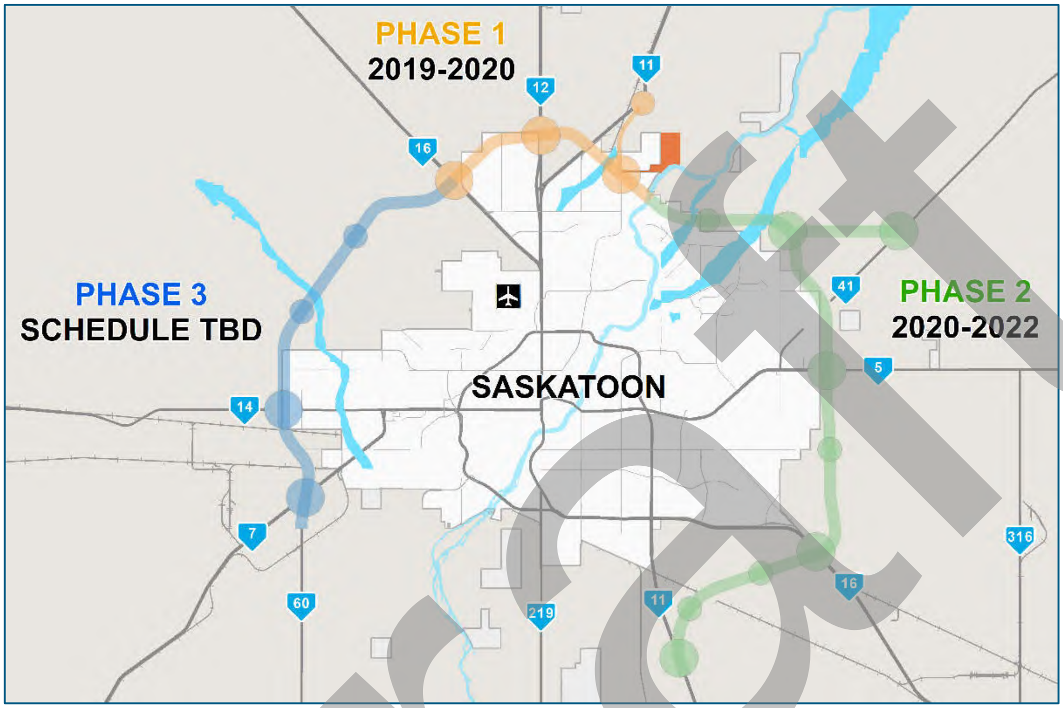


Figure 1.2: Saskatoon freeway Functional Planning Study phasing

The second phase of the SFFPS covered by this report is focused on the east side of the CoS extending from Highway 11 south of Grasswood to the beginning of Phase 1 at the South Saskatchewan River. This phase has developed important conceptual alignments for Highway 11 and Highway 16. This phase also evaluated options for the number of interchanges required between Highway 5 and the Central Avenue interchange. This phase encompassed significant existing and future residential developments, environmentally sensitive land in the northeast, as well as some commercial development areas. Completion of the functional plan allows for better definition of required property and thus allowing development to proceed with certainty of the freeway location. Phase 2 is approximately 33 km in length and intersects major roads, such as Central Avenue, Blackley Road, Highway 41, Highway 5, 8th Street, Patience Lake Road, Highway 16, the Zimmerman Road extension replacing the Range Road 3045, Highway 11, and various other minor roadways.

Although no longer within the scope of the SFFPS, the third phase will look at the west side of the CoS extending from a point just south of Highway 16 to Highway 7 at the junction with Highway 60. This phase generally encompasses agricultural lands, including a large land holding by Moosomin First Nation in the vicinity of the Highway 16/Highway 684. Highway 684 is a rural paved road that connects at the junction with Highway 7/Highway 14 and the Dalmeny Access at Highway 16. This is a well traveled road that is intersected by the Saskatoon Freeway. Phase 3 is approximately 18 km in length and will intersect Beam Road, Claypool Drive, Highway 14, and Highway 7/Highway 60.

1.3 Schedule of Work

The Phase 1 report was finalized and submitted to the Ministry on November 30, 2021. This report marks the completion of Phase 2 functional design work. Phase 3 will be completed in the future and is no longer part of the current SFFPS scope. The final deliverable will include a summary report finalizing the details of completed phases. The summary report is anticipated to be delivered late 2022.

1.4 Project Governance Structure and Communications

Project communication between the Ministry and the design team was primarily between the Ministry's Senior Project Manager and the design team Project Director, Deputy Project Director, and Project Technical & Commercial Manager.

While the Project Director (David Stearns) was the Ministry's communication point, the Deputy Project Director (Allan Duff and later David Smith) was an integral part of the team to ensure that communication between the Ministry and the design team was seamless. This was done with coordination meetings with the Technical Working Group (TWG) Leads and project wide engineering specialists to ensure the integration of the engineering disciplines as well as managing the design interfaces.

The project was governed in accordance with the structure shown in the organizational chart shown in **Figure 1.3**. The TWGs were staffed by personnel as shown in the figure and supplemented by Ministry experts and other stakeholders.

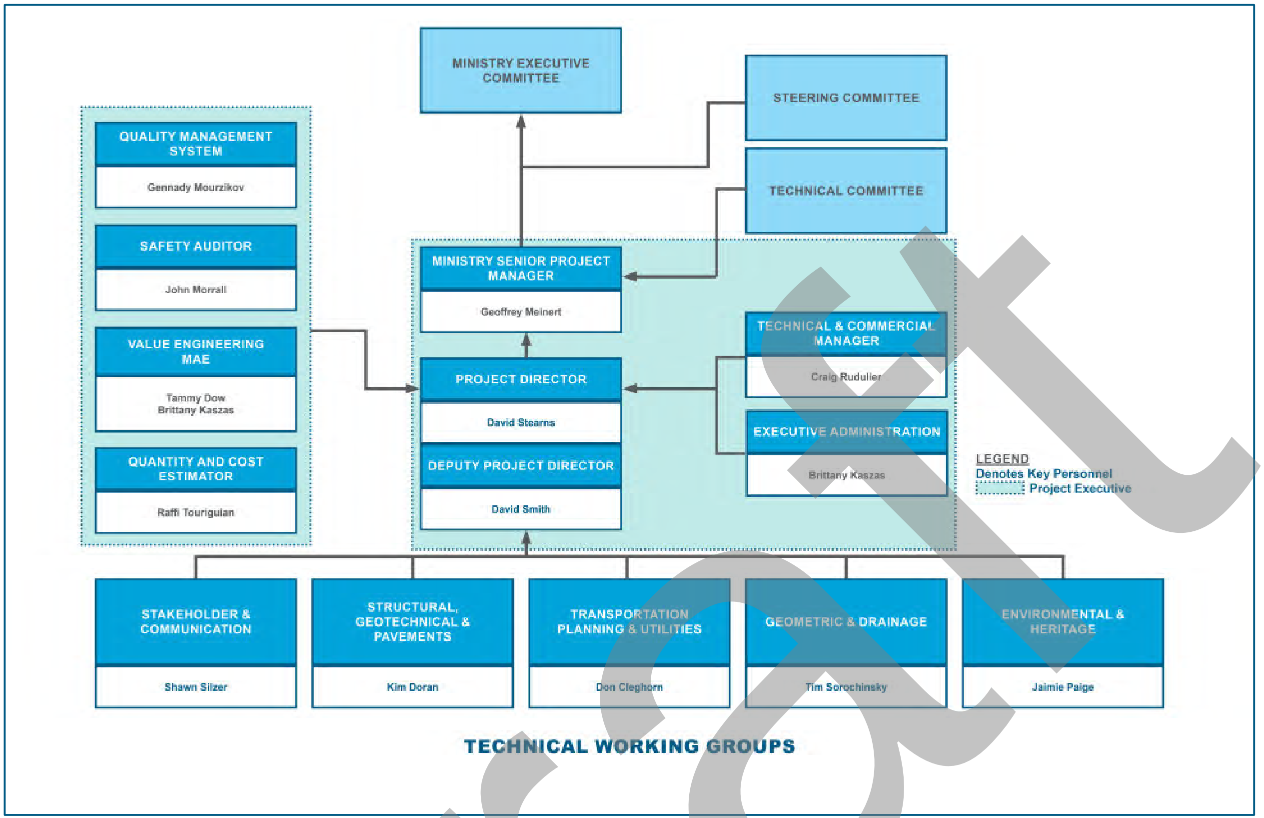


Figure 1.3: Project management reporting structure

1.4.1 Ministry Executive Committee

The Ministry Executive Committee generally met on a bi-weekly schedule to discuss critical projects within the Ministry's programs, with the SFFPS as a key project. The Ministry's Senior Project Manager provided a brief presentation on the status of the project and any key issues requiring direction.

1.4.2 Steering Committee

Representatives from the CoS, Ministry of Government Relations, North Saskatoon Business Association (NSBA), Saskatoon Tribal Council (STC), Meewasin Valley Authority (MVA), Saskatoon Chamber of Commerce, City of Warman, City of Martensville, the Rural Municipality (RM) of Corman Park, and the Ministry sat on the Project Steering Committee. These representatives helped guide the project at a high-level, providing direction on the design options to ensure they met acceptance to their respective organizations. Consensus from this group was required for the ultimate approval of the proposed Functional Design. The team held bi-monthly meetings with the Steering Committee to discuss formal approval requirements from the major stakeholders.

1.4.3 Technical Committee

The Technical Committee was composed of representatives from the CoS, City of Warman, City of Martensville, the RM of Corman Park, Saskatoon North Partnership for Growth (P4G), various Ministry personnel including the Ministry's Senior Project Manager and senior personnel from the Design Branch, Network Planning and Investment Branch, and the Central Region Operation and Maintenance Branch. The committee meetings were also attended by discipline leads from AECOM and SNC-Lavalin as well as the Project Director, Deputy Project Manager, and Project Technical and Commercial Manager. The Technical Committee generally met bi-monthly to update the ministry Technical Committee on the progress of each discipline team.

1.4.4 Technical Working Groups

The TWGs generally met bi-weekly or as required and were the primary tool for internal communication. Each TWG was comprised of project team staff, applicable Ministry staff and third-party stakeholders from the CoS, RM of Corman Park, and other organizations that had pertinent issues on the agenda. During the TWG meetings, outstanding technical issues within each discipline were discussed and the schedule and deadlines were communicated.

When input was needed from the Ministry or other stakeholders, the appropriate people were invited. These external TWG members had an open invitation to add agenda items and to attend meetings as often as they felt were required.

1.5 Functional Design Methodology

A functional planning study, sometimes referred to as a functional design, determines the form and function of a road based on projected traffic volumes and road user needs as well as incorporating input from the public and specialist groups such as environmental groups. A functional design is typically done 2-10 years in advance of the detailed design and construction. The reason for the delay between the functional design and detailed design is to provide adequate time for proper public communication, land acquisition, and time to arrange for funding.

The form of the road is the physical characteristics of the road:

- Number of driving lanes required to meet future needs – cross section;
- Need for auxiliary lanes for turning – operation and safety;
- Road alignment – vertical and horizontal;
- Need for interchanges or intersections;
- Interchange layout and spacing;
- Intelligent Transportation System (ITS) infrastructure such as enforcement screening stations;
- Rest areas; and
- Environmental mitigation infrastructure such as wildlife underpasses.

The form of the road helps set the route and width of the right of way required as well as specialized appurtenances. This information generates preparation of the land acquisition plan and is the basis for explaining the project to the public.

The function; also known as the service function, of the road is the purpose of the road:

- Set speed limits;
- Access control;
- Set level of service for an anticipated volume of traffic in the future;
- Set design vehicle for turning, clearance, and weight requirements; and
- Pedestrians/bicycles - allowed or prohibited.

The function of the road helps set adjacent land use, or in some cases, the function can be set to best serve existing/future adjacent land use.

Setting the form and function of a road relies on considering many things, such as physical constraints (buildings, power poles, underground utilities), environmental constraints (aquatic protection, endangered species, noise impacts) and natural constraints (rivers, topography, geologic conditions). Public and stakeholder input, and safety concerns are other major considerations.

A functional planning study also looks at benefits and costs of all components and how construction of the new road can be staged based on projected traffic volumes. Construction staging provides flexibility for project funding as the entire cost does not have to be available initially.

Key deliverables for the SFFPS are:

- Report detailing the form and function of the new freeway;
- Property acquisition plan; and
- Report detailing Public, First Nations, and Metis Engagement.

2 Background

2.1 Previous Studies

Previous studies were reviewed as part of the Saskatoon Freeway Functional Planning Study (SFFPS) planning stage. Studies specific to the Phase 2 area of the project are presented in **Table 2.1** and summarized below.

Table 2.1: Summary of previous studies

STUDY	AUTHOR	DATE
East Perimeter Highway Functional Planning Study	UMA Engineering Ltd.	June 2005
Highway 5 East Functional Planning Study	iTrans Consulting Lit.	March 2010
Saskatoon Perimeter Highway Validation Study	Tetra Tech	May 2014
South Saskatoon Freeway General Location Study	Associated Engineering	November 2017

East Perimeter Highway Functional Planning Study

The East Perimeter Highway Function Planning Study was commissioned to define the alignment for the Perimeter Highway around the east side of Saskatoon between Highway 11 to the south and Highway 16 to the north. The recommended alignment attempted to minimize impact on existing development while accommodating future CoS growth sectors. Features of the route included:

- Utilizing predetermined interchange sites at Highway 11 and Highway 16, minimizing impact on existing development;
- Compatibility with the Future East Residential Development Sector between Highway 41 and Highway 16;
- No requirement to remove existing businesses at the junction of Highway 5 and Highway 41;
- Avoided the University of Saskatchewan Kernen Research Farm;
- Provided ample spacing between interchanges at Highway 5 and Highway 41; and
- Provided the most route continuity and directness, as well as, least impact on commercial properties between the South Saskatchewan River and Highway 16.

Traffic projections for the Perimeter Highway were based on a future population of 400,000. A key recommendation of this report outlined the need for a shared-purpose river crossing, serving both CoS and highway traffic needs.

Highway 5 East Functional Planning Study

This study aimed at providing configuration and alignment alternatives along Highway 5 from McOrmond Drive intersection to the future Perimeter Highway Intersection east of Highway 41. Intersection concepts were evaluated at three intersections. The recommended alternatives at the necessary locations were as follows:

- Highway 5/McOrmond Drive – Parclo AB, with loops in the SE and NE quadrants;
- Highway 5/Highway 41 – Parclo AB, with loops in the SE and NE quadrants; and
- Highway 5/Perimeter Highway – Full clover with collector-distribution roads in all directions.

Additional analysis was recommended once land use and density plans are established to confirm the selected intersection configurations remain valid.

Saskatoon Perimeter Highway Validation Study

The validation study aimed at assessing conditions that may have changed since approval of the route of the Perimeter Highway around the CoS. The CoS and Rural Municipality (RM) of Corman Park have identified future development areas that may extend outside of the proposed Future Perimeter Highway, northeast of its existing alignment. The perimeter highway location detailed in the 2005 functional planning study may provide problematic future access points for the CoS to support their future land use. A conditions assessment was completed to identify conditions that had changed between the approval of the route and the time of writing (2005 to 2014), results of which included:

- Population growth and traffic demand accelerated beyond what was initially considered;
- Existing and future changes to land use around the CoS raised concerns over the future geometric requirements and traffic operations of the Perimeter Highway; and
- There was no need to consider moving Perimeter Highway based on other road networks. Adequate access will be provided to adjacent land with some modification.

Invalid sections of the route were deemed to be the South terminal at Highway 11 and between Highway 11 south to Highway 5 due to adjacent land development constraints. The South terminal should be considered at a location that would facilitate a west connection should the Perimeter Highway continue further through the southwest area of the city. The southeast corridor is considered invalid due to geometric and operational concerns at the Highway 16 east intersection. Moving the perimeter further east would allow for a system level interchange to be constructed and for city land use plans for the Holmwood neighborhood to be fulfilled.

South Saskatoon Freeway General Location Study

The purpose of this study was to define a 500 m wide corridor from which the detailed location of the future Perimeter Highway could be established. The study area for the South Saskatoon Freeway alignment extended from south of Highway 5 on the east to the south terminal on Highway 11, and from Highway 14 to Highway 7 in the southwest. Connections from Highway 11 south to Highway 7 were eliminated from the scope as cost benefit analysis indicated this corridor was not warranted. The southeast recommended alignment intersects Highway 11 South of the Grasswood Commercial Node and is relatively similar to the previous proposed alignment. The proposed alignment in the west would connect the Saskatoon Freeway north of Highway 7 to Highway 60 south of Highway 7.

2.2 Existing Conditions

2.2.1 National Highway System

Canada's National Highway System (NHS) ties key highways together as illustrated in **Figure 2.1**. The national highways are a critical component of the economic wellbeing of Canada, Provinces, Municipal Governments, and First Nations.

Canada's NHS is an evolution of the Trans-Canada Highway concept originally launched in 1949. Construction of the Trans-Canada Highway began in 1950 under the authority of the Trans-Canada Highway Act. In 1962 Prime Minister John Diefenbaker officially opened the Trans-Canada Highway, although construction continued until 1971. A key goal of the Trans-Canada Highway was to connect all the provinces together by highway, which was pursued through a cost-sharing partnership between federal and provincial governments to upgrade existing roadways to "Trans-Canada" standards. (Council of Ministers Responsible for Transportation and Highway Safety, 2019)

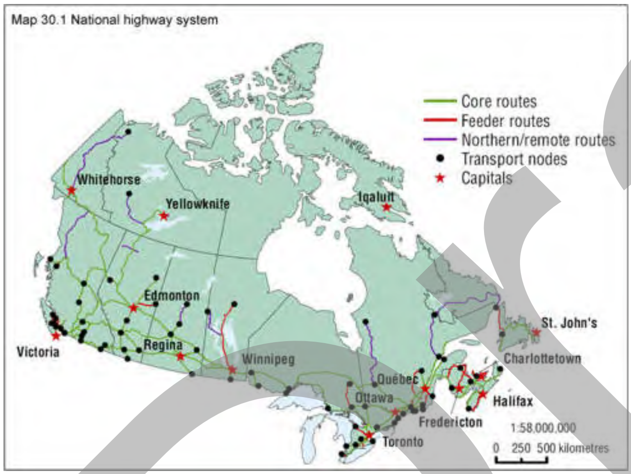


Figure 2.1: Canadian National Highway System (Transport Canada, 2018)

Canada's NHS is a network of highways across Canada that serves road transportation which is the dominant mode for moving both freight and passengers across Canada. (Transport Canada, 2018)

In 2017, NHS had over 38,098 lane-kilometers, including:

- 72.8% classified as "core" routes
- 11.7% classified as "feeder" routes
- 15.5% classified as "Northern and remote" routes

The total travel on the provincial highway network during 2018 was approximately 9,762 million vehicle-km (Ministry, personal communication, March 31, 2020). Approximately 4,670 million vehicle-km occurred on the Provincial National Highway System or approximately 48% (Ministry, personal communication, March 31, 2020) of all travel in Saskatchewan occurs on Saskatchewan's national highways illustrated in Figure 2.2.

The Ministry plan for 2019-20 (Saskatchewan Ministry of Highways and Infrastructure, 2019) includes a Ministry goal: Efficient Travel for People and Goods. A key action stemming from this goal is to "Continue functional planning for the future traffic demand around Saskatoon to reduce the amount of land currently restricted for development."

The Saskatoon Freeway encompasses three national highways: Highway 11, Highway 16, and Highway 7 as illustrated in **Figure 2.2**. Saskatchewan's portion of the National Highway System is comprised of 2,687.5 km of Highways (Council of Ministers Responsible for Transportation and Highway Safety, 2019).

The 2018 provincial truck travel was 1,924.50 million veh-km. The truck travel was 1,111.13 million veh-km in 2018 on the provincial NHS, or 58% of overall truck travel (Minsitry, Personnel Communication, March 31, 2020). The Ministry has defined a Core Highway Network, which is made up of approximately 10,000 km of provincial highways (including national highways in the vicinity of the CoS) which makes up approximately 37% of the total highway network but accommodates approximately 78% of the total travel on provincial highways (Ministry, Personnel Communication, March 30, 2020). The Core Highway Network accommodates approximately 84% of the truck travel in Saskatchewan. Saskatoon is a key hub where three National Highways intersect: Highway 7, Highway 11, and Highway 16, as well as the Core Highway Network, which includes Highway 5, Highway 12, Highway 14, and Highway 41.

Figure 2.2: Saskatchewan's National Highway System

2.2.2 Geotechnical

2.2.2.1 Surficial geology

The Saskatoon Group makes up the surficial deposits evident at the surface within the Phase 2 area. These deposits comprise till, eolian sediments, and glaciolacustrine deposits.

The till (a heterogeneous mixture of grain sizes ranging from clay to boulders) is soft and oxidized, with clasts commonly comprising igneous and metamorphic rocks, limestone, and marine shale. Till forms planar to hummocky deposits and underlies the Highway 41 and 8th Street interchanges as well as the eastern portion of the Highway 5 interchange. Till also underlies sections of the mainline alignment between the Central Road and Blackley Road interchange locations and between the Highway 5 and 8th Street interchange locations.

Glaciolacustrine units are fine-grained: they comprise grey silt/clay deposits. Topography is undulating to flat. Glaciolacustrine sediments underlie the Central Avenue, Blackley Road, 8th Street, Highway 16, and Zimmerman Road interchanges. Glaciolacustrine sediments also underlie the Highway 41 flyover, the west portion of the Highway 5 interchange and part of the proposed freeway extending to the north from Highway 5.

Eolian deposits consist of wind-blown silt and sand. Sediments formed by wind action generally have a sandy layer 1 m or more thick, consisting mainly of well-sorted fine sand. Eolian deposits underlie the Floral Road and Highway 11 interchanges, as well as the Freeway mainline connecting them.

The proposed freeway crosses over planar fluvial deposits of Holocene age on either side of the South Saskatchewan River crossing. These consist of clay, silt, sand, and gravel.

At depth, the various units of the Saskatoon Group are interbedded with nonglacial sediments (fluvial silt/sand/gravel/organics, lacustrine silt/clay, aeolian sand, and paleosols).

Older glacial deposits, consisting of thick till/intertill sequences, underlie the Saskatoon group. The latter consist of clay, silt, sand, and gravel, (rarely, gravel/sand only), while the till units are grey, with a silt/clay matrix and varying carbonate content. These tills generally have significantly higher clay contents than those of the Saskatoon Group.

The Tertiary Empress Group underlies the oldest till/intertill units and overlies bedrock. It comprises stratified fluvial quartzite and chert gravel that is well rounded for the most part, but also includes igneous, metamorphic, and carbonate rocks. Finer clastic deposits, organic-rich sediments, fine-grained lacustrine, and fine to coarse-grained colluvial deposits may be present as well.

2.2.2.2 Bedrock geology

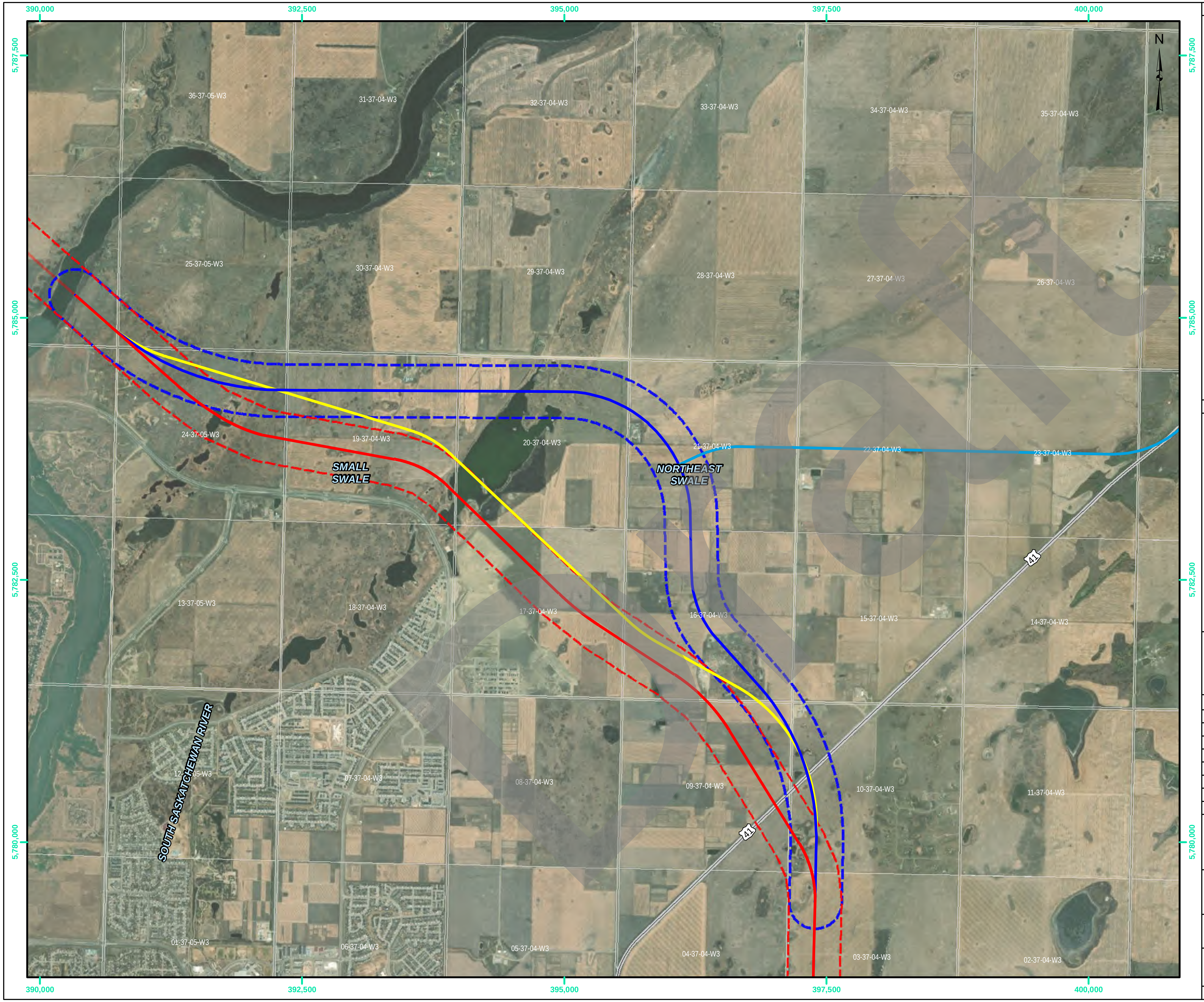
The Upper Cretaceous Bearpaw Formation is the uppermost bedrock unit in the area. It is composed of dark grey to grey non-calcareous marine claystone, silty claystone, and siltstone, commonly forming discrete units of interbedded sandstone/siltstone or siltstone/claystone. Minor brownish-grey silty sandstone, sandstone, concretionary beds and thin beds of bentonite may also be present.

Additional geotechnical details are discussed in **Section 8.1**.

2.2.3 Environment and Heritage Resource Review

SNC-Lavalin Inc. (SNC-Lavalin) conducted a Phase 2 Biological Assessment in support of the SFFPS. The Phase 2 Biological Assessment serves as an addendum to the 2020 SFFPS Environmental and Regulatory Review and is presented in **Appendix A**. The assessment focus primarily on the area between the Northeast Swale and the South Saskatchewan River, as these areas were identified as areas of concern and biological significance. Other important environmental areas may also be identified during the Environmental Assessment (EA) phase of the project within Phase 2. This report also focuses primarily on the wildlife and vegetation in these areas, as other descriptions of the environment (soils, land cover, climate, etc.) were already discussed in the 2020 SFFPS Environmental and Regulatory Review. In addition to detailed design Environmental Impact assessments; detailed design processes will also require Transport Canada reviews and permits related to navigation requirements for the South Saskatchewan River.

Several options were initially presented as potential routes in the area as a result of extensive stakeholder consultations and opportunities for environmental expert input. The shortlisted alignment concepts are described below and presented in **Figure 2.3**.



LEGEND

🟥	ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
🟨	ROUTE CONCEPT 2
🟦	ROUTE CONCEPT 3
🟦	ROUTE CONCEPT 4
┼	RAILWAY
═	HIGHWAY
▭	GENERAL LOCATION CORRIDOR (PHASE 2)
▭	2021 STUDY AREA

NOTES

1. COORDINATE SYSTEM: NAD 1983 UTM ZONE 13N.
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DWG No.	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
00	2022 10 06	ISSUED FOR INFORMATION	KH	KVG	KH	JP

0 250 500 1,000
METRES

SCALE: 1:35,500

SNC·LAVALIN

CLIENT
SASKATCHEWAN MINISTRY
OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
PROPOSED SASKATOON FREEWAY PHASE 2
ROUTE ALTERNATIVES

DATE	2022 01 31	DWG No.	659183-0000-4EDD-0072	FIG No.2.3	REV	00

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0072 2021 Proposed Saskatoon Freeway Phase 2.mxd

SIZE 11x17

- Route Concept 1: the alignment of which was identified in a previous study shown in red dashed lines representing the original 500 m wide corridor;
- Route Concept 2 (yellow): shifts the portion of the alignment between the South Saskatchewan River and Highway 41 approximately 250 m north to avoid the most sensitive areas of the Small and Northeast Swales.
- Concept 3 (purple): moves the alignment further north to avoid areas with high potential for open water. The alignment travels west, parallel to Township Road 374, from approximately the Small Swale to Blackley Road. From Blackley Road, the alignment turns south to meet up with the original alignment at existing Highway 41; and
- Route Concept 4 (purple plus blue): adds the east-west realignment of Highway 41 to Concept 3.

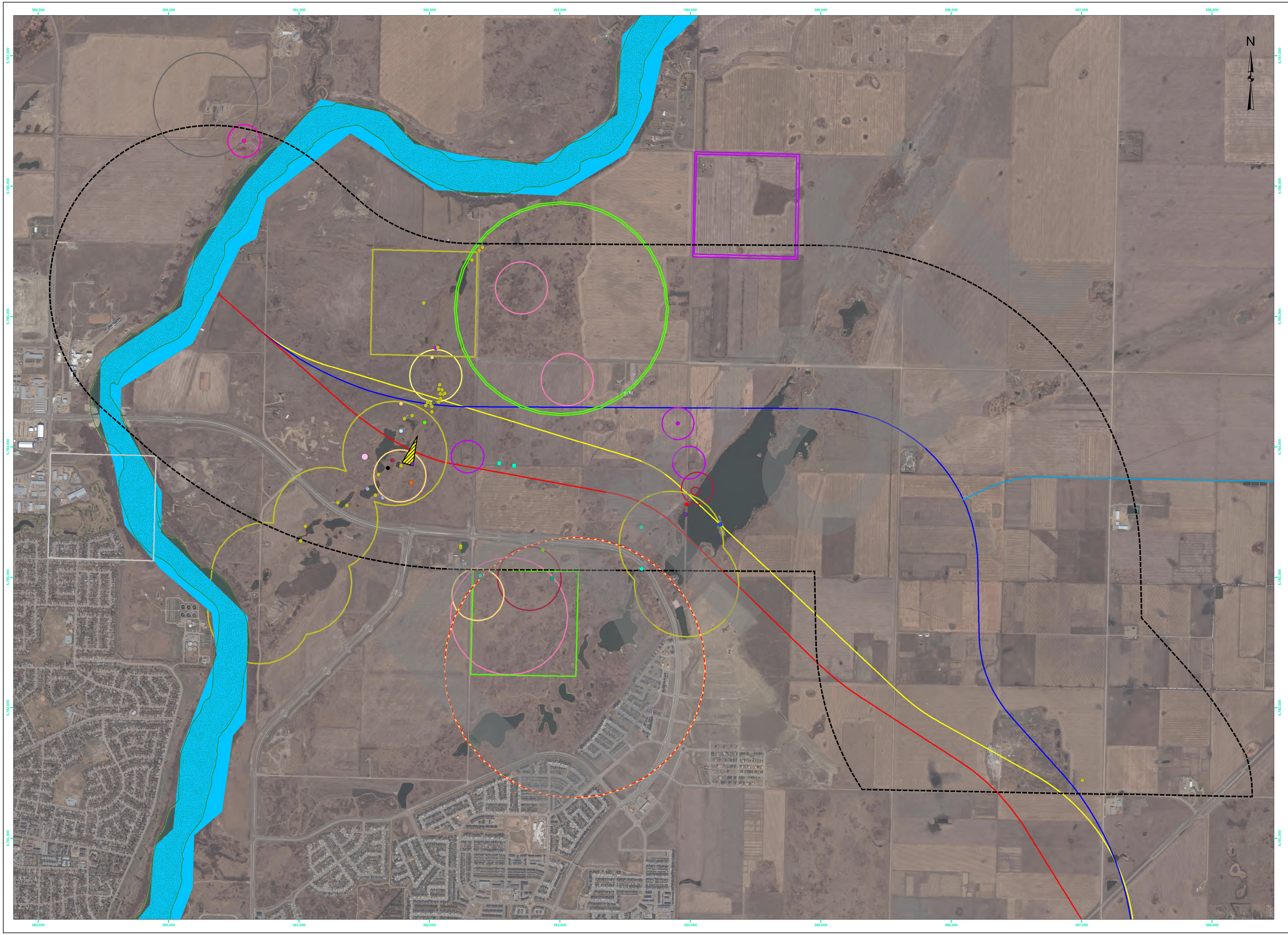
SNC-Lavalin conducted a wildlife and wildlife habitat study and a preliminary vegetation study as part of the Phase 2 Biological Assessment. These surveys were completed in 2020 and 2021 between the Northeast Swale and the South Saskatchewan River. The surveys also included the Small Swale, as well as some cropland, grassland, and riparian habitat between these landmarks. The following surveys were completed according to Saskatchewan Ministry of Environment (ENV) protocols (**Appendix A**):

- Snow tracking surveys;
- Sharp-tailed grouse (*Tympanuchus phasianellus*) lek surveys;
- Auditory amphibian surveys;
- Common nighthawk (*Chordeiles minor*) and short-eared owl (*Asio flammeus*) surveys;
- Yellow rail (*Coturnicops noveboracensis*) surveys;
- Incidental wildlife observations; and
- A preliminary vegetation study.

2.2.3.1 Wildlife and Wildlife Habitat

Phase 2 of the project is entirely within the Moist Mixed Grassland Ecoregion. The Ecoregion supports 51 mammal species, 13 reptile and amphibian species, and 198 migratory and resident birds. A review of desktop resources, including databases and previous reports found a total of 36 wildlife Species of Conservation Concern (SOCC) within the 2021 desktop study area, 20 of which are considered Species at Risk (SAR) (**Figure 2.4**). If specific locations or SOCC/SAR are known, they are presented in this figure (point/dot). However, general locations (polygons/circles) are presented where the exact coordinates of the SOCC/SAR observations are not presented (for example, HABISask data).

A total of 114 wildlife species were observed during the 2020 and 2021 species detection surveys, 13 of which were identified as SOCC Of the SOCC observed during species detection surveys, 11 were birds, one was a mammal, and one was an amphibian (**Table 2.2**). Six of those species are SAR, including the American badger, barn swallow, common nighthawk, horned grebe, northern leopard frog, and short-eared owl. Common nighthawk, short-eared owl, and northern leopard frog were detected during species-specific surveys targeting these species (**Figure 2.5** and **Figure 2.6**). Other species were observed incidentally. Some significant wildlife features, such as a new previously undiscovered sharp-tailed grouse lek were also discovered in the small swale (**Figure 2.7**). 3,924 wildlife sign observations (tracks, scat, live animal observations, etc.) were made during the 2020 and 2021 snow tracking surveys in the Phase 2 study area (**Figure 2.8** and **Figure 2.9**, respectively).



LEGEND

- 🟥 ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- 🟨 ROUTE CONCEPT 2
- 🟦 ROUTE CONCEPT 3
- 🟦 ROUTE CONCEPT 4
- ▭ 2021 DESKTOP STUDY AREA

ANIMAL ASSEMBLAGE
- ▨ MIGRATORY BIRD CONCENTRATION SITE

INVERTEBRATE
- 🟧 GOLDENROD GALL FLY
- ▨ YELLOW-BANDED BUMBLE BEE*

VERTEBRATE
- 🟩 AMERICAN BADGER*
- ▨ BAIRD'S SPARROW*
- 🟪 BANK SWALLOW*
- ▭ BARN SWALLOW*
- 🟦 BLACK-NECKED STILT
- ⬛ BOBOLINK*
- 🟦 GREAT BLUE HERON
- ▭ HORNED GREBE*
- 🟦 LAKE STURGEON*
- ▭ LOGGERHEAD SHRIKE*
- ▭ NORTHERN LEOPARD FROG*
- 🟩 NORTHERN SHRIKE
- 🟪 OSPREY
- 🟦 PEREGRINE FALCON*
- ▭ RUSTY BLACKBIRD*
- ▭ SHORT-EARED OWL*
- ▭ TURKEY VULTURE
- ▭ WHOOPING CRANE*
- ▭ YELLOW RAIL*

WILDLIFE FEATURE
- 🟫 AMERICAN BADGER DEN
- ▭ SHARP-TAILED GROUSE LEK *

*** DENOTES SPECIES AT RISK**

SIZE 22 x 34

NOTES

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4. TOPOGRAPHIC FEATURES OBTAINED FROM CANVEC V12.0 DATASET, NATURAL RESOURCES CANADA EARTH AND SCIENCES SECTOR CENTRE FOR TOPOGRAPHIC INFORMATION, 2013-09-30.
5. HIGHWAYS AND ROADS OBTAINED FROM THE NATIONAL ROAD NETWORK SASKATCHEWAN EDITION 11.0 DATASET, 2020-06-18.
6. RAILWAYS OBTAINED FROM THE NATIONAL RAILWAY NETWORK SASKATCHEWAN EDITION 2.0 DATASET, 2019-07-25.
7. RARE SPECIES INFORMATION OBTAINED FROM HABISASK COLLECTED BY THE SASKATCHEWAN CONSERVATION DATA CENTRE, MEEWASIN VALLEY AUTHORITY (GRILZ AND HOOEY 2020); NORTH COMMUTER PARKWAY – BASELINE TERRESTRIAL AND AQUATIC FIELD STUDIES, AND HERITAGE RESOURCE IMPACT ASSESSMENT (STANTEC 2013A); AND NORTH CENTRAL/NORTH EAST NATURAL AREA SCREENING STUDY, CITY OF SASKATOON (STANTEC 2013B). INFORMATION IS SENSITIVE AND INTENDED FOR CONSERVATION PURPOSES ONLY. ONLY SPECIES WITHIN STUDY AREA ARE SHOWN.

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00	2022 10 06	ISSUED FOR INFORMATION	HR	KVG	HY	JP

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SCALE: 1:13,000

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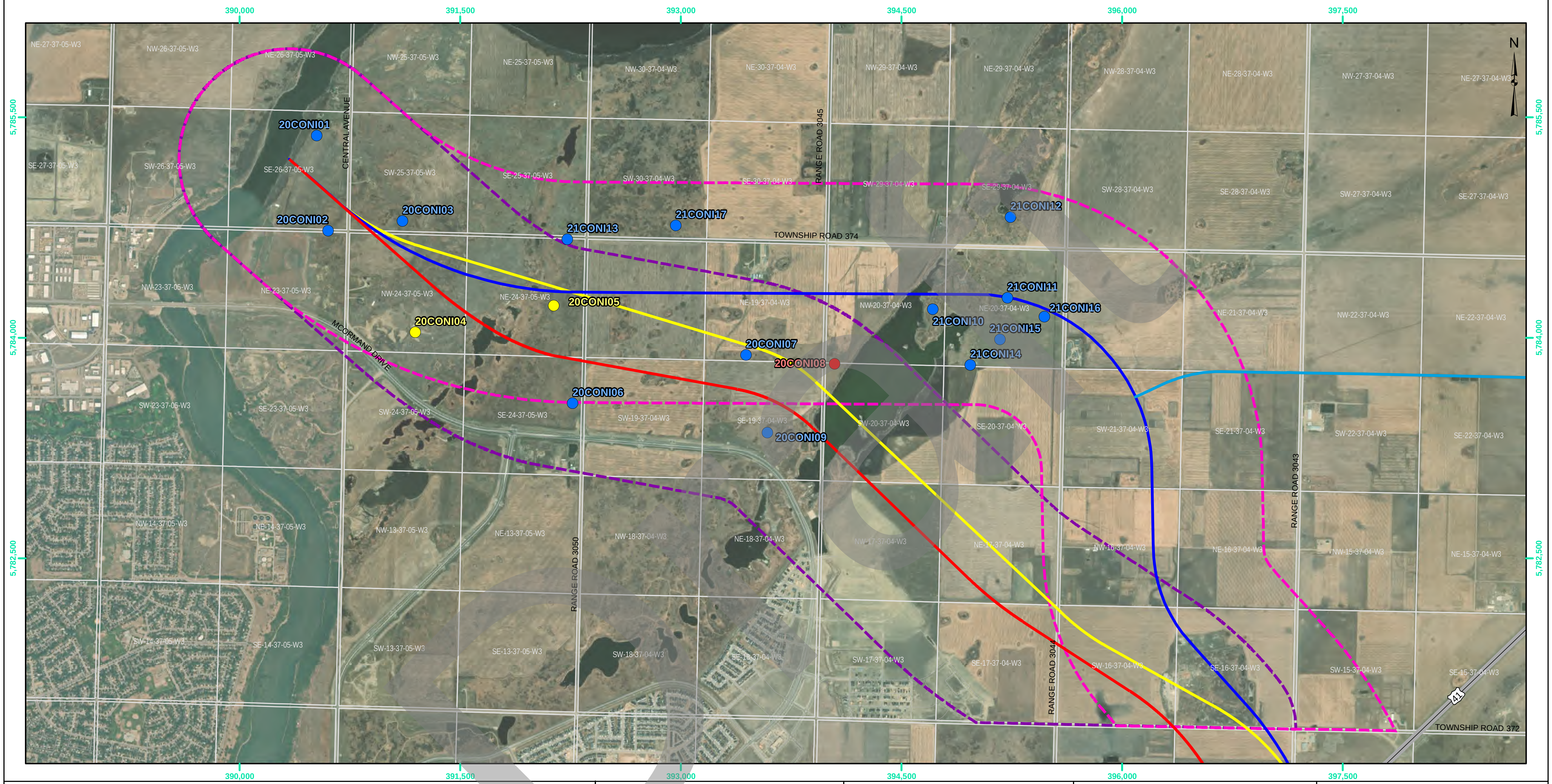
CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
DESKTOP WILDLIFE SOCC SCREENING RESULTS

DATE 2021 12 20 | DWG No 659183-0000-4EDD-0063 | FIG No. 2.4 | REV 00

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0063 2021 Desktop Wildlife Study Area_.mxd



● COMMON NIGHTHAWK AND SHORT-EARED OWL SURVEY STATIONS - NOT DETECTED

● COMMON NIGHTHAWK AND SHORT-EARED OWL SURVEY STATIONS - SHORT-EARED OWL DETECTED

● COMMON NIGHTHAWK AND SHORT-EARED OWL SURVEY STATIONS - COMMON NIGHTHAWK DETECTED

ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)

ROUTE CONCEPT 2

ROUTE CONCEPT 3

ROUTE CONCEPT 4

HIGHWAY

2020 AUDITORY AMPHIBIAN STUDY AREA

2021 AUDITORY AMPHIBIAN STUDY AREA

NOTES

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0 165 330 660 990 1,320 Metres

SCALE: 1:26,000

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REFERENCE DRAWINGS

DWG No.	DESCRIPTION

CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 COMMON NIGHTHAWK AND SHORT-EARED OWL SURVEY STATIONS AND DETECTION RESULTS

DATE	DWG No.	FIG No.	REV
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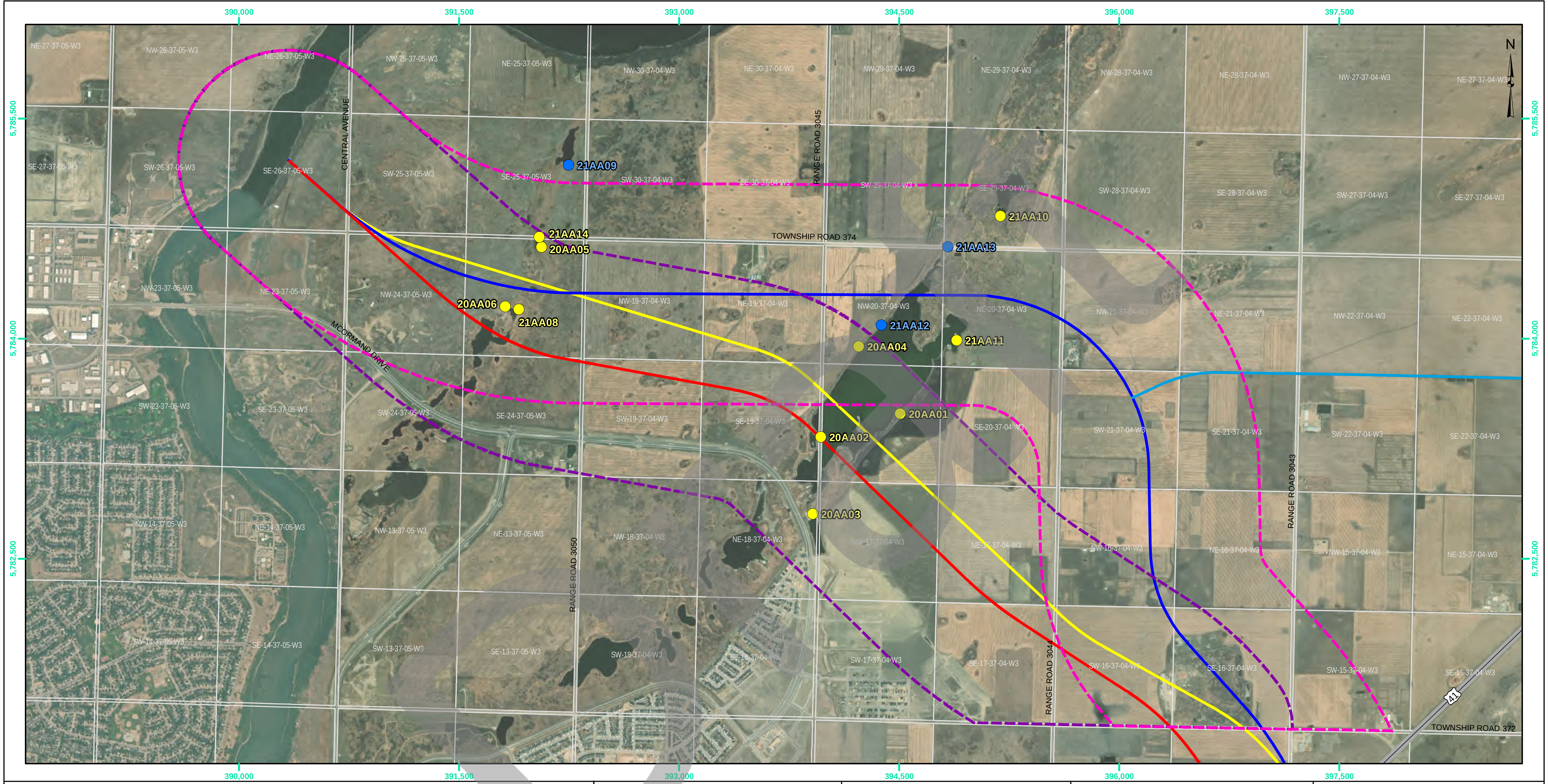

🔵 AMPHIBIAN AUDITORY SURVEY STATION - NOT DETECTED

🟡 AMPHIBIAN AUDITORY SURVEY STATION - DETECTED

🟥 ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)

🟨 ROUTE CONCEPT 2

🟦 ROUTE CONCEPT 3

🟦 ROUTE CONCEPT 4

▬ HIGHWAY

▨ 2020 AUDITORY AMPHIBIAN STUDY AREA

▨ 2021 AUDITORY AMPHIBIAN STUDY AREA

NOTES

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0 165 330 660 990 1,320 Metres

SCALE: 1:26,000

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00	2022 10 06	ISSUED FOR INFORMATION	HR	KVG	HY	JP

REFERENCE DRAWINGS

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SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 AMPHIBIAN AUDITORY SURVEY STATIONS AND DETECTION RESULTS

DATE	DWG No.	FIG No.	REV
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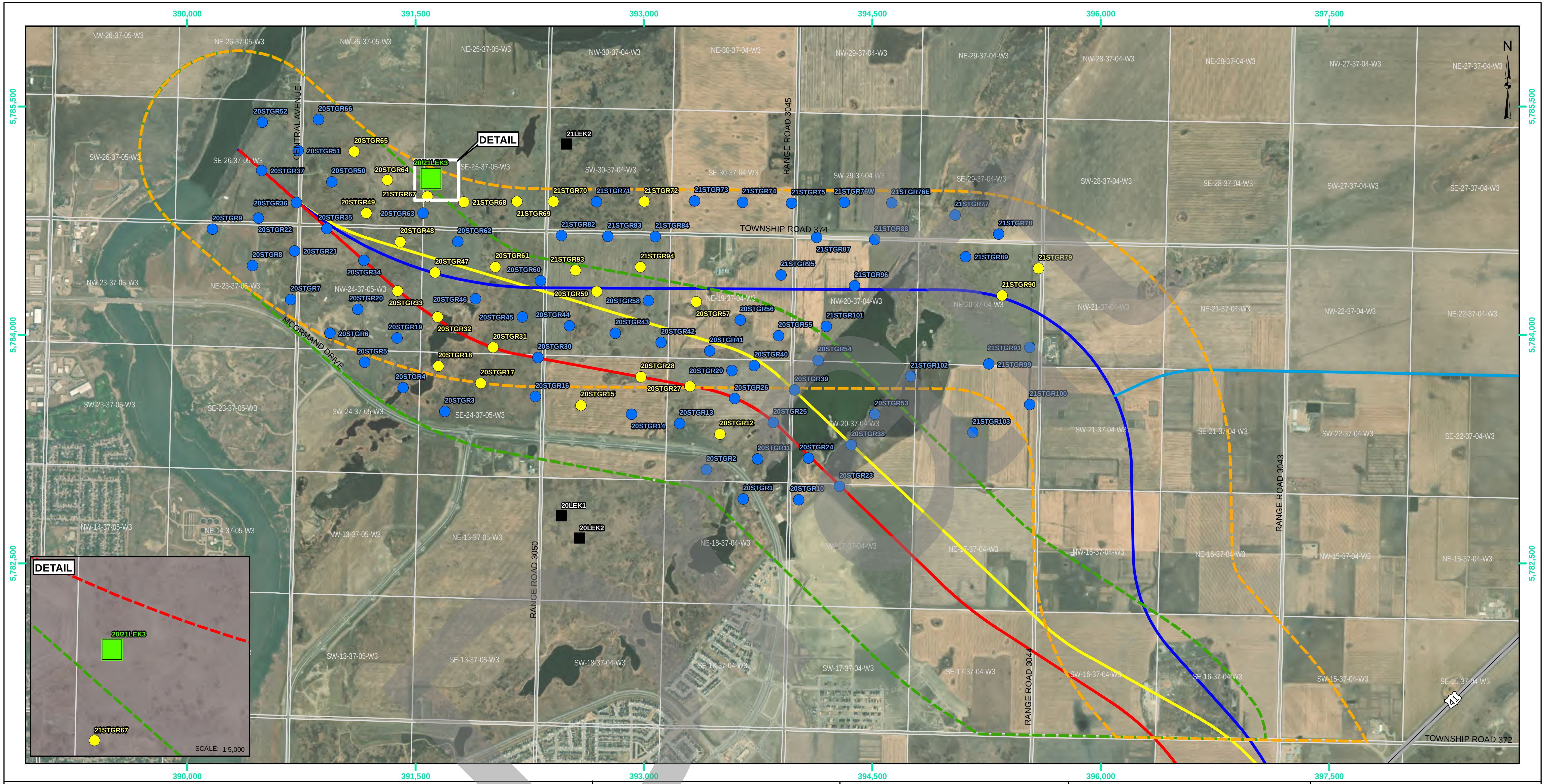

ABUNDANCE OF INDIVIDUALS AT LEKS

☐	1 TO 5
☐	5 TO 10
☐	10 TO 15
☐	15 TO 20

ACTIVE LEK

■	NO*5
🟩	YES

●	SHARP-TAILED GROUSE SURVEY STATION - NOT DETECTED
●	SHARP-TAILED GROUSE SURVEY STATION - DETECTED
═	HIGHWAY
🟥	ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
🟨	ROUTE CONCEPT 2
🟦	ROUTE CONCEPT 3
🟦	ROUTE CONCEPT 4
▭	2020 SHARP-TAILED GROUSE LEK STUDY AREA
▭	2021 SHARP-TAILED GROUSE LEK STUDY AREA

NOTES

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5. INACTIVE LEKS WERE PREVIOUSLY RECORDED LEK OCCURENCES BY OTHER OBSERVERS. SNC-LAVALIN RE-ASSESSED THESE LEKS IN 2021, BUT DID NOT OBSERVE LEKKING BIRDS.

0 160 320 640 960 1,280 Metres

SCALE: 1:25,000

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00	2022 10 06	ISSUED FOR INFORMATION	HR	KVG	HY	JP

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DWG No.	DESCRIPTION

CLIENT

SASKATCHEWAN MINISTRY
OF HIGHWAYS

PROJECT LOCATION

SASKATOON FREEWAY

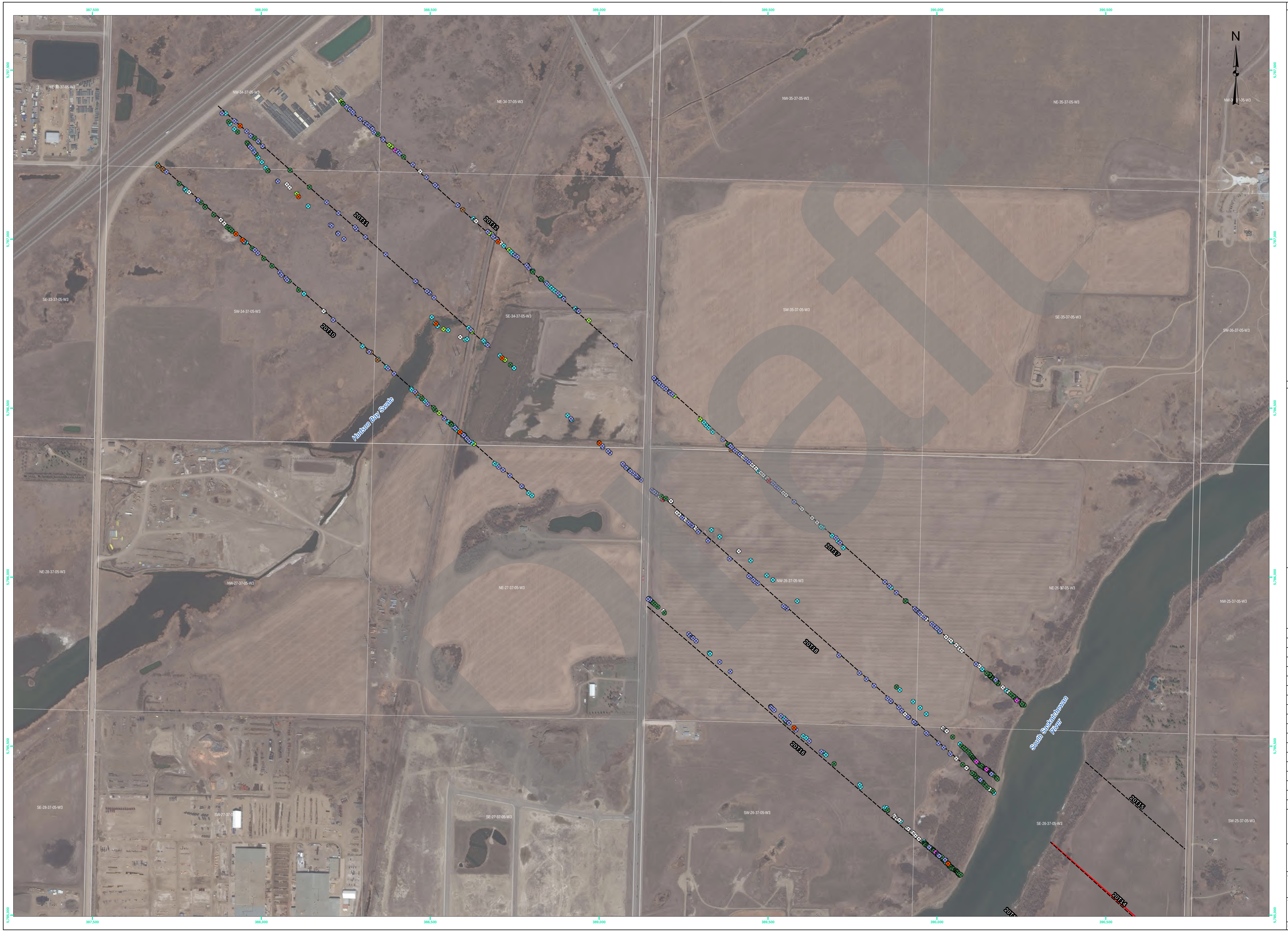
TITLE

2020/2021 SHARP-TAILED GROUSE LEK SURVEY
STATIONS AND DETECTION RESULTS

DATE	DWG No.	FIG No.	REV
2021 11 30	659183-0000-4EDD-0065	2.7	00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0065 2021 STGR.mxd



LEGEND

SPECIES DETECTED

- ⊗ BIRD
- ⊗ COYOTE
- ⊗ GROUSE
- ⊗ HARE / RABBIT
- ⊗ PORCUPINE
- ⊗ RED FOX
- ⊗ SMALL RODENT
- ⊗ WEASEL
- ⊗ WHITE-TAILED DEER / MULE DEER
- - - - SNOW TRACK SURVEY TRANSECT
- ━ ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)

SIZE 22 x 34

NOTES

1. COORDINATE SYSTEM: NAD 1983 UTM ZONE 13N.
2. PHASE 2 FREEWAY ALIGNMENTS DIGITIZED FORM GEREFERENCED PDF - AECOM A1_NE_SWALE, DATED 18/06/20.
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DWG No	DESCRIPTION

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REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
00	2022 10 06	ISSUED FOR INFORMATION	HY	WH	HY	JP

0 50 100 200 Metres

SCALE: 1:5,000

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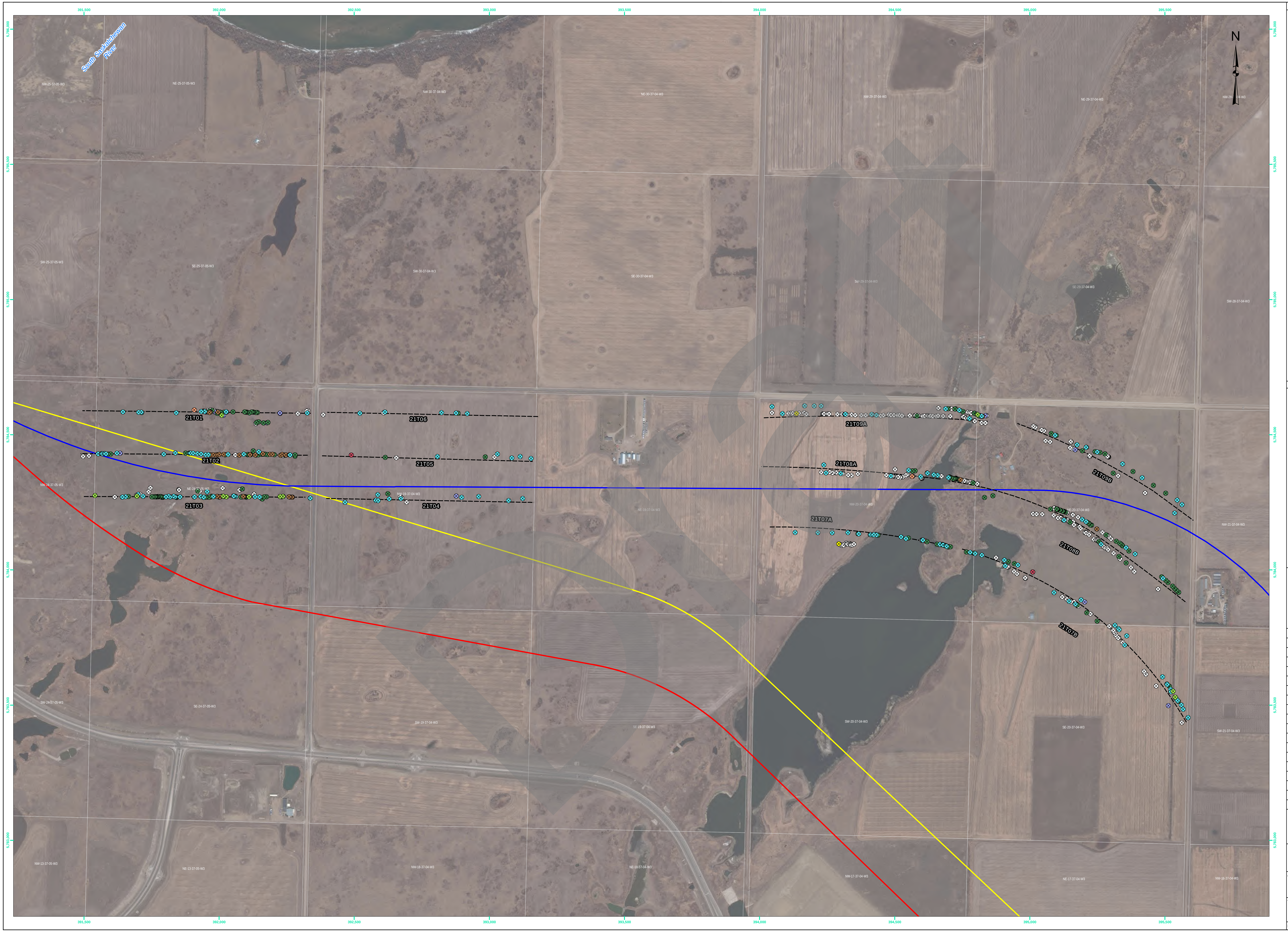
CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020 PHASE 1 SNOW TRACK SURVEY TRANSECTS AND DETECTION RESULTS

DATE 2022 03 17 **DWG No** 659183-0000-4EDD-0074 **FIG No.** 2.8 **REV** 00

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0074 2020 West Snow Track Survey 22BY34.mxd



LEGEND

SPECIES DETECTED

- ⊗ BEAVER LODGE
- ⊗ BIRD
- ⊗ COYOTE
- ⊗ GOOSE
- ⊗ GROUSE
- ⊗ HARE / RABBIT
- ⊗ MOOSE
- ⊗ RED FOX
- ⊗ SMALL RODENT
- ⊗ WEASEL
- ⊗ WHITE-TAILED DEER / MULE DEER
- - - - SNOW TRACK SURVEY TRANSECT
- ━ ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- ━ ROUTE CONCEPT 2
- ━ ROUTE CONCEPT 3

SIZE 22 x 34

NOTES

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REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
00	2022 10 06	ISSUED FOR INFORMATION	HY	WH	HY	JP

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SCALE: 1:6,250

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAY	SASKATOON FREEWAY

TITLE

2021 SNOW TRACK SURVEY TRANSECTS AND DETECTION RESULTS

DATE	DWG No	FIG No.	REV
2021 12 15	659183-0000-4EDD-0064	2.9	00

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0064 2021 Snow Track Survey - NE Swale Area (34X22).mxd

2.2.3.2 Vegetation and Wetlands

The portion of the vegetation and soils study area that is located within Phase 2 is located within the Moist Mixed Grassland Ecoregion of the Prairie Ecozone and is entirely within the Saskatoon Plain Landscape Area

The Saskatoon Plain Landscape Area is a level glacial lake and eroded glacial till plain with very gently undulating topography (Acton et al., 1998). It encompasses most of the CoS and the surrounding areas located north and west of the city. Cereals are the major crop, and most of the land within the Saskatoon Plain has been converted to cropland. Native moist mixed grassland vegetation is limited to sandy sites in the South Saskatchewan River valley. Grassland and shrubland communities associated with sandy soils are common on upland sites, while saline depressions are vegetated by salt-tolerant species like Nuttall's alkaligrass and red samphire. Trembling aspen stands occur frequently in non-saline areas with high water tables, such as the South Saskatchewan River's riparian corridor.

A search of HABISask produced records of nine plant SOCC within the 2021 vegetation study area. No plant SAR element occurrences or lands requiring additional environmental protections or conservation easements were identified within the 2021 vegetation study area.

Field surveys focused on areas of native-dominant vegetation within the 2020 and 2021 vegetation study areas, including the Northeast Swale and Small Swale wetland complexes, upland sites surrounding the swales, and the South Saskatchewan River floodplain and banks. All plant taxa observed during the vegetation surveys were identified to the lowest possible taxonomic designation with the aid of floras, technical keys, and other resources. Occurrence data was collected for all positive SOCC detections made during the vegetation surveys. The 2020 and 2021 field-level vegetation surveys each consisted of two seasonal surveys. Spring surveys took place between 1 June and 5 June 2020 and between 29 May and 1 June 2021. Summer surveys took place between 27 August and 2 September 2020 and between 22 July and 28 July 2021.

A total of 371 vascular plant taxa were identified during the 2020 and 2021 field vegetation surveys. A total of 13 plant SOCC and 124 plant SOCC occurrences were detected and documented during the vegetation surveys (**Table 2.3, Figure 2.10 a-i**). 2020/2021 SOCC Detection Result Maps were only created in areas were SOCC were observed during the surveys. The majority of these detections were observed in the swales and along the South Saskatchewan River where the land has been relatively less developed than surrounding farmland and municipal lands. Larger areas of identified SOCC are shown on the maps as polygons; points/dots are smaller areas of occurrence.

Table 2.2: Wildlife SOCC observed during species detection surveys

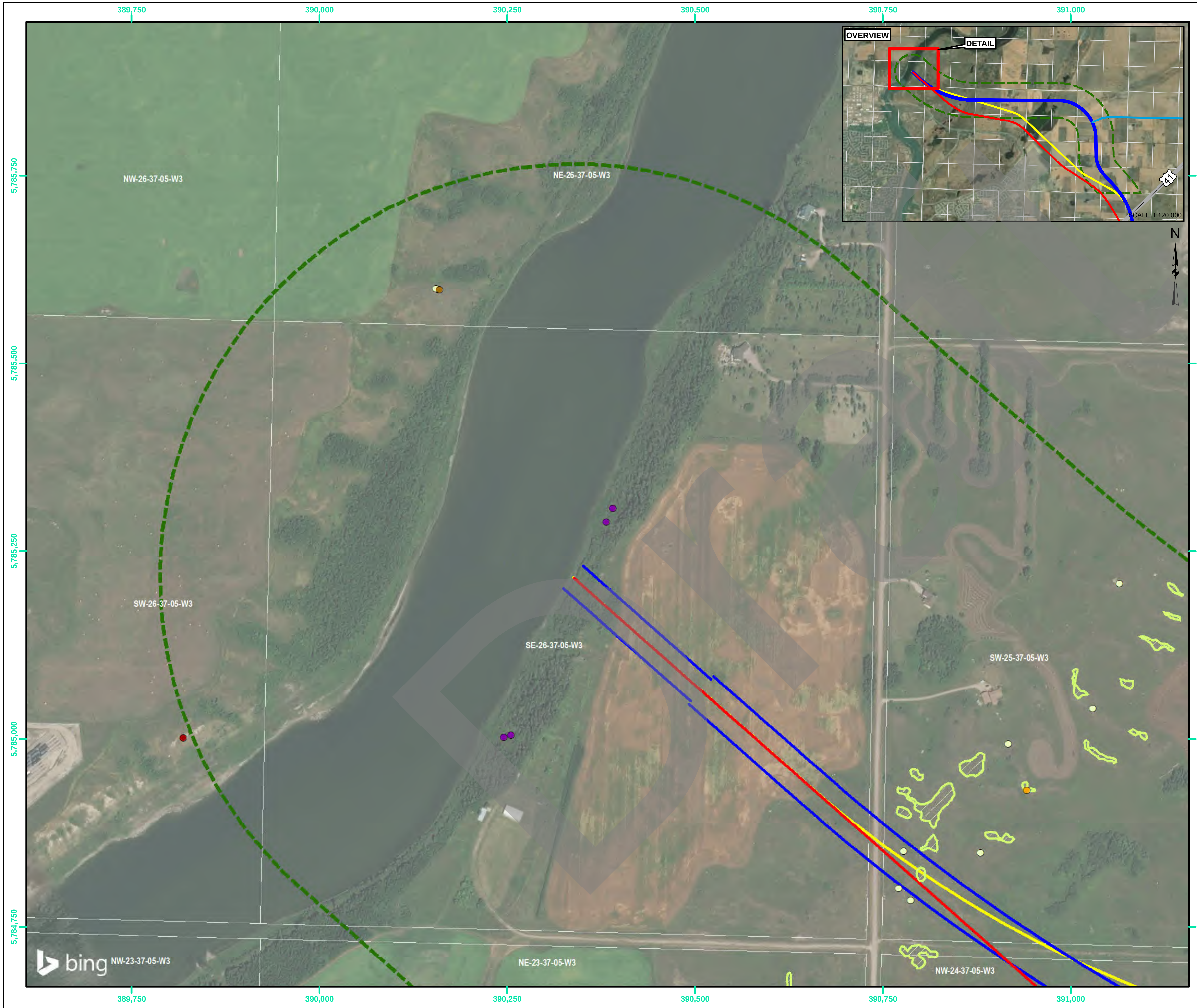
Common Name	Scientific Name	Taxonomic Group	SKCDC Ranking	COSEWIC Status	SARA Status	SAR	ARG for Species or Feature
American badger	*Taxidea taxus taxus*	mammal	S3; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a
American white pelican	*Pelecanus erythrorhynchos*	bird	S5B, S5M	Not at Risk	No Status		nesting colony
barn swallow	*Hirundo rustica*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	✓	n/a
common nighthawk	*Chordeiles minor*	bird	S4B, S4M; tracked	Special Concern	Schedule 1, Threatened	✓	breeding bird
black-crowned night heron	*Nycticorax nycticorax*	bird	S4B	No Status	No Status		nesting colony
double-crested cormorant	*Phalacrocorax auritus*	bird	S5B, S5M	Not at Risk	No Status		nesting colony
great blue heron	*Ardea herodias*	bird	S5B, S5M; tracked	No Status	No Status		nesting colony
horned grebe	*Podiceps auritus*	bird	S5B, S5M; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a
northern leopard frog	*Lithobates pipiens*	amphibian	S3; tracked	Special Concern	Schedule 1, Special Concern	✓	breeding and overwintering habitat
prairie falcon	*Falco mexicanus*	bird	S3B, S3N, S3M; tracked	Not at Risk	No Status		nest site
sharp-tailed grouse	*Tympanuchus phasianellus*	bird	S5; tracked	No Status	No Status		lek
short-eared owl	*Asio flammeus*	bird	S3B, S2N, S3M; tracked	Threatened	Schedule 1, Special Concern	✓	breeding bird
trumpeter swan	*Cygnus buccinator*	bird	S3B, S3M; Tracked	Not at Risk	No Status		breeding bird

Source: (ENV 2017; Government of Saskatchewan 2021; SKCDC 2021a and 2021c)

Table 2.3: Plant SOCC detected during vegetation surveys

Scientific Name	Common Name	Family	SKCDC Ranking	Area(s) Detected			No. of Occurrences (Patches)		Estimated No. of Plants		Total Area of Patches Recorded as Polygons* (m^2)	
				Small Swale and Surrounding Areas	Northeast Swale	South Saskatchewan River Valley	2020 Vegetation Study Area	2021 Vegetation Study Area	2020 Vegetation Study Area	2021 Vegetation Study Area	2020 Vegetation Study Area	2021 Vegetation Study Area
Alisma gramineum	narrow-leaved water plantain	Alismataceae	S3; tracked		✓		5	0	23	-	n/a	-
Almutaster pauciflorus	few-flowered aster	Asteraceae	S3; tracked	✓			1	6	61	> 5,300	n/a	1,123
Blysmopsis rufa	red bulrush	Cyperaceae	S3; tracked	✓			0	1	-	no estimate	-	113
Festuca hallii	plains rough fescue	Poaceae	S3; tracked	✓		✓	57	63	no estimate	no estimate	14,340	35,182
Gentianopsis virgata ssp. macounii	Macoun's gentian	Gentianaceae	S3; tracked	✓		✓	4	5	40	375	n/a	544
Lomatogonium rotatum	marsh felwort	Gentianaceae	S3; tracked	✓			3	8	92	380	1,156	2,466
Paronychia sessiliflora	low whitlowwort	Caryophyllaceae	S3; tracked			✓	1	1	5	5	n/a	n/a
Potentilla concinna var. concinna	early cinquefoil	Rosaceae	S2; tracked	✓			1	1	4	4	n/a	n/a
Potentilla hudsonii	Hudson's cinquefoil	Rosaceae	S2; tracked	✓		✓	2	3	15	16	n/a	n/a
Sisyrinchium mucronatum	mucronate blue-eyed grass	Iridaceae	S3; tracked	✓			1	3	1	4	n/a	n/a
Solidago ptarmicoides	upland white goldenrod	Asteraceae	S3; tracked	✓			4	12	20	80	n/a	n/a
Teucrium canadense var. occidentale	hairy germander	Lamiaceae	S3; tracked	✓	✓		7	6	387	162	86	n/a
Viola pedatifida	crowfoot violet	Violaceae	S3; tracked	✓			5	6	45	69	n/a	n/a

*Patches of plant SOCC with a radius under or equal to 5 m were recorded as waypoints as per the SKCDC Guidelines for Collecting Spatial Data during Vascular Plant Surveys (2016)



LEGEND

●	PLAINS ROUGH FESCUE
●	MACOUN'S GENTIAN
●	EARLY CINQUEFOIL
●	HUDSON'S CINQUEFOIL
●	LOW WHITLOWWORT
—	ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
—	ROUTE CONCEPT 2
—	ROUTE CONCEPT 3
▭	PLAINS ROUGH FESCUE
▭	2021 VEGETATION STUDY AREA

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SCALE: 1:5,000

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON FREEWAY

TITLE

2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	DWG No.	659183-0000-4EDD-0050	FIG No.	2.10a	REV	00

SIZE 11x17

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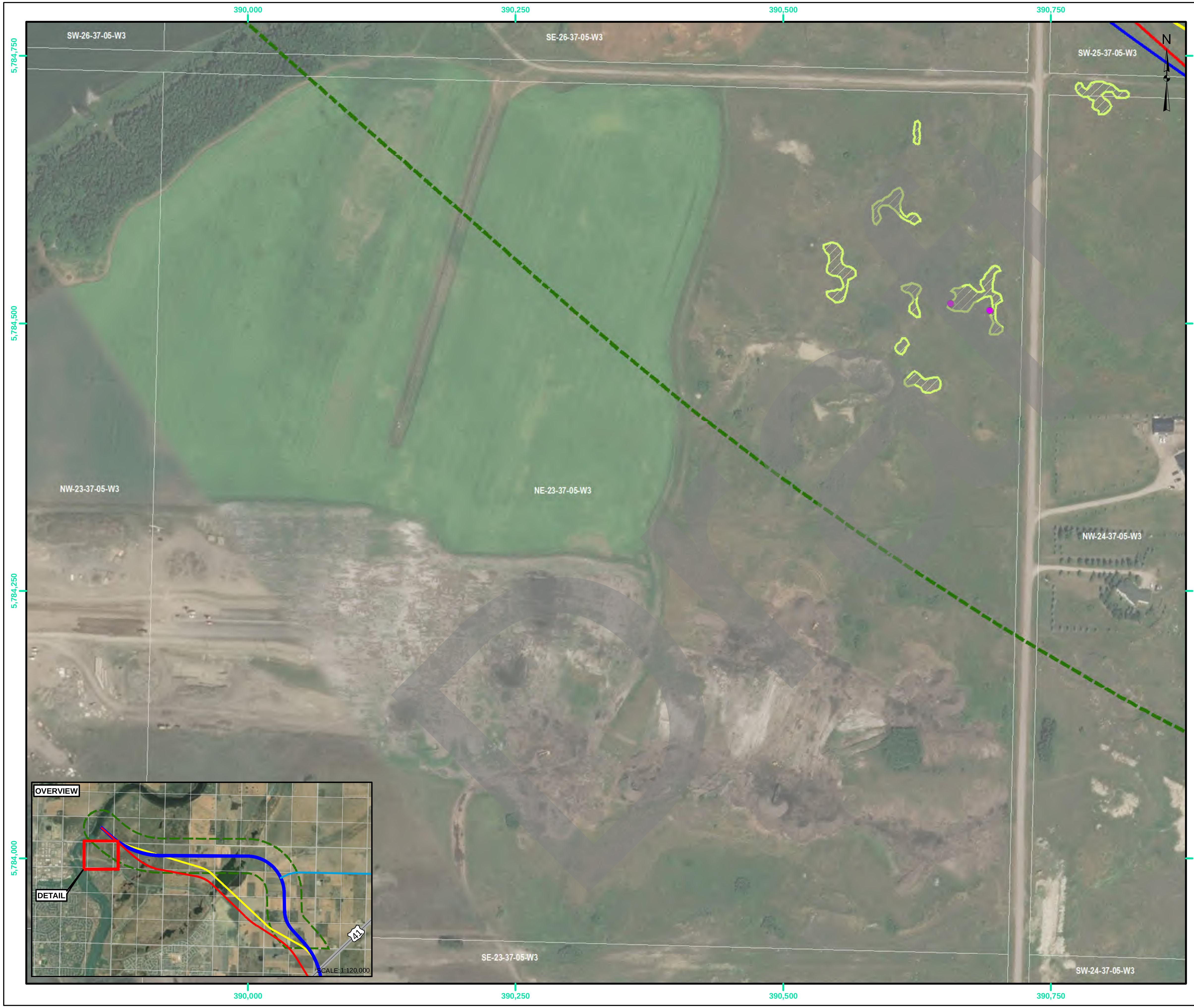

LEGEND

- ● CROWFOOT VIOLET
- 🟥 ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- 🟨 ROUTE CONCEPT 2
- 🟦 ROUTE CONCEPT 3
- ▨ PLAINS ROUGH FESCUE
- 🟩 2021 VEGETATION STUDY AREA

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0 50 100 200 METRES

SCALE: 1:3,500

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CLIENT
SASKATCHEWAN MINISTRY
OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	DWG No.	659183-0000-4EDD-0051	FIG No.	2.10b	REV	00

SIZE 11x17

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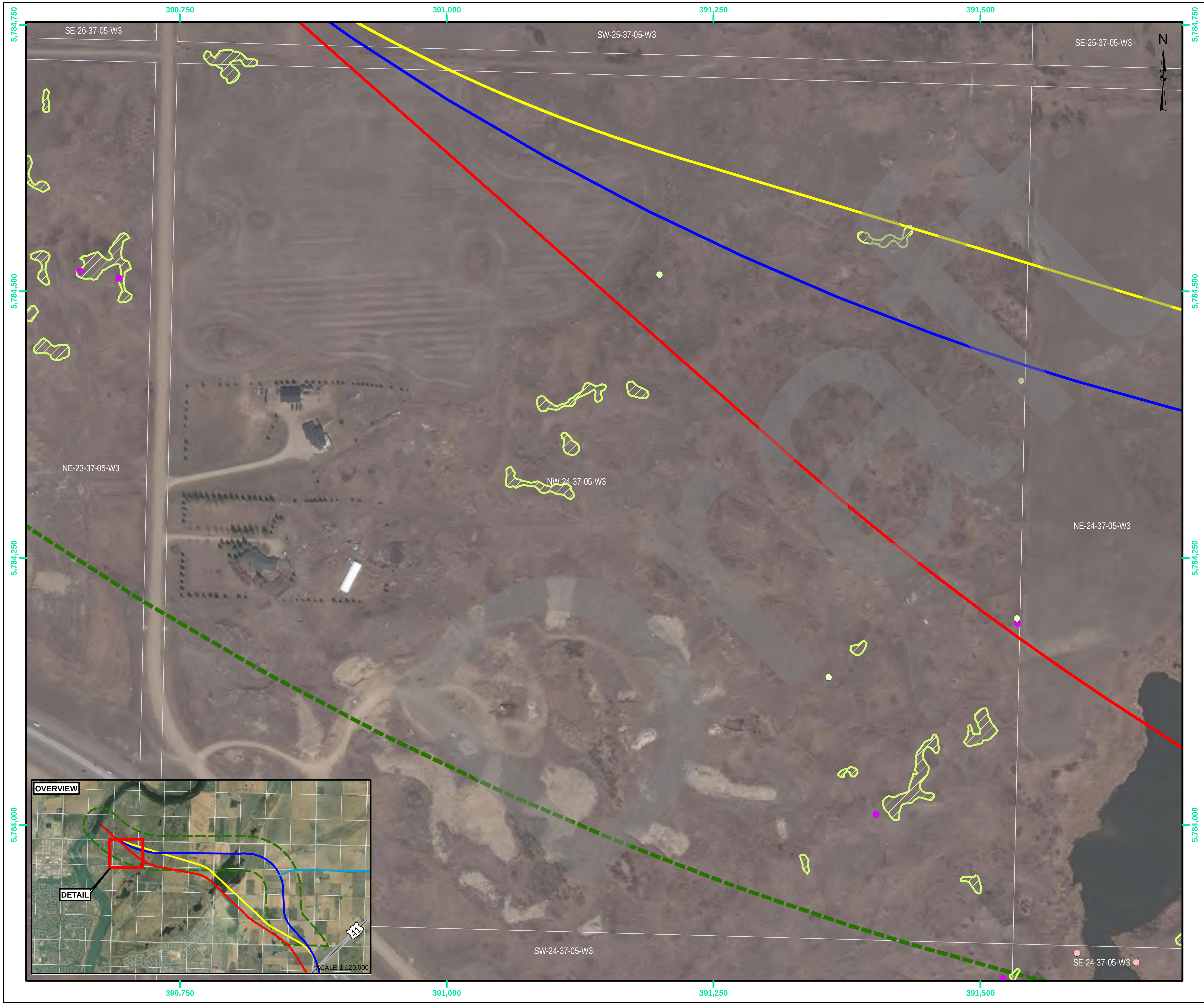

LEGEND

- ● PLAINS ROUGH FESCUE
- ● HAIRY GERMANDER
- ● CROWFOOT VIOLET
- ━ ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- ━ ROUTE CONCEPT 2
- ━ ROUTE CONCEPT 3
- ▨ PLAINS ROUGH FESCUE
- ⬚ 2021 VEGETATION STUDY AREA

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SCALE: 1:3,500

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON FREEWAY

TITLE

2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	DWG No.	659183-0000-4EDD-0051	FIG No.2.10c	REV	00

SIZE 11x17

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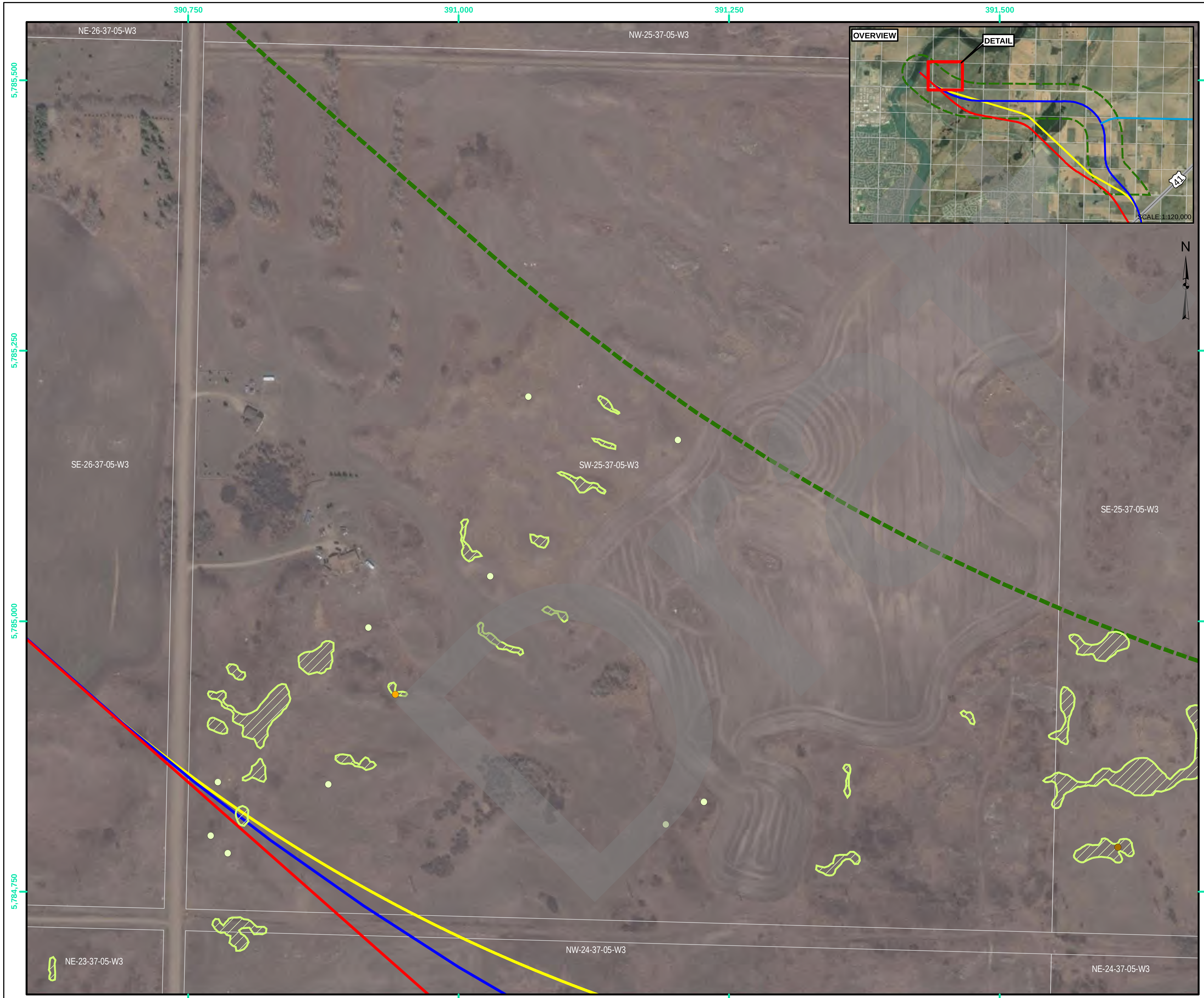

LEGEND

- ● PLAINS ROUGH FESCUE
- ● EARLY CINQUEFOIL
- ● HUDSON'S CINQUEFOIL
- ━ ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- ━ ROUTE CONCEPT 2
- ━ ROUTE CONCEPT 3
- ▨ PLAINS ROUGH FESCUE
- ⬚ 2021 VEGETATION STUDY AREA

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SCALE: 1:3,500

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SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE

2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	**DWG No.**	659183-0000-4EDD-0052	**FIG No.2.10d**		**REV**	00

SIZE 11x17

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LEGEND

- ● FEW-FLOWERED ASTER
- ● PLAINS ROUGH FESCUE
- ● HUDSON'S CINQUEFOIL
- ● MUCRONATE BLUE-EYED-GRASS
- ● UPLAND WHITE GOLDENROD
- ● CROWFOOT VIOLET
- ▨ FEW-FLOWERED ASTER
- ▨ RED BULRUSH
- ▨ PLAINS ROUGH FESCUE
- ▨ MACOUN'S GENTIAN
- ▨ MARSH FELWORT
- ⬚ 2021 VEGETATION STUDY AREA

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0 50 100 200 METRES

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2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	DWG No.	659183-0000-4EDD-0054	FIG No.	2.10e	REV	00

SIZE 11x17

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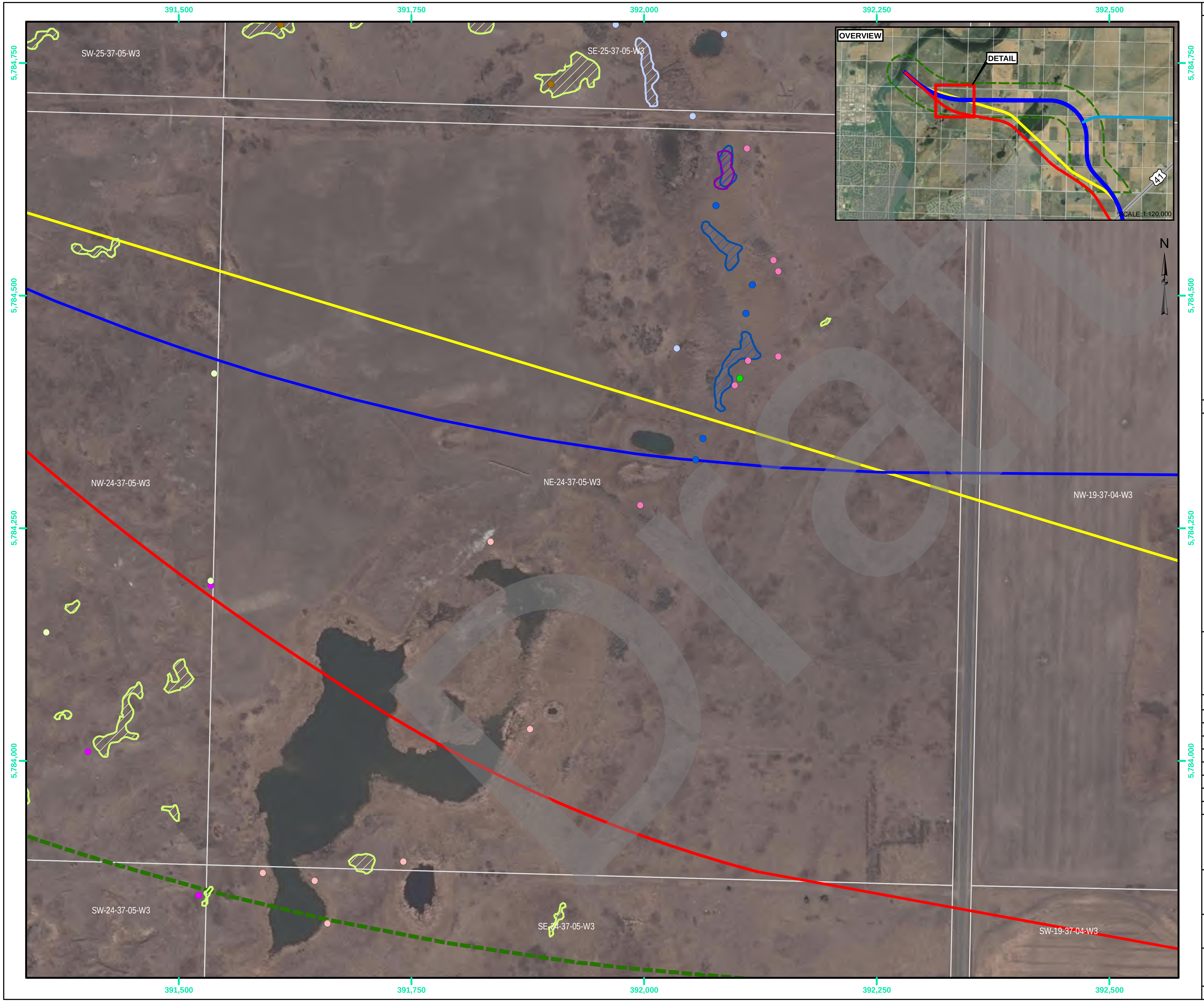

LEGEND

- ● FEW-FLOWERED ASTER
- ● PLAINS ROUGH FESCUE
- ● MARSH FELWORT
- ● HUDSON'S CINQUEFOIL
- ● MUCRONATE BLUE-EYED-GRASS
- ● UPLAND WHITE GOLDENROD
- ● HAIRY GERMANDER
- ● CROWFOOT VIOLET
- ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- ROUTE CONCEPT 2
- ROUTE CONCEPT 3
- ▨ FEW-FLOWERED ASTER
- ▨ PLAINS ROUGH FESCUE
- ▨ MACOUN'S GENTIAN
- ▨ MARSH FELWORT
- 2021 VEGETATION STUDY AREA

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0 50 100 200 METRES

SCALE: 1:4,000

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	DWG No.	659183-0000-4EDD-0055	FIG No.	2.10f	REV	00

SIZE 11x17

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LEGEND

- ● HAIRY GERMANDER
- ● CROWFOOT VIOLET
- ━ ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- ▨ PLAINS ROUGH FESCUE
- ⬚ 2021 VEGETATION STUDY AREA

NOTES

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0 50 100 200 METRES

SCALE: 1:3,500

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TITLE

2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	**DWG No.**	659183-0000-4EDD-0056	**FIG No.2.10g**		**REV**	00

SIZE 11x17

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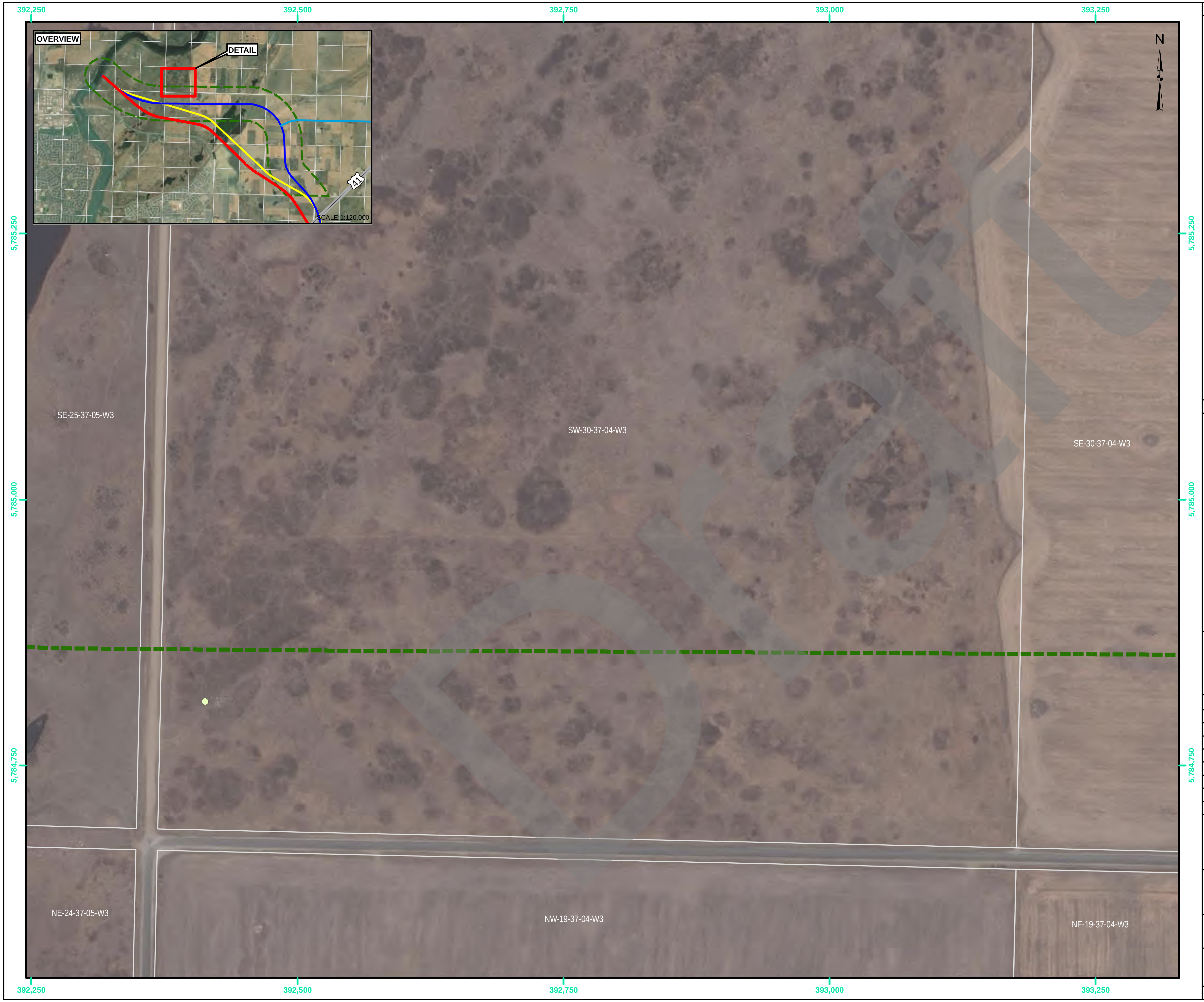

LEGEND

- ● PLAINS ROUGH FESCUE
- ▭ 2020 VEGETATION STUDY AREA
- ▭ 2021 VEGETATION STUDY AREA

NOTES

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0 50 100 200 METRES

SCALE: 1:3,500

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	DWG No.	659183-0000-4EDD-0057	FIG No.2.10h	REV	00

SIZE 11x17

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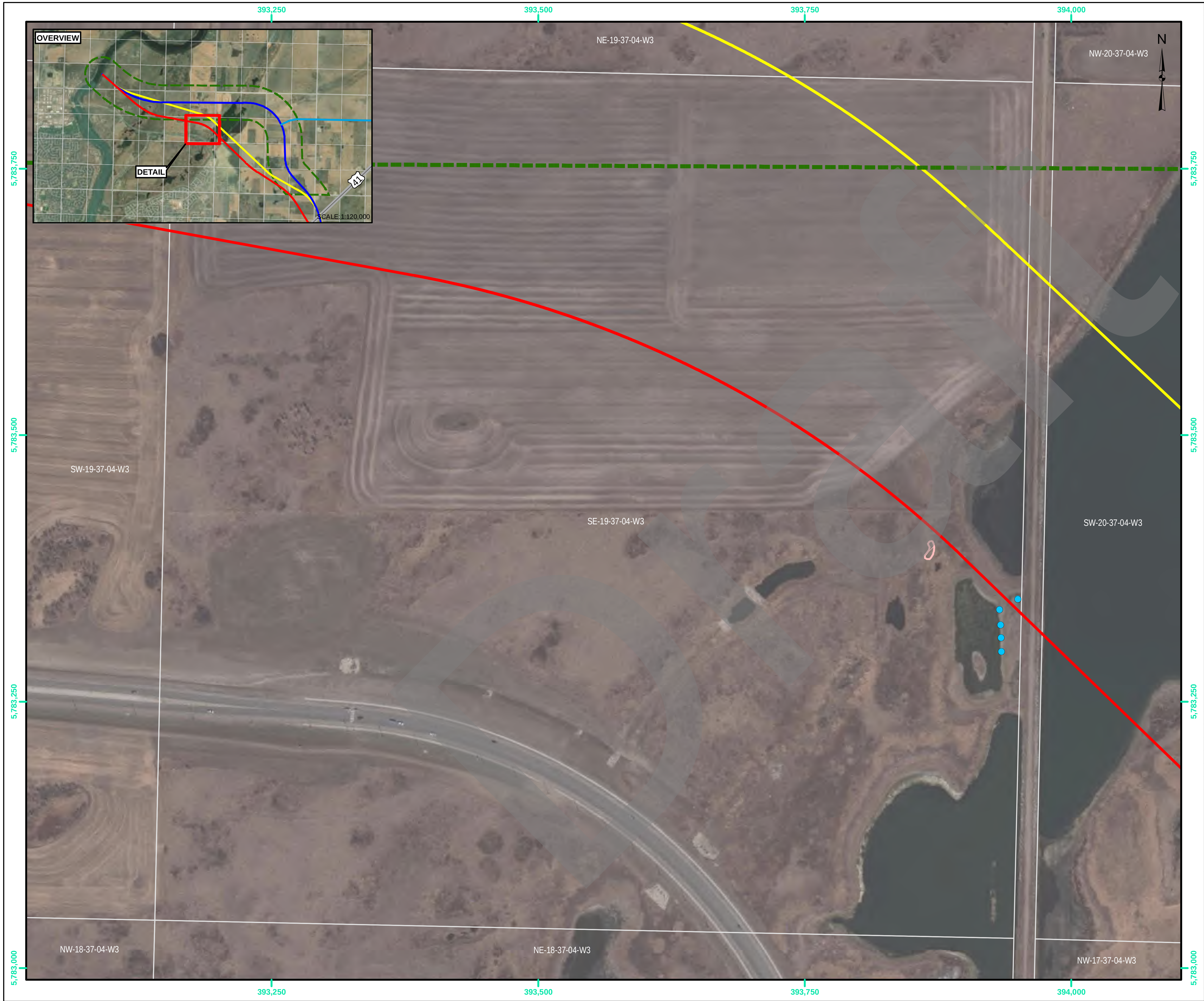

LEGEND

●	NARROW-LEAVED WATER PLANTAIN
—	ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
—	ROUTE CONCEPT 2
▨	HAIRY GERMANDER
▭	2021 VEGETATION STUDY AREA

NOTES

1. COORDINATE SYSTEM: NAD 1983 UTM ZONE 13N.
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DWG No.	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
00	2022 10 06	ISSUED FOR INFORMATION	KH	KVG	KH	JP

0 50 100 200 METRES

SCALE: 1:3,500

SNC · LAVALIN

CLIENT
SASKATCHEWAN MINISTRY
OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE 2021 11 30 **DWG No.** 659183-0000-4EDD-0058 **FIG No. 2.10i** **REV** 00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0058 Vegetation 2021.mxd

2.2.3.3 Fish and Fish Habitat

Phase 2 of the project is adjacent to the South Saskatchewan River, where at least 34 species of fish have been previously captured within the river and its tributaries (Knight Piesold 2010; Atton and Merkowsky 1983; Miles and Sawchyn 1988; Acton et al., 1998, SPRR 1991). This information is identical to that found in the Phase 1 Report, as there are no other major fish-bearing watercourses in the alignment, although there is some evidence of minnows occurring within the Northeast swale if water conditions allow.

Six fish species that have the potential to be found in the vicinity of the proposed river bridge crossing are identified as SOCC (SPRR 1991; **Table 2.4**). These species have been previously observed in the South Saskatchewan River. One fish SOCC (lake sturgeon, *Acipenser fulvescens*) element occurrence was identified in the HABISask query. A total of 83 individual lake sturgeon were captured and radio tagged by the Water Security Agency (WSA) from 2009 to 2012 (Government of Saskatchewan 2021), and the river contains habitat important for this species.

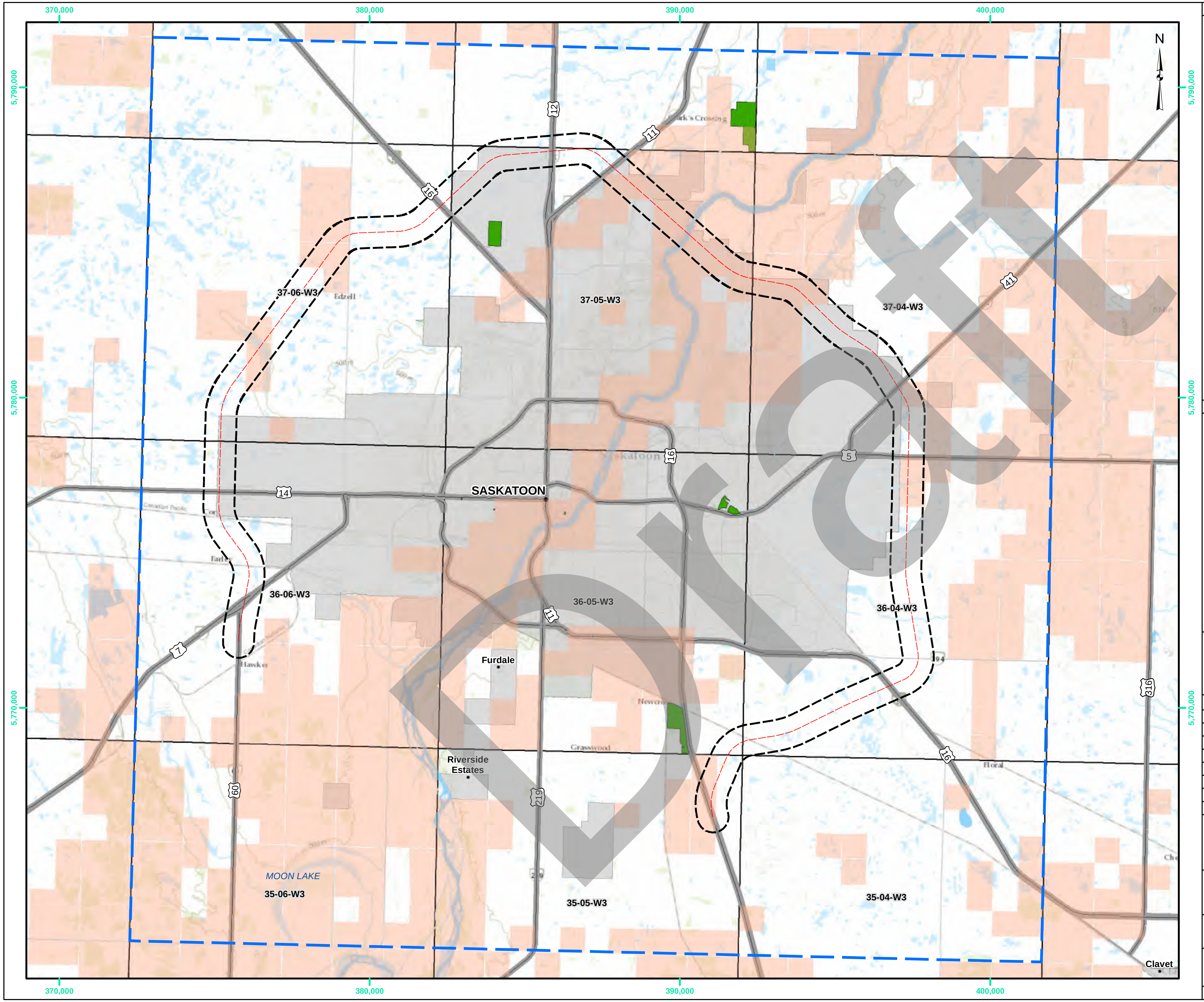
Table 2.4: SOCC fish occurring within the South Saskatchewan River

COMMON NAME	SCIENTIFIC NAME	SKCDC RANK	COSEWIC STATUS	SARA STATUS
Blacknose Dace	*Rhinicthys obtusus*	S3	Not ranked	Not ranked
Common Shiner	*Luxilus cornutus*	S3	Not ranked	Not ranked
Flathead Chub	*Platygobio gracilis*	S3	Endangered	Not ranked
Lake Sturgeon	*Acipenser fulvescens*	S2	Not ranked	Not ranked
Moon Eye	*Hiodon tergisus*	S3	Not ranked	Not ranked
River Shiner	*Notropis blennis*	S3	Not ranked	Not ranked

Source: SPPR 1991

2.2.3.4 Heritage Resources

There are multiple heritage sensitive quarter sections within the Phase 2 corridor, including almost all lands within the Northeast and small swales (**Figure 2.11**). In additional, several previous Heritage Resource Impact Assessments have been completed adjacent to the Phase 2 alignments. These have identified at least two heritage sites within the Phase 2 corridor, located within the vicinity of the small swale. (**Figure 2.12**).



LEGEND

- - - PRELIMINARY FREEWAY ALIGNMENT
▬ HIGHWAY
🟧 HERITAGE SENSITIVE LOCATION
🟩 FIRST NATION LAND
⬜ URBAN MUNICIPALITY
⬚ PRELIMINARY FREEWAY ALIGNMENT 500 METER CORRIDOR
⬚ HERITAGE STUDY AREA
☐ TOWNSHIP

NOTES

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5. HIGHWAYS AND ROADS OBTAINED FROM THE NATIONAL ROAD NETWORK SASKATCHEWAN EDITION 9.0 DATASET, 2017-06-05.
6. RAILWAYS OBTAINED FROM THE NATIONAL RAILWAY NETWORK SASKATCHEWAN EDITION 2.0 DATASET, 2016-10-06.
7. SERVICE LAYER CREDITS: SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), (C) OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY.
8. HERITAGE CONSERVATION BRANCH, SASKATCHEWAN PARKS, CULTURE AND SPORT. THE DATASET INDICATES WHETHER ANY PORTION OF A QUARTER-SECTION IS HERITAGE SENSITIVE. IN THIS CASE, HERITAGE SENSITIVE DESCRIBES THE POTENTIAL OF A QUARTER TO CONTAIN INTACT ARCHAEOLOGICAL OR PALAEONTOLOGY SITES.
9. FIRST NATION LEGISLATED BOUNDARIES OBTAINED FROM ISC.

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REVISIONS

00	2020 07 23	ISSUED FOR INFORMATION	JL	KVG	HY	JP
REV	**DATE**	**DESCRIPTION**	**DES**	**DRN**	**CHK**	**APP**

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METRES

SCALE: 1:120,000

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CLIENT
SASKATCHEWAN MINISTRY OF
HIGHWAYS AND INFRASTRUCTURE

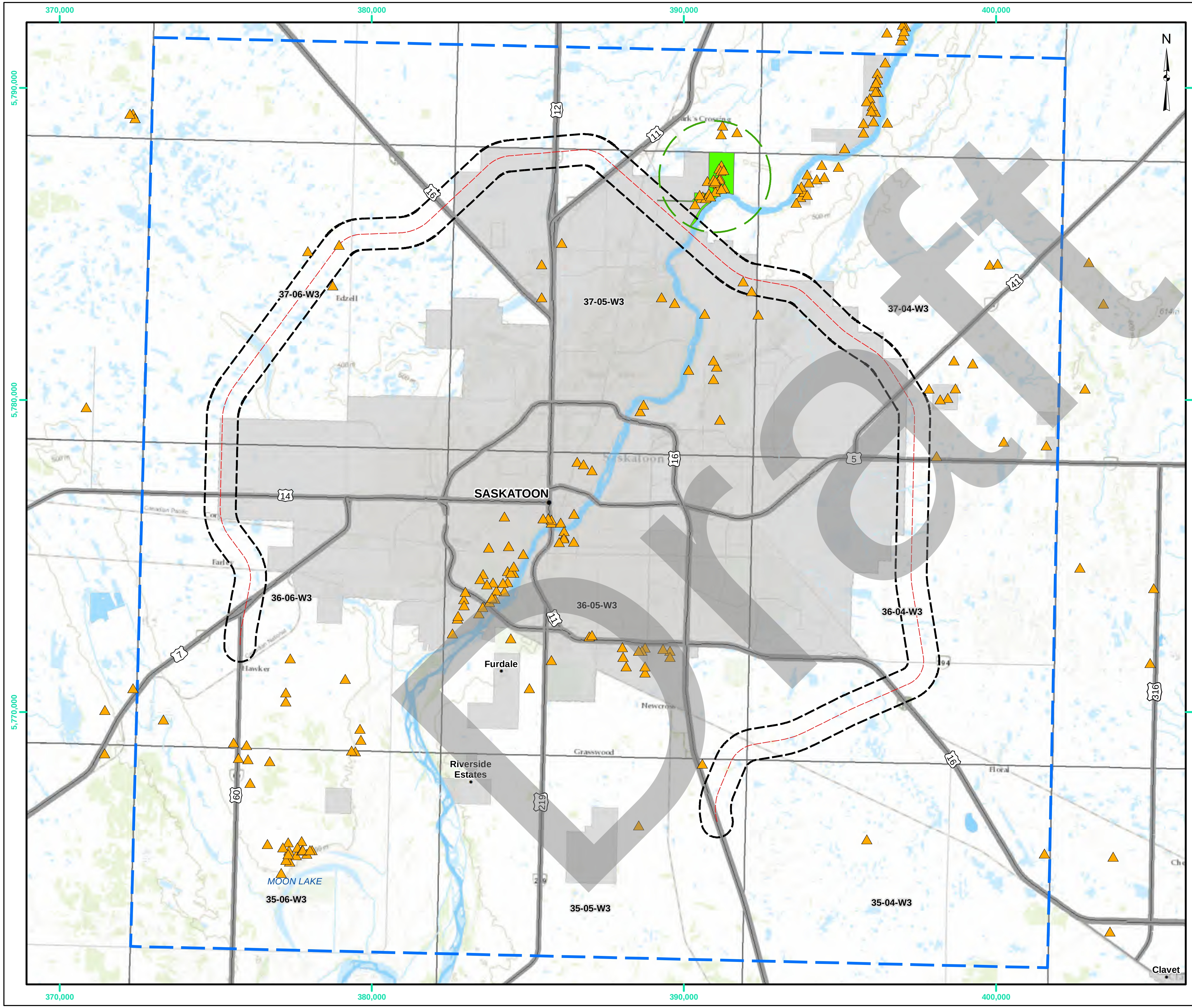
PROJECT LOCATION
SASKATOON FREEWAY

TITLE
HERITAGE RESOURCE OVERVIEW STUDY AREA

DATE 2019 08 09 | **DWG No.** 659183-0000-4EDD-0018 | **FIG No.** 2.11 | **REV** 00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0018 Heritage Resource Overview.mxd



LEGEND

- ▲ HERITAGE SITE
- PRELIMINARY FREEWAY ALIGNMENT
- HIGHWAY
- URBAN MUNICIPALITY
- PRELIMINARY FREEWAY ALIGNMENT 500 METER CORRIDOR
- HERITAGE STUDY AREA
- TOWNSHIP
- 🟩 WANUSKEWIN HERITAGE PARK
- WANUSKEWIN HERITAGE PARK VISUAL BUFFER

NOTES

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5. HIGHWAYS AND ROADS OBTAINED FROM THE NATIONAL ROAD NETWORK SASKATCHEWAN EDITION 9.0 DATASET, 2017-06-05.
6. RAILWAYS OBTAINED FROM THE NATIONAL RAILWAY NETWORK SASKATCHEWAN EDITION 2.0 DATASET, 2016-10-06.
7. HERITAGE SITE DATA OBTAINED FROM THE HERITAGE CONSERVATION BRANCH OF SASKATCHEWAN.

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REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
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METRES

SCALE: 1:120,000

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
HERITAGE SITES IN THE STUDY AREA

DATE 2019 08 09 | DWG No. 659183-0000-4EDD-0020 | FIG No. 2.12 | REV 00

SIZE 11x17

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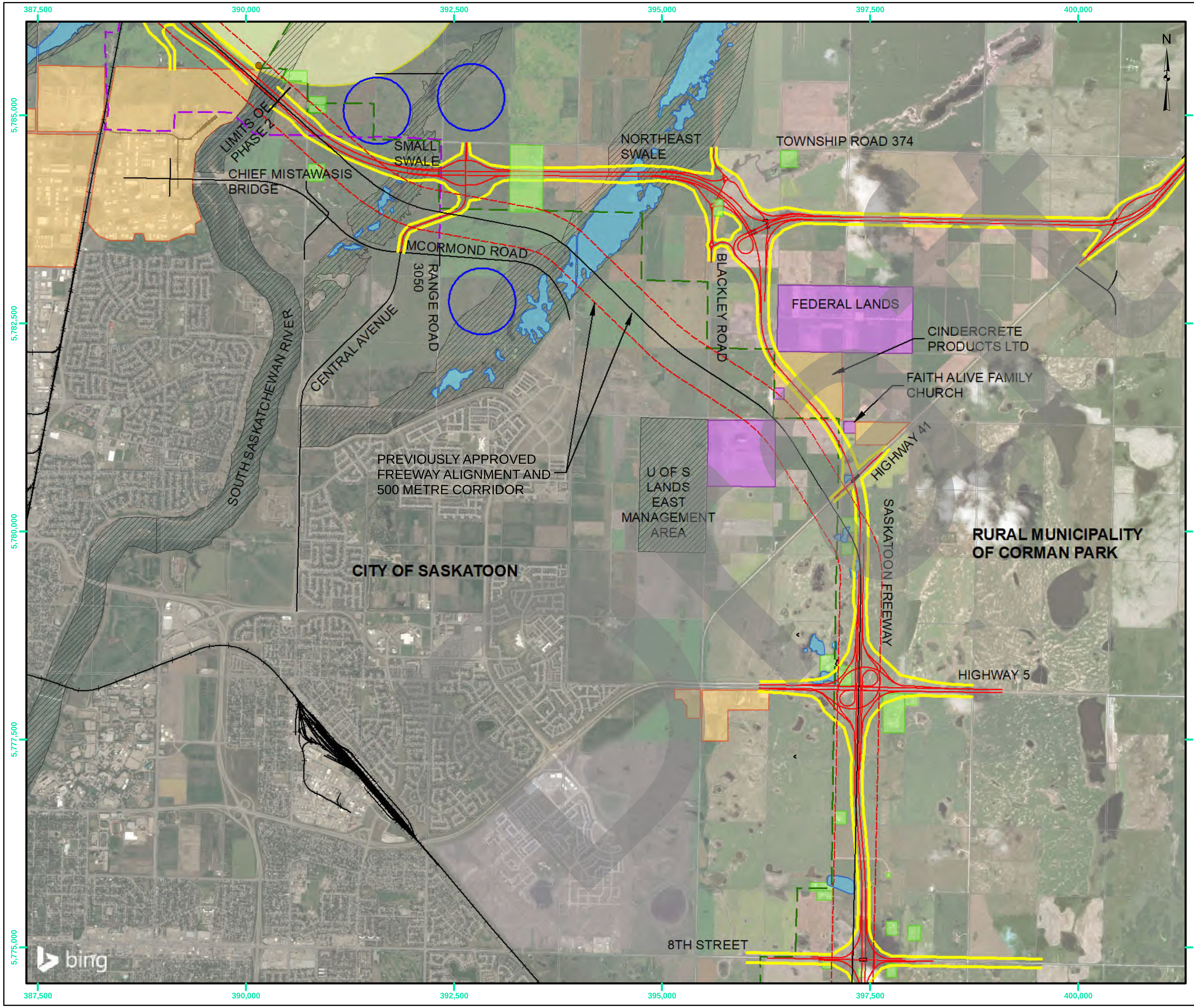
2.2.4 Constraints/Considerations

There are a number of existing conditions which present challenges to completing Phase 2 of the functional planning study for the Saskatoon Freeway and interchanges. Key constraints/existing conditions are illustrated in **Figure 2.13** for the north section of Phase 2 and **Figure 2.14** for the south. Notable features include:

- South Saskatchewan River, which requires complex bridge construction with minimal disruption to the river and river valley;
- Northeast Swale is a post-glacial channel scar of the South Saskatchewan River that covers 2,800 ha of land running 26 km parallel along the South Saskatchewan River (Meewasin, 2016). The Northeast Swale has three outlets to the South Saskatchewan River: Peturrson's Ravine just east of Central Avenue in Saskatoon, near Bosco Homes Camp north of Saskatoon, and north of Clarksboro Ferry west of Aberdeen. (Meewasin Valley Authority, April 2020);
- The Small Swale is a smaller post-glacial channel scar of the South Saskatchewan River that covers approximately 268 hectares of land running approximately four km parallel to the South Saskatchewan River, west of the Northeast Swale. The Small Swale has two outlets to the South Saskatchewan River. The south outlet is at Peggy McKercher Conservation Area located south of McOrmond Drive on the old Central Avenue. The north outlet is west of Riversedge and across the river from Wanuskewin Heritage Park. (Meewasin Valley Authority, April 2020);
- University of Saskatchewan and Federal research lands are generally not accessible for provincial highway (freeway) right of way. The University of Saskatchewan owns lands used for agricultural and animal research. The Saskatoon Freeway has been aligned to minimally impact the University lands in the northeast and southeast parts of Phase 2. The Ministry worked extensively with the University to minimize impacts to their land holdings;
- CP Railway has a major line that is parallel to Highway 16 which presents some significant geometric design challenges related to the Highway 16 interchange;
- CN Rail has a major freight line corridor crossing the projects proposed roadways in five locations. High speed or high-volume rail crossings should be grade separated. Future expansion of the railway operation should be provided for in the freeway design;
- Utilities, including a SaskPower high voltage corridor crosses the proposed mainline alignment south of Highway 16;
- There are a number of rural farmyards and rural acreage properties which are within the General Location 500 m corridor.
- There are a number of commercial properties considered. Notable is the Rawlco Radio towers adjacent to Highway 16, and Costco located along Zimmerman Road; and
- There are several existing and proposed development areas that are near or impacted by the Saskatoon Freeway alignment.

Additional details on existing structures, utilities, and environmental constraints are discussed in more detail in the following sections.



LEGEND

- RAILWAY
- SASKATOON FREEWAY PREFERRED ALIGNMENT
- SASKATOON FREEWAY PREFERRED ALIGNMENT PROPERTY LIMITS
- SASKPOWER HIGH VOLTAGE CORRIDOR
- SASKATOON CITY LIMITS
- 🟨 WANUSKEWIN HERITAGE PARK (1.8 KM BUFFER)
- 🟦 WATER FEATURE
- ▨ ENVIRONMENTAL, ECOLOGICAL, OR LOW LYING GROUND
- 🟧 EXISTING INDUSTRIAL PARKS
- 🟪 CRITICAL CONSTRAINT
- 🟩 RESIDENTIAL BUILDING
- SHARP-TAILED GROUSE LEK BUFFER AREA

NOTES

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REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	
PA	2022 10 23	ISSUED FOR INFORMATION	CR	LC		JP

0 500 1,000 2,000 METRES

SCALE: 1:45,000

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SASKATCHEWAN MINISTRY OF HIGHWAYS

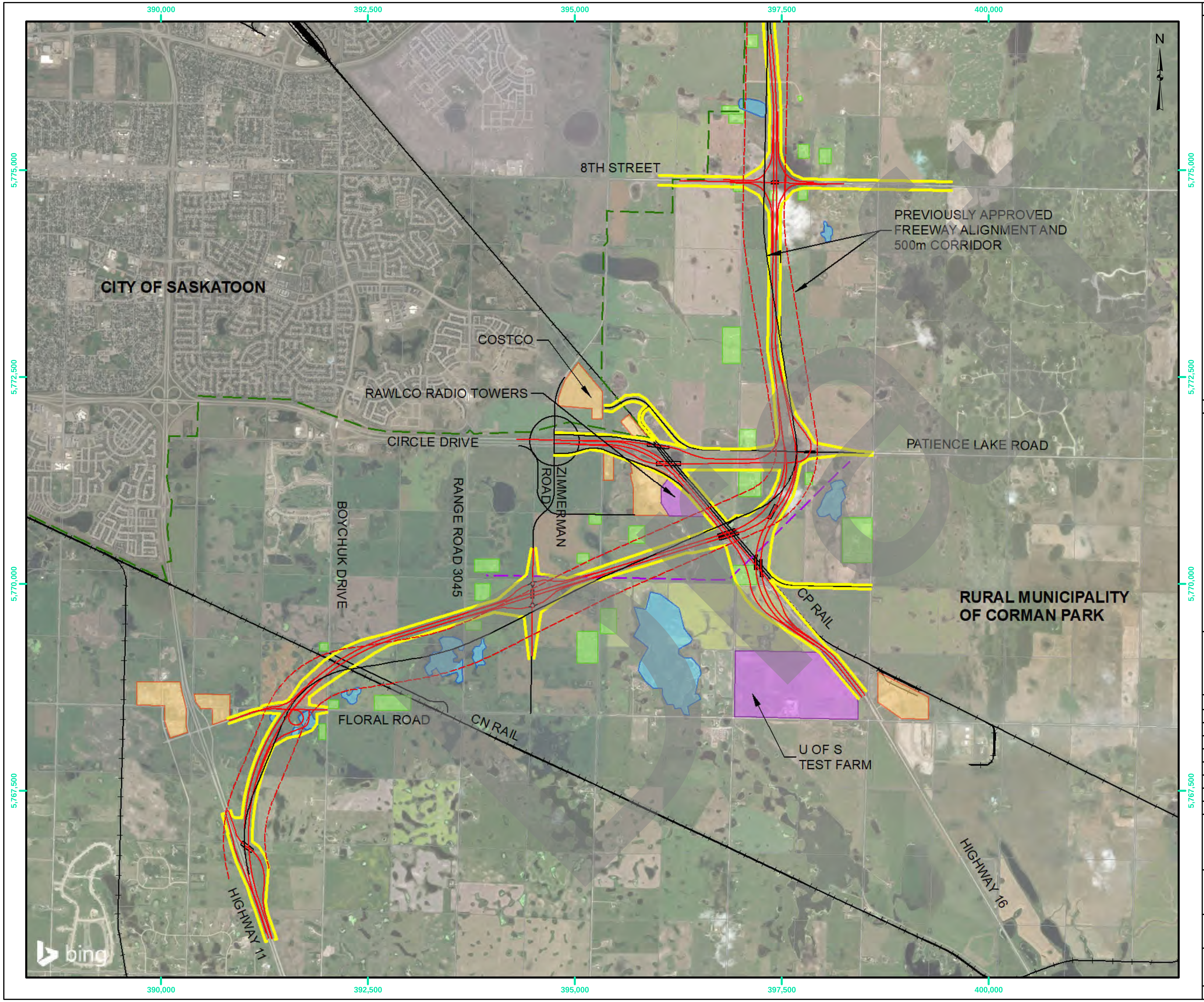
PROJECT LOCATION
SASKATOON FREEWAY

TITLE
EXISTING CONDITIONS PHASE 2 - NORTH LIMITS

DATE	DWG No.	FIG No.	REV
2022 10 23	659183-0000-4EDD-0091	2.13	PA

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0091 Existing Conditions North.mxd



LEGEND

—+—	RAILWAY
- -	SASKPOWER HIGH VOLTAGE CORRIDOR
—	SASKATOON CITY LIMITS
🟦	WATER FEATURE
🟧	EXISTING INDUSTRIAL PARKS
🟪	CRITICAL CONSTRAINT
🟩	RESIDENTIAL BUILDING

NOTES

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0 500 1,000 2,000 METRES

SCALE: 1:45,000

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SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
EXISTING CONDITIONS PHASE 2 - SOUTH LIMITS

DATE	DWG No.	FIG No.	REV
2022 10 23	659183-0000-4EDD-0092	2.14	PA

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0092 Existing Conditions South.mxd

2.2.4.1 Utilities

The proposed alignment of the Saskatoon Freeway intersects several communications, electrical, energy, and water and sewer utilities located overhead and underground. SNC-Lavalin began contacting utility stakeholders in January 2019 to identify locations of utilities that are located within the entire project corridor and where mitigation may be required. The following stakeholders were contacted during utility mapping:

- Access Communications;
- Alliance Pipeline;
- Bell Canada;
- CoS Light and Power;
- CoS Water and Sewer;
- CNOOC Ltd.;
- Highway 41 Water Utility;
- Rogers Communications Inc.;
- SaskEnergy;
- SaskPower;
- SaskTel;
- SaskWater;
- Shaw Communications Inc.;
- Telus Communications Inc.; and
- TransGas.

Utility locations were confirmed again by stakeholders in December 2019 for Phase 1 of the project, and October 2021 for Phase 2. Utility details were obtained where possible in CAD format and uploaded to SNC-Lavalin's GIS database and web viewing applications. Where only PDF records could be obtained, the files where digitized by SNC-Lavalin and geo-referenced as accurately as possible. Utility location accuracy is considered commensurate with the requirements of the functional plan.

There were no known utility conflicts for the entire project corridor with Alliance Pipeline, CNOOC, Access Communications, and CoS Light and Power. All known utility locations for the entire corridor are shown in **Figure 2.15**, and utilities identified for each phase are summarized in **Table 2.5**. Specific conflict details for Phase 2 are discussed in the following sections.

Table 2.5: Utility type summary by Phase.

PHASE 1	PHASE 2	PHASE 3
SaskEnergy (Distribution)	SaskEnergy (Distribution)	SaskEnergy (Distribution)
SaskEnergy (TransGas))	SaskEnergy (TransGas))	SaskEnergy (TransGas))
SaskPower (Distribution)	SaskPower (Distribution)	SaskPower (Distribution)
SaskPower (Transmission)	SaskPower (Transmission)	SaskPower (Transmission)
SaskTel	SaskTel	SaskTel
SaskWater	SaskWater	SaskWater
CoS Water and Sewer	CoS Water and Sewer	CoS Water and Sewer
Shaw Communications	Nutrien Raw Water	Bell Communications
	Highway 41 Water Utility	Rogers Communications
	Bell Communications	Telus Communications
	Rogers Communications	
	Telus Communications	

2.2.4.1.1 Communications Utilities

All communication utility stakeholders in the project area were contacted and maps or .kmz files of existing utilities were obtained. SaskTel identified conflicts with their fiber and copper networks at various locations along the Phase 2 preferred alignment (**Figure 2.16**).

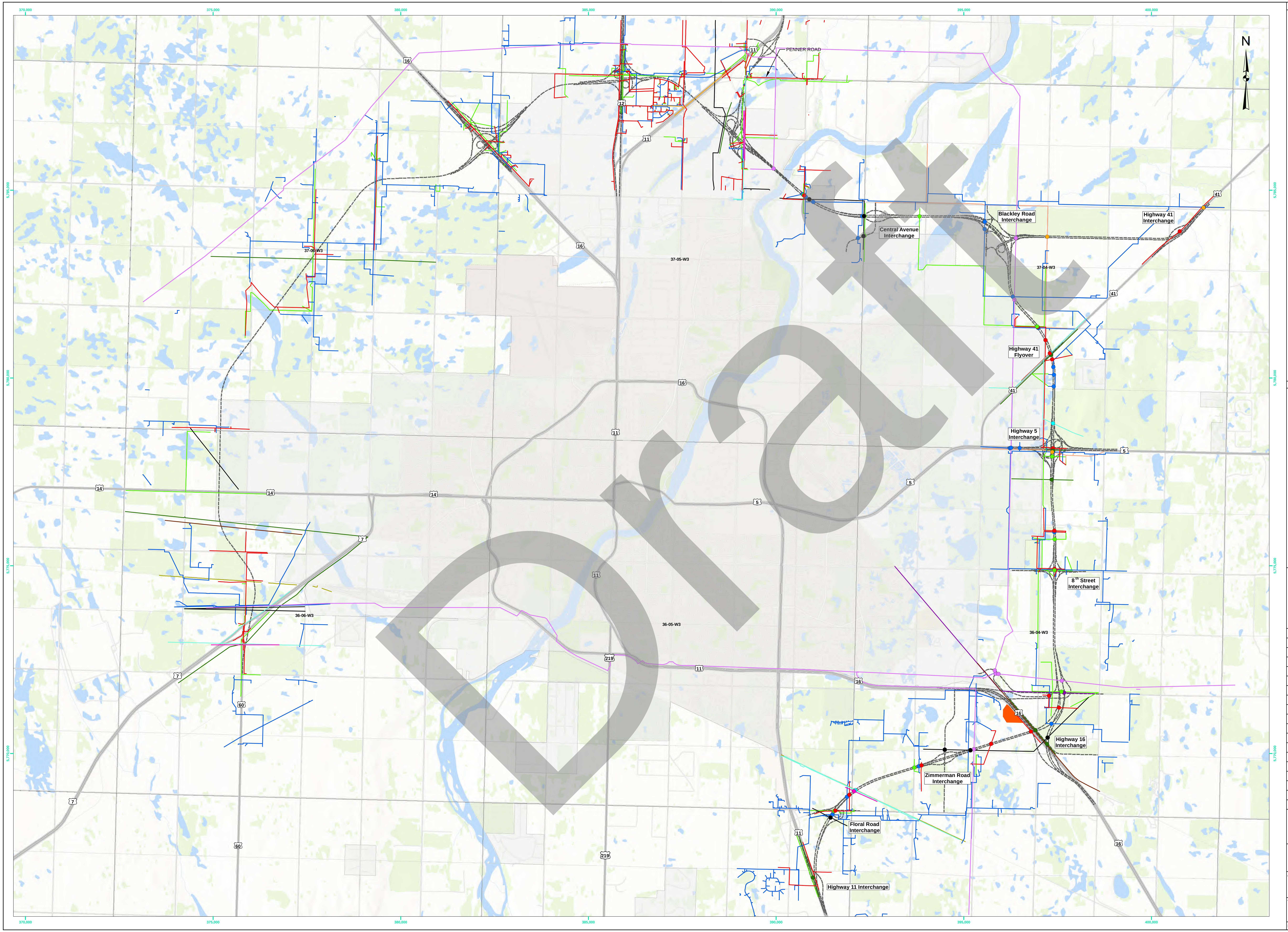
Telus and Bell fiber infrastructure is located within the Canadian Pacific (CP) rail ROW at the Highway 16 interchange location, and Rogers fiber infrastructure is located within the Canadian National (CN) rail ROW immediately east of the Floral Rad interchange in Phase 2. Although these utilities cross the freeway corridor they are not in conflict as no disturbance is planned within the rail ROWs.

2.2.4.1.2 Energy Utilities

Energy companies including TransGas, SaskEnergy, and SaskPower identified conflicts with the proposed alignment of the Saskatoon Freeway and their own infrastructure. These conflicts are shown in **Figure 2.17**.

2.2.4.1.3 Water Utilities

Conflicts were identified with SaskWater, Nutrien, and Highway 41 Water Utility. These conflicts are shown in **Figure 2.18**.



LEGEND

UTILITY CONFLICTS

- ● HWY 41 WATER UTILITY
- ● CITY OF SASKATOON
- ● NUTRIEN RAW WATER LINE
- ● ROGERS FIBER
- ● SASKENERGY
- ● SASKPOWER DISTRIBUTION
- ● SASKPOWER TRANSMISSION
- ● SASKTEL - FIBER
- ● SASKTEL - COPPER CABLE
- ● SHAW
- ● SASKWATER
- ● TELUS AND BELL FIBERS
- ● TRANSGAS

UTILITY LINE

- CITY OF SASKATOON
- HWY 41 WATER UTILITY
- NUTRIEN RAW WATER LINE
- ROGERS FIBER
- SASKENERGY
- SASKPOWER DISTRIBUTION (25 kV AND BELOW)
- SASKPOWER TRANSMISSION (72kV - 230 kV)
- SASKTEL - COPPER CABLE
- SASKTEL - FIBER
- SASKWATER
- SHAW
- TELUS AND BELL FIBERS
- TRANSGAS
- PRELIMINARY FREEWAY ALIGNMENT
- 🟧 RAWLCO RADIO ANTENNAS

SIZE 22 x 34

NOTES

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DWG No	DESCRIPTION
	DRAFT

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
PA	2022 05 30	ISSUED FOR REVIEW	CR	KVG		

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SCALE: 1:45,000

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SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS

DATE 2022 05 30 **DWG No** 659183-0000-4GDD-0071 **FIG No.** 2.15 **REV** PA

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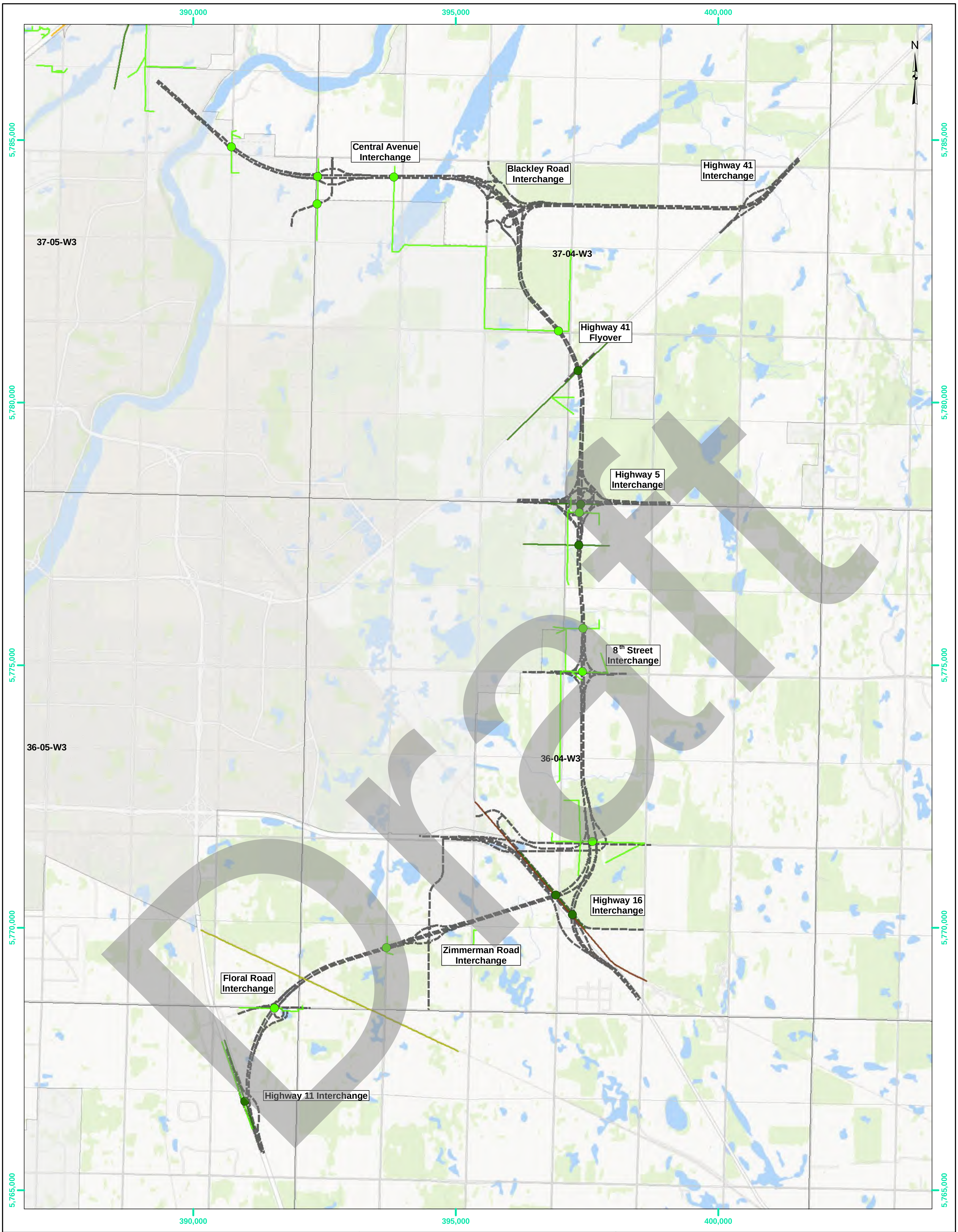

LEGEND

UTILITY CONFLICTS

- ● SASKTEL - MAJOR FIBER
- ● SASKTEL - COPPER CABLE

UTILITY LINE

- — ROGERS FIBER
- — SASKTEL - FIBER
- — SASKTEL - COPPER CABLE
- — SHAW
- — TELUS AND BELL FIBERS
- - - - PHASE 2 ROUTE

NOTES

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DRAFT

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Metres

SCALE: 1:70,000

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CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

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REFERENCE DRAWINGS		REVISIONS						
		PA	2022 05 31	ISSUED FOR REVIEW	CR	KVG		
DWG. No.	DESCRIPTION	REV	DATE	DESCRIPTION	DES	DRN	CHK	APP

TITLE
UTILITY CONFLICTS
COMMUNICATIONS

DATE 2022 05 30 | DWG No. 659183-0000-4GDD-0072 | FIG No 2.16 | REV PA

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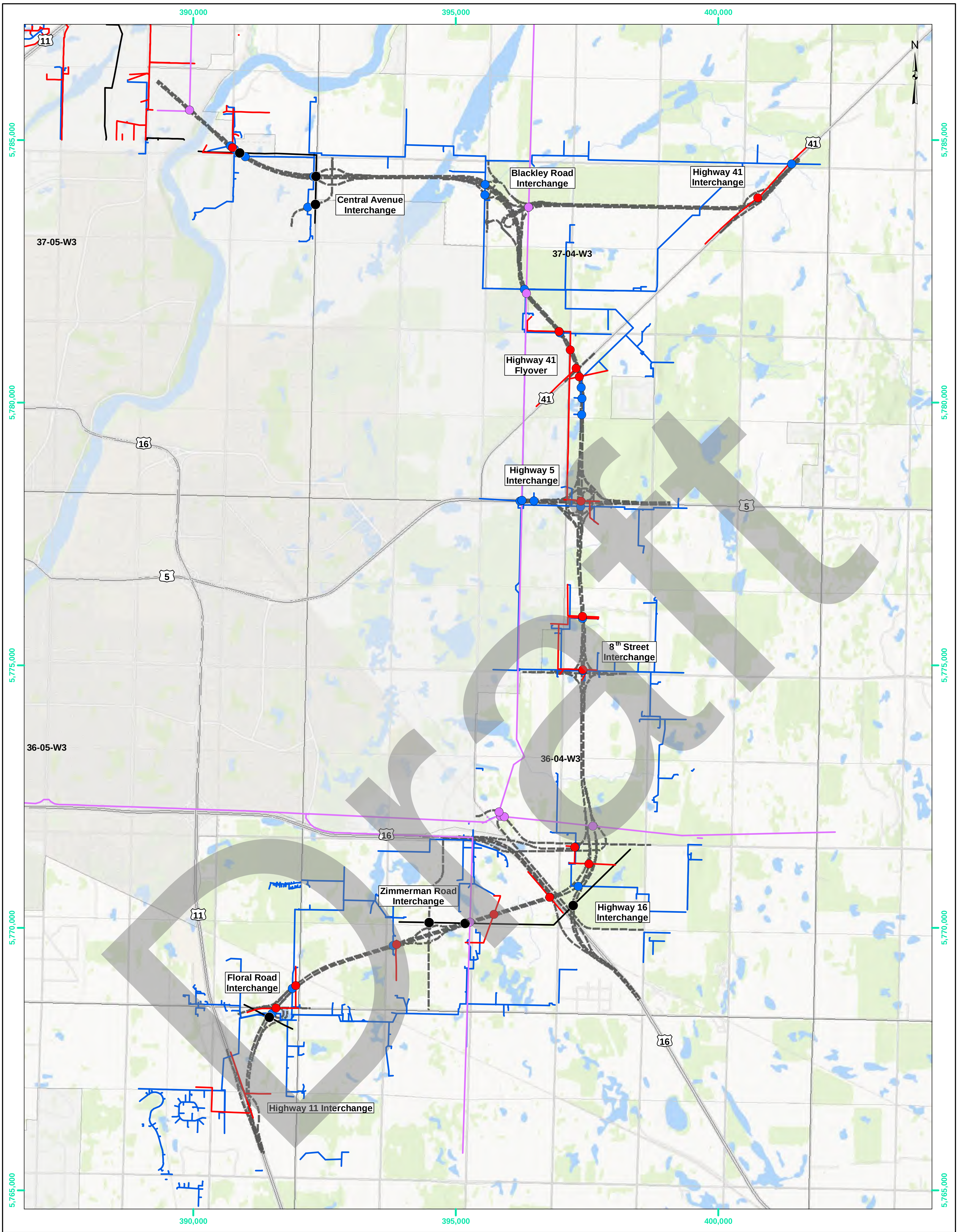

LEGEND

UTILITY CONFLICTS

- 🔵 SASKENERGY
- 🔴 SASKPOWER DISTRIBUTION
- ⚫ SASKPOWER TRANSMISSION
- 🟣 TRANSGAS

UTILITY LINE

- SASKENERGY
- SASKPOWER DISTRIBUTION (25 kV AND BELOW)
- SASKPOWER TRANSMISSION (72 kV - 230 kV)
- TRANSGAS

- - - PHASE 2 ROUTE

NOTES

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CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
ENERGY

REFERENCE DRAWINGS

DWG. No.	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
PA	2022 05 31	ISSUED FOR REVIEW	CR	KVG		

DATE	DWG No.	FIG No.	REV
2022 05 30	659183-0000-4GDD-0073	2.17	PA

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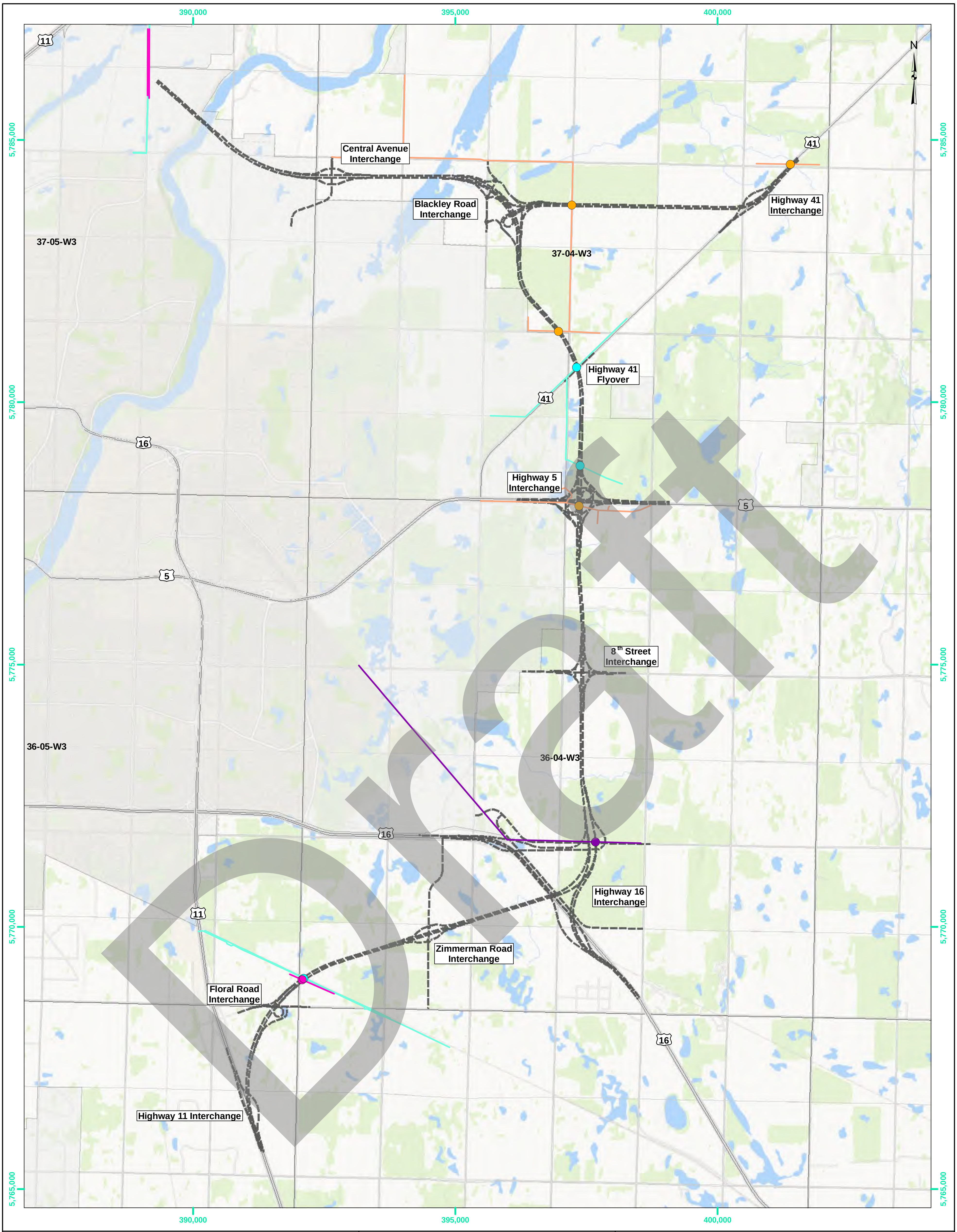

LEGEND

UTILITY CONFLICTS

- ● HWY 41 WATER UTILITY
- ● CITY OF SASKATOON
- ● NUTRIEN RAW WATER LINE
- ● SASKWATER

UTILITY LINE

- — CITY OF SASKATOON
- — HWY 41 WATER UTILITY
- — NUTRIEN RAW WATER LINE
- — SASKWATER

NOTES

1. COORDINATE SYSTEM: NAD 1983 UTM ZONE 13N.
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4. TOPOGRAPHIC FEATURES OBTAINED FROM CANVEC V12.0 DATASET, NATURAL RESOURCES CANADA EARTH AND SCIENCES SECTOR CENTRE FOR TOPOGRAPHIC INFORMATION, 2013-09-30.
5. HIGHWAYS AND ROADS OBTAINED FROM THE NATIONAL ROAD NETWORK SASKATCHEWAN EDITION 11.0 DATASET, 2020-06-18.
6. RAILWAYS OBTAINED FROM THE NATIONAL RAILWAY NETWORK SASKATCHEWAN EDITION 2.0 DATASET, 2019-07-25.

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PROJECT LOCATION
SASKATOON FREEWAY

REFERENCE DRAWINGS		REVISIONS						
		PA	2022 05 31	ISSUED FOR REVIEW	CR	KVG		
DWG. No.	**DESCRIPTION**	**REV**	**DATE**	**DESCRIPTION**	**DES**	**DRN**	**CHK**	**APP**

TITLE
UTILITY CONFLICTS
WATER

DATE 2022 05 30 **DWG No.** 659183-0000-4GDD-0074 **FIG No** 2.18 **REV** PA

SIZE 11x17

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2.2.4.1.4 Wetlands

The wetlands within Phase 2 may pose as a constraint as wetlands are protected under a combination of federal and provincial legislation. Wetlands also provide habitat for a number of wildlife species, including SOCC and SAR species, which may act as additional constraints. Approximately 190.6 hectares of wetlands are found within Phase 2 corridor, and up to 248.9 hectares are within the Phase 2 Vegetation and Soils study area. This includes the area that is exclusively within the corridor and study area. Additional wetlands may also be connected to these wetlands which might also be impacted by construction activity near or within the wetlands.

2.2.4.1.5 Native Grasslands

Unseeded and native-dominant grasslands within Phase 2 provide important habitat for a variety of wildlife and plant species. Although most plant species are not legally protected in Saskatchewan, and grasslands themselves do not have legal protections like wetlands, grasslands may be home to SOCC and SAR species that have legal protections. Native grasslands may act as a constraint as proponents in Saskatchewan may be required to compensate for the loss of this habitat based on approval requirements (i.e. compensation has been a condition in some recent ministerial decisions).

2.2.4.1.6 Wildlife and Nesting Birds

The majority of bird species are protected under both federal and provincial legislation, the disruption or loss of active migratory nests, or harm or loss of eggs, young, and breeding adults is strictly prohibited. Permits will be required to: scare migratory birds; collect, destroy, or dispose of migratory bird eggs; remove, relocate, and/or destroy birds/nests/eggs.

It is very likely that nesting birds will be encountered during project construction. Bird species will breed in almost any habitat, and may be a temporary or long-term constraint, depending on the species. If a legally protected nest is found within the work area, an appropriate setback will be established to allow nesting to continue without disturbance. While the setback is active, no personnel is permitted to work in the area. Modifications to activities within the setback may be required.

Most mammal wildlife is also protected under provincial legislation, and disturbance or killing of protected wildlife is prohibited. While most wildlife will disperse on its own during construction, breeding wildlife or wildlife that establish semi-permanent residences (such as American badgers) may be a potential constraint. Permits from federal and/or provincial governments will be required if relocation or removal of any protected wildlife is required.

2.2.4.1.7 Species of Conservation Concern (SOCC) and Species at Risk (SAR)

In addition to protections granted to all wildlife, SOCC and SAR species have additional protections. These species may act as constraints and may require significantly larger setbacks than non SOCC/SAR wildlife. Saskatchewan Activity Restriction Guidelines (ARG) are used to determine setback distances to avoid key habitats of these species during sensitive periods. Relevant setbacks based on species identified in Phase 2 during surveys or desktop studies are presented in **Table 2.6**. Additional SOCC/SAR are also likely to be discovered during additional surveys and may require different setbacks. Permits from federal and/or provincial governments will be required if relocation or removal of any protected wildlife is required. However, in many cases, permits will not be issued for SOCC/SAR species and waiting until the species disperses from the area naturally is the only option.

Table 2.6: Saskatchewan ARG for plant and wildlife SOCC identified within Phase 2

COMMON NAME	SCIENTIFIC NAME	TAXONOMIC GROUP	ARG FOR SPECIES OR FEATURE	RESTRICTION ACTIVITY PERIODS	MAXIMUM SETBACK DISTANCE
American White Pelican	*Pelecanus erythrorhynchos*	bird	Nesting colony	Apr 1 – Jul 31	1000 m
Black-crowned	*Nyctiocorax nycticorax*	Bird	Breeding colony	Apr 1 – Jul 31	1000 m
Common nighthawk	Chordeiles minor	Bird	Breeding bird	May 1 – Aug 31	200 m
Double-crested	*Phalacrocorax auratus*	bird	Nesting colony	Apr 1 – Jul 31	1000 m
Eared grebe	*Podiceps nigricollis*	bird	Nesting colony	Apr 1 – Jul 31	1000 m
Great blue heron	*Ardea herodias*	bird	Nesting colony	Apr 1 – Jul 31	1000 m
Lake sturgeon	*Acipenser fulvescens*	Fish	South Saskatchewan	Apr 15 – Jul 15	N/A
Loggerhead shrike	*Lanius ludovicianus*	Bird	Breeding bird	May 1 – Aug 15	400 m
Northern leopard frog	*Lithobates pipiens*	Amphibian	Breeding and overwintering	Year-Round	500 m
Osprey	*Pandion haliaetus*	Bird	Nest site	May 1 – Aug 15	1000 m
Peregrine falcon	*Falco perigrinus anatum*	Bird	Nest stie	Apr 1 – Aug 15	1000 m
Prairie falcon	*Falco mexicanus*	Bird	Nest site		1000 m
Rusty blackbird	*Euphagus carolinus*	Bird	Breeding bird	May 1 – Jul 31	300 m
Sharp-tailed grouse	*Tympanuchus phasianellus*	Bird	lek	Mar 15 – May 15	400 m
Short-eared owl	*Asio flammeus*	Bird	Breeding bird	Mar 25 – Aug 1	500 m
Sprague's pipit	*Anthus spragueii*	bird	breeding bird	Apr 21 – Aug 31	250 m
Trumpeter swan	*Cygnus buccinator*	Bird	Breeding bird	Apr – Jul 31	1000 m
Whooping crane	*Grus americana*	Bird	Staging area	May 1 – Nov 1	1000 m
Yellow rail	*Coturnicops noveboracensis*	Bird	Breeding bird	May 1 – Jul 15	350 m
Plant (SAR)*		plant	occurrence	year round	300 m
Plant (tracked)**		plant	occurrence	year round	30 m

*Plants listed under the Species At Risk Act (SARA) as *Endangered, Threatened, Special Concern, or Extirpated* and/or plants listed in the *[Saskatchewan] Wildlife Act,* 1998.
**Plants listed on the Saskatchewan Conservation Data Centre (SKCDC) tracking list (e.g., usually ranked S1, S2, S3, SX, SH).
Source: (ENV 2017; Government of Saskatchewan 2021; SKCDC 2021a and 2021c)

2.2.4.1.8 Fish and Fish Habitat

Phases 1 and 2 of the project involve the construction of a bridge to cross the South Saskatchewan River. Fish presence within this river will act as a potential constraint as construction will likely lead to a small, permanent loss of fish habitat, and the project may cause the death of fish during in-water pier construction. Permitting and authorizations from the federal and provincial government will be required for any in-water work or work that is expected to impact fish species. Options can also be evaluated to avoid in-water pier construction.

2.2.4.1.9 Heritage Resources

The project corridor passes through areas that have the potential to contain heritage resources, as many heritage sensitive quarters are present. If heritage resources are found and are sufficiently significant, they could be a potential constraint and may require extensive mitigation, avoidance, or excavation.

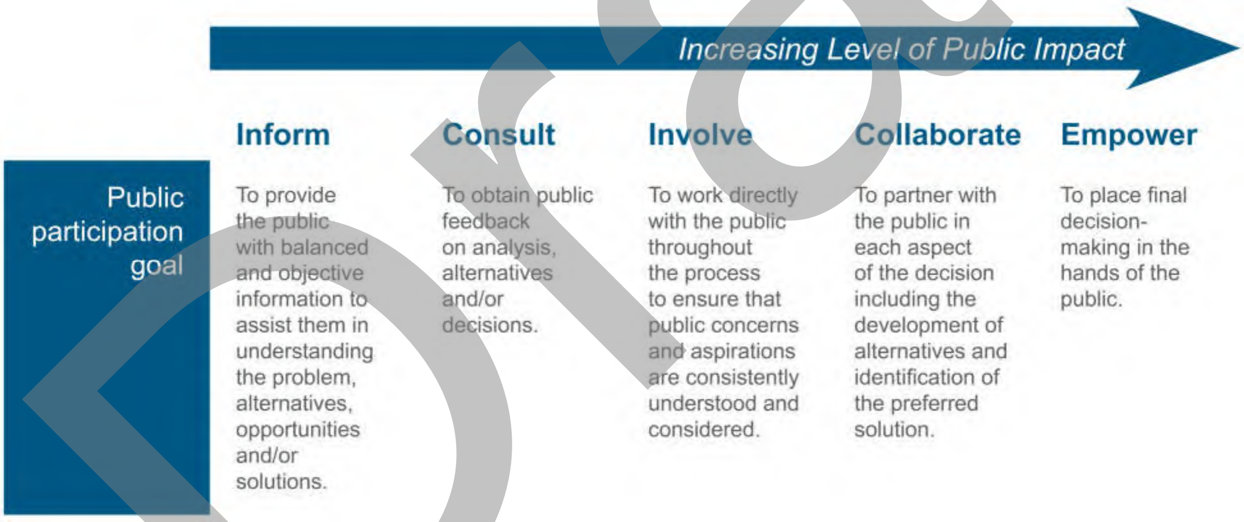
3 Public and Stakeholder Engagement

3.1 Methodology and Approach

The Saskatchewan Ministry of Highways (Ministry) identified from the onset that stakeholder consultations, effective and engaging communication, and community dialogue are extremely important components of the Saskatoon Freeway Functional Planning Study (SFFPS).

Throughout Phase 2 of the SFFPS, Praxis Consulting Ltd. (Praxis) was part of the overall project team and served as a collaborative partner of the Ministry to build rapport with stakeholders and the public that would create safe environments for honest information sharing and feedback on the project. Praxis also led development of appropriate engagement and communication solutions that were respectful and responsive to the needs of stakeholders and the public.

The guiding methodology of the ongoing stakeholder engagement and communications for Phase 2 was consistent with the approach for Phase 1 of the project and remained rooted in the International Association for Public Participation (IAP2) methodology. IAP2 provides a framework for involvement of the public and stakeholders through the Spectrum of Public Participation, as shown below in **Figure 3.1**.



Increasing Level of Public Impact

	Inform	Consult	Involve	Collaborate	Empower
Public participation goal	To provide the public with balanced and objective information to assist them in understanding the problem, alternatives, opportunities and/or solutions.	To obtain public feedback on analysis, alternatives and/or decisions.	To work directly with the public throughout the process to ensure that public concerns and aspirations are consistently understood and considered.	To partner with the public in each aspect of the decision including the development of alternatives and identification of the preferred solution.	To place final decision-making in the hands of the public.

Figure 3.1: Spectrum of public consultation (International Association for Public Participation (IAP2))

3.1.1 Stakeholder Engagement and Communications Technical Working Group

Throughout Phase 2, the Stakeholder Engagement and Communications Technical Working Group (TWG) met as needed to discuss stakeholder engagement and communications plans. Meetings were scheduled to occur monthly but were not held if there were no substantial updates, or if the updates could be just as effectively shared via email to TWG members. The TWG was comprised of representatives from the following:

- The Ministry;
- SNC-Lavalin;
- AECOM;
- Praxis;
- City of Saskatoon (CoS);
- Rural Municipality (RM) of Corman Park;
- Saskatoon Tribal Council (STC)[1]; and
- Saskatoon North Partnership for Growth (P4G)[2].

All TWG meetings sought feedback and input from the attendees at the IAP2 level of *Involve*.

- NOTE: STC representatives chose not to attend TWG meetings through Phase 2 but requested to remain engaged through email updates.
- NOTE: The P4G liaison ended his position in summer 2021 and at that point ceased attending TWG meetings.

3.1.2 Approach and Tactics

Phase 2 continued the stakeholder engagement and communications approach that was established in Phase 1, which was to *Inform* the public of the SFFPS, per IAP2 methodology. Key stakeholders from Phase 1 continued to serve as important guides and touchstones for the stakeholder engagement and communications team's actions; these included representatives from: Meewasin Valley Authority; RM of Corman Park; CoS, P4G; STC; Wanuskewin Heritage Park; the Ministry; and North Saskatoon Business Association.

The NESW withdrew from the Environment and Heritage TWG at the conclusion of Phase 1. The stakeholder engagement and communications team continued to share information with NESW leadership and propose opportunities where their members could provide input on Phase 2 route concepts, including presentations and focused invitations to public events;

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[1] STC member nations include: Kinistin Saulteaux Nation; Mistawasis First Nation; Muskeg Lake Cree Nation; Muskoday First Nation; One Arrow First Nation; Whitecap Dakota First Nation; Yellow Quill First Nation.

[2] Cities of Saskatoon, Martensville and Warman, the Town of Osler and the RM of Corman Park formed the P4G. The partners are developing a Regional Plan. The departure of the P4G liaison during Phase 2 resulted in the stakeholder engagement and communications team relying more on stakeholders from the RM of Corman Park.

The playbook created to guide the stakeholder engagement and communications team in Phase 1 was updated and used as the basis for all effort in Phase 2. Consistent with the approach in Phase 1; stakeholders continued to be categorized into four pillars:

- Indigenous rights-holders;
- Environment/Heritage partners;
- Landowners; and
- Industry/Associations.

The impact of COVID-19 on limits to public gatherings had a profound impact on Phase 2 stakeholder engagement plans, requiring the team to pivot quickly and implement new tactics that relied almost exclusively on online engagement. The impact of a provincial election in the fall of 2020 also required a pause on any public stakeholder engagement activities from August 2020 until November 2020, reflecting direction from the Ministry.

As compared to Phase 1, communications and social media staff from the Ministry were more active partners/collaborators in the development and dissemination of information to stakeholders and the public during Phase 2.

Key tactics deployed by the stakeholder engagement and communications team during Phase 2 are noted below:

- The project website – saskatoonfreeway.org – was updated to include detailed information about Phase 2. A blog post in June 2020 announced the formal commencement of Phase 2;
- Letters were used at multiple key milestones during Phase 2 to engage the approximately 500 impacted landowners in the Phase 2 area and provide timely updates, as well as identified Indigenous rights-holders, environmental/heritage stakeholders, and industry/association stakeholders;
- 12,000 pieces of paid direct mail advertising were distributed in June 2020 to CoS citizens living in neighbourhood communities within and adjacent to the proposed route for Phase 2, inviting them to visit the project website and sign up to a blog offering the latest project updates. A social media advertising campaign was used to support this direct mail campaign;
- Three online focus groups were held with the public on July 20 and 21, 2020 to share information about Phase 2 and specifically the environmental research being conducted within the scope of the functional planning study. The focus groups provided a unique and important opportunity to gather input and feedback on environmental concerns and possible mitigations. A total of 28 attendees participated in the sessions, which had a specific focus on the route that the freeway would cross through the Swales;
- An online design workshop was held in August 2020 where the project team worked with key stakeholders (MVA, the Saskatoon Nature Society, the CoS) to develop a new option for how the freeway would cross the Swales. A member of the public also attended the session, having been chosen from the list of interested attendees at the July 2020 focus group sessions; and
- An online public information session was held from February 16 to March 2, 2021, as an alternative to a traditional in-person information session. This unique approach was used to ensure the project aligned with public health orders in place due to COVID-19. During the online session, participants were able to view multiple concepts for various aspects of Phase 2 and provide comments to the project team through multiple surveys and a LiveChat function. The session was promoted via direct letters to all stakeholders identified in the team's playbook, along with targeted social media advertising. More

than 2,100 people visited the website, and more than 360 responded to surveys embedded within the site;

  - Results from the surveys embedded into this 2021 online public information session are found in **Appendix B**;

- A virtual Multiple Account Evaluation (MAE) process involving representatives from the Ministry, the project leadership team, the CoS, and the RM of Corman Park, was completed in the spring/summer of 2021, where the preferred route and interchange configurations for Phase 2 were selected;
- Functional plans were also updated to include the CoS and impacted RM road connections through to the freeway interchanges, as well as roads for local land access;
- A letter with the initial view of the preferred route for Phase 2 was shared with all landowners, environmental/heritage stakeholders, and industry/association stakeholders in October 2021. The letter provided an opportunity for landowners, in particular, to engage in one-on-one discussions with the Ministry's Senior Project Manager; they also set the stage for an upcoming second online public information session where more details would be provided, and input would be solicited; and
- A second online public information session was held from February 14 to 27, 2022 as an alternative to a traditional in-person information session due to ongoing concerns about in-person group gatherings because of the pandemic. During this second online session, 1800 virtual attendees were able to view the preferred route and interchange configurations for Phase 2 and provide comments to the project team through multiple surveys and a LiveChat function. More than 100 surveys were completed. The session was promoted via direct letters to all stakeholders identified in the team's playbook;
  - Results from the surveys embedded into this second online public information session are found in **Appendix B**.

3.2 Stakeholders

Phase 2 activities focused on four major stakeholder groups, also known as *pillars*:

- Landowners;
- Environmental/Heritage partners;
- Indigenous rights-holders; and
- Industry/Associations.

Efforts to engage and communicate with these groups were over and above those that used with the public.

These four stakeholder engagement pillars – which were first established in Phase 1 – allowed the stakeholder engagement and communications team to effectively target its efforts at stakeholders with similar interests and potential concerns. A summary of the activities undertaken for each of the four pillars is outlined below.

3.2.1 Stakeholder Pillar 1: Landowners

The focus of engagement with landowners in Phase 2 was on communicating the design concepts and better determining the potential impact that the Saskatoon Freeway would have on those possessing land near the 500 m corridor for Phase 2.

A total of 517 landowners within the Phase 2 study area were contacted. Ownership of the land parcels contacted included:

- Individual ownership;
- Corporations and business ownership;
- Holding companies; and
- First Nations landownership.

The main method of engagement and communication with landowners was through direct mail. Any letter to impacted landowners was sent on behalf of the Ministry. Landowners were sent letters at the outset of Phase 2, when the preferred concept for Phase 2 was finalized, as well as in advance of both online information sessions held in winter 2021 and winter 2022. Each letter not only provided a focused update on Phase 2, but also directed the recipients to the SFFPS website for more information and encouraged anyone with questions or concerns to contact the Ministry's Senior Project Manager for more information.

The Ministry responded directly to all requests for a meeting or a phone call by hosting Microsoft Teams or Zoom virtual meetings, due to safety concerns related to the pandemic, where maps detailing the potential and specific impact of Phase 2 for a specific landowner could be shared and discussed.

The two online information sessions coordinated by the stakeholder engagement and communications team gave landowners the opportunity to first review and comment on a short-list of design concepts (at a winter 2021 event) and then ultimately review and comment on the preferred route and interchange configurations (at a winter 2022 event).

Issues and concerns raised by landowners during ongoing stakeholder engagement and communications activities during Phase 2 include the following:

- The ability to do future business on their land;
- Access to their land;
- Broken up parcels of land that would result in less efficient farming and development opportunities;
- Decrease in property value;
- Quality of life during and after the build, related to safety, noise, and construction gestation;
- Environmental concerns both during and after construction, and permanently effecting untouched ecosystems; and
- Consideration for a future characterized by autonomous vehicles, which will lead to decreased truck traffic and decommissioning of roads.

Additionally, as some landowners learned that their land would need to be acquired if/when construction commences on the Saskatoon Freeway, they wanted to understand the procedure and timing for land acquisition including options for selling the land early through willing buyer/willing seller provisions, and then leasing back land until construction began. This information was primarily provided by the Ministry through one-on-one meetings with landowners which were documented and tracked in an internal registry maintained by the stakeholder engagement and communications team.

3.2.2 Stakeholder Pillar 2: Environment & Heritage

Understanding and mitigating/offsetting the impact that the proposed Phase 2 route and interchange configurations for the Saskatoon Freeway may have on cultural, heritage and environmental assets is the focus of interest for stakeholders within this pillar. The fact that the portion of the freeway route being studied in Phase 2 passed through the Northeast Swale and Small Swale served to amplify the attention of environmental and heritage stakeholders.

During Phase 2, the stakeholder engagement and communications team continued to engage with the same three primary organizations that were first identified in Phase 1:

- Wanuskewin Heritage Park (Wanuskewin);
- Meewasin Valley Authority (MVA);
- Northeast Swale Watchers (NESW);
    - The NESW withdrew from the Environment and Heritage TWG at the conclusion of Phase 1. The stakeholder engagement and communications team continued to share information with NESW leadership and propose opportunities where their members could provide input on Phase 2 route concepts, including presentations and focused invitations to public events;
- The stakeholder engagement and communications team also worked with the following organizations who are under the umbrella of NESW: Ducks Unlimited; Wild About Saskatoon; Saskatoon Nature Society; Canadian Parks and Wilderness Society (Western Canada); Saskatchewan Environmental Society; Nature Conservancy Canada (SK branch);
    - In Phase 1, the Endangered Grasslands Alliance provided the stakeholder engagement and communication team with notice that they wanted to be kept up to date on

developments and news regarding the project but did not wish to participate in a more formal engagement effort. This request continued to be honoured during Phase 2.

A variety of engagement techniques were employed while working with these stakeholders.

- Blogs highlighting environmental initiatives related to the project were posted on saskatoonfreeway.org, and available via email subscription;
- Regular phone calls and emails with key contacts;
- Meetings/presentations with the Board of Directors for Wanuskewin and MVA;
- Invitations to participate in online focus groups in July 2020 to discuss the environmental impacts of proposed Phase 2 routes through the Swales;
- Invitations to Wanuskewin, Saskatoon Nature Society, and MVA to participate in an online design workshop held in August 2020 to develop a new option for how the freeway would cross the Swales. A member of the public also attended the session, having been chosen out of a list of interested attendees from the July 2020 focus group sessions;
- A meeting with NESW leadership to discuss Phase 2 routing options in advance of the first online information session in winter 2021;
- Ongoing efforts to highlight how NESW input had contributed to the creation of a new route option through the Swales; and
- Letter, email and phone invitations to stakeholders inviting them to participate in both online information sessions and to leave comments via survey.

Issues and concerns raised by environmental/heritage groups during ongoing stakeholder engagement and communications activities during Phase 2 include the following:

- Carrying over from Phase 1, Wanuskewin provided ongoing feedback focused on ensuring that the project team strike a balance between making it easier for visitors to come to Wanuskewin while also not impinging on the viewscape and soundscape surrounding Wanuskewin. These are both factors that will be crucial in any application that Wanuskewin makes for UNESCO status. The project team responded to feedback from Wanuskewin officials by updating them on the Saskatoon Freeway route and interchange configuration property requirements reported on in the Phase 1 Functional Design Report. They were also informed that functional design plans for the South Saskatchewan River crossing were not finalized and that two bridge types would be carried forward to the completion of the functional study;
- The NESW continued to be clear in their opposition to the proposed route for the Saskatoon Freeway. The NESW have consistently advocated that elected officials consider a broader decision-making framework for the SFFPS that more closely reflects a triple bottom line methodology and considers wider economic and environmental criteria. Additionally, the NESW group has called for the stakeholder engagement and communications team to pursue wider engagement efforts with Saskatoon and area residents, with a focus on building broader education/awareness regarding the Northeast Swale. The stakeholder engagement and communications team acted on this suggestion in Phase 2 by using a direct mail and social media campaign to reach 12,000 citizens living in or close to areas of Saskatoon that would be impacted by the proposed Phase 2 route. These citizens were specifically invited to learn more about the project by subscribing to updates through a dedicated project website; and
- MVA played an important role in coordinating additional research that gave the project team a better understanding of the environmental assets currently found in the Northeast and Small Swales. This work was highlighted in a blog post on saskatoonfreeway.org that was published in August 2020. To maintain its impartiality and thus ensure the organization can continue to serve as an advocate for increased awareness of the Swales and environmental areas around Saskatoon, MVA advised the

stakeholder engagement and communications team that they would be taking no formal position regarding an endorsement for any preferred concepts for the Saskatoon Freeway.

3.2.3 Stakeholder Pillar 3: Indigenous Rights-Holders

Through the stakeholder identification work and leadership interviews completed during Phase 1, a total of 39 Indigenous rights-holders were identified; these rights-holders (highlighted below) remained the focus of stakeholder engagement and communications work in Phase 2:

- The STC (the STC includes eight member First Nations);
- Cowessess First Nation/Cowessess Ventures Ltd. (south Saskatoon landowners);
- Whitecap Dakota First Nation (a member of the STC);
- Moosomin First Nation (landowner near Highway 16);
    - NOTE: Regular meetings were held with economic development representatives for Moosomin First Nation during Phase 1; these continued into Phase 2;
- Red Pheasant Cree Nation (urban reserve landowners within the CoS city limits);
- English River/Des Nedhe Development Corporation (south Saskatoon developers/landowners);
- Saskatchewan First Nations Economic Development Network;
- The Metis Nation – Saskatchewan;
- Beardy's and Okemasis Cree Nation (impacted by Saskatchewan River bridge crossing);
- One Arrow First Nation (STC member; impacted by Saskatchewan River bridge crossing)
- Saskatoon Metis Local #11, Local #126, and Local #165 (impacted by Saskatchewan River bridge crossing);
- Little Pine First Nation; and
- Muskoday First Nation (STC member; interested in more information and material).

The main method of engagement and communication with Indigenous rights-holders was through direct mail. Letters were sent to Indigenous rights-holders from the Ministry at the outset of Phase 2 and were followed up with texts, phone calls, and meetings (if requested by the Indigenous rights-holder contacted). Letters were also sent in advance of the winter 2021 online information session to share the preliminary preferred route for Phase 2 released in October 2021, and in advance of the second online information session in winter 2022. Each letter not only provided a focused update on Phase 2, but also directed the recipients to the SFFPS website for more information and encouraged anyone with questions or concerns to contact the Ministry for more information. The Ministry responded directly to all requests for a virtual meeting or phone call as a follow up to these letters.

The two online information sessions coordinated by the stakeholder engagement and communications team gave Indigenous rights-holders the opportunity to first review and comment on a short-list of design concepts (at a winter 2021 event) and then ultimately review and comment on the preferred route and interchange configurations (at a winter 2022 event).

During Phase 1, the Ministry determined that Duty-to-Consult protocols were applicable to the proposed South Saskatchewan River bridge crossing. The Ministry proceeded with a Level 3 letter in Phase 1. A Level 3 letter is sent when a project was deemed to meet the following criteria created by the Government of Saskatchewan in its Duty to Consult framework: *to cause a short-term disturbance to land and/or a change in resource availability with a potentially significant impact, or a long-term disturbance to land and/or change in resource availability and/or permanent uptake of land with a potentially minor impact.* A Level 3 impact requires that written notice be provided, with an offer to meet with community to discuss project and seek input. Follow up is not required but may be appropriate. With the support of the stakeholder engagement and communications team and the Ministry of Government Relations, a Level 3 letter was developed and distributed by the Ministry during Phase 1 to First Nation and Metis rights holders with geographic proximity: Beardy's and Okemasis Cree Nation; One Arrow First Nation; Whitecap Dakota First Nation; and Saskatoon Metis Local 11, Metis Local 126, and Saskatoon Local 165. Due to limited responses, the stakeholder engagement and communications team recommended that a second Level 3 letter be sent during Phase 2 to the same recipients; this was completed in May 2021. No responses were received.

Issues and concerns raised by Indigenous rights-holders during stakeholder engagement and communications work that began in Phase 1 continued into Phase 2; these include the following:

- Remain informed on project progression and involved in key milestones;
- Concern regarding traffic being diverted away from their landholding area;
- Interested in understanding access plans;
- Wanting to ensure that SFFPS project team provides sufficient time for proper Indigenous governance and protocols;
- Burning ceremonies on the Northeast Swale (want to ensure that smoke does not blow onto highway);
- Concern regarding potential bridge lighting options and its and impact on bison habitat;
- Bird conservation issues;
- Highlighting the importance of considering visual colors from a First Nations and Metis perspective in any potential bridge design;
- Plans to include Indigenous communities on procurement and construction; and
- Impact on heritage sites and their traditional uses (west bank of river valley crossing).

3.2.4 Stakeholder Pillar 4: Industry/Sector Partners

Through the stakeholder identification work and leadership interviews completed during Phase 1, a total of 31 industry/sector partners were identified; they remained the focus of stakeholder engagement and communications work in Phase 2:

- CoS
- RM of Corman Park
- P4G Members
- City of Warman and Martensville
- North Saskatoon Business Association (NSBA)
- Colliers International
- Greater Saskatoon Chamber of Commerce/Regional Chambers of Commerce
- Saskatoon Regional Economic Development Authority (SREDA)
- Saskatchewan Trucking Association (STA)

- Regional Transportation Groups

With favourable responses received during focused engagement work completed in Phase 1 regarding the project, the stakeholder engagement and communications team elected to focus its efforts during Phase 2 on engagement via direct mail letter with this pillar, to maximize the team's limited resources. Letters were sent to industry/sector partners at the outset of Phase 2 and in advance of both online information sessions. A letter was also sent in October 2021 advising of the initial preferred route for Phase 2 and indicating that this route would be the focus of the second online information session in the winter of 2022. Each letter provided a focused update on Phase 2 and directed the recipients to the SFFPS website for more information and encouraged anyone with questions or concerns to contact the Ministry for more information. The Ministry responded directly to all requests for a virtual meeting or phone call as a follow up to these letters.

The two online information sessions coordinated by the stakeholder engagement and communications team gave industry/sector partners the opportunity to first review and comment on a short-list of design concepts (at a winter 2021 event) and then ultimately review and comment on the preferred route and interchange configurations (at a winter 2022 event).

During stakeholder engagement and communications activities conducted as part of Phase 2, industry/sector partners conveyed the following messages to the project team; these were consistent with what was heard during Phase 1:

- Continue with constant messaging and updates with leadership and representatives;
- Participation on the project team is critical;
- Ensure continued communication on the project itself;
- A theme of general support for the project and a desire for it to proceed to construction as soon as possible; and
- Consistent, clear, and transparent information that is up-to-date will help manage any possible land sale and development disruption.

While no broad themes emerged as it relates to concerns among industry/sector partners; nevertheless, a list of specific and unique issues raised by those in this stakeholder engagement pillar is provided below:

- Concern regarding intersection with agricultural lands;
- Questions regarding bringing an irrigation line in from the river and potential impacts;
- Concerns regarding access, traffic, and noise;
- The ability to plant trees to function as a dividing line;
- Concern that potential realignment on Highway 41 may add additional time to commute, causing residents to not use interchange; and
- Questions regarding land assessment processes.

3.3 Public

The key tactics used to engage and consult the general public focused on regular blogs posted on the project website and available through email subscription, as well as two online information sessions in winter 2021 and winter 2022. Multiple surveys were available to participants in both online information sessions.

- As noted earlier, 12,000 pieces of paid direct mail advertising were distributed in June 2020 to CoS citizens living citizens living in neighbourhood communities within and adjacent to the proposed route for Phase 2, inviting them to visit the project website and sign up for a blog offering the latest project updates. A social media advertising campaign was used to support this direct mail campaign.

3.3.1 Virtual Public Information Session and Surveys

Due to restrictions on public gatherings resulting from COVID-19, the project team presented the initial concepts for Phase 2 through an online open house that ran from February 16 to March 2, 2021. More than 2,100 people visited the website, and more than 360 responded to surveys embedded within the site. This first online information session featured multiple concepts for freeway route and interchange locations/design within Phase 2. Attendees were offered the chance to complete surveys to share their preferences and concerns around each concept. Results from this online information session were shared with the general public through a blog.

Key input from public stakeholders that was received through this online information session, and which directly impacted the project's team work on preferred route and interchange configurations, is highlighted below (these efforts are discussed more fully in other sections of this report):

- Changes to the freeway's route through the Northeast and Small Swales;
- The additional of two access points and a service road to serve the potential industrial development north of Highway 16 and south of Patience Lake Road;
- The combination of two initial concepts for the Highway 16 interchange (presented at the winter 2021 online information session) to create a new concept that was ultimately presented as the preferred option at the winter 2022 online information session;
- Shifting of the location of the 8th Street interchange to avoid wetlands; and
- Shifting the alignment between Highway 11 and Highway 16 to minimize impacts on wetlands.

In addition, public input from the winter 2021 online information session prompted the project team to initiate a study to measure potential noise impacts from the freeway, to add full wildlife fencing along both sides of the freeway between the Blackley Road interchange and the South Saskatchewan River, and to undertake additional investigation into overpass and underpass options at the Small Swale and Northeast Swale.

A second online public information session was held from February 14 to 27, 2022 to present the preferred alignment and interchange configurations for Phase 2. Approximately 1,800 people visited the website, and over 100 responses were received to surveys embedded within the site.

Praxis prepared reports summarizing the survey methodologies and results from the Phase 2 online information sessions 1 and 2. The reports are presented in **Appendix B**.

4 Transportation Planning

4.1 Traffic Modelling

4.1.1 Overview

4.1.1.1 Purpose

The transportation modelling component of the SFFPS is intended to provide support to the advancement of the design concept for the Saskatoon Freeway by assessing the forecast interactions between the future freeway system and the planned and anticipated future developments in the region. This work is based upon a calibrated model of the study area developed previously. This model was reviewed at a high level for general structure and operation, and validation was done to get an indication as to whether it was continuing to perform as intended when originally developed. Then the model was modified for use in the SFFPS in several ways:

- Updating of planned development within the study area based on new sector planning work that has been carried out since the model was initially built in 2013-2015, and correction of future development assumptions that no longer stand. This included updating of zone residential and employment forecasts, as well as addition and/or modification of zone connectors and arterial road links as necessary to load the anticipated development onto the network in a reasonable manner, in the absence of developed road network plans in areas of future development;
- Updating the representation of the Saskatoon Freeway within the model to something closer to the current planning concepts, including locations of interchanges and, particularly in the southeast quadrant, the general alignment of the freeway; and
- Modification of network elements to correct model operations where it became evident it was not producing realistic assignments in the 2063 horizon year.

These steps are described in more detail in the sections that follow.

The model was further updated in 2021 as part of the Phase 2 SFFPS work. This included additional information related to the Moosomin First Nation's planned development in the vicinity of the Dalmeny Access/Highway 16 intersection. Previous updates also accounted for development in the Grasswood Business area and the Aspen Ridge neighborhood plan. Multiple model runs were considered in relation to the realignment of Highway 41 and access options including a flyover at Highway 41 and Range Road 3043.

4.1.1.2 Model Structure

The forecasts prepared for this functional planning study were prepared using the Saskatoon Regional Travel Demand Model (SRTDM) which was developed by HDR Corporation and completed in April 2015, jointly for the Ministry and the CoS. The original model and report (HDR, 2015) were reviewed to confirm the model validity. That report describes the development process and structural details of the model. The following provides a brief summary of the model development process carried out to create the model. The original report should be consulted for additional details.

The model was calibrated to the 2013 base year using applicable household survey data to consider trip purposes including employment and education. The application of calibration factors was implemented directly in VISUM as a series of automated procedures. The factors developed included generation factors to adjust total trip volumes to observed demand by purpose and trip distribution factors to adjust global Origin-Destination (OD) matrices to observed demand by purpose.

The model was then extended to the prescribed horizon years based on land use forecasted by Urban Systems, with cooperation from the CoS and the Partnership for Growth (P4G) Task Force, comprised of the Rural Municipality (RM) of Corman Park, and Cities of Martensville and Warman. It should be noted that Urban System's forecasts assume that the CoS population will grow at a compound annual growth rate (CAGR) of 2.5% based on a medium growth scenario prepared by the CoS's Mapping and Research Group.

Table 4.1 shows land-use information that the HDR model originally provides. It appears that population per household is anticipated to decline over the 50-year horizon.

Table 4.1: HDR Model

HORIZON YEAR	HDR SCENARIO NAME	HDR REPORT STATED POPULATION[1]	MODEL DWELLING UNITS (DUs)	CALCULATED MODEL POPULATION PER DU	TOTAL EMPLOYMENT
2013	Base-year	247,000[2]	119,195	2.07*	133,883
2021	300k	300,000	147,315	2.04	161,464
2032	400k	400,000	201,603	1.98	218,354
2041	500k	500,000	257,707	1.94	272,797
2063	50-year	850,000	464,892	1.83	463,428

Note: [1]Population horizon is calculated based on the population of the CoS, not the entire region.
[2]Calculated from Appendix B; Urban System Land Use Forecasts part of the SRTDM report.
Source: SRTDM HDR Model Development Report (Table 7-5).

Internal passenger trip forecasts were produced by running the model with updated land use and networks for the corresponding horizon year. The actual factors used to inflate external travel (from the base year) were 1.25 for the 300K scenario, 1.70 for the 400K scenario, 2.05 for the 500K scenario and 3.00 for the 50-year horizon. These were distributed based on taking the counts at the Ministry's external stations and using this information to construct a synthetic matrix.

It is noted that the 2.5% growth rate is consistent with the expected growth in jobs in the CoS, whose compound annual growth rates range between 2.5% and 2.6%, as shown in **Table 4.2** below (the CoS job growth rates are slightly higher, which is consistent with the CoS and its economic climate being a major driver in long-distance truck traffic growth to and from the CoS).

Table 4.2: Projected CoS employment growth

HORIZON	2013	2021	2032	2041	2063
Total Employment	122,673	148,988	198,651	248,313	422,000
CAGR wrt 2013	-	2.5%	2.6%	2.6%	2.5%

Source: SRTDM HDR Model Development Report (Table 7-6)

The model incorporates approximately 33,000 links representing freeway, arterial, collector, local streets as well as rural roads in the study area. However, the local and rural network is represented just for visual context and those links are not calibrated or assigned in the modelling. A total of 361 Traffic Analysis Zones (TAZ) are defined, each representing an area of land with its existing or anticipated homes and jobs used to represent demand within the TAZ corresponding with existing and proposed development plans.

The original modelling includes anticipated network modification (in the future 50-year horizon (2063)) model, also presented in **Table 4.3** and on **Figure 4.1**:

Table 4.3: HDR Model Anticipated Network Modifications

NEW CONSTRUCTION	UPGRADE TO EXISTING FACILITY
Martensville Interchange (MHI)	Highway 7 twinning (MHI)
Warman Interchange (MHI)	Highway 16 twinning (MHI)
Highway 305 realignment (MHI)	7 upgraded interchanges (CoS)
North Perimeter Highway (MHI)	8th Street upgrades (CoS)
McOrmond South Extension (CoS)	Traffic Bridge (CoS)
North Commuter Parkway (CoS)	Realignment of Highway 41
West Connector Route	Existing Highway 41 flyover at the Saskatoon Freeway

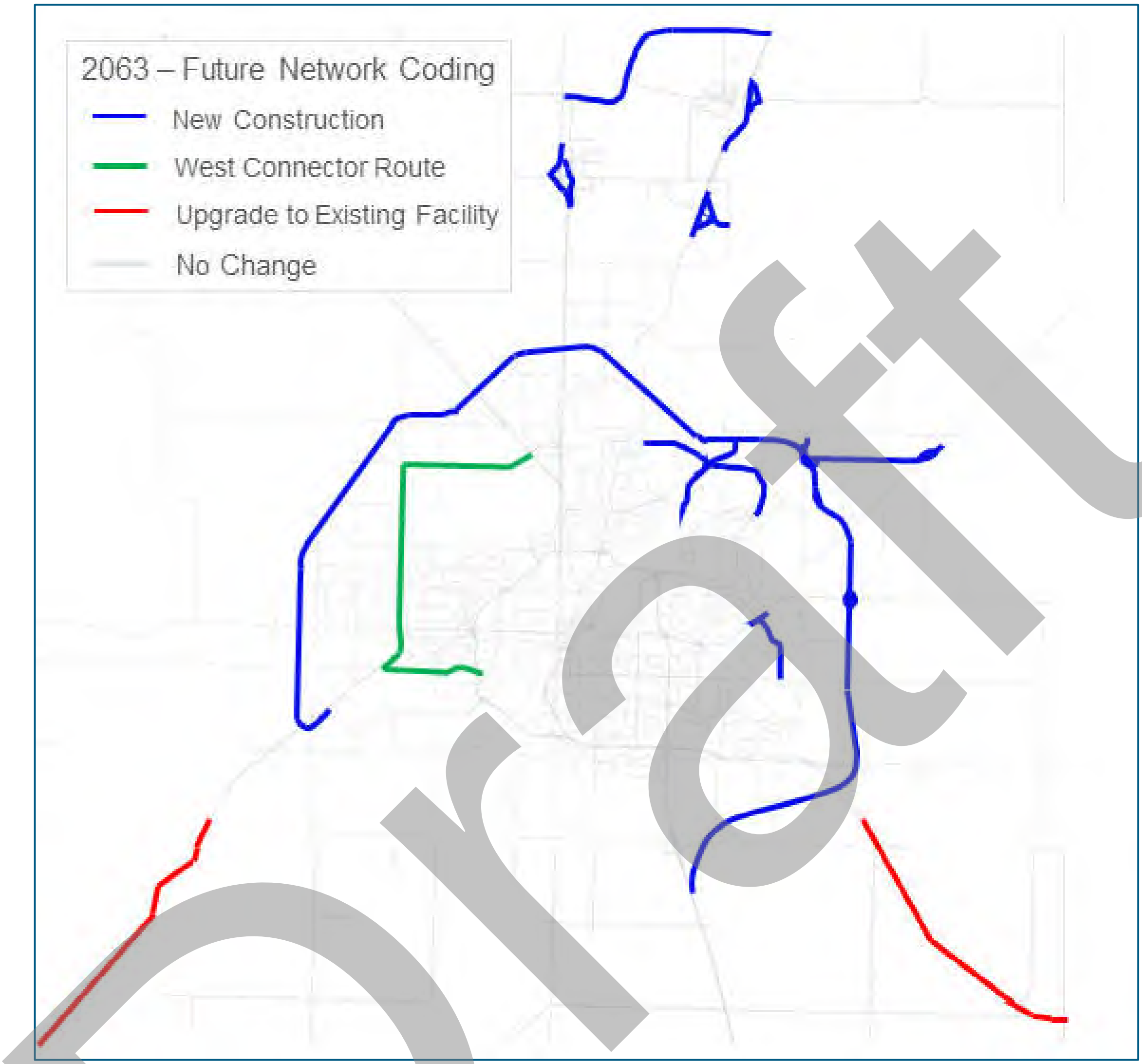


Figure 4.1: Future network enhancements (2063)

4.1.1.3 Validation

While the original model was calibrated and validated as documented in the 2015 report, an effort was made as part of the SFFPS to spot-check that the model is still performing reasonably five years after it was published, and 7 years after the original base calibration year. A couple of approaches were tried, based on readily-available information, and the constraint that the model's first horizon year is 2021. The checks were therefore essentially looking at whether recent actual planning and traffic data available appears consistent with the model. This is described in the following sections.

4.1.1.3.1 Bridge volumes

A standard measure of macroscopic modelling performance is the fit of assigned volumes at screenlines, with one of the best being a river crossing, and the South Saskatchewan River is a prominent feature in this model. River crossings are particularly good tests as they have limited crossing points which are typically major roads and so are well-reflected in the model. The overall total volumes crossing screenlines give a check of the distribution of origins and destinations in the model, and since the crossing links are usually high order connections, the volumes individually or in localized clusters can also indicate the effectiveness of the model's network capacity in routing traffic to appropriate crossings. The CoS bridge network is presented in **Figure 4.2**.

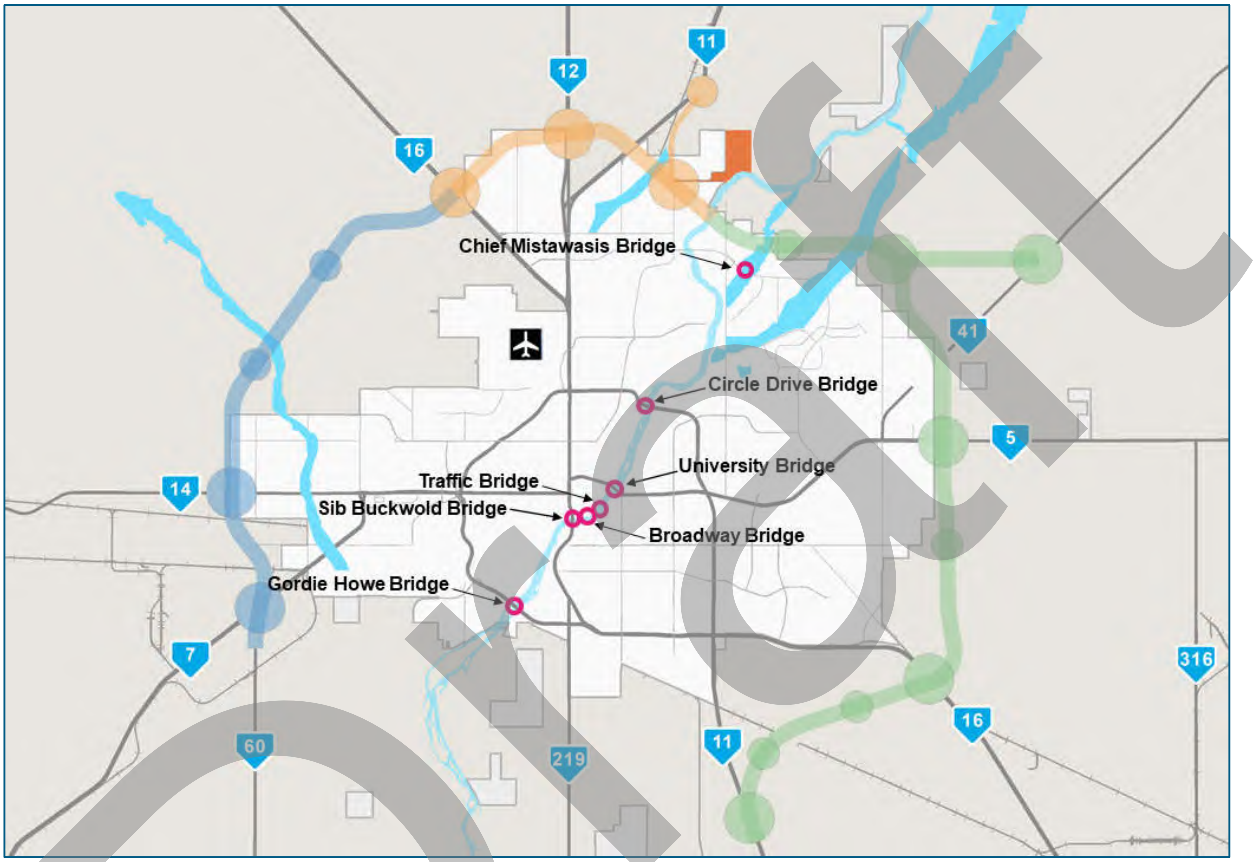


Figure 4.2: Bridge network in the CoS

The CoS provided all 7 bridge traffic counts conducted in spring 2019, which was compared with the original model's base and 2021 horizon scenarios to see any correlation in traffic volume. It should be noted that both Traffic Bridge and Chief Mistawasis Bridge were opened in 2018 so they were not modelled in the 2013 base model, but they were counted by the CoS in 2019. As shown in **Figure 4.3** and **Figure 4.4** below, the CoS's bridge traffic count generally aligns well with the model projections, indicating that for the fundamental river screen-line in the study area, the model is performing reasonably well.

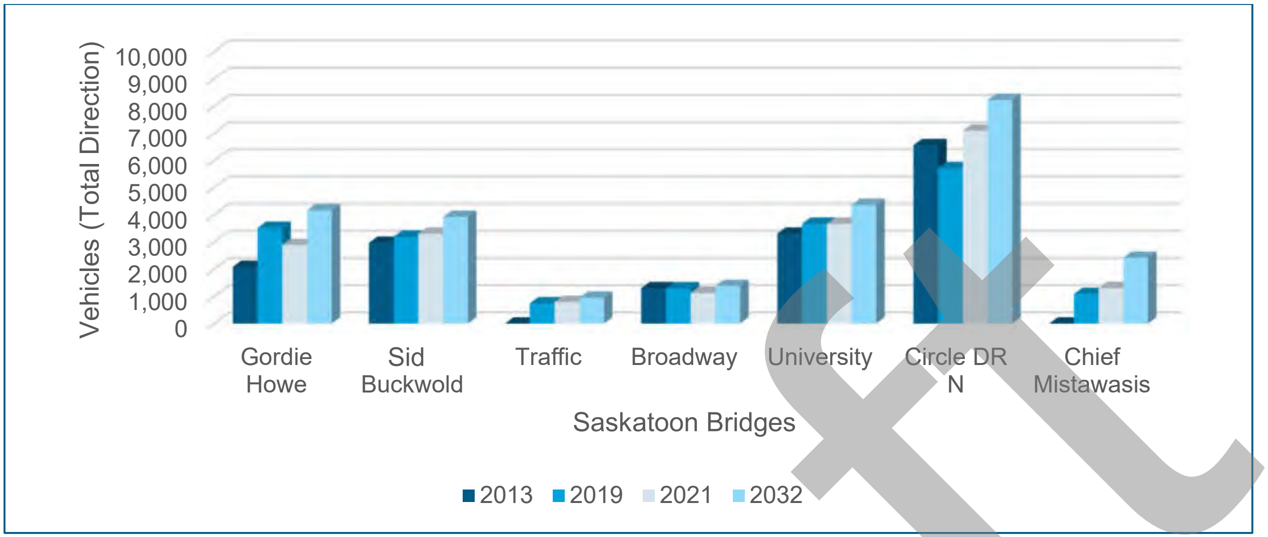


Figure 4.3: Bridge traffic volume comparison (AM peak hour)

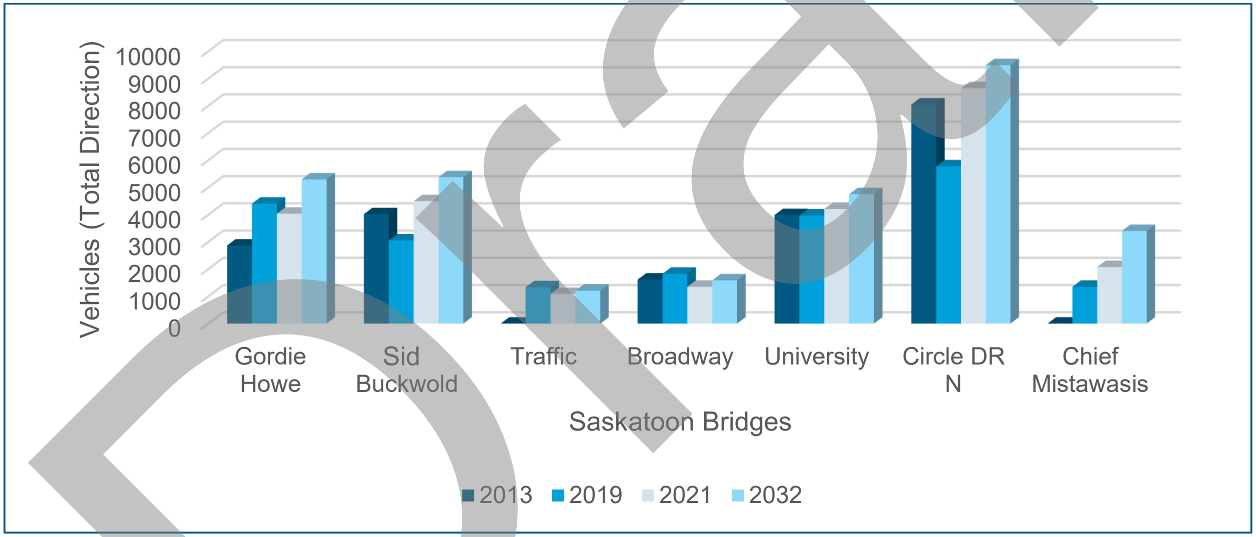


Figure 4.4: Bridge traffic volume comparison (PM peak hour)

The bridge count compared very well to the interpolated model forecast between 2013 and 2021 models in both AM and PM Peak hour. **Table 4.4** and **Table 4.5** show the comparison between the 2019 volume and interpolated 2019 volume using 2013 and 2021 data. In the AM peak hour, the total bridge volume is off by less than 1.5% from the interpolated model forecasts. However, the model appears to forecast about 13% higher than observed volume for 2019 in the PM peak hour. This could be due to some spreading of peak demand in the observed data. For the purposes of the SFFPS work this result is satisfactory.

Table 4.4: 2019 Counts (AM peak)

HORIZON YEAR	GORDIE HOWE	Sid BUCKWOLD	TRAFFIC	BROADWAY	UNIVERSITY	CIRCLE DR N	CHIEF MISTAWASIS	TOTAL
2019	3516	3192	742	1291	3668	5719	1087	19215
2019 (Interpolated)	2690	3222	593	1170	3579	6962	979	19194

Table 4.5: 2019 Counts (PM peak)

HORIZON YEAR	GORDIE HOWE	Sid BUCKWOLD	TRAFFIC	BROADWAY	UNIVERSITY	CIRCLE DR N	CHIEF MISTAWASIS	TOTAL
2019	4403	3051	1332	1826	3967	5777	1349	21705
2019 (Interpolated)	3742	4374	816	1417	4152	8493	1556	24552

Having more lanes on a given bridge could cause the bridge to attract more traffic. **Table 4.6** shows the number of lanes on each bridge are mostly consistent except for Chief Mistawasis bridge. In 2013 the model did not incorporate the bridge because it was not opened until 2018. In the 2021 model, it shows one lane less in each direction, which could attract less traffic. However, the 2019 counts are not approaching capacity of even a 4-lane bridge, so the additional open lanes are evidently not yet a sufficient draw to divert traffic from the bridges to the south. Even so, the Circle Drive North bridge in the 2013 model is busier than in the CoS 2019 count but this decline in volume is explained by the opening of the Chief Mistawasis Bridge in 2018.

Table 4.6: Bridges in the CoS

BRIDGE NAME	OPENING DATE	# LANE TOTAL (2020)	# LANE TOTAL (2013)	# LANE TOTAL (2021)
Gordie Howe	2013	6	6	6
Sid Buckwold	1966	6	6	6
Traffic	1916, reopened in 2018			
Broadway	1932	4	4	4
University	1916	4	4	4
Circle Drive North	1983	6	6	6
Chief Mistawasis	2018	6	(not open)	4

4.1.1.3.2 Dwelling Units

The CoS census data was provided to compare against the original 2013 base and 2021 horizon model scenarios. The CoS also provided their 2018 counts of dwelling unit by neighbourhood. All these data sets are shown in **Figure 4.5**.

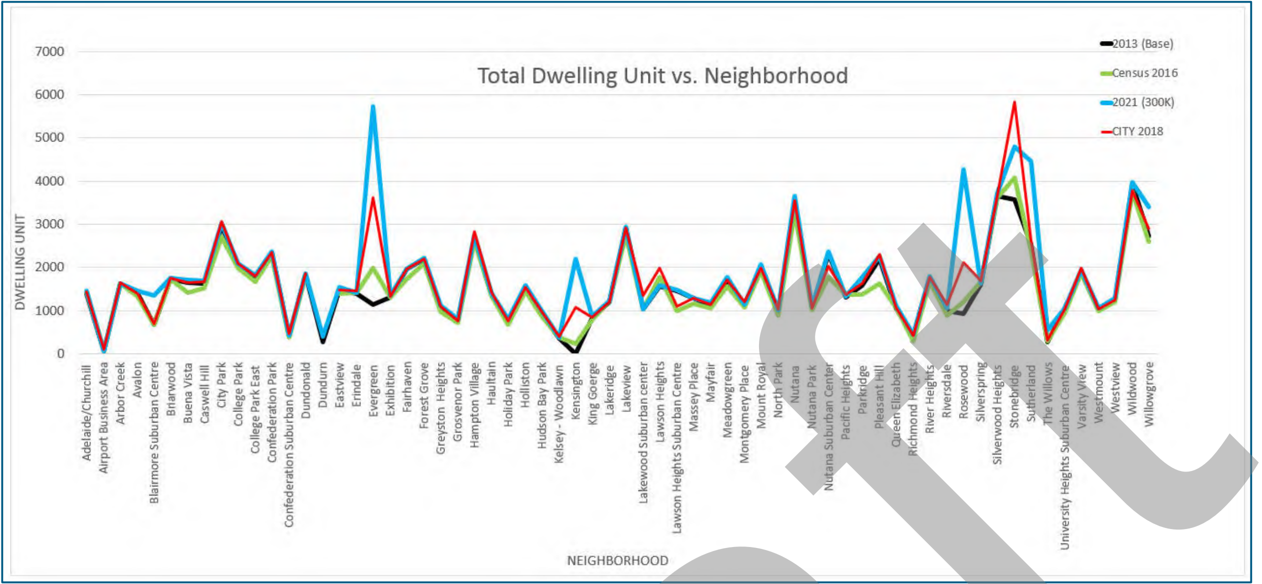


Figure 4.5: Example of model validation

In general, the comparison shows reasonable agreement between the modelled and measured data from 2013 to 2021. In specific locations, for example Evergreen, Kensington, and Rosewood, the dwelling unit counts grow reasonably from the 2013 base model to the 2021 model horizon year. In most neighbourhoods there is negligible growth, as expected for mature areas of the CoS.

In a few locations the 2018 CoS count already exceeds the forecasted 2021 model totals, most notably in Stonebridge. The CoS commented that the Stonebridge community might be at capacity now with many infill developments taking place recently. It was agreed that the model forecast Dwelling Units total for this neighbourhood should be matched to the CoS's 2018 counts.

4.1.2 Updating

Modification of the model for use in the SFFPS was carried out carefully, with the guiding principle being to change as little as possible in order to minimize the invalidation of the model calibration that was achieved by the original effort in 2015. However, some changes were necessary to accommodate the freeway itself, and new plans for development. Changes were also needed to correct poor behaviour in future year models, such as excessive use of U-turns and traffic taking unrealistically circuitous routes. Corrections to the model were also required such as removal of roads that existed in 2013 but will not remain connected once the freeway is in place (e.g. Range Road 3055 between Township Road 374 and Township Road 380).

The initial stage of model modification included review of the model documentation along with the actual model as implemented in the VISUM software. This effort revealed a number of cases of the model implementation not being aligned with the documentation or with the current plans of study area authorities. For example, the original model showed 62,000 dwelling units and 67,000 employment in Traffic Area Zone (TAZ) 272, however in discussions with TWG members, it was concluded this would not happen in the future.

Phase 2 functional planning work included consideration to realigning Highway 41 to intersect at the Blackley Road interchange. This also included maintaining the existing Highway 41 travel pattern by incorporating a flyover; existing Highway 41 overpasses the Saskatoon Freeway.

4.1.2.1 Growth Plan Updates

It was noted from the HDR model development report that the forecasts done in the model are expected to be updated in future as P4G and other regional stakeholders continue to carry out their own land use planning processes. This updating was carried out through review of a number of relevant sources, listed in **Table 4.7**.

Table 4.7: Model modification data sources

DEVELOPMENT SECTOR	SOURCE	URL
P4G Regional Plan	P4G website	https://partnershipforgrowth.ca/regional-plan/
Blairmore Sector Plan	CoS Website	https://www.saskatoon.ca/sites/default/files/documents/community-services/planning-development/future-growth/sector-planning/approved_blairmore_sector_plan_amendment_march_7_2011.pdf
Holmwood Sector Plan	CoS Website	https://www.saskatoon.ca/sites/default/files/documents/community-services/planning-development/future-growth/sector-planning/holmwood_sector_plan_2017_final.pdf
Riel Industrial Sector Plan	CoS Website	https://www.saskatoon.ca/sites/default/files/documents/community-services/planning-development/future-growth/sector-planning/riel_industrial_sector_plan_-_amended_january_25_2016.pdf
University Heights Sector Plan	CoS Website	https://www.saskatoon.ca/sites/default/files/documents/community-services/planning-development/future-growth/sector-planning/UniversityHeightsSectorPlan2013Amendment.pdf
P4G Regional Plan	P4G website	https://partnershipforgrowth.ca/regional-plan/
Blairmore Sector Plan	CoS Website	https://www.saskatoon.ca/sites/default/files/documents/community-services/planning-development/future-growth/sector-planning/approved_blairmore_sector_plan_amendment_march_7_2011.pdf

It was confirmed that the P4G report development zone boundaries are generally aligned with the boundaries of the CoS limits and development sector plans. The one exception was an area of apparent overlap between the CoS's current limits and the future P4G lands in the north of the Holmwood Sector Plan (TAZ 417, discussed below). However, the impact of this mismatch is negligible as the current model data for this TAZ is rather minimal (14 Dwelling Units and 13 Employments).

4.1.2.1.1 CoS Sector Plans

Four Sector Plans had been developed (shown in **Figure 4.6**) in more detail following the completion of the original base model, so these were reviewed and added to the 2063 horizon year model. This required both modifications to the model network and adjustments to the zone growth forecasts. The four new sector plans are described below.

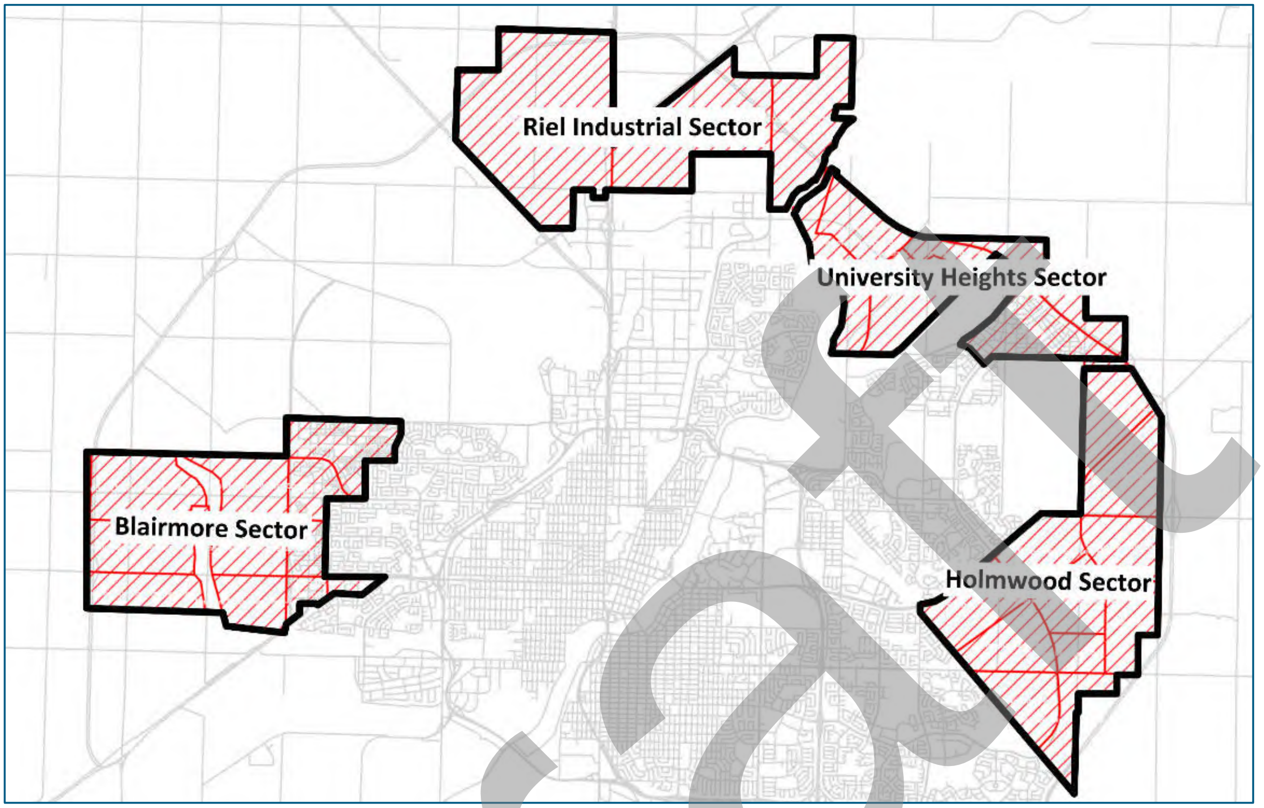


Figure 4.6: Four sector plan location

Blairmore

The Blairmore sector is located east of Perimeter Highway; north of the Canadian Pacific Railway rail line; west of Hampton Village, Dundonald, Confederation Park, Pacific Heights, and Parkridge neighbourhoods; and south of Beam Road (RM of Corman Park road). There are five main roads that form the major arterial links within the Blairmore sector; 33rd Street W, 22nd Street W, Diefenbaker Drive, McClocklin Road, and Claypool Drive. Five additional major roads were added to provide better network connections including connection to the freeway at the future Claypool Drive interchange.

Holmwood

The Holmwood Sector Plan report states the sector is Saskatoon's newest Suburban Development Area (SDA) for future urban expansion and the majority of the lands remain un-serviced and undeveloped at this point in time. The updated model has added major roads and intersections within the sector to provide better network connection.

Riel Industrial

The Riel Industrial Sector is north of the Marquis Industrial Area and northeast of Highway 16, south of the Perimeter Highway alignment, and west of the South Saskatchewan River. The Riel Industrial Sector will accommodate fully-serviced light and heavy industrial, four commercial nodes, recreation areas/facilities, and the incorporation of the wetland complex. The Riel Industrial Sector is anticipated to employ 32,000 employees at full build out.

University Heights

The University Heights SDA is made up of Saskatoon's northeast neighborhoods, the University of Saskatchewan (University) lands, Agriculture and Agri-food Canada research lands, and future urban development lands.

Updating the model to accommodate the four sector plans required modification to the network in the model including zone connectors. As these details were added in each sector a number of flow checks were done, often using the VISUM "flow bundle" tool to check that the major vehicle flows were making reasonable route choices. Through these checks a number of network shortcomings were observed and changes made to mitigate the issues. For example, some interchanges were modelled in the original network where there were none planned in any of the sector plans and links and nodes were disabled or removed in places to produce more realistic traffic flow. Other network adjustments were made to reduce misuse of low-capacity links and eliminate routes that will not exist in future (e.g. roads that cross the future freeway alignment were typically remaining in the original 2063 model). For zones, the numbers of connectors were modified in every development area to provide a better connection between the zone and the road traffic network. For example, one of the connectors modelled as crossing over the freeway which would not be realistic once the freeway is in place (see **Figure 4.7**).

ORIGINAL	MODIFIED

Figure 4.7: Connector changes in 2063 model (Riel Industrial)

The following **Table 4.8** shows the key modifications made in the model to incorporate and account for future traffic flows specific to each of the four sector plans. This table does not show every modification made, but the most significant ones and examples of typical sorts of changes that were implemented in the 2063 modified network.

Table 4.8: Key modifications for sector plan updates in the Model

DEVELOPMENT SECTOR	ORIGINAL 2063 MODEL	UPDATED 2063 MODEL
Blairmore		
Key Modifications	Removal of links in model (provided freeway crossing where the sector plan didn't indicate). Removal of links & nodes (interchange with 33rd Street West), which is not shown in the sector plan. Grade separation modification at the Township Road 364 crossing of the freeway (grade separation, not an interchange).	
Holmwood		
Key Modifications	Removal of existing road link that crosses the freeway where no grade separation was indicated in the sector plan. Created collector and arterial links including new interchanges at the intersection of 8th Street and the freeway as per the Holmwood sector plan.	

DEVELOPMENT SECTOR	ORIGINAL 2063 MODEL	UPDATED 2063 MODEL
Riel Industrial		
Key Modifications	Removal of link at Highway 12 service road because it is too attractive compared to future congested Highway 12 (misleading flow resulted). Wanuskewin road existing south of Marquis is 4-lane major arterial, north it reduces to 2-lanes. However, in future with freeway to the north, 4-lane should be extended through the interchange all the way to Highway 11. This section was changed to Major Arterial all the way to Highway 11. Removed Highway 11 crossing the freeway. Created arterial and collector links including new intersections as per the Riel Industrial sector plan.	
University Heights		
Key Modifications	Removed link which accessed the freeway where there is no interchange planned. Existing Central Avenue road straight part was removed in University of Heights sector plan because traffic showed diverting from the future network/should not be continued in the future. Removed link in model because connection unlikely as a new interchange is right beside it. Created arterial and collector links including new intersections as per the University Heights sector plan.	

4.1.2.1.2 Grasswood and Aspen Ridge Sector Plans

Additional revisions were made in 2021 during the Phase 2 planning work: Aspen Ridge (June 2018) and Grasswood (May 2016). Only land-use data was updated from the respective plans. The connectors in the original TAZ were appropriate.

Aspen ridge zone modifications illustrated in **Figure 4.8** and include:

- Realign zone boundary with the land use concept plan figure provided in the Aspen Ridge Sector Plan Report;
- Assign 160 zone with mostly residential; and
- Retain land use employment information from the original model.

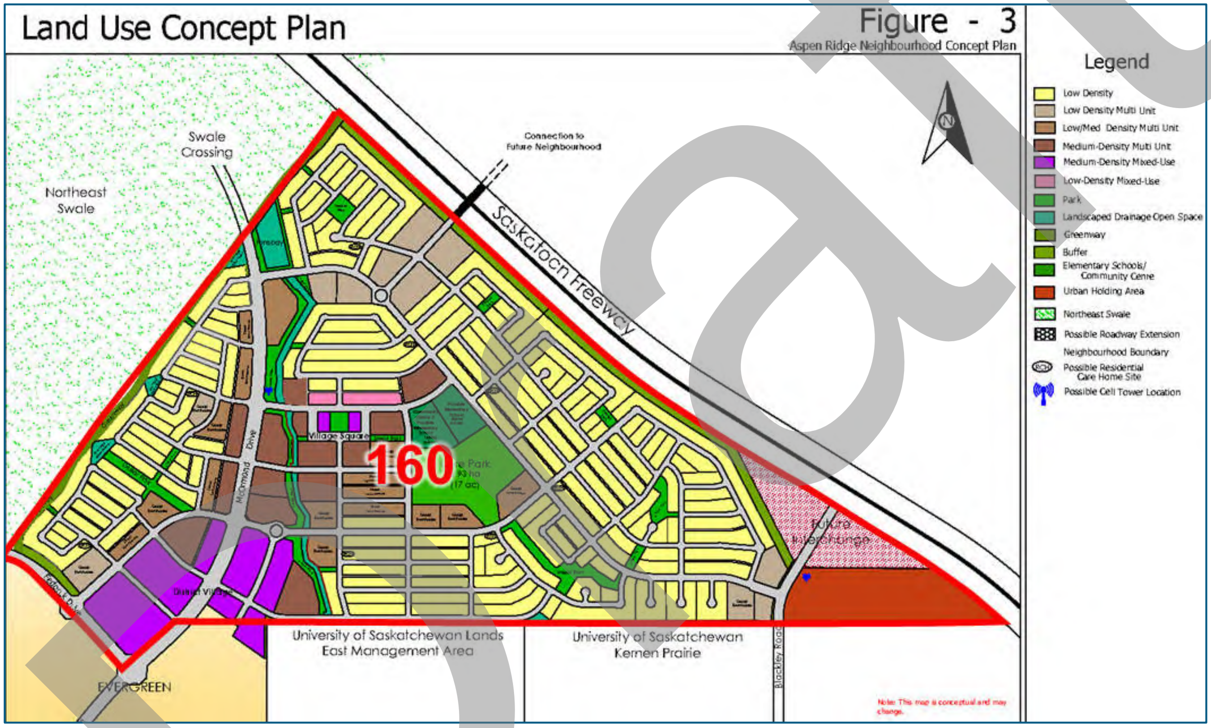


Figure 4.8: Aspen Ridge zone modifications

Grasswood zone modifications are illustrated in **Figure 4.9** and include:

- Realign zone boundary with the land use concept plan figure provided in the Grasswood Sector Plan Report;
- Assign 405 zone with mostly residential;
- Assign 407 and 408 zones with industrial and recreation; and
- Increase in population and employment information over the original model.

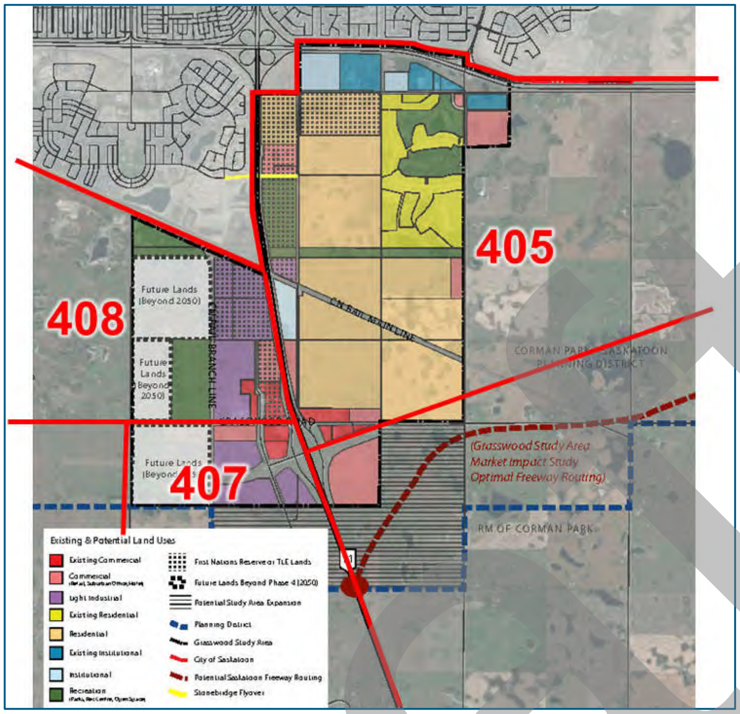
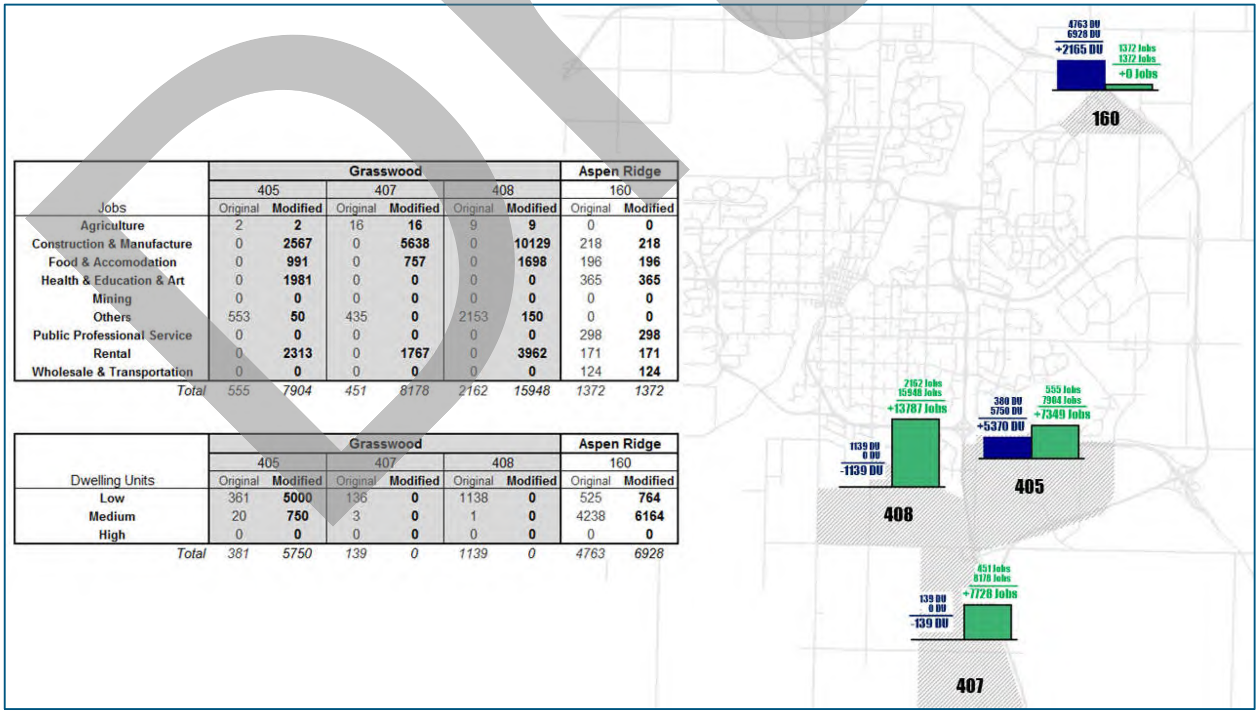


Figure 4.9: Grasswood zone modifications

The population and employment data was updated as illustrated in **Figure 4.10**.



Jobs	Grasswood						Aspen Ridge	
	405		407		408		160	
	Original	**Modified**	Original	**Modified**	Original	**Modified**	Original	**Modified**
Agriculture	2	**2**	16	**16**	9	**9**	0	**0**
Construction & Manufacture	0	**2567**	0	**5638**	0	**10129**	218	**218**
Food & Accomodation	0	**991**	0	**757**	0	**1698**	196	**196**
Health & Education & Art	0	**1981**	0	**0**	0	**0**	365	**365**
Mining	0	**0**	0	**0**	0	**0**	0	**0**
Others	553	**50**	435	**0**	2153	**150**	0	**0**
Public Professional Service	0	**0**	0	**0**	0	**0**	298	**298**
Rental	0	**2313**	0	**1767**	0	**3962**	171	**171**
Wholesale & Transportation	0	**0**	0	**0**	0	**0**	124	**124**
Total	*555*	*7904*	*451*	*8178*	*2162*	*15948*	*1372*	*1372*

Dwelling Units	Grasswood						Aspen Ridge	
	405		407		408		160	
	Original	**Modified**	Original	**Modified**	Original	**Modified**	Original	**Modified**
Low	361	**5000**	136	**0**	1138	**0**	525	**764**
Medium	20	**750**	3	**0**	1	**0**	4238	**6164**
High	0	**0**	0	**0**	0	**0**	0	**0**
Total	*381*	*5750*	*139*	*0*	*1139*	*0*	*4763*	*6928*

Figure 4.10: Updated population and employment forecast

4.1.2.1.3 Moosomin Plains Development – Vicinity of the Highway 16/Grid 684 (Dalmeny Access)

Additional revisions were made in 2021 during the Phase 2 planning work: The traffic impact assessment (TIA) was completed for the Moosomin Plains development. The land use information in TAZ 421 (**Figure 4.11**) was updated to reflect planned land uses. Current linkages in the model were maintained; however, the resulting traffic flows on access roads in the vicinity will require consideration as part of the Phase 3 planning work. Resulting model runs and peal hour volumes for Phase 1 and Phase 2 were checked to confirm there were no major impacts to previous assumptions and outcomes for Phase 1 and Phase 2.

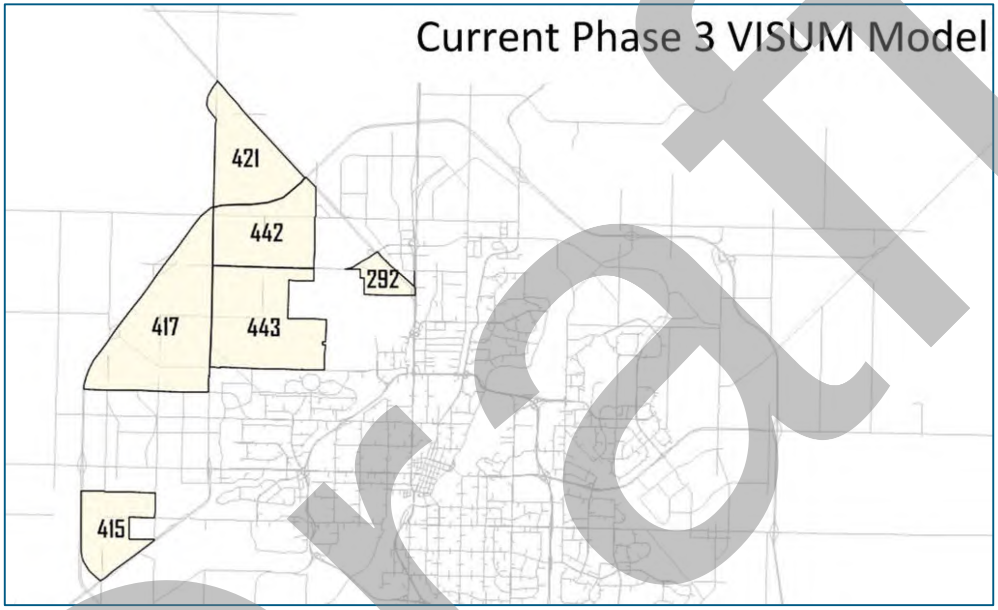


Figure 4.11: Updated Phase 3 VISUM model

The TIA peak hour traffic volumes were used to back calculate land use details for loading into the travel demand model. This may be a need to make further updates to the TDM as part of the Phase 3 planning work to account for any additional development plans contemplated by the RM of Corman Park.

4.1.2.1.4 Saskatoon North Partnership for Growth

The P4G Regional plan was used to develop the rural area land-use. A review of the model zones in the area surrounding the CoS was carried out to establish the content of the model and data available. A visual check by overlapping the model network with the P4G map image (**Figure 4.12**) determined that the boundary lines in the model essentially match the P4G geography.

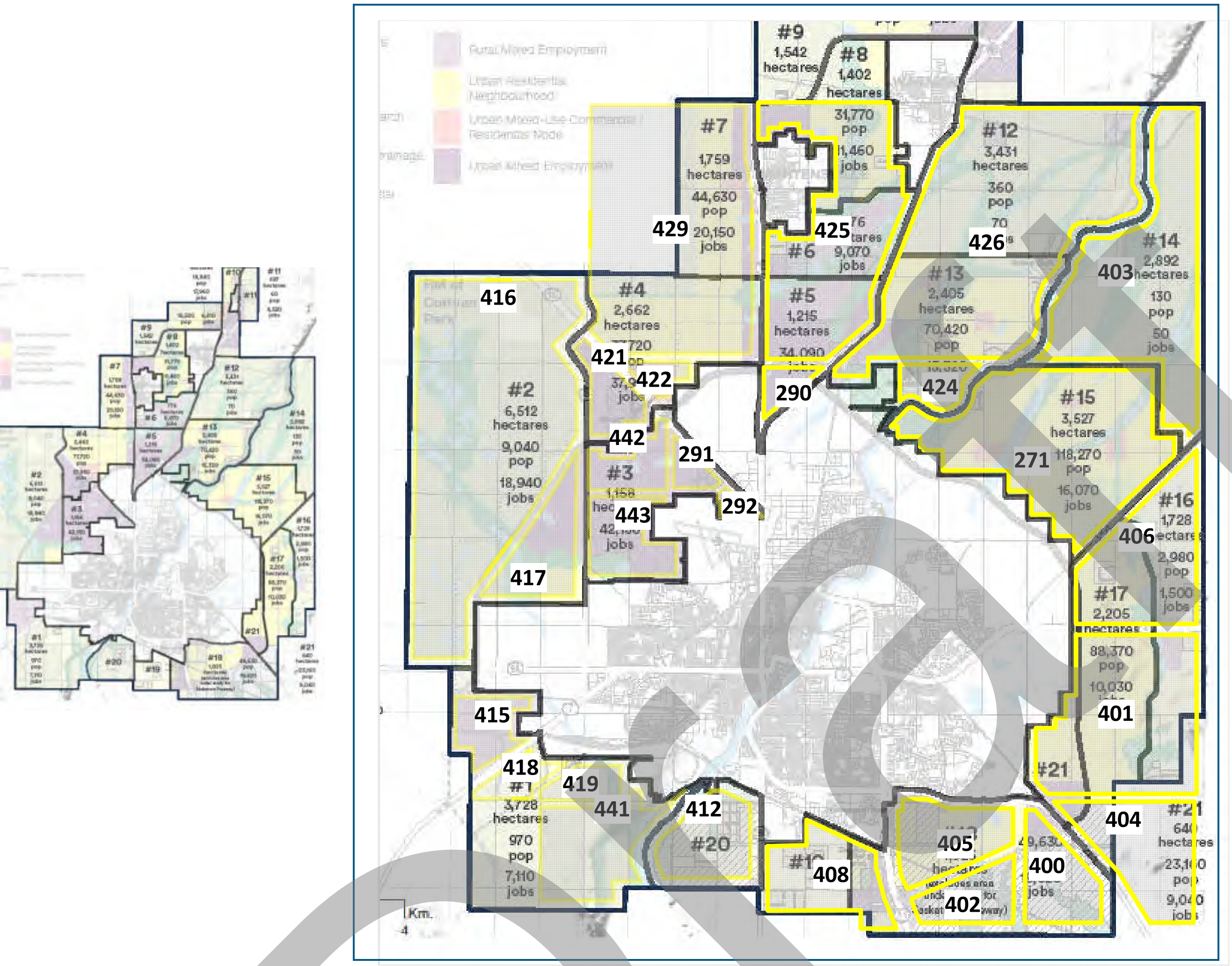


Figure 4.12: P4G Area map overlaid on the model TAZ system

Table 4.9 shows the VISUM model contains all TAZ boundaries that are generally aligned with the boundaries of the CoS limits, and so in most cases each P4G zone corresponds to one or more whole model TAZ. In some cases, one P4G area covers some fractional combination of model TAZ as indicated in the table.

Table 4.9: P4G model zone

P4G AREA	TAZ	MODEL ULTIMATE				P4G	P4G MODEL	
		Dwellings Total	Population	Jobs Total	Population	Jobs	Population	Jobs
1	415+418+419+441	30.3	55	21	970	7,110	915	7,089
2	416+417	57.3	105	63	9,040	18,940	8,935	18,877
3	291+292+442+443	14.2	26	891		42,150	-26	41,259
4	421+422+1/3 of 429	62.8	115	24	77,720	37,950	77,605	37,926
5	290+1/3 of 425	122.8	225	588		34,090	-225	33,502
6	1/3 of 425	114.0	209	460		9,070	-209	8,610
7	1/3 of 429	46.1	84	16	44,630	20,150	44,546	20,134
8	1/3 of 425	114.0	209	460	31,770	11,460	31,561	11,000
9	427	198.9	364	184	18,520	6,410	18,156	6,226
10	1/3 of 426	43.1	79	37	18,840	17,960	18,761	17,923
11	423	114.8	210	116	60	4,520	-150	4,404
12	1/3 of 426	43.1	79	37	360	70	281	33
13	424+1/3 of 426	52.5	96	49	70,420	15,320	70,324	15,271
14	403	610.1	1,117	39	130	50	987	11
15	271	0.0	-	19,888	118,270	16,070	118,270	-3,818
16	1/2 of 401 + 1/2 of 406	95.0	174	27	2,980	1,500	2,806	1,473
17	1/2 of 401 + 1/2 of 406	95.0	174	27	88,370	10,030	88,196	10,003
18	400+402+405	557.7	1,021	987	49,630	19,820	48,609	18,833
19	408+407	1278.3	2,339	2,612			-2,339	-2,612
20	412	3720.5	6,808	164			-6,808	-164
21	404	31.9	58	1,110	23,160	9,040	23,102	7,930
		Totals:	**13,547**	**27,800**	**554,870**	**281,710**	**541,323**	**253,910**

There was one significant modification made in the model, being TAZ 272 shown in **Figure 4.13** just west and south of Wanuskewin Heritage Park. In the original 2063 model, this particular TAZ contained over 60,000 Dwelling units (approximately 113,000 population). However, it was agreed in discussion among the TWG that there was little chance of residential development in this TAZ owned by the CoS but leased to Wanuskewin and slated for introduction of buffalo (N. Sarnecki personal communication, October 15, 2019). As such all dwelling units were removed from TAZ 272 in the model.

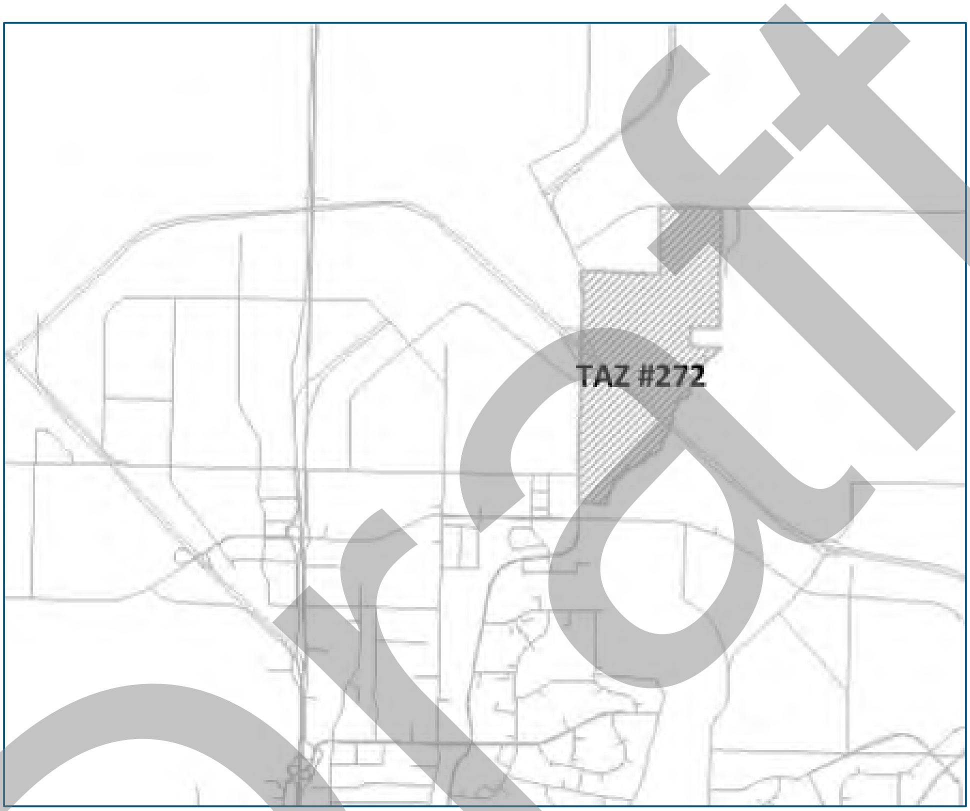


Figure 4.13: Modification in TAZ 272

An additional change developed in TWG discussions was the addition of 100,000 population in the model to the east of the Saskatoon Freeway (see **Figure 4.14**). Land-use data at three TAZs (271, 401, and 406) were modified based on distributing the population simply by the area of the TAZ.

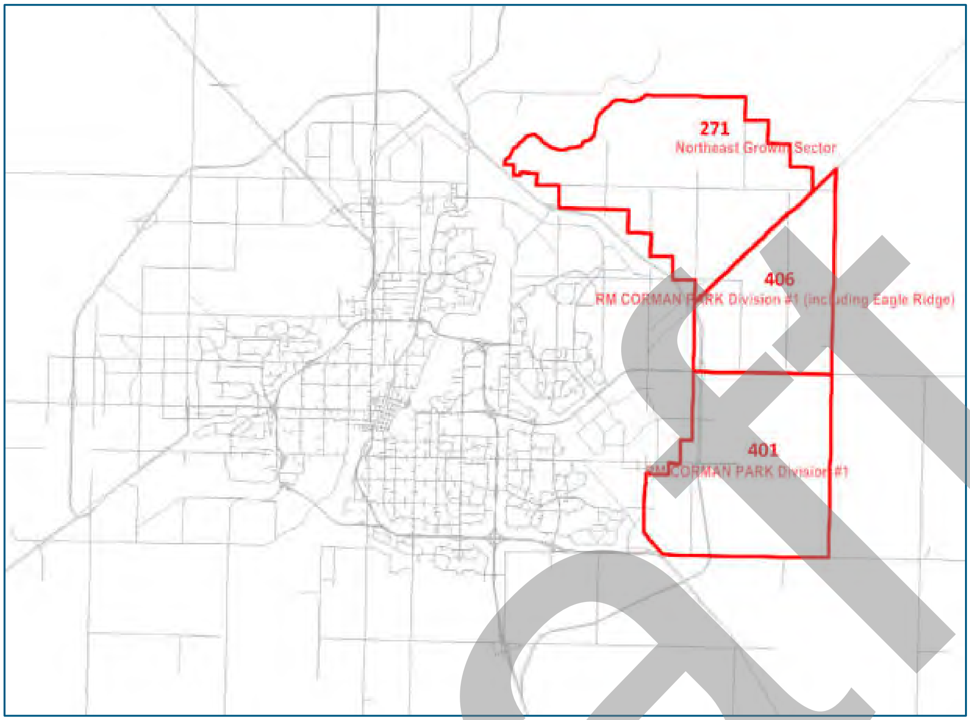
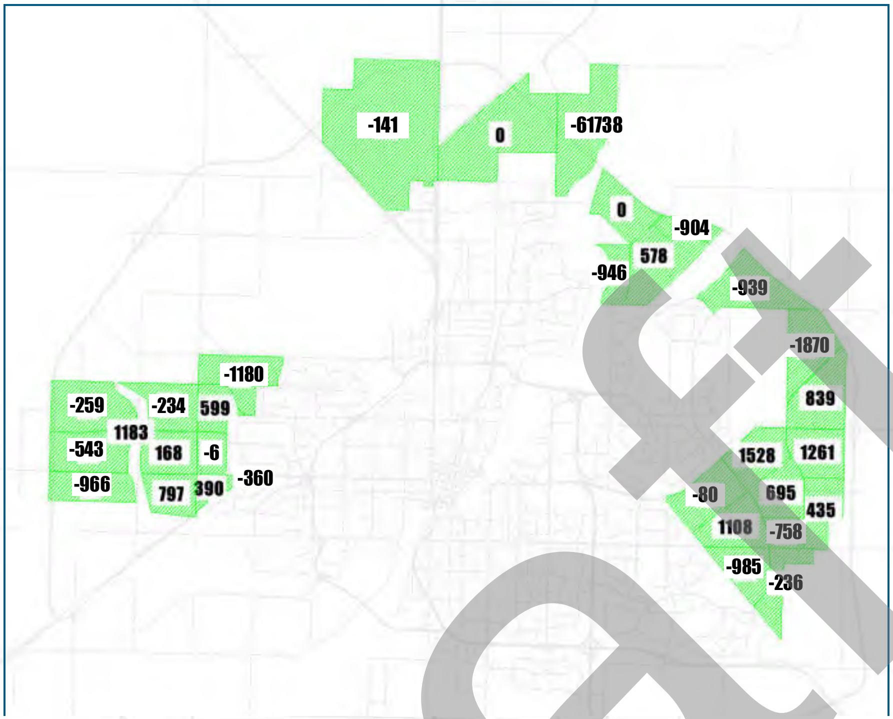


Figure 4.14: Additional 100k population modification

It is noted that total population of the network had slightly reduced from original HDR model. This is due to the updating of population and dwelling unit land-use information using the new sources, for example most of the employment was removed in the Blairmore development area as the sector plan shows most of the area planned as residential. Below **Figure 4.15** and **Figure 4.16** are representing the land-use difference between original model and modified model.



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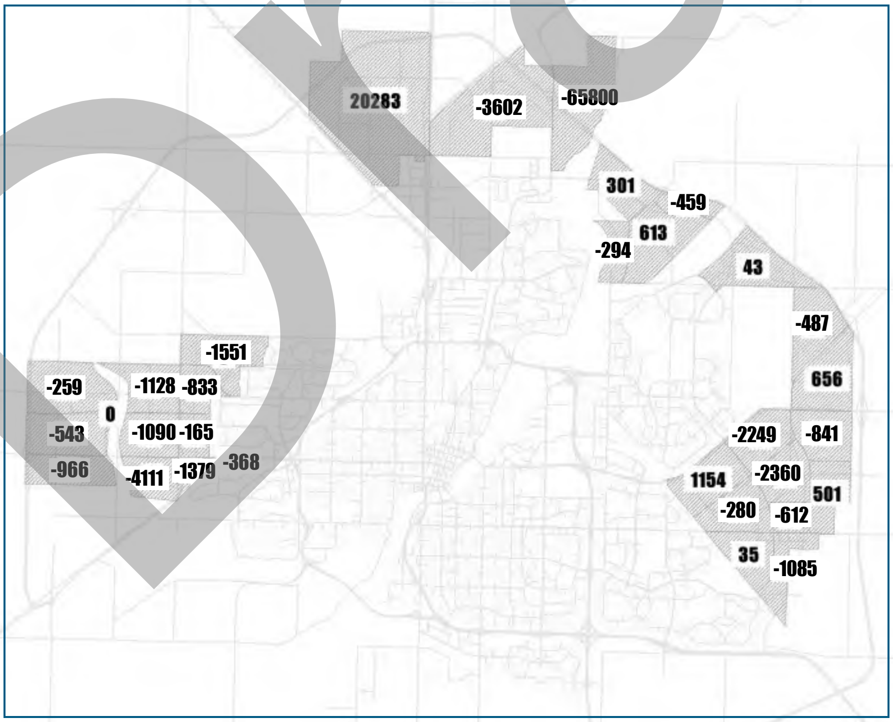

Figure 4.16: Employment data changes between original and modified

Thus, the modified 2063 model contains approximately 830,000 population totals for the entire model with approximately 400,000 employments (using 1.83 conversion factor (population/DU) to calculate the input value of dwelling unit in the model based on the original model's 2063 assumption as noted earlier). 2063 Dwelling Unit, Population, and Total Employment totals are presented in **Table 4.10**.

Table 4.10: 2063 Dwelling unit and employment information

LAND	TOTAL DWELLING UNIT	POPULATION	TOTAL EMPLOYMENT
Inner CoS	349,098	638,848	352,761
Outer CoS (P4G Area)	59,642	109,145	24,228
City of Martensville	21,963	40,193	5,125
City of Warman	23,324	42,683	11,506

4.1.2.1.5 Martensville & Warman

The City of Martensville official community plan (September 2016) notes the Statistics Canada 2011 population of 7,716 and experience of robust annual population growth of 55% over the last five years. However, it was agreed in the TWG meeting that no modification would be made from the original model long term growth assumption of 4% CAGR.

The City of Warman official community plan (December 2014) also states that average annual growth rate between 2000 and 2013 is 6.8% with a median annual change of 6.6%. It was agreed with City of Warman (B. Toth, personal communication, September 4, 2020) that a 4% annual growth rate is a reasonable long-term estimate given fluctuations above and below that figure.

The TAZ P4G map overlay image confirms that the TAZ boundaries for Martensville are well aligned, but the zone boundaries are not completely aligned for the City of Warman. For the purposes of assessing the usage of the new freeway however, the exact alignment of TAZ with the limits of these Cities is not critical, as they are not directly adjacent to the freeway corridor, and so the future development is still likely to access the same freeway interchanges to the south of the cities regardless of the precise arrangement of development in Warman. This was agreed in a TWG meeting and as such, the Warman zones were not modified in the model.

4.1.2.1.6 Highway 41 Realignment and Existing Highway 41 Flyover

The proposed realignment and four-laning of Highway 41 was analyzed using several access connection scenarios:

- The first scenario did not allow for northeast bound to westbound left turns onto the realigned Highway 41 nor a midpoint at-grade intersection with the realigned Highway 41 nor a midpoint flyover over the realigned Highway 41. This results in a number of U-turns occurring to the northeast of the proposed interchange location. The model suggested that local trips between the realigned Highway 41 and existing Highway 41 nearer to the interchange were travelling northeast to complete a U-turn and then heading southwest to the CoS;

- The second scenario considered an at-grade crossing on Highway 41 located at Llewellyn Road or at approximately 1.6 km east of Llewellyn Road. This scenario has potential to address local trips across Highway 41 recognizing the approximate 32,000 dwelling in the northeast part of the CoS. This scenario is not recommended given the high risk of right-angle high speed collisions; and
- The third scenario considered a flyover at Highway 41 located at Llewellyn Road or at approximately 1.6 km east of Llewellyn Road. This would also necessitate a connection of Llewellyn Road to Highway 41 via Township Road 372. This scenario would provide a safe connection across Highway 41.

The proposed interchange at the realigned Highway 41 does not include provision of the northeast bound to westbound left turn given the likelihood that the existing Highway 41 southeast of the interchange through to the CoS may be reclassified allowing for increased access points. There is also uncertainty of how development and the resulting road network may evolve between Highway 41 and Highway 5 with the Highway 5 interchange providing access to the Saskatoon Freeway.

Figure 4.17 illustrates an example model run of several scenarios using the TAZ volumes in the vicinity of the realigned Highway 41. Scenarios included:

- At-grade intersection with Highway 41 at Llewelyn Road;
- At-grade intersection east of Llewelyn Road;
- Flyover the realigned Highway 41;
- No connection with Highway 41; and
- Mid-point at-grade crossing Highway 41.

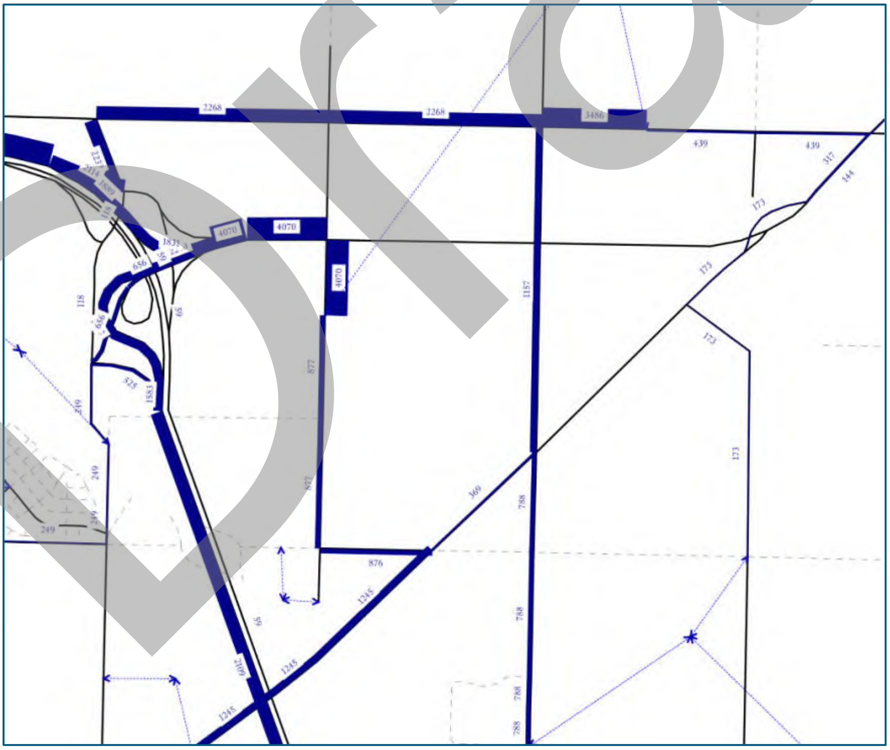

Figure 4.17: Example model run in the vicinity of Highway 41

Modeling confirmed that a flyover of the realigned Highway 41 would serve local traffic in the vicinity and is the preferred scenario; thereby maintain access control along the realigned Highway 41. The existing Highway 41 access between the Highway 41 east interchange and the CoS could serve as local traffic as well as commuter traffic in and out of the city.

4.1.3 Forecasting

The 2063 horizon model, with the modifications described in the preceding sections of this report, was used to the test the impacts of planned Saskatoon Freeway interchanges in the Phase 2 (northeast quadrant) area of the Saskatoon Freeway. The AM and PM peak hour travel volumes by all modelled modes are summarized in **Figure 4.18**.

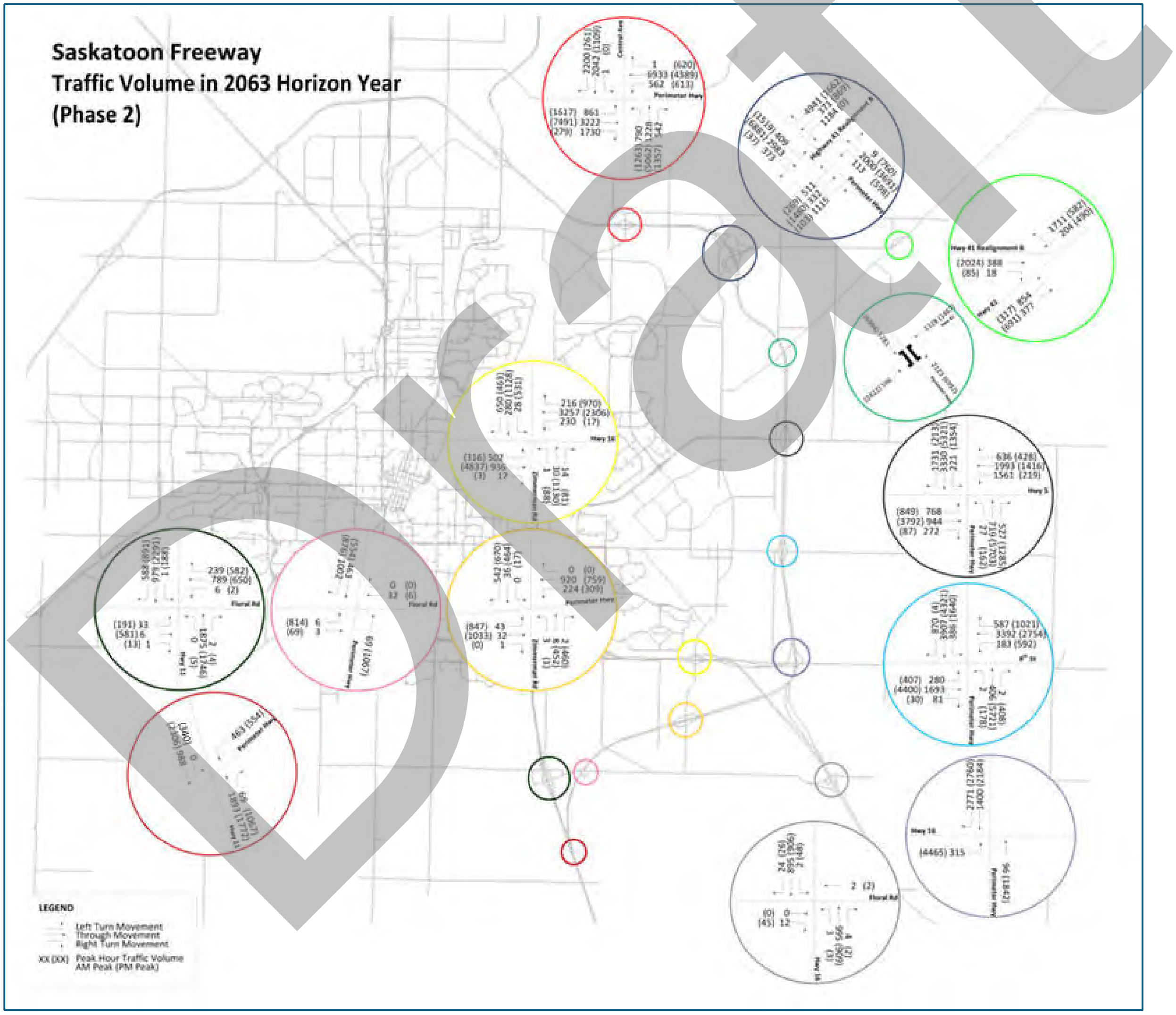

Figure 4.18: Total travel demand (vehicle trips) 2063 horizon

The number of lanes for each segment of the freeway was based on LOS C criteria used for the Regina Bypass project.

4.2 Route Continuity

Driving a vehicle involves six basic driving conditions (SGI, 2019):

- Driver Condition
- Vehicle Condition
- Light Condition
- Weather Condition
- Road Condition
- Traffic Condition

Most important is the Driver Condition so that the driver *"…can adjust to all the other conditions…"* (SGI, 2019). Freeway driving involves increased speed and multiple lanes of traffic along with many other features. The driver's task load increases with complexity. *"The degree of this risk is a function of the traffic volumes on the minor road, the complexity of the curved alignment, and the complexity of the intersection geometry"* (Minsitry, 2009).

Route continuity refers to the provision of a directional path along and throughout the length of a designated route (TAC, 2007). *"The principle of route continuity simplifies the driving task in that it reduces lane changes, simplifies signing, delineates the through route, and reduces the driver's search for directional signing"* (TAC, 2007). *"Desirably, the through driver, especially the unfamiliar driver, should be provided a continuous through route on which it is not necessary to change lanes and through traffic vehicular operation occurs on the left of all other traffic. In maintaining route continuity through cities and bypasses, interchange configurations need not always favour the heavy movement but rather the through route"* (TAC, 2007). The Transportation Association of Canada (TAC) definition of Route Continuity states that it is not necessary to change lanes; however, the Ministry has accepted that some lane changes are acceptable if direction is provided well in advance, given that additional lanes are being added between Highway 16 and Highway 11 for capacity requirements.

Highway 11 and Highway 16; which are National Highways, share a segment of the Saskatoon Freeway illustrated in **Figure 4.19** purple and green highway routes.

A major fork design can be used at points where a shared freeway segment begins. *"A major fork occurs when a terminating freeway/expressway divides into two directional ramps that connect to another crossing freeway or when a freeway branches into two connecting ramps to separate high-speed road routes of equal importance. In effect, there is a left exit"* ramp and a right exit ramp with no through movement. A high ramp design speed should be provided" (TAC, 2007). Major connectors are used where two freeways merge into one shared freeway.

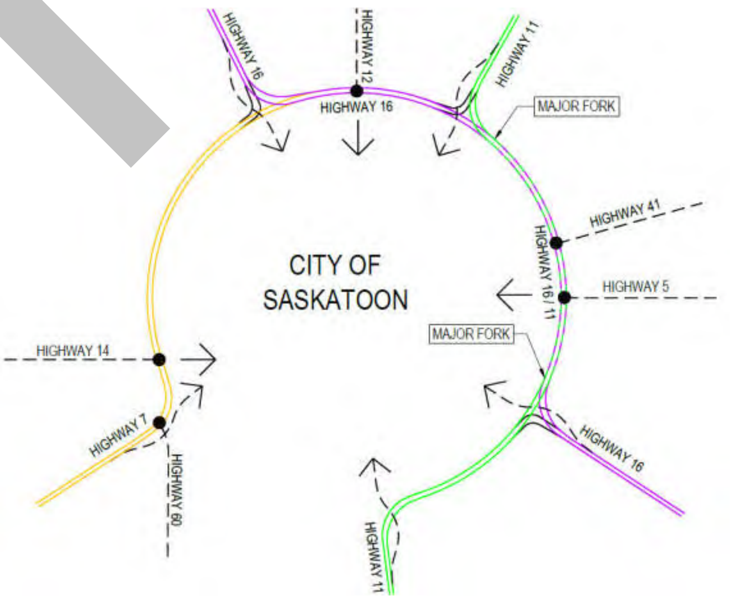

Figure 4.19: Highway 11 and Highway 16 route continuity

In simple terms a driver should not have to exit Highway 16 or Highway 11 to stay on these routes. Additionally, the driver should be able to maintain the posted speed along the highway route. The point in Phase 2 where Highway 11 and Highway 16 merge into the shared portion of the Saskatoon Freeway occurs at the Highway 16 Interchange; therefore, the functional design concept incorporates a major fork design as a means of maintaining route continuity. Route continuity is considered an important freeway attribute for these national highway routes.

A major fork design concept was considered at the south terminal at Highway 11 for northbound traffic. However, the portion between the Saskatoon Freeway (south terminal at Highway 11) and the existing Highway 11/Circle Drive interchange would no longer be Highway 11. It would likely be renamed to Highway 11A or Circle Drive. This means that a conventional right exit ramp for northbound traffic on Highway 11, travelling into the city, could be implemented; therefore, land has been included in the right-of-way requirements for this design.

5 Functional Design

5.1 Design Criteria

5.1.1 Freeway

The Saskatoon Freeway will be designed, as a minimum, a divided four-lane freeway with a 130 km/h design speed. The freeway will be classified as a D-130-7430 roadway in accordance with the Ministry of Highways (Ministry) Design Manual (DM) and Standard Plans (SP), Transportation Association of Canada Geometric Design Guide for Canadian Roads (TAC), and the Ministry Supplement to the TAC Geometric Design Guide (SKS). The freeway includes a 32 m median, and would be constructed within a minimum right-of-way (ROW) width of 101.4 m. A summary of the geometric design standards for the Saskatoon Freeway is provided below in **Table 5.1.**

Table 5.1: Highway geometric design standards

ITEM		GEOMETRIC DESIGN STANDARD
Functional Highway Classification		D-130-7430 (Divided) Provincial Highways Saskatoon Freeway
Minimum ROW Width (m)		101.4 m
Equivalent Minimum "K" Factor	Crest	195
	Sag	75
Minimum Stopping Sight Distance (m)		290 m
Maximum Grade (%)	Upgrade	3%
	Downgrade	5%
Minimum Grade (%)		0.0%
Maximum Superelevation (%)		6%
Minimum Radius (m)		950 m
Minimum Spiral "A" Parameter (m)		300 m
Number of Lanes		4
Through Lane Width (m)		3.7 m
Shoulder Width (m)	Inner	1.0 m
	Outer	3.0 m
Standard Cross-Fall (%)	Lanes	2%
	Inner Shoulder	2%
	Outer Shoulder	5%
Median Width (m)		32 m
Surfacing Structure		Standard Pavement - Asphalt Concrete

The Saskatoon Freeway crosses the following three highways through the Phase 2 limits:

Highway 41: Highway 41 is an undivided two-lane highway with a 100 km/h posted speed which runs northeast from the CoS to the City of Melfort. South of the proposed Saskatoon Freeway crossing, Highway 41 curves to the south and terminates at Highway 5 at a stop-controlled intersection.

> **Note:** It is proposed that Highway 41 is realigned from a point near Bergheim Road (Township Road 374) west to the proposed integrated Blackley Road interchange. The realigned highway will comply with Ministry standards for access controlled four-lane highways.

Highway 5: Highway 5 runs east-west between the CoS and the Manitoba border. East of the CoS, Highway 5 is an undivided two-lane Highway with a 100 km/h posted speed. Within the CoS limits, Highway 5 becomes College Drive, a four-lane divided arterial which runs through the CoS and terminates at /Idylwyld Drive. It is understood that the Ministry is planning for the twinning of Highway 5 by adding westbound lanes on the north side of existing Highway 5 lanes from west of Llewellyn/Winmill Road to Highway 316. As such, the Highway 5 interchange alternatives have been developed to tie-into the future twinned Highway 5.

Highway 16: Highway 16 is a divided four lane highway with a 130 km/h design speed within the study limits. Highway 16 is part of the National Highway System and connects the CoS with the City of Edmonton to the west and the City of Winnipeg to the east.

Highway 11: South of the Saskatoon Freeway, Highway 11 is a divided four lane highway with a 130 km/h design speed and connects the CoS with the City of Regina. Highway 11 becomes Idylwyld Drive though the CoS and is part of the NHS. North of the CoS, Highway 11 continues north and connects the CoS with the City of Prince Albert.

5.1.2 Interchanges

Within the Phase 2 study limits, system level interchanges are recommended along the Saskatoon Freeway at Highway 16 and Highway 11: freeway to freeway intersections. As discussed previously in this report, these highways are part of the NHS and share a segment with the Saskatoon Freeway. As such, these provincial highways will be designed to the same D-130-7430 standard as the Saskatoon Freeway and will intersect the Saskatoon Freeway utilizing a major fork design. This means that the 130 km/h design speed will be maintained along the NHS route with other movements being designed at a lower speed.

In addition to the two system level interchanges, Phase 2 includes service level interchanges along Saskatoon Freeway at Central Avenue, Blackley Road, Highway 41 east at the realignment location, 8th Street, Zimmerman Road, and Floral Road west.

A hybrid interchange (Partial System and Service Level) is proposed at Highway 5 and the realigned Highway 41/Blackley Road/Saskatoon Freeway intersection.

The geometric design standards for interchange ramps are summarized in **Table 5.2** below:

Table 5.2: Interchange geometric design standards - ramps

ITEM	GEOMETRIC DESIGN STANDARD	
Single Lane Ramp Width (m)		4.8 m
Minimum Design Speed of Loop Ramp (km/h)		50 km/h
Shoulder Width (m)	Left	0.6 m
	Right	2.5 m
Minimum Radius of Curve	DS=50*	90 m
	DS=60*	130 m
	DS=70*	190 m
	DS=80*	250 m
	DS=90*	340 m
	DS=100*	440 m
	DS=110*	600 m
	DS=120*	750 m
	DS=130*	950 m
Equivalent Minimum "K" Factor Crest (Sag)	DS=50*	10 (10)
	DS=60*	15 (15)
	DS=70*	25 (25)
	DS=80*	40 (30)
	DS=90*	50 (35)
	DS=100*	85 (45)
	DS=110*	125 (55)
	DS=120*	165 (65)
	DS=130*	195 (75)

*50 km/h design speed to be used for loop ramps only. 60 km/h – 90 km/h design speed to be used for Highway – Arterial connections. 100 km/h – 120 km/h to be used for Highway – Highway connections. 130 km/h Design speed to be used along Saskatoon Freeway and maintaining route continuity between National Highways (Highway 16, Highway 11).

In addition to the above, the following design standards were considered in the development and evaluation of interchange concepts:

Interchange Spacing: Based on the Saskatchewan Roadside Management Manual (RSMM 430-30), the Saskatoon Freeway is considered 'U-1' access management level which represents the highest level of urban control and is considered a freeway standard. At-grade intersections are not permitted at this access management level and interchanges are to be spaced at a minimum of 3.2 km. Additionally, a minimum weaving length will be maintained to ensure efficient operation on freeways. In particular, Section 3.7.3.3 of TAC Geometric Design Guide for Canadian Roads recommends ‘weaving length between a freeway interchange and an arterial interchange normally should be in the range of 800 m to 1000 m and between arterial interchanges in the range of 550 m and 700 m.

Consecutive Exits: One exit point per direction of travel will be permitted at each interchange. An exception is allowed at interchanges where major forks are provided such as the Saskatoon Freeway southbound at the Highway 16 interchange. Collector-Distributor C-D roads (or sub-collectors) will be utilized along the Saskatoon Freeway to combine consecutive exits at each interchange. C-D roads will be designed as single lane exits from the freeway with a separation of 17 m between mainline and C-D driving lanes.

Ramp Design: Direct tapers shall be used for freeway exit as per TAC Figures 10.8.2. Freeway entrances will be designed as parallel entrances as per TAC Figure 10.8.5 and 10.8.6. Parallel lane entrances will be used for more conservative property protection and allow for future direct taper replacement if required during future design phases.

Design Vehicles: Critical interchange movements and at intersections along the NHS (as described in **Section 2.2.1**) will be designed to accommodate at a minimum WB-20 design vehicle (**Figure 5.1**), as well as consideration to Long Combination Vehicle (LCV) trucks permitted in Saskatchewan.

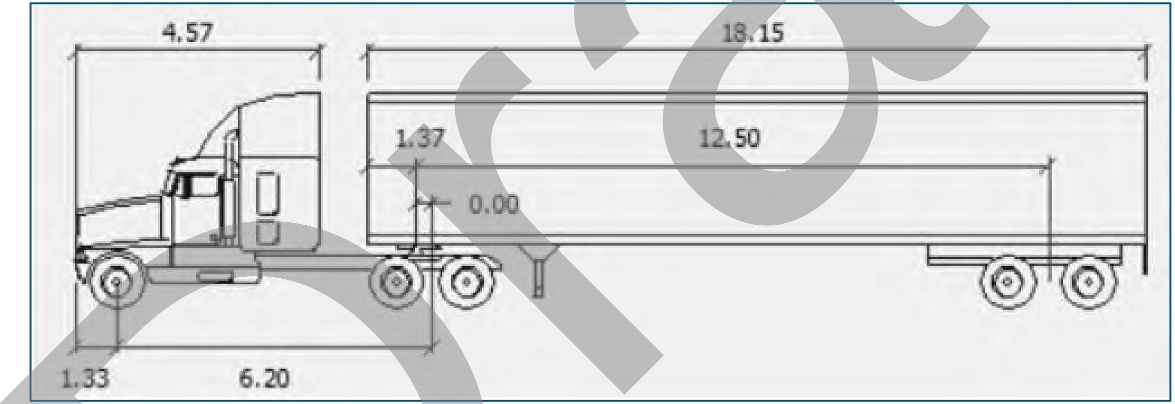

Figure 5.1: WB-20 design vehicle dimensions

Roundabouts: Roundabouts will be considered at ramp terminal intersections as an alternative to signalized intersections. If warranted, roundabouts will be designed in accordance with the Alberta Transportation Design Bulletin 68, Roundabout Design Guidelines on Provincial Highways. The Alberta Ministry of Transportation standards (Design Bulletin #68/2010) for roundabouts has been used in Saskatchewan, which requires a minimum WB-21 design vehicle.

Saskatchewan is now considering two-lane roundabouts in Saskatchewan since submission of the Phase 1 Functional Design Report.

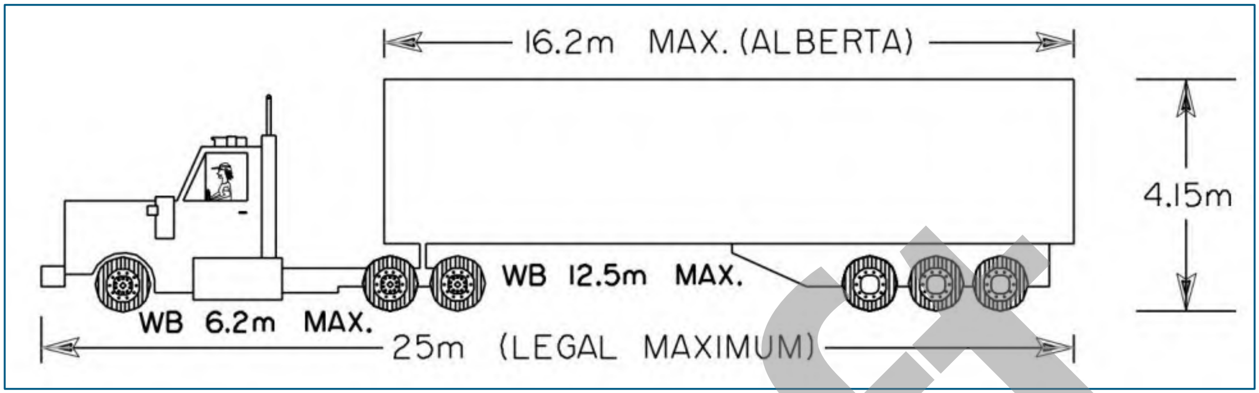

Figure 5.2: WB-21 design vehicle dimensions

Pavement Widening at Structures: Mainline pavement widening (including speed change lanes for ramps, forks, and connectors) adjacent to the South Saskatchewan River shall begin a minimum of 100 m from the structure abutments.

5.1.3 Secondary Roads

Central Avenue: The Central Avenue cross road is a planned six-lane divided road with a posted speed of 60 km/h through the study limits. Central Avenue runs north-south along the east side of the CoS from Highway 5 in the south to McOrmond Drive in the north.

Range Road 3050: Range Road 3050 is a two-lane undivided road with a posted speed of 80 km/h through the study limits. Range Road 3050 runs north-south between Fedoruk Road and the South Saskatchewan River and crosses the Northeast Swale south of the Saskatoon Freeway.

Blackley Road: Blackley Road (Range Road 3044) is a two-lane undivided road that runs north-south from Township Road 374 in the north to Highway 41 in the south. Blackley Road terminates at Highway 41 approximately 600 m north of the Highway 5/Highway 41 intersection.

8th Street: West of Boychuk Drive, 8th Street is currently a six-lane urban street with a 50 km/h speed limit. It has a concrete median and significant retail and commercial frontage. East of Boychuk Drive 8th Street is a two-lane undivided road. At the proposed future Freeway crossing location, 8th Street is an unpaved rural municipal road. For interchange planning purposes, it is assumed the six-lane urban cross section will be extended beyond the Freeway in the future.

Circle Drive: Circle Drive is a ring road freeway within the CoS that currently serves as both Highway 11 and Highway 16 for parts of its route. Highway 16 connects to Highway 11/Circle Drive approximately 7 km west of the proposed Freeway crossing. This 7 km of Highway 16 is expected to be converted to an urban freeway or expressway with a lower speed limit upon construction of the Saskatoon Freeway. Both Circle Drive and Highway 11 are four-lane divided rural cross sections.

Patience Lake Road: Patience Lake Road is an east-west two-lane municipal road with a speed limit of 90 km/h. The west terminal is at Zimmerman Road. The future location of Patience Lake Road in the vicinity of the Saskatoon Freeway may be revised depending on development needs in the future. This report considered flyovers along the current alignment.

Zimmerman Road: Zimmerman Road is a north south municipal road that currently connects Highway 5 to Highway 16 on the east side of Saskatoon. For most of its alignment, Zimmerman Road is an unpaved two-lane rural cross section that becomes a four-lane divided urban cross section near Highway 16/Circle Drive. Zimmerman Road currently terminates at Highway 16 but is expected to be extended south to cross the proposed Saskatoon Freeway in the future. For planning purposes, the future extension is assumed to be a two-lane rural cross section with a speed limit of 80 km/h.

Floral Road: Floral Road is an unpaved east-west rural municipal road with a speed limit of 80 km/h. Just west of the study area, Floral Road intersects with Highway 11 near the Grasswood Development. At the southeast limit of the study area, Floral Road intersects with Highway 16.

The Rural Municipality (RM) of Corman Park surrounds the CoS and includes over 1,200 km of municipal roads spanning over 2,000 km^2. The roadway standards for an Industrial Paved Road in the RM of Corman Park are summarized below in **Table 5.3**.

Table 5.3: RM of Corman Park standards – industrial paved road

ITEM	GEOMETRIC DESIGN STANDARD
Minimum Right-of-Way Width (m)	46.0 m
Design Speed (km/h)	100 km/h
Finished Top Width (m)	4.5 m/lane
Standard Cross-Fall (m/m)	0.02
Minimum Radius (m)	440 m
Side Slope	3:1 to 4:1
Ditch Bottom Width (m)	4.0 m to 7.0 m
Maximum Road Gradient (%)	5%
Stopping Sight Distance (m)	200 m

Additional details are provided in the Design Criteria Memorandum located in **Appendix C**.

5.1.4 Bridge

The Bridge Design Criteria is documented in the "Structure Design Criteria Summary" dated April 15, 2020 included in **Appendix D**. The roadway geometry determines the bridge opening for the roadway and railway overpasses. Vertical and horizontal clearances have been set to meet Ministry bridge requirements and the use of open abutments with headslopes set at 3:1 (H:V). The use of Mechanically Reinforced Earth (MSE) retaining walls are an option to reduce bridge span lengths and will be preferred at overpass locations with a high skew angle to the underlying roadway. Foundation support for the abutments will be independent of the MSE walls.

In general, the following Ministry standards are used for the conceptual design of the roadway, railway and river bridges:

- Bridge Design Criteria BD100-Ver 2018-1;
- Standard Plans 20150, 20152 & 20154; and
- TAC Geometric Design Supplement SKS2.2.10-A.

Vertical Alignment: A minimum longitudinal grade of 0.5% has been provided on bridge decks that are not located on vertical curves. Bridges located on vertical curves shall have the crest of the vertical curves located beyond the length of the superstructure and approach slabs and in no case shall more than 20 m length of bridge have a gradient less than 0.5%.

Vertical clearance for roadway overpasses shall be a minimum of 5.3 m clear from the top of the underlying roadway to the underside of the superstructure.

Vertical clearance for railway overpasses shall be a minimum of 7.31 m from the top of rail to the underside of the superstructure.

Horizontal Alignment: The location of abutments, piers, straddle bents and MSE retaining walls is based on providing lateral clearances shown on Standard Plan 20154 – Lateral Clearances at Underpasses for Roadway Structures. A minimum clearance of 9.0 m shall be provided from the edge of the lane to the face of from abutment, pier, straddle bent or MSE retaining wall.

Locations of abutments and pier for all railway overpasses shall provide clearances and allowance for a second future track, a maintenance road and a multi-use pathway in accordance CN Rail and Transport Canada Standards.

Overpass widths shall accommodate the lane and shoulder widths of the roadway.

5.1.5 Drainage

The functional drainage design considered standards and recommendations from several sources. Detailed information on where these criteria were applied are found throughout the Drainage Concept section of this report.

The primary focus of the drainage design was to identify and pass existing watershed with no change to the flow or drainage path. This functional design recommends some minor exceptions which have been outlined in **Section 9.4** Drainage Recommendations. Otherwise, all flow intercepted by the Freeway is directed such that it re-joins its natural drainage path and generally, the only significant modification to drainage is where natural overland sheet flow is intercepted by the ditch and focused into a culvert where it crosses the Freeway. This flow will still make its way to the same primary downstream drainage path.

The *Transportation Association of Canada Geometric Design* Guide for Canadian Roads and the *Saskatchewan Supplement to the Geometric Design Guide for Canadian Roads* were both referenced.

Table SKS 2.2.8-A.1 in the Geometric Design Guide Supplement (Interim) indicates minimum ditch grades.

The standard maximum culvert spacing of 800 m was applied. This spacing was not necessary to achieve functional drainage. Several culverts were proposed only to meet this standard and have been noted as such. This provides a conservative design at this stage that meets all requirements. In the detailed design stage the drainage plans may be refined to optimize trade-offs between ditch gradient, ditch depth, and embankment profile.

Ministry *Design Directive #1/2019 Design High-water Level* may be applicable during detailed design. It indicates that, in cases where the current water level is near or exceeding the previous high-water level (HWL) and there is a n expectation that future water levels may exceed the HWL, a projected future HWL may be used for design purposes. The projected future HWL can be used in place of the HWL in the table. The future HWL should be based on trend analysis, spill elevation, risk assessment, or other appropriate methods and documented in the design file.

Saskatchewan Supplement (SKS) to TAC Geometric Design Guide for Canadian Roads (TAC-GDG) indicates that in areas that naturally drain towards trapped low areas, the longitudinal ditch profile may be less than 0.05% grade.

Through correspondence during Phase 1 the Saskatchewan Water Security Agency (WSA) provided guidance on detention of increased peak runoff and lost retention.

5.2 Freeway Alignment Concepts

Due to the length of the Saskatoon Freeway in Phase 2, it was reviewed in two sections, a north section and a south section. The freeway north and including Highway 5 was in the north section and everything south of Highway 5 was in the south section.

5.2.1 North Section

The alignment for the Saskatoon Freeway was identified in a previous study shown as Freeway Concept 1 (red) in **Figure 5.3**, with red dashed lines representing the original 500 m wide corridor. The previous study recommended interchanges at Central Avenue, Blackley Road, Highway 41, and Highway 5. Some of the key challenges associated with the north section are the crossings of the Small Swale and the Northeast Swale and the close spacing of interchanges. Additional constraints for the north half include areas of Sharp-Tailed Grouse Leks, University of Saskatchewan Lands, Federal Lands, and existing land use.

As discussed further in **Section 2.2.3**, the area surrounding the Small Swale and Northeast Swale is considered environmentally sensitive and as such, two alternative concepts were developed to reduce impacts. Freeway Concept 2 (yellow) shifts the freeway approximately 250 m north to avoid the most sensitive areas of the Small and Northeast Swales. Freeway Concept 3 (purple) shifts the freeway further north to further reduce environmental impacts associated with the Northeast Swale, and to minimize the length of water crossing.

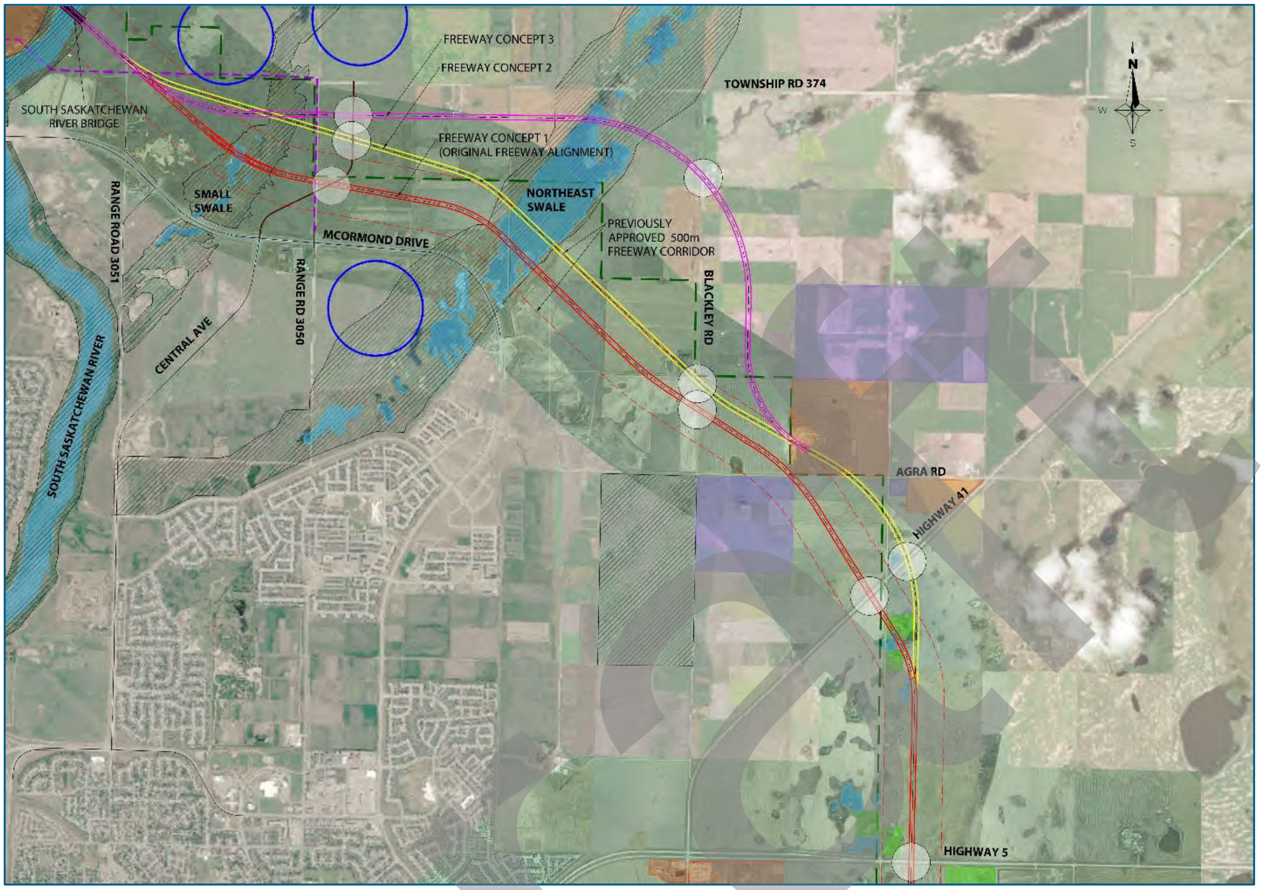

Figure 5.3: Northern alignments through the Swales

As discussed in **Section 5.1.2**, the Saskatchewan Access Management Standards require a 3.2 km minimum spacing between freeway interchanges. While Freeway Concept 3 would increase the separation between Blackley Road and Highway 41 interchanges such that the spacing exceeds the 3.2 km minimum requirement, the spacing between Highway 41 and Highway 5 is less than desirable (2.4 km) in all three concepts. As such, there is insufficient spacing between Central Avenue and Highway 5 for four full movement interchanges (all turns and crossings). To address this concern, additional mainline alignment concepts were developed with consideration of minimum interchange spacing requirements. The first two concepts provide access to the freeway without changing Highway 41; however, some traffic would need to use the Blackley Road interchange for freeway access which would mix some local neighborhood trips with highway traffic. Blackley Road would become a partial or full move interchange depending on the preferred freeway alignment and interchange spacing. The next two concepts consider a realignment of Highway 41 north of the Saskatoon Freeway with a new interchange midway between Blackley Road and Highway 41 to create more space between interchange and improve traffic flow. These four mainline alignment concepts are discussed further below:

5.2.1.1 Concept 2

Concept 2 (shown in Yellow in **Figure 5.4**) maintains the existing Highway 41 location and includes full interchanges at Central Avenue, Highway 41, and Highway 5. Based on the close spacing between Blackley Road and Highway 41, Blackley Road would need to be a partial interchange which means not all turns are accommodated at this interchange. It should also be noted that the spacing between Highway 41 and Highway 5 interchanges would still be substandard.

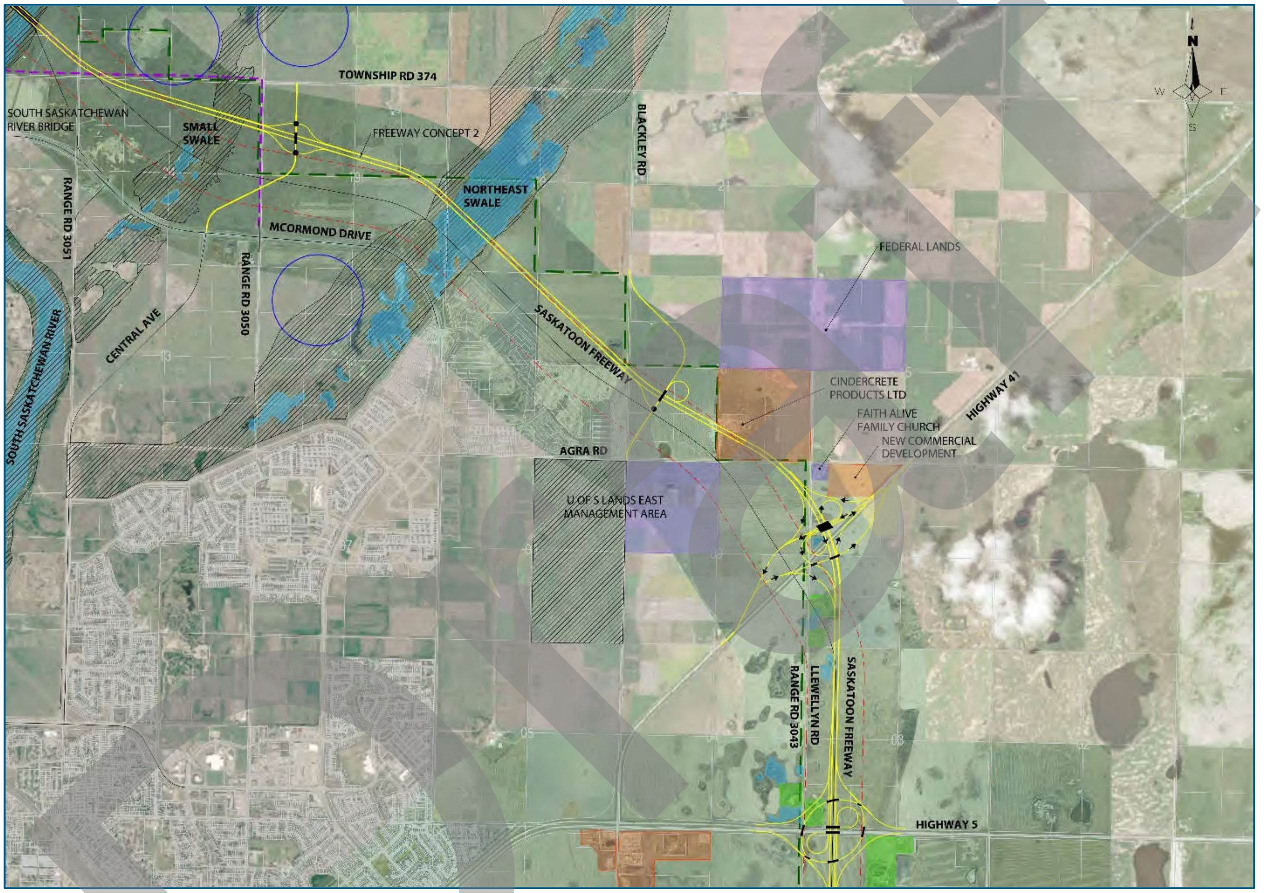

Figure 5.4: Saskatoon Freeway Phase 2 northern alignment Concept 2

5.2.1.2 Concept 3

Concept 3 (shown in purple in **Figure 5.5**) maintains the existing Highway 41 location and includes full interchanges at Central Avenue, Highway 41, and Highway 5. The additional spacing provided by the purple alignment (Freeway Concept 3) allows for a full moves interchange at Blackley Road; however, the spacing between Highway 41 and Highway 5 interchanges would still be substandard.

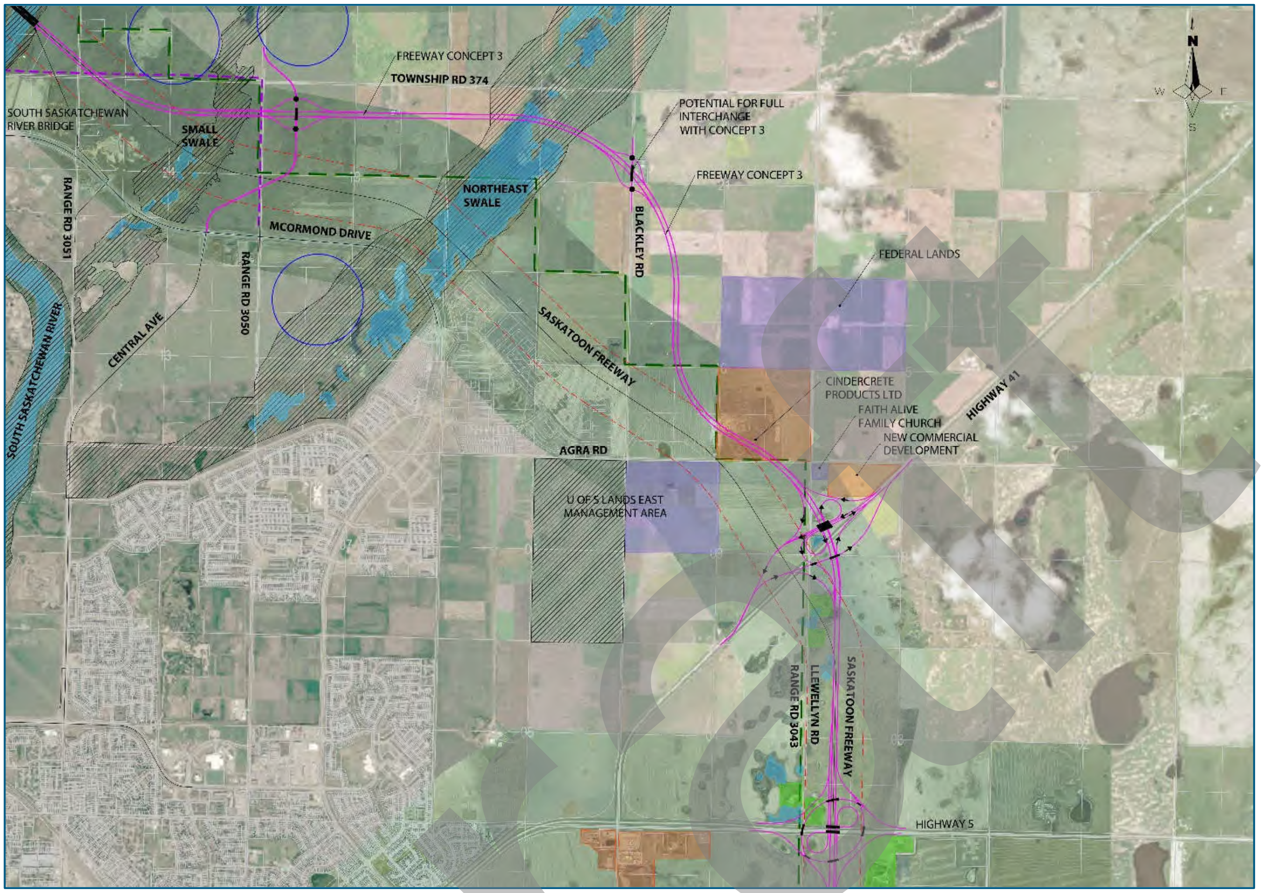

Figure 5.5: Saskatoon Freeway Phase 2 northern alignment Concept 3

5.2.1.3 Concept 4A

Concept 4A (shown in purple in **Figure 5.6**) is based on the purple alignment (Freeway Concept 3) with Highway 41 realignment 'A' (shown in blue) immediately north of the Federal Lands. This concept allows for a full interchange at Central Avenue, Highway 41 Realignment 'A', and Highway 5 while complying with Saskatchewan Access Management Standards. Flyovers with no freeway access would be provided at Blackley Road and at the existing Highway 41 location.

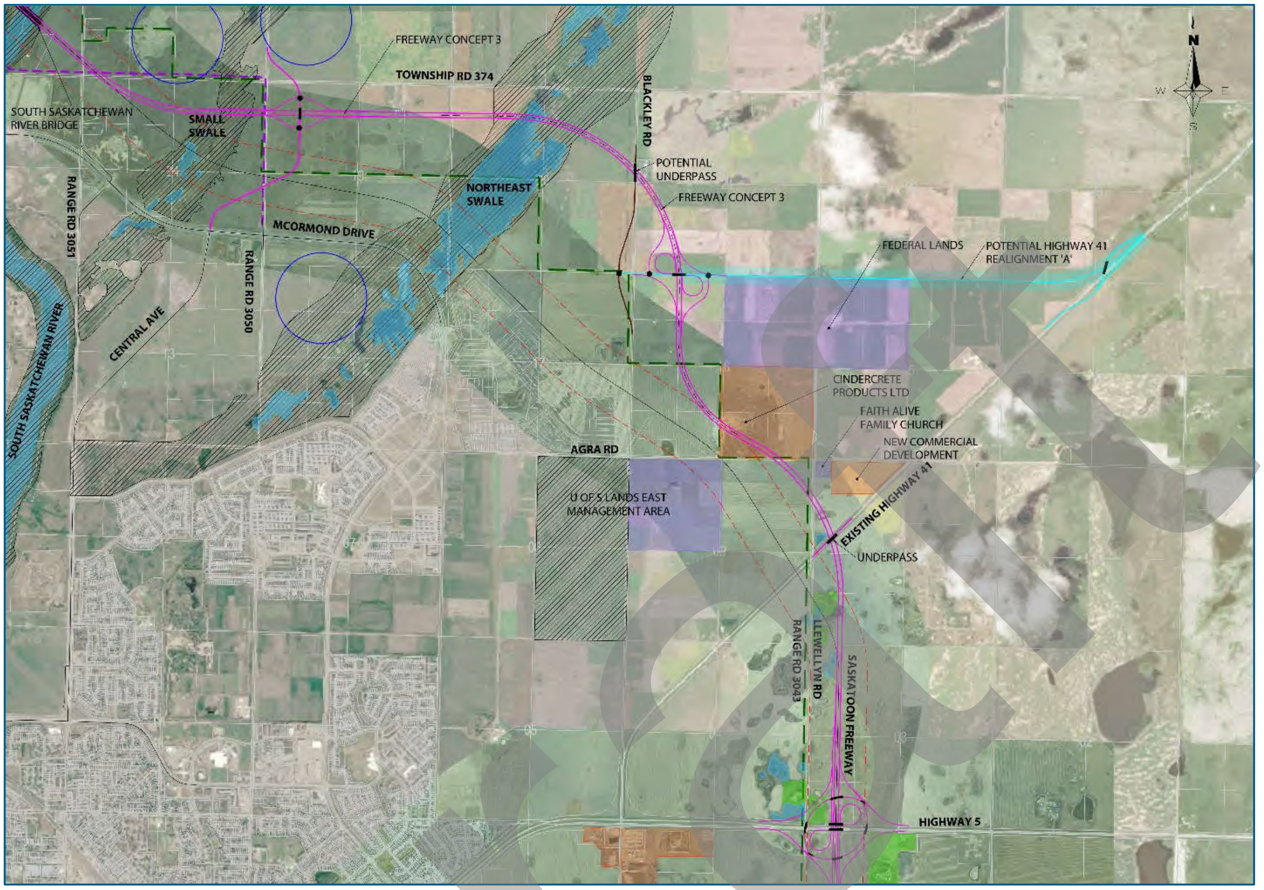

Figure 5.6: Saskatoon Freeway Phase 2 northern alignment Concept 4A

5.2.1.4 Concept 4B

Concept 4B (shown in purple in **Figure 5.7**) is based on the purple alignment (Freeway Concept 3) with Highway 41 realignment ‘B’ (shown in blue) further north. This concept allows for a full interchange at Central Avenue, Highway 5, and a combined interchange at Blackley Road and Highway 41 Realignment ‘B’. A flyover with no freeway access would be provided at the existing Highway 41 location and the remaining parts of the existing Highway 41 would become an arterial road, transitioning to lower speeds.

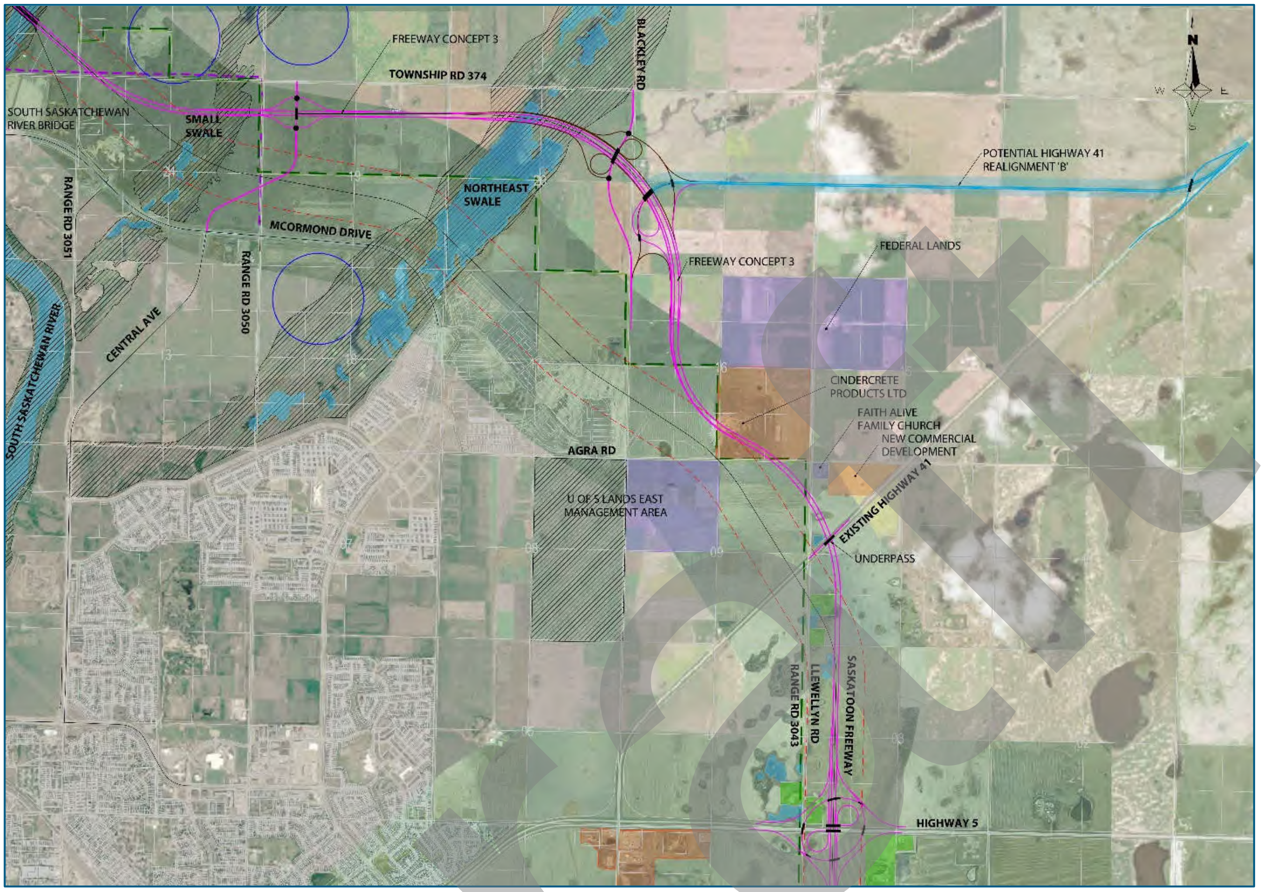

Figure 5.7: Saskatoon Freeway Phase 2 northern alignment Concept 4

Based on feedback from the Virtual Public Information Sessions, and confirmed through the Multiple Account Evaluation (MAE), Freeway Concept 3 (Figure 5.3) was selected as the preferred alignment through the Swales. Following the MAE, executive team members and subject matter experts met to discuss the concept of realigning Highway 41. They decided that the preferred Freeway alignment would include Highway 41 realignment B. The primary driver for this was to better serve the travel desire lines between Highway 41, the Saskatoon Freeway, and the employment area north of the CoS as discussed in **Section 4.1.2.1.6** of this report. The realigned Highway 41 is estimated to serve over 4,000 Annual Average Daily Traffic (AADT) in 2063.

5.2.2 South Section

The Phase 2 south section are from Highway 11 to south of Highway 5 (**Figure 2.14**). The mainline alignment is generally located within the previously approved 500 m wide corridor and maintains a standard 32 m wide median. Minor modifications to the mainline alignment were identified at three locations:

1. North of 8th Street, the alignment was shifted to the east side of the 500 m wide corridor to fit between a wetland and a yard site. This required the introduction of two flat horizontal curves between Highway 5 and 8th Street.

2. Near Patience Lake Road, the northbound and southbound lanes split to accommodate a bridge for southbound traffic to overpass the northbound lanes and connect to Highway 16 from the mainline. The median width varies by concept but becomes as wide as 90 m in some concepts.

3. Between Highway 16 and the Floral Road crossing, the mainline is shifted beyond the north limits of the 500 m wide corridor. This shift avoids several large wetlands, eliminates some of the curves in the original 500m corridor, minimizes construction risk, and creates a superior crossing angle with the CN Rail line. The mainline shift also reduces the skew and allows for shorter bridges at the railway overpass.

5.3 Interchange Layout Concepts

In conjunction with the freeway alignment concepts, a number of interchange concepts were developed at each location to address the system and service interchange needs. Preliminary concepts were developed to a thick line level of detail and presented to the public and other stakeholders at an online Virtual Public Information Session held between February 16 and March 2, 2021. Interchange concepts were developed with consideration for both maintaining the existing Highway 41 alignment (Freeway Concept 1 & 2) and realignment of Highway 41 (Freeway Concept 3 & 4).

The following sections describe the development and evaluation of interchange concepts at Central Avenue, Blackley Road, Highway 41, Highway 5, 8th Street, Highway 16, Grasswood/Floral Road and Highway 11. Directional descriptions within this section utilize a from-to or origin-destination convention. For example, the description of “Ramp N-W” describes traffic flow originating from the north, with an ultimate destination west of the interchange.

5.3.1 Central Avenue Interchange Concepts

To increase separation between the Central Avenue Interchange and the Small Swale, it is recommended to shift the alignment of Central Avenue to the east. This significantly reduces the impact to the Small Swale and was an option generally supported by environmental stakeholders and experts. Since Central Avenue is anticipated to be a higher volume roadway than Range Road 3050 south of the Freeway, the recommended plan includes closing the existing Range Road 3050 north of McOrmond Drive and utilizing Central Avenue as the primary roadway for Freeway access/crossing. The two Central Avenue Interchange concepts are discussed below.

5.3.1.1 Central Avenue Concept 1

Concept 1 is a diamond configuration with two-lane ramps to/from the west and single-lane ramps to/from the east. This configuration will provide full access to/from Central Avenue and can be constructed using either signalized intersections or roundabouts depending on the findings of the traffic analysis. Based on preliminary traffic projections, there is a need for five lanes per direction west of Central Avenue and four lanes per direction east of Central Avenue. As such, the interchange provides a transition opportunity through use of two-lane ramps. Concept 1 is presented below in **Figure 5.8.**

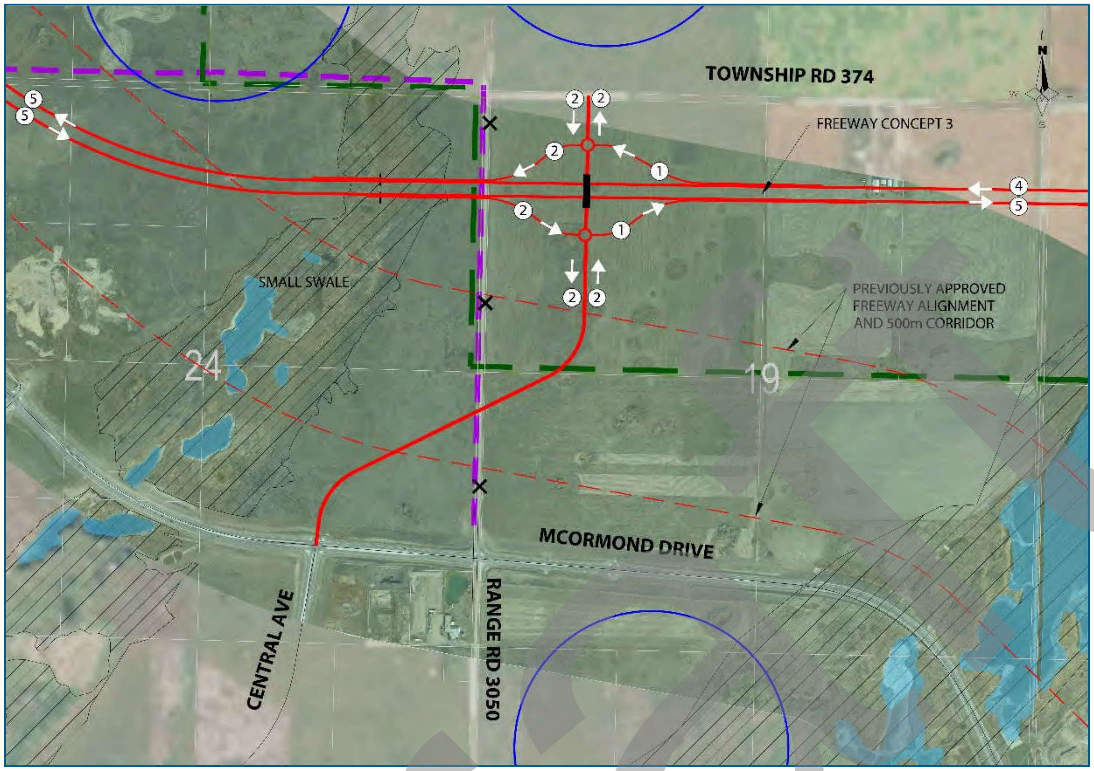

Figure 5.8: Central Avenue Interchange Concept 1

5.3.1.2 Central Avenue Concept 2

Concept 2 is a diamond configuration on the north with a Parclo A2 configuration on the south. In the eastbound direction, a Collector Distributer (C-D) road will be required along the Saskatoon Freeway to combine the W-S and W-N ramp exits with a single freeway exit. This configuration will provide full access to/from Central Avenue and provide greater access for eastbound vehicles to exit and travel north through a dedicated W-N loop ramp. Based on preliminary traffic projections, there is a need for five lanes per direction west of Central Avenue and four lanes per direction east of Central Avenue. As such, the interchange provides a transition opportunity through use of the two-lane ramps for the C-D road and eastbound on-ramp. Concept 2 is presented below in **Figure 5.9**.

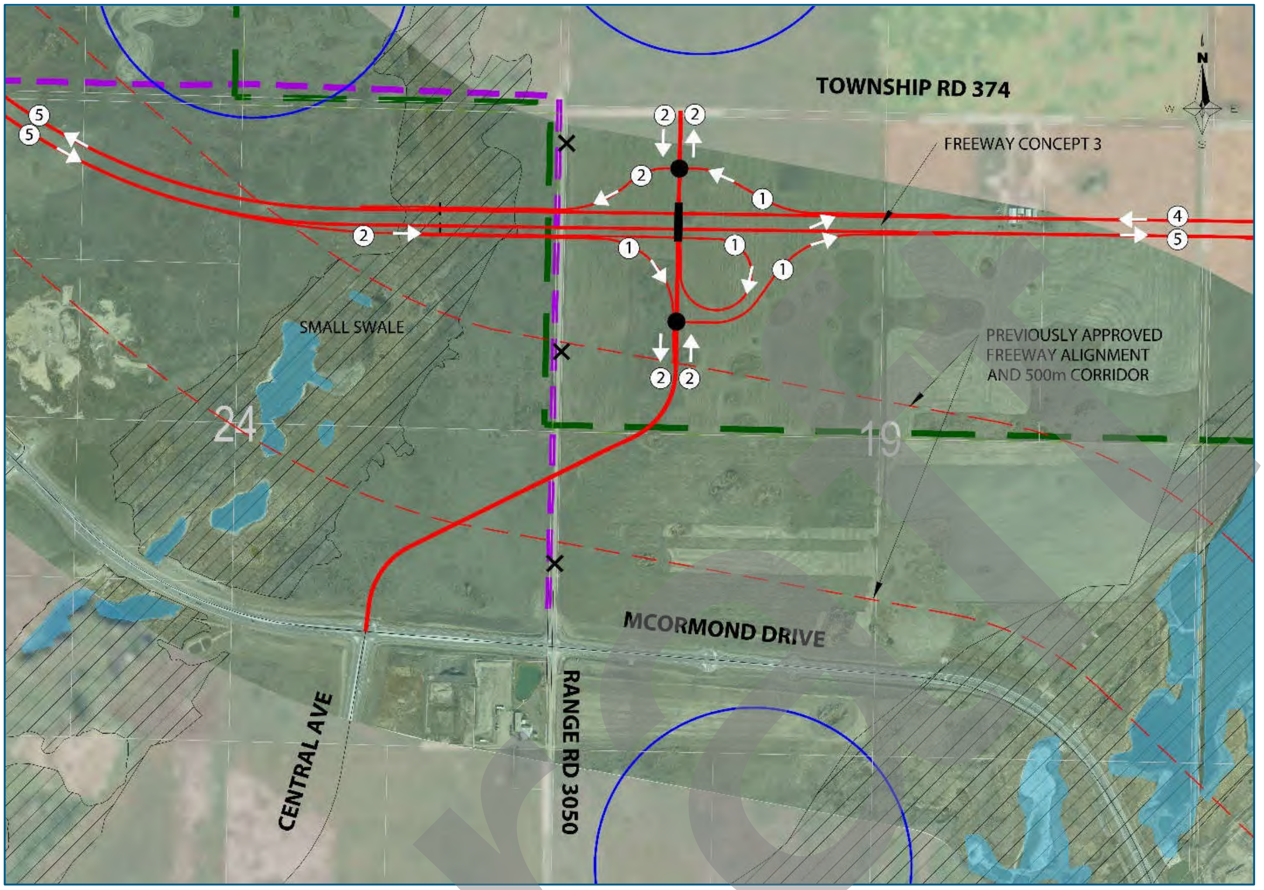

Figure 5.9: Central Avenue Interchange Concept 2

Based on feedback from the Virtual Public Information Sessions, and confirmed through the MAE, Concept 1 was selected as the preferred interchange configuration. Additional property will be protected to accommodate a potential future loop ramp in the SE quadrant. Furthermore, if warranted by traffic, the property envelope could accommodate a diverging diamond interchange.

5.3.2 Highway 41/Blackley Road

As discussed in the sections above, alternatives were developed for Highway 41/Blackley Road which considered maintaining the existing Highway 41 crossing location and realignment of Highway 41. As discussed further in **Section 5.2.1**, the purpose of this realignment is to provide standard interchange spacing between Central Avenue, Highway 41, and Highway 5 interchanges. Initially, alternatives were developed for Highway 41 under the assumption that Highway 41 would be a three-leg interchange with the portion of Highway 41 between Saskatoon Freeway and Highway 5 closed. However, based on consultation with the CoS, there was a strong preference for maintaining through traffic along Highway 41. As such, Interchange Concepts 1 and 2 are based on maintaining the existing alignment of Highway 41 and a four-leg interchange with the Saskatoon Freeway. These two interchange alternatives are compatible with North Section Concept 1 or 2 as discussed in **Section 5.2.1**. Interchange Concept 3 and 4 are based on the Highway 41 realignment as illustrated in North Section Freeway Concept 4. As part of Interchange Concept 3 and 4, a new interchange would be required between existing Highway 41 and the realigned portion of Highway 41. The existing portion of Highway 41 would continue south as a lower speed roadway and cross the freeway with a flyover structure. The four Interchange concepts for Highway 41/Blackley Road are discussed below.

5.3.2.1 Existing Highway 41 Concept 1

Existing Highway 41 Concept 1 (**Figure 5.10**) includes a modified partial cloverleaf interchange configuration which provides for free-flow movements at the interchange. However, due to the configuration of this interchange, not all moves can be provided without causing significant weaving concerns. The northbound to westbound could be serviced by a partial or full move interchange at Blackley Road as per North Section Concept 1 or 2. As this configuration has multiple exits at the interchange, a Collector-Distributor Road would be required along northbound and southbound Saskatoon Freeway.

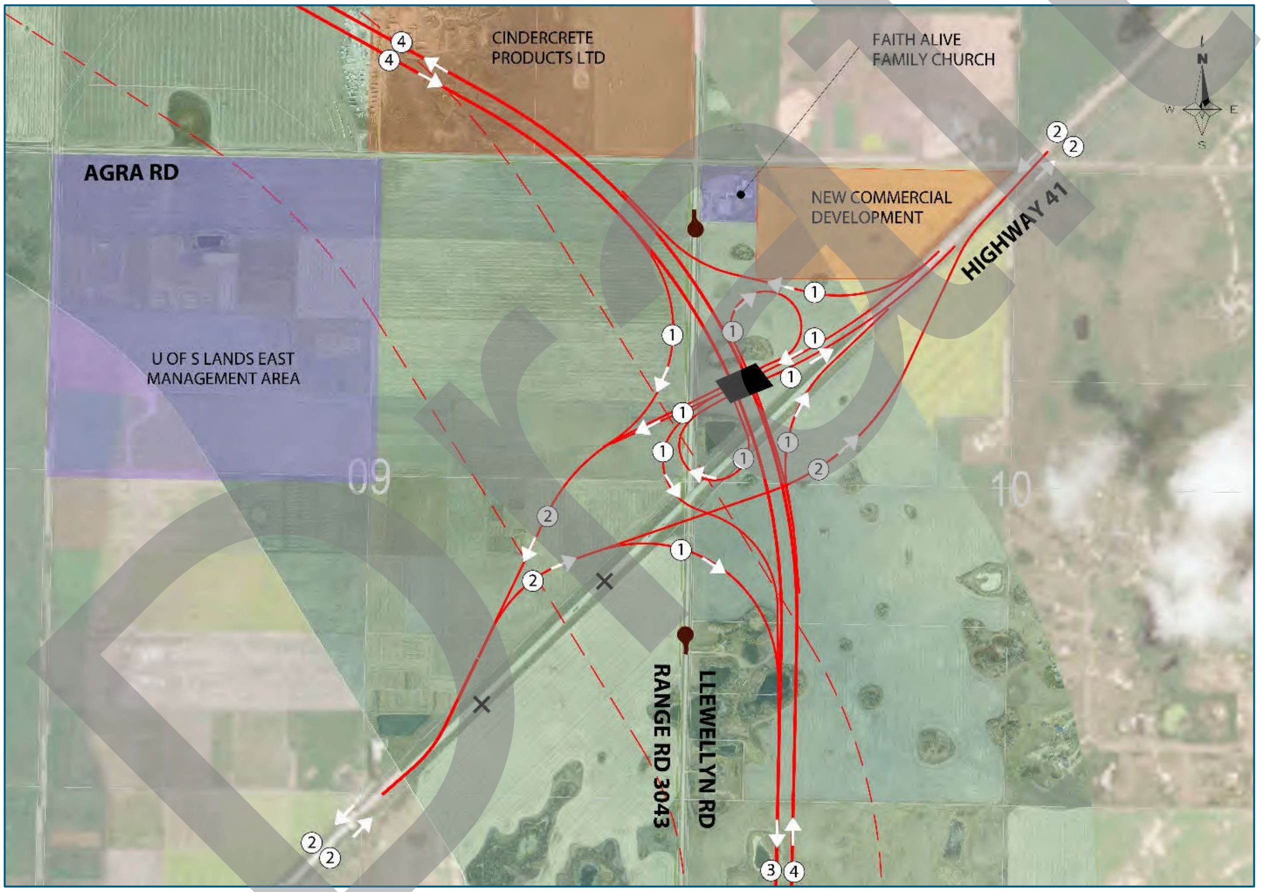

Figure 5.10: Existing Highway 41 Interchange Concept 1

5.3.2.2 Existing Highway 41 Concept 2

Existing Highway 41 Concept 2 (**Figure 5.11**) is a Parclo A4 configuration which requires two intersections along Highway 41. Although this is considered a lower speed interchange relative to Concept 1, the Parclo configuration provides all moves to/from Saskatoon Freeway and Highway 41. Based on initial traffic analysis, there is a potential need for a two-lane loop ramp due to high northbound to westbound traffic volumes.

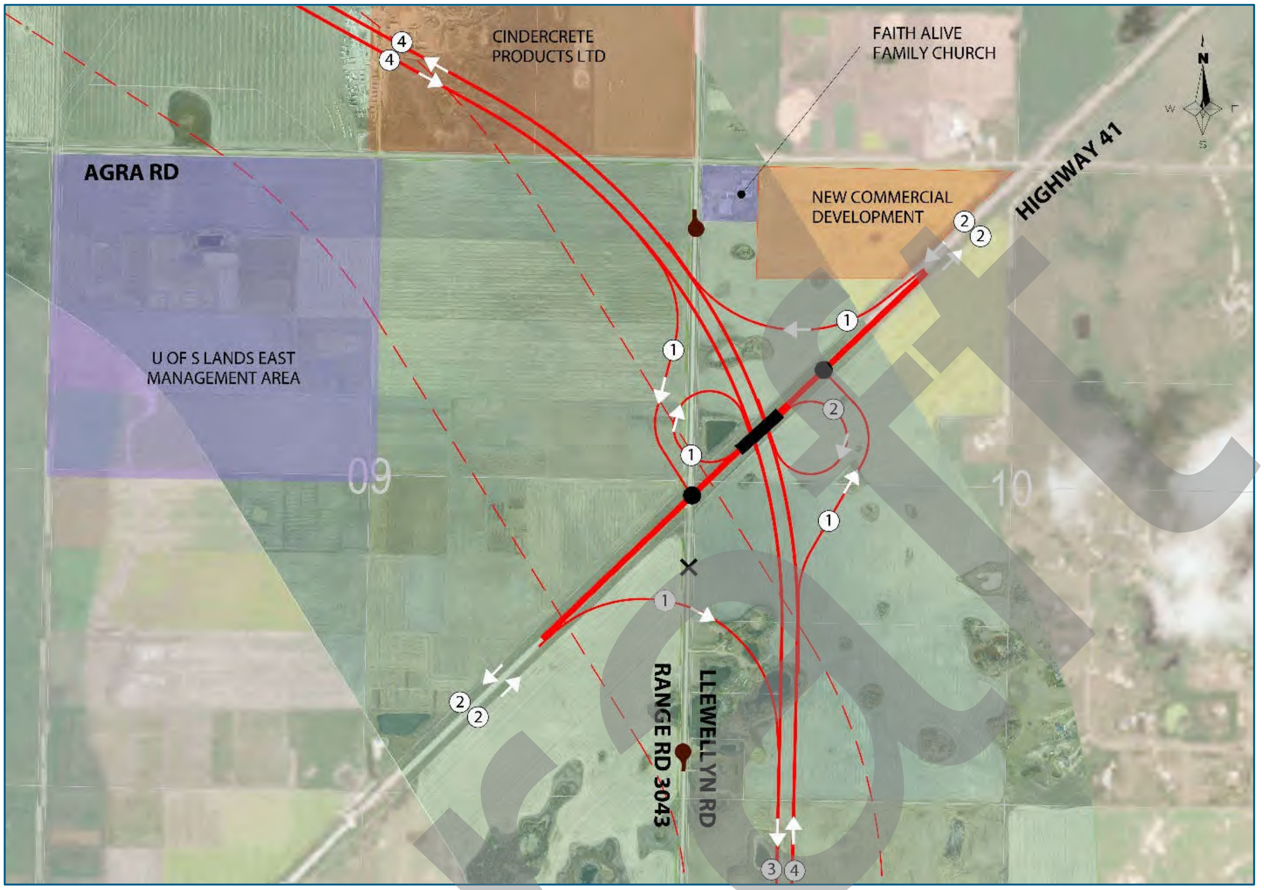

Figure 5.11: Existing Highway 41 Interchange Concept 2

5.3.2.3 Highway 41 Realignment Interchange Concept 1

Highway 41 Realignment Interchange Concept 1 (**Figure 5.12**) is a traditional Parclo A4 configuration which requires two intersections along the Highway 41 realignment. Highway 41 Realignment 'B' accommodates the large desire of vehicles wanting to access the industrial areas in North Saskatoon. These vehicles are currently using Township Road 374 and crossing Chief Mistawasis Bridge which is predicted to reach capacity by 2063 in the travel demand model as the area grows in the future. Adding more traffic to the Chief Mistawasis Bridge crossing would likely result in reaching capacity earlier than originally predicted. Blackley Road would be realigned to the west with a flyover structure. Access to the Saskatoon Freeway from Blackley Road would be via the Highway 41 interchange, which would require a left turn from southbound Blackley Road to Highway 41. To help alleviate some of the left turn traffic, a southbound to westbound ramp along Blackley Road could be provided in the future if warranted by traffic. Although this is considered a lower speed interchange, the Parclo configuration provides all moves to/from Saskatoon Freeway and Highway 41 realignment.

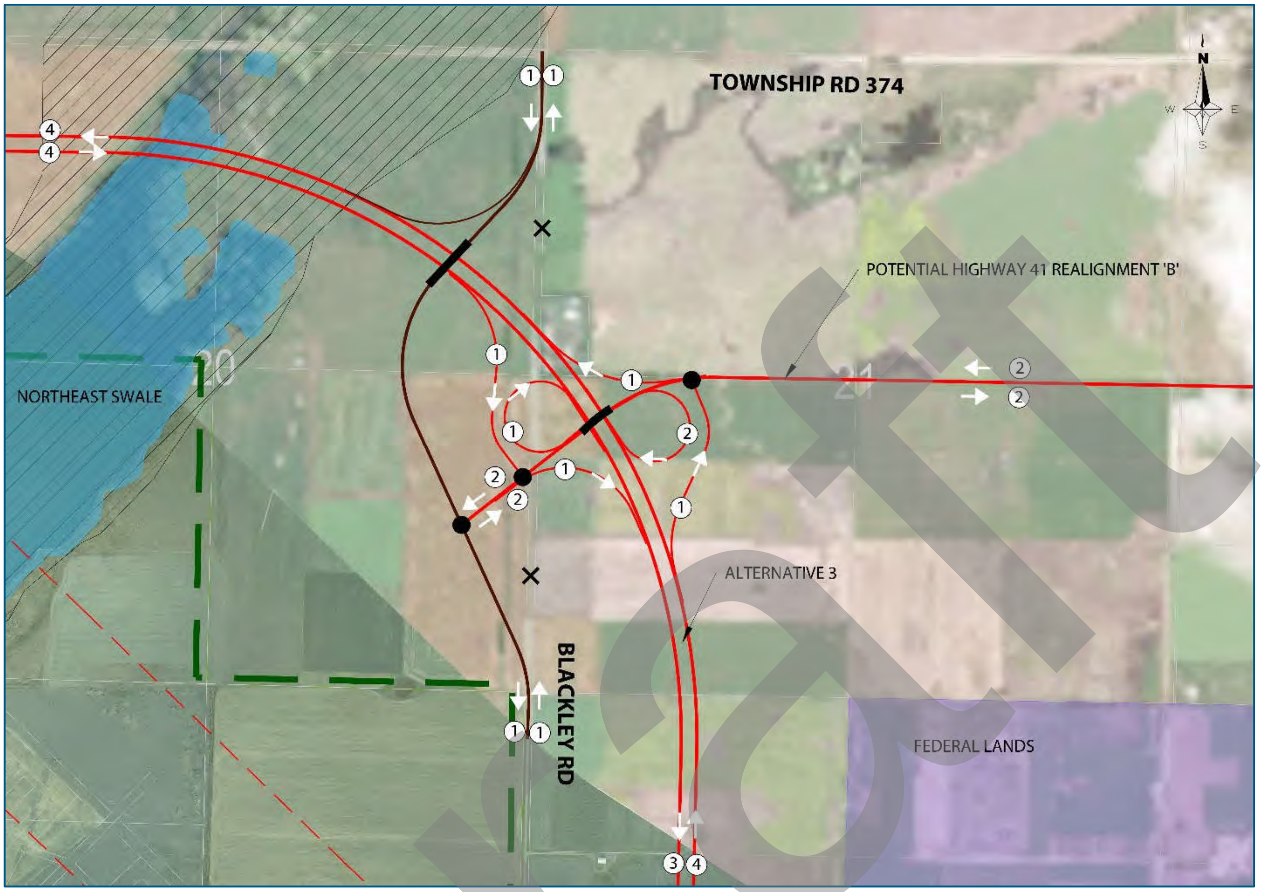

Figure 5.12: Highway 41 Realignment Interchange Concept 1

5.3.2.4 Highway 41 Realignment Interchange Concept 2

Highway 41 Realignment Interchange Concept 2 (**Figure 5.13**) combines Blackley Road and the realigned Highway 41 into a single larger interchange that allows for increased free flow movement of traffic and allows for all movements to/from the Saskatoon Freeway, Blackley Road, and Highway 41. Realigning Highway 41 further to the north with Highway 41 Realignment 'B' also accommodates the large desire of vehicles accessing the industrial areas in North Saskatoon. These vehicles are currently using Township Road 374 and crossing Chief Mistawasis Bridge. The existing Highway 41 will remain but will be converted to an arterial roadway and will continue to provide access to various parcels of land and the CoS without access to the Saskatoon Freeway. This interchange configuration also allows for a staged construction approach where in the interim, Blackley Road could be a flyover with vehicles utilizing the adjacent road network for Saskatoon Freeway access. The ultimate combined interchange could be subsequently constructed with Blackley Road to provide all moves to/from the Saskatoon Freeway. As this configuration would have multiple exits at the interchange, a Collector-Distributor Road would be required along both northbound and southbound Saskatoon Freeway. Additionally, compared to Highway 41 Realignment Interchange Concept 1, the ramps at Blackley Road interchange would extend further west, requiring a wider structure over the Northeast Swale.

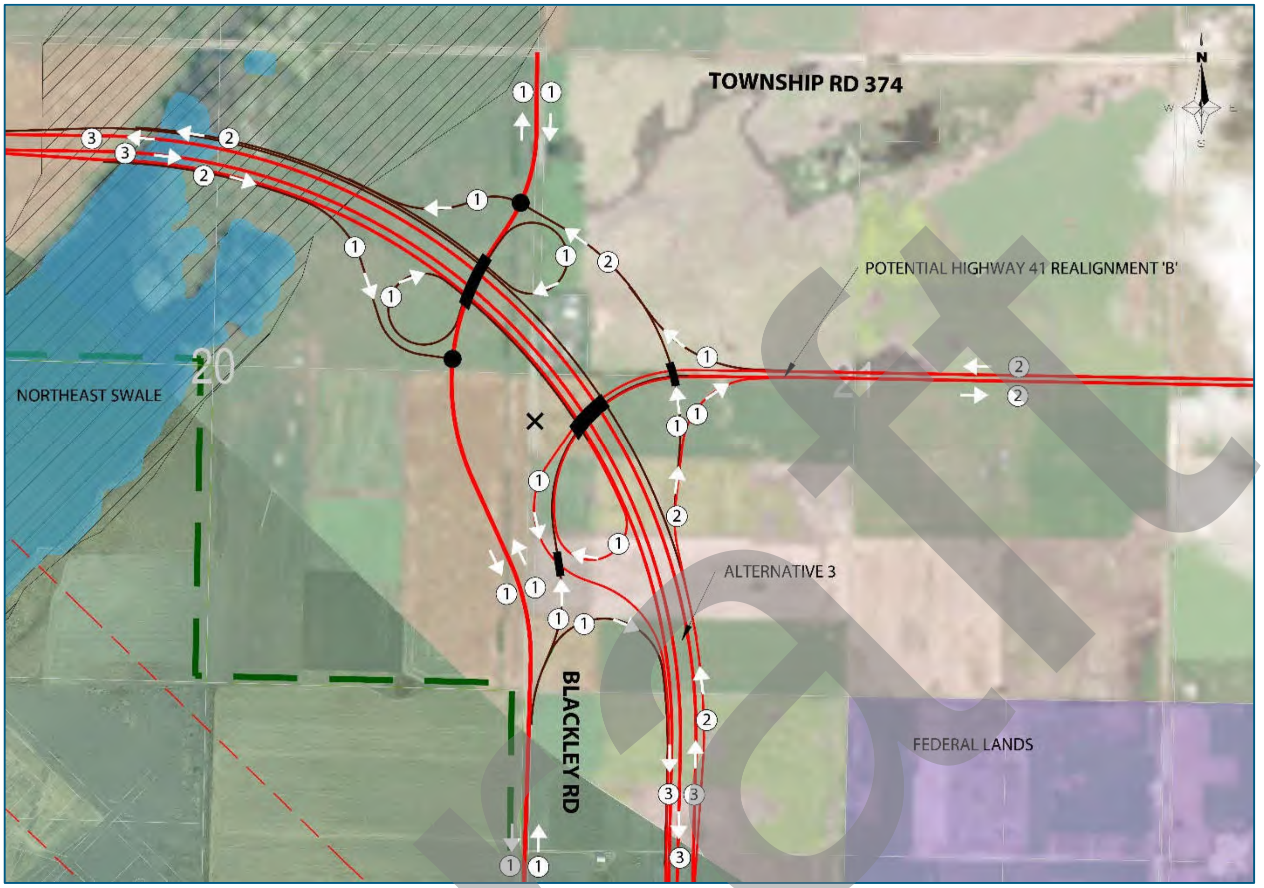

Figure 5.13: Highway 41 Realignment Interchange Concept 2

Based on feedback from the Virtual Public Information Session, and confirmed through the MAE, Highway 41 Realignment interchange Concept 2 was selected as the preferred interchange configuration. Further refinements also reduced the impact on the Northeast Swale by moving the CD road exit ramp further to the east as illustrated in **Figure 5.14**.

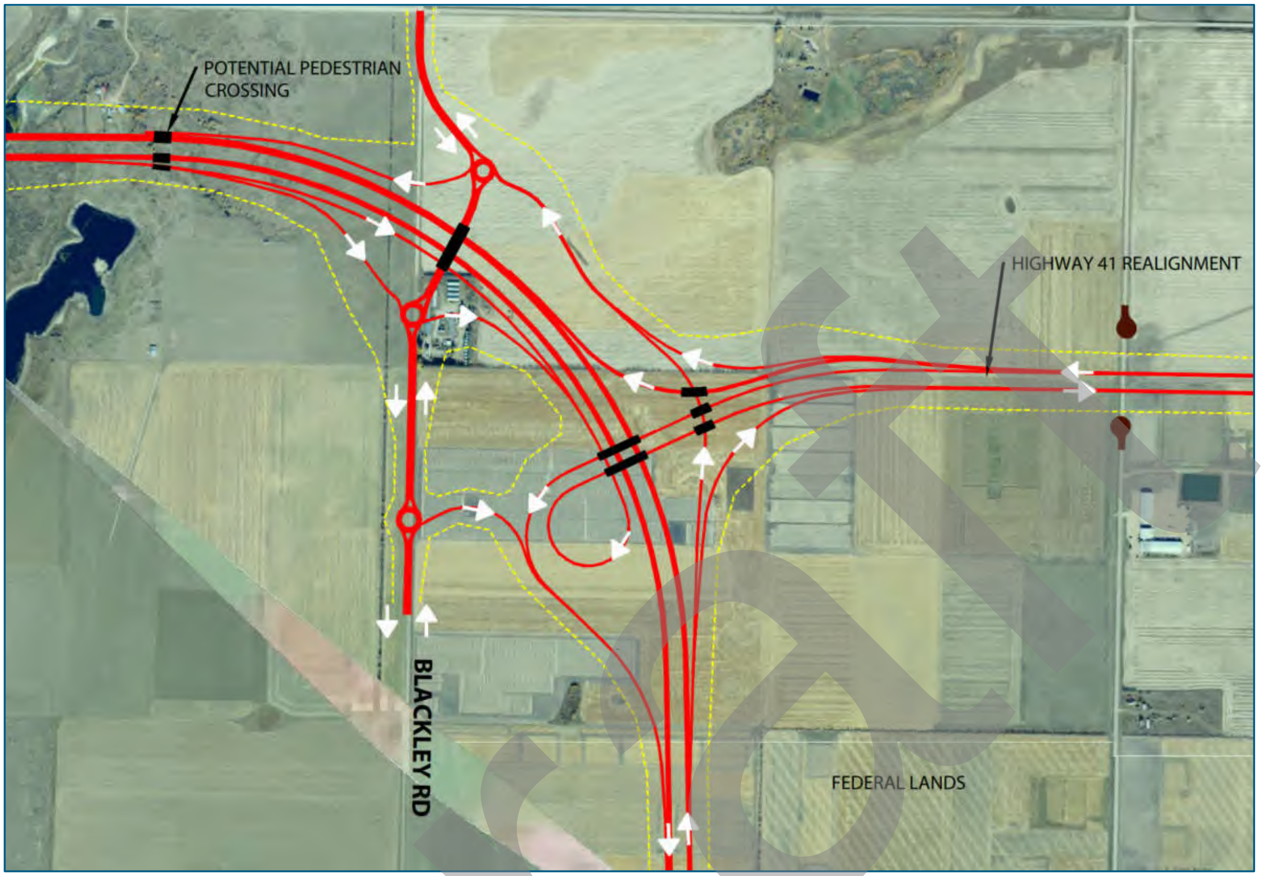

Figure 5.14: Highway 41 Realignment Interchange Concept 2 (refined)

5.3.3 Highway 5

It is understood that the Ministry is planning for the twinning of Highway 5 by constructing westbound lanes on the north side of existing Highway 5 lanes extending from west of Llewellyn Road/Winmill Road eastward. As such, the Highway 5 interchange alternatives have been developed to tie-into the future twinned detailed design of Highway 5. Additionally, due to the proximity of the Highway 5 interchange with Llewellyn Road/Winmill Road, access to the existing portion of Llewellyn Road/Winmill Road approaching Highway 5 would be modified.

5.3.3.1 Highway 5 Concept 1

Concept 1 includes Parclo B loop ramps for northbound to westbound and southbound to eastbound moves from Saskatoon Freeway with direct ramps for the remaining moves. The eastbound to northbound and westbound to southbound moves would be considered high speed direct flyover ramps. As this configuration would have multiple exits at the interchange, a Collector-Distributor Road would be required along southbound Saskatoon Freeway. This configuration will provide full access to/from Highway 5 and would be completely free-flowing without requiring signalized intersections. Concept 1 is presented below in **Figure 5.15**.

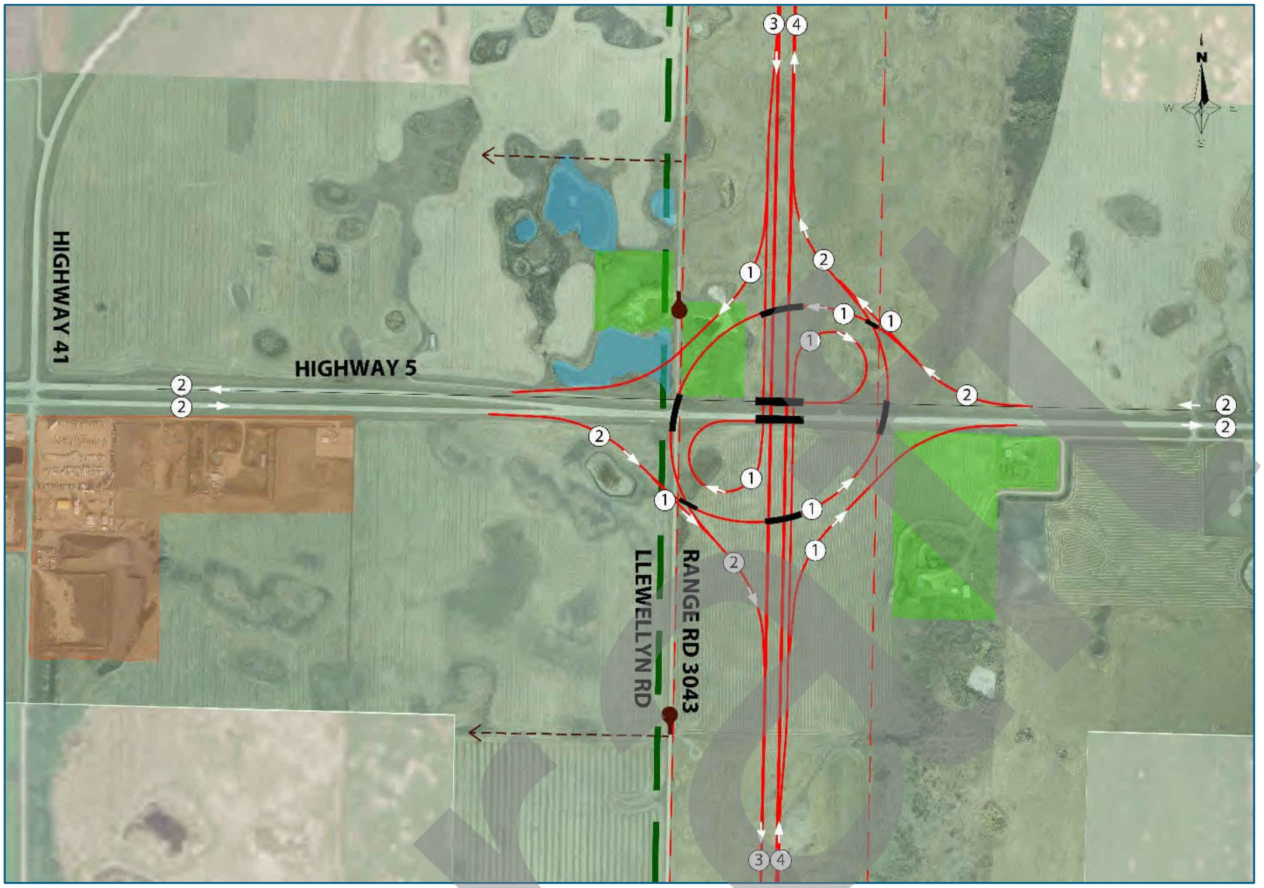

Figure 5.15: Highway 5 Interchange Concept 1

5.3.3.2 Highway 5 Concept 2

Concept 2 includes loop ramps for eastbound to northbound, westbound to southbound, and northbound to westbound traffic moves with direct ramps for the remaining moves. Additionally, the southbound to eastbound move would be considered a high-speed direct flyover ramp. Due to the cloverleaf configuration, there are potential weaving concerns associated with this alternative. As this configuration would have multiple exits at the interchange, a Collector-Distributor Road would be required along northbound Saskatoon Freeway. This configuration will provide full access to/from Highway 5 and would be completely free-flowing without requiring signalized intersections. Concept 2 is presented below in **Figure 5.16**.

Figure 5.16: Highway 5 Interchange Concept 2

Based on feedback from the Virtual Public Information Sessions, and confirmed through the MAE, Highway 5 Concept 1 was selected as the preferred interchange configuration.

5.3.4 8th Street

8th Street at the Saskatoon Freeway crossing is currently a rural, two-lane undivided street. To protect land for a future widening of 8th Street, it has been assumed that a six-lane cross section with a concrete median similar to the current cross section west of Boychuk Drive would ultimately extend through the 8th Street interchange. Development models project future growth to the east of the Freeway.

Constraints at this location include several yard sites and a sizable wetland north of 8th Street. The Freeway mainline alignment through this area was shifted towards the eastern half of the previously approved 500 m wide corridor to fit between these constraints.

5.3.4.1 Concept 1

Concept 1 is a diamond interchange with signalized intersections at the ramp terminals. The intersections may be controlled with stop signs upon initial construction depending on the traffic volumes on 8th Street. Ramp terminal spacing is 105 m as per MoH standards. This concept could be converted to a diverging diamond interchange during future design phases if needed based on traffic and level of service forecasts at that time, with no additional land being required. Concept 1 is presented below in **Figure 5.17**.

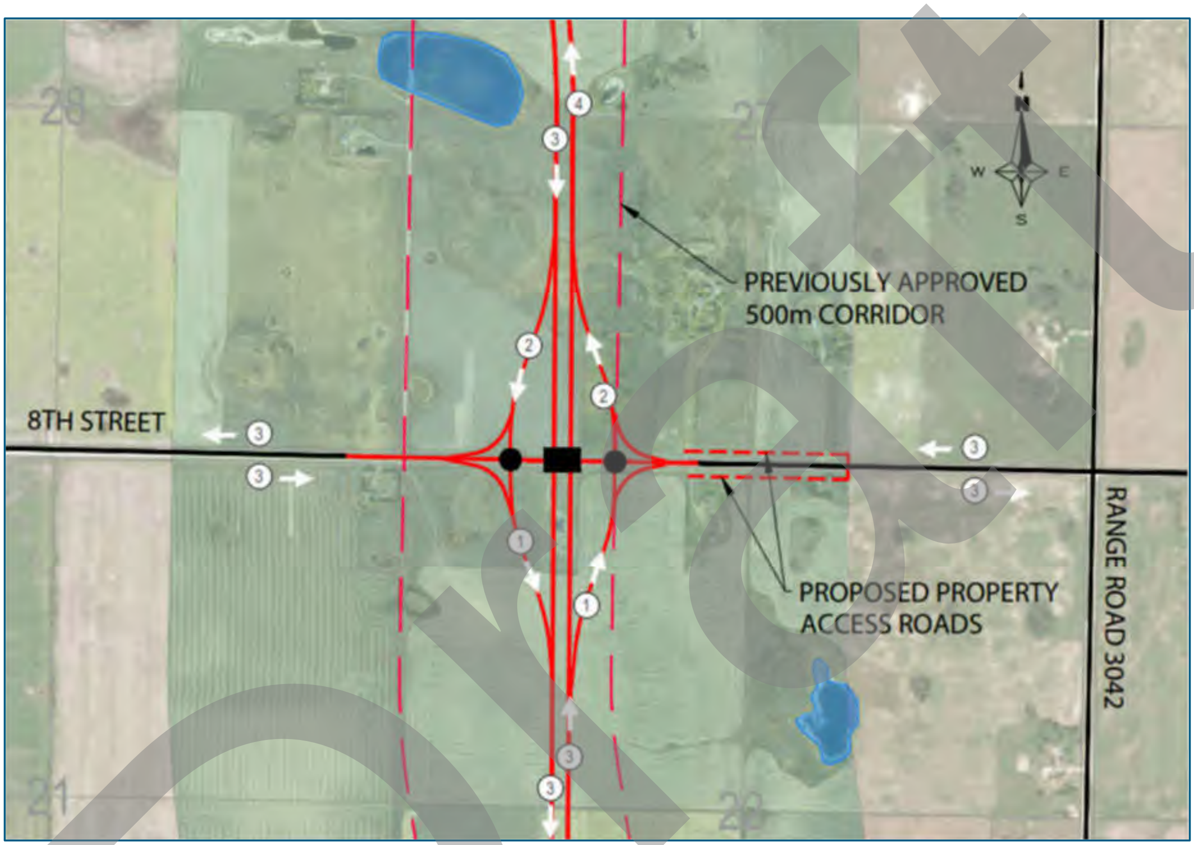

Figure 5.17: 8th Street Interchange Concept 1

5.3.4.2 Concept 2

Concept 2 includes a Parclo B configuration on the west half of the interchange and a diamond configuration on the east half of the interchange. The Parclo B4 loop was provided to service a large volume of north to east traffic requiring two lanes. Passing this volume through an intersection or roundabout could cause capacity issues. A collector-distributor road would be constructed in the southbound direction to accommodate the loop and north to west directional ramp. Concept 2 is presented below in **Figure 5.18**.

Figure 5.18: 8th Street Interchange Concept 2

5.3.5 Highway 16

According to the mainline route continuity scheme and as Highway 16 is within the National Highway System, a system level interchange is required between the mainline and Highway 16. Design speeds on the Highway 16 to mainline connections are 130 km/h. Interchange concepts in this area also need to provide connection to Circle Drive.

There are several constraints that need to be considered. These include University of Saskatchewan research lands and Rawlco Radio lands shaded purple on the sketches below. All roads and ramps will also need to overpass the CP Rail line which is parallel to Highway 16 while providing sufficient clearance and space for embankments or retaining walls. An additional constraint is the close proximity of the intersection of Highway 16 with Floral Road; maximum spacing for a potential future interchange at this intersection needs to be considered. Patience Lake Road is to remain open to maintain a connection to rural lands to the east of the Freeway.

All concept sketches below include a brown shaded area at the intersection of Zimmerman Road and Circle Drive. This is the location of a planned interchange to be constructed by the CoS. At the time of the SFFPS, the configuration of this interchange is unknown. This location is important due to conflicts with the ramps connecting Circle Drive and the Saskatoon Freeway mainline. Although not shown on the concept sketches below due to scale and clarity, a basket weave can be incorporated into this area to provide appropriate weaving distances. This is shown in the recommended concept drawings in the following section and on the interchange plates in the appendices. Brown lines on the three concept sketches indicate proposed municipal roads.

Concepts do not provide certain low volume movements. These include:

- Southbound on Circle Drive to westbound on mainline. This move has been provided at the Zimmerman Road interchange; and
- Eastbound on mainline to southbound on Highway 16 and Northbound on Highway 16 to westbound on mainline. These moves are low volume because they form a U-turn between Highway 11 and Highway 16. Traffic wishing to connect to these two highways would use a west/west municipal road further south. Traffic originating locally can use the Floral Road or Zimmerman Road interchanges as access points.

5.3.5.1 Concept 1

Concept 1 utilizes a land parcel between Highway 16, Range Road 3042, and the CP rail tracks as an embankment location for an overpass crossing the CP rail tracks. The Highway 16 lanes then merge/converge from the mainline south of Patience Lake Road. Highway 16 connections would have a design speed of 130 km/h and would use a major fork/major connector to merge with the mainline. As the southbound lanes of Highway 16 must cross the northbound mainline lanes, the mainline separates in this location to create space for an embankment and bridge. Directional ramps connecting to Circle Drive are aligned just south of Patience Lake Road with both eastbound to northbound and southbound to westbound connections being two-lane ramps.

Although a full functional design of the Floral Road and Highway 16 interchange is not in the scope of this study, a conceptual design is shown to demonstrate one option for how the southbound weaving conflict that is introduced by merging the southbound Highway 16 connection from mainline with the existing Highway 16 at this location could be addressed. The oblong loop ramp extends the diverge point of this movement to 800 m beyond the Highway 16 connection. Concept 1 is presented below in **Figure 5.19**.

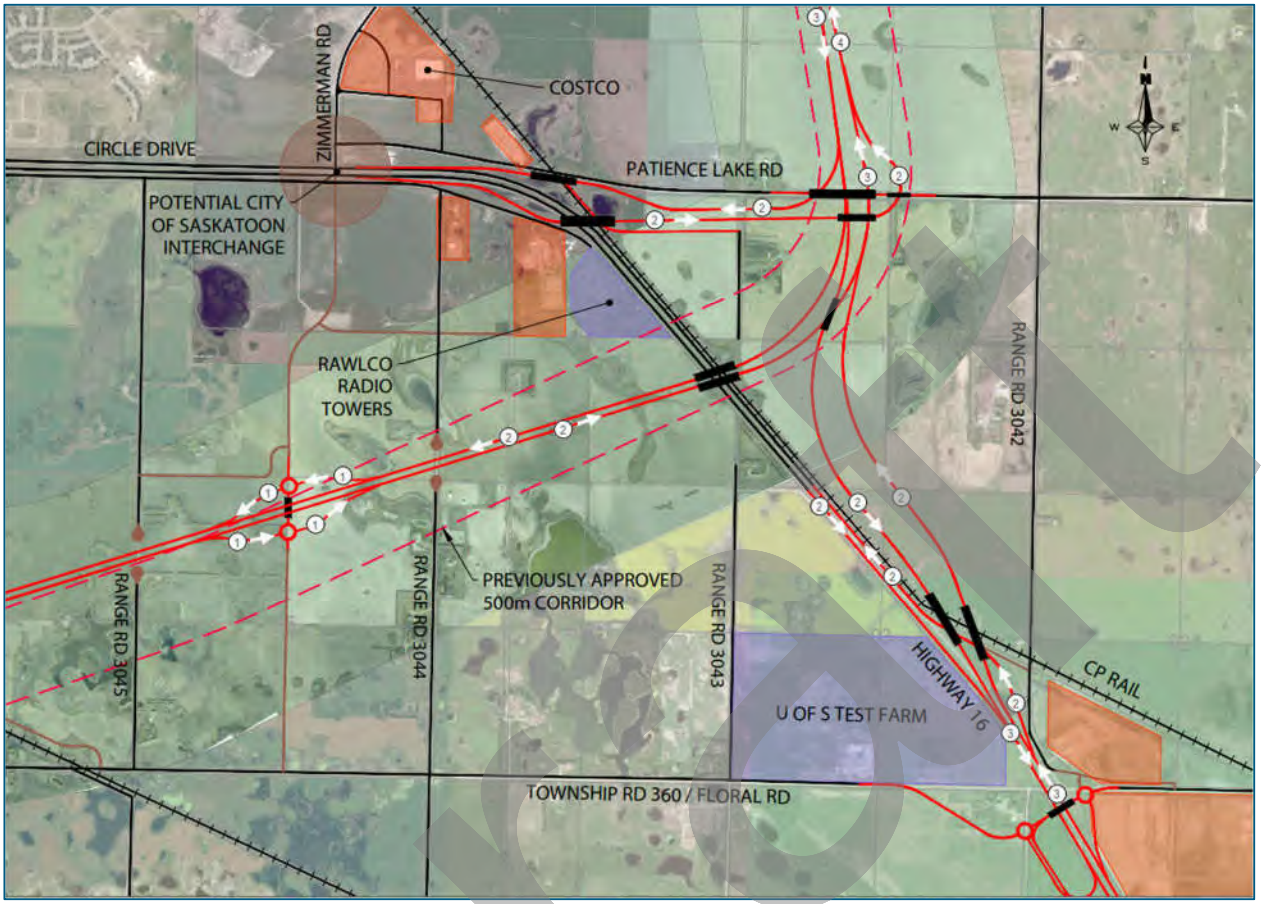

Figure 5.19: Highway 16 Interchange Concept 1

5.3.5.2 Concept 2

Concept 2 moves the merge/diverge point further north on Highway 16. This requires shifting these lanes to the west to create a crossing angle over the existing Highway 16 and CP rail. The southbound lane from Circle Drive would be realigned parallel to the Highway 16 connections. Moving the merge/diverge point north allows for a simple diamond interchange at Floral Road and Highway 16. Directional ramps between the mainline and Circle Drive are located closer to the mainline compared to Concept 1.

This concept requires less land than Concept 1. However, it requires a third level bridge structure on the eastbound to northbound ramp from Circle Drive, which would be expected to have a higher initial cost. In addition, there are geometric and laning challenges with the northbound traffic as the major connector between Highway 16 and the mainline as well as the northbound ramp from Circle Drive converge at a similar location. The ramp from Circle Drive is shown to merge with Highway 16 with a major connector to the mainline being located further north. The final issue with this concept is that the northbound ramp from Circle Drive is squeezed between two parcels of private property resulting in a longer ramp and creating some challenges with property access. Concept 2 is presented below in **Figure 5.20**.

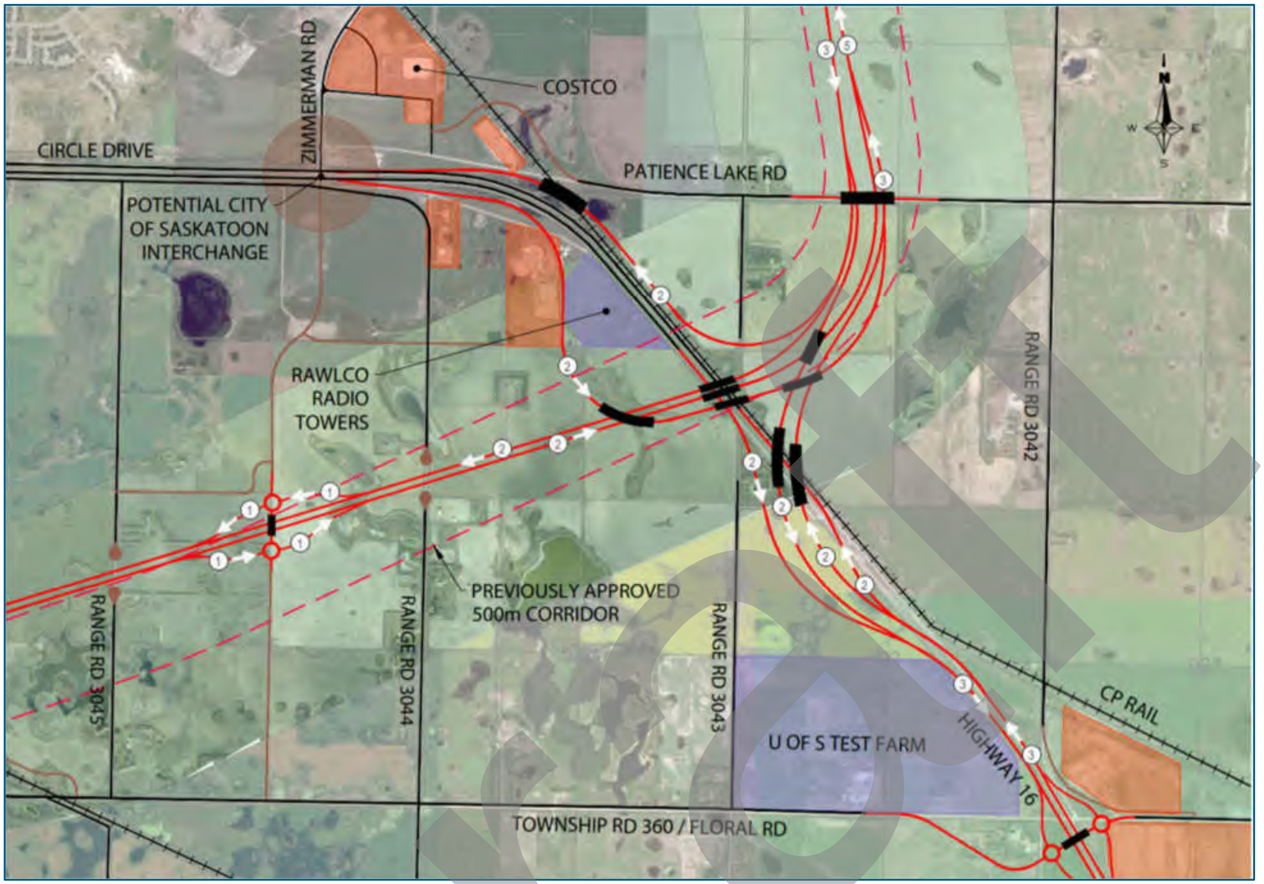

Figure 5.20: Highway 16 Interchange Concept 2

5.3.5.3 Concept 3

Concept 3 combines the Circle Drive to mainline ramps from Concept 1 with the Highway 16 to mainline connections from Concept 2. Benefits of this concept are that fewer land parcels are impacted compared to Concept 1 and there is less expense for bridge construction compared to Concept 2. Concept 3 is presented below in **Figure 5.21**.

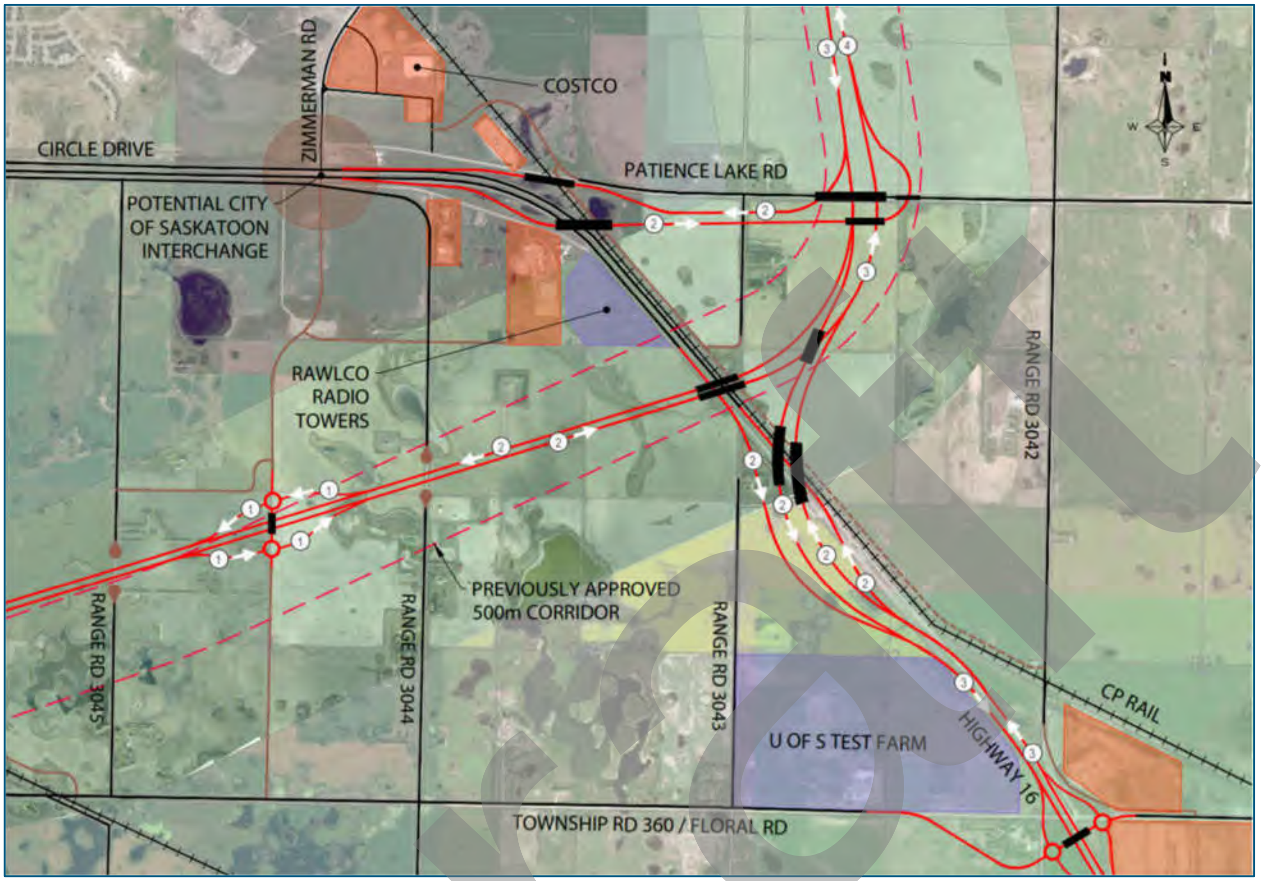

Figure 5.21: Highway 16 Interchange Concept 3

5.3.6 Zimmerman Road

The previous location plans proposed an interchange location at Range Road 3044. The interchange was shifted eastward to better align with Zimmerman Road and is referenced as the Zimmerman Road interchange. The location also maintains a 3.2 km of separation to Highway 16 and is located along a quarter section line in order to minimize current local land uses. It is noteworthy that the RM of Corman Park initiated a planning project in the vicinity. The final alignment of Zimmerman Road between the interchange and Circle Drive may be revised based on future development plans.

Only one concept was developed for this location given that diamond interchanges are known to be a very cost-efficient configurations for a service level interchange, no other concepts were considered for this location. The diamond interchange and shifted future extension of Zimmerman Road are both shown in the Highway 16 concept sketches in **Figure 5.21** above. Roundabouts are shown at the ramp terminals as they are considered safer and have positive operational characteristics. However, these may be modified into other intersection types during future detailed design phases depending on updated traffic forecasting that may be available at that time. Right turn bypass lanes been added on the north half of the interchange to facilitate a four-lane cross section between the freeway and Circle Drive (**Figure 5.22**).

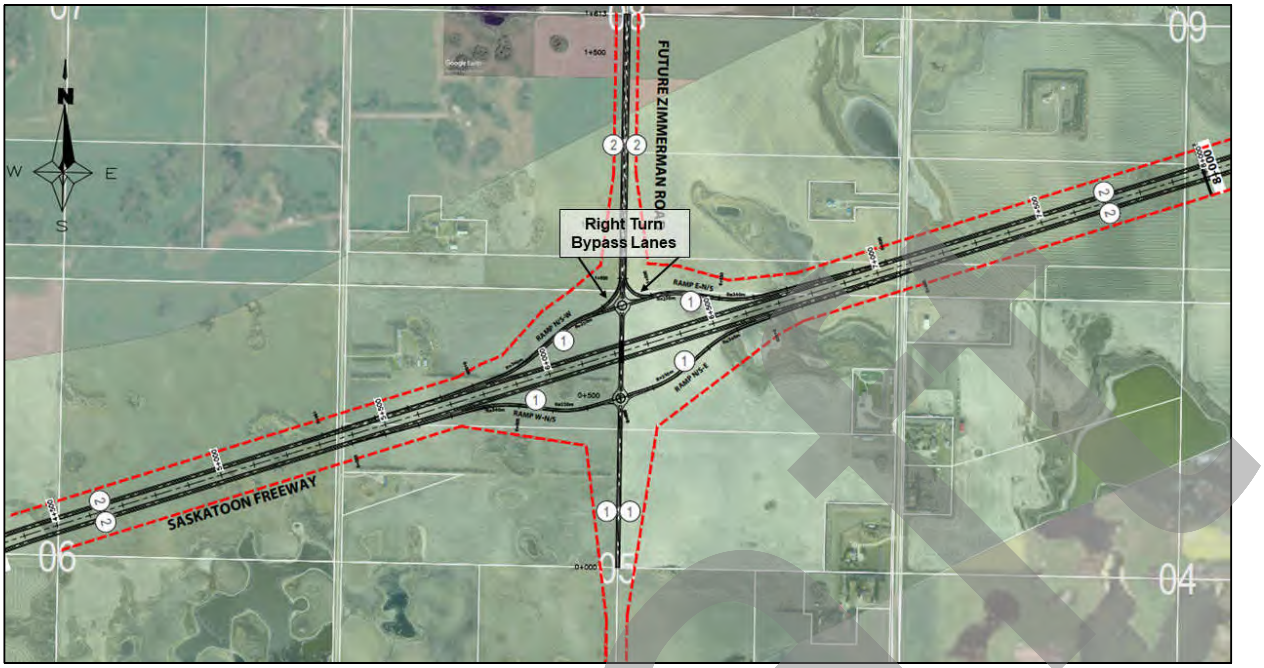

Figure 5.22: Zimmerman Road Interchange Concept

5.3.7 West Floral Road

One concept was developed for an interchange at West Floral Road. This concept allows most movements but there are three that are not provided: westbound to northbound, westbound to southbound, and eastbound to southbound. These three movements were projected to be very low volume in the TDM as they can typically be accomplished along a shorter route by using a different access point: either the Zimmerman Road interchange or Highway 11/Floral Road at-grade intersection. Another feature of this area is an overpass over the CN rail. Brown roads are municipal road connection work that are shown as one option demonstrating how connectivity could be achieved. Ultimate configurations will depend on future development. The West Floral Road interchange concept is presented below in **Figure 5.23**.

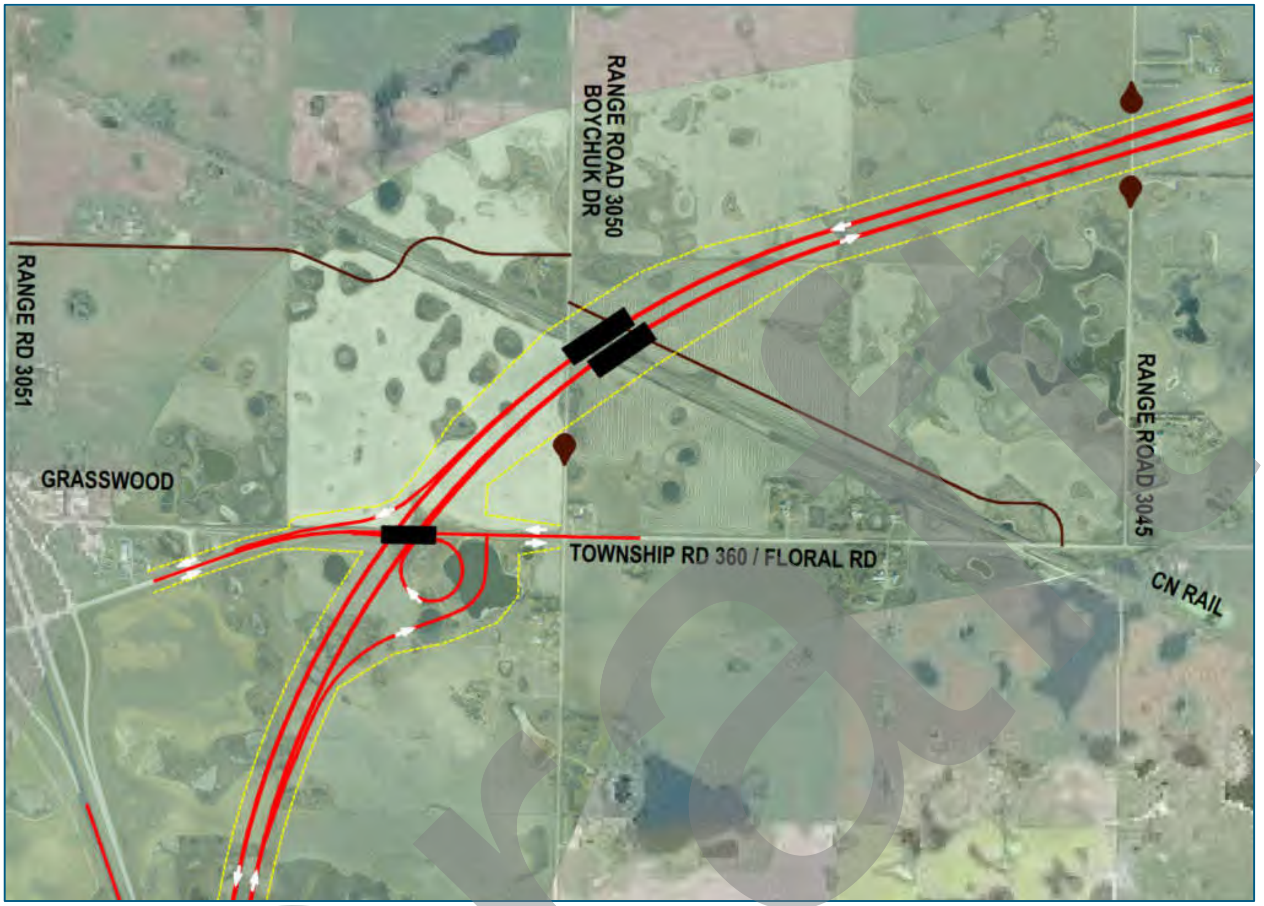

Figure 5.23: West Floral Road Interchange

5.3.8 Highway 11

Highway 11 is the south terminal of the Saskatoon Freeway mainline. There are only four movements required at this interchange. The route continuity scheme for the project is that the Saskatoon Freeway will be signed as Highway 11. The existing Highway 11 inside the Freeway limits may be downgraded to a CoS expressway or arterial. Therefore, northbound on Highway 11 to eastbound on the Freeway mainline and westbound on the Freeway mainline to southbound on Highway 11 are to provide 130 km/h design speed. Ramps for traffic to and from Saskatoon can use lower design speeds matching existing Highway 11 posted speeds in the vicinity of Grasswood. In addition, the classification of the existing Highway 11 segment between the Saskatoon Freeway and Circle Drive may be re-evaluated.

Concept 1 was the preferred option based on the outcome of the MAE process.

5.3.8.1 Concept 1

Concept 1 is for traffic exiting Highway 11 to go into Saskatoon to use a right exit and go over the mainline lanes. Northbound traffic staying on Highway 11/mainline would not have to make a lane change. Similarly, southbound traffic from Saskatoon would enter on the right-hand side of Highway 11 as per a standard two-lane entrance ramp. Concept 1 is presented below in **Figure 5.24**.

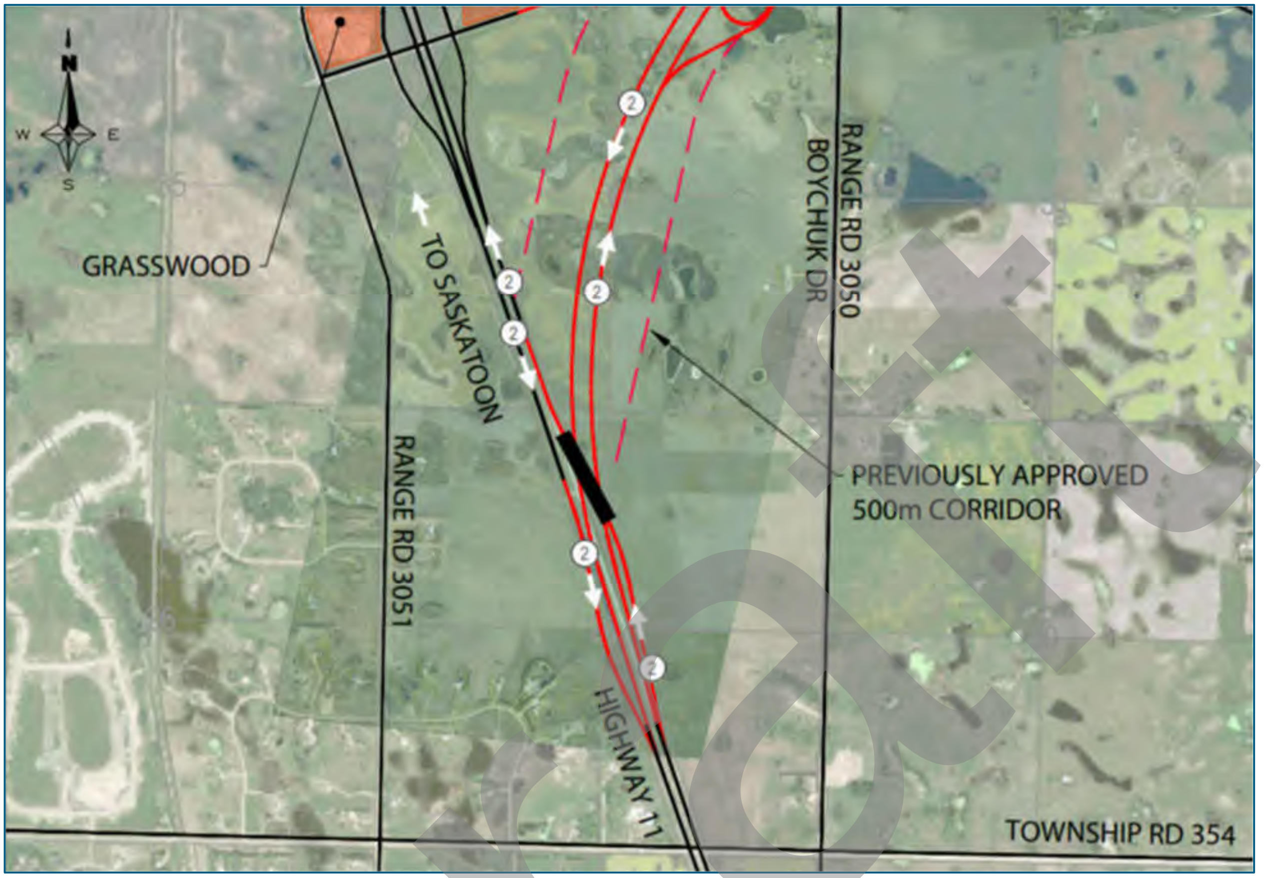

Figure 5.24: Highway 11 Interchange Concept 1

5.3.8.2 Concept 2

Concept 2 is for northbound traffic on Highway 11 to exit right to proceed on the Freeway while traffic going into Saskatoon would stay left. This conflicts with the desired route continuity as drivers would be expected to exit Highway 11 to stay on Highway 11. Southbound traffic from Saskatoon entering Highway 11 would use a right-hand entrance, as per Concept 1.

This configuration would see the southbound mainline/Highway 11 lanes overpass the northbound lanes to Saskatoon while the other roads and ramps remain at-grade. In addition to conflicting with the route continuity scheme for the project, there are geometric and technical challenges associated with having an overpass and bridge in between two at-grade ramps. This will likely require significant retaining walls. The crossing angle also creates a long bridge and the 130 km/h design speed for this movement requires a 195 K value and therefore a large fill. Concept 2 is presented below in **Figure 5.25**.

Figure 5.25: Highway 11 Interchange Concept 2

5.4 Access Management Concepts

The Ministry standards require a minimum spacing of 3.2 km between access points on a freeway. Desirable spacing is 8.0 km. Access points are to be grade separated interchanges with no access permitted between interchanges.

The new freeway will sever existing roads and parcels of land necessitating consideration to land access alternatives with access to the Saskatoon Freeway limited to interchange locations. Access management concepts were generated that illustrate how local property owners, business and road users can use a system of existing and new secondary roads to access the freeway. The interchanges allow full access to the freeway and a method to cross over or under the freeway. Another option that allows access across, but not onto, the freeway are flyovers. The proposed interchanges may also require closure of existing road intersections due to their close proximity to interchange ramps. The Combined Roll Plan included in **Appendix E** for Phase 1 and Phase 2 illustrates an access scheme that will require further consultation with local governments as part of the detailed design process.

Flyovers at Patience Lake Road and at the existing Highway 41 intersection with the Saskatoon Freeway are included in the functional plans. Additional flyovers may be considered in the future at other locations shown on the Combined Roll Plan included in **Appendix E**.

5.5 Drainage Concepts

Phase 2 of the SFFPS is the longest section and includes everything east of the South Saskatchewan River. In contrast to Phase 1 this section of Freeway is not bound by as much development and most of the land it crosses is agricultural with some nearby country residential. This land is characterized by three distinct areas. In the north, most runoff concentrates into the swales which drain to the South Saskatchewan River. In the middle section, runoff generally comes from the hills in the east and flows west across the Freeway towards Saskatoon with some entering the CoS storm sewer system and some flowing north to the Northeast Swale. Finally, in the south the terrain is dominated by numerous small water bodies or wetlands with poorly defined drainage paths.

As in Phase 1, the drainage design for Phase 2 predominately retained existing drainage patterns and recommends storage attenuation where runoff patterns were changed or increased. Drainage design for this phase focused on four parts:

- Quantify and Manage Existing Drainage;
- Interchange and Freeway Design;
- River Outfall; and
- Regulatory Agencies and Stakeholders.

5.5.1 Quantify and Manage Existing Drainage

5.5.1.1.1 Data Acquisition

As in Phase 1, NRCAN (Natural Resources Canada) geometric data was used to analyse the natural drainage paths. The grid road system has had some effect on the natural drainage paths but to a lesser extent than what was found in Phase 1. The geometric data was used to define the current catchment boundaries in areas that were not covered by LiDAR data. LiDAR data along the Saskatoon Freeway route was provided by the Ministry.

Analysis started with a desktop study to identify drainage paths and existing culvert locations. The Ministry's culvert database was reviewed to identify culverts along Highways 5, 11, 16, and 41. Satellite images and Google Street View were referenced to identify missing culverts and to further refine the catchment areas. Historic satellite imagery from May of 2012 is especially useful for identifying natural drainage patterns as this was a relatively wet year. A preliminary assessment of catchment boundaries and drainage paths was completed to identify key areas where additional data was needed to confirm drainage patterns. Site surveys were then conducted to identify the presence or absence of key culverts and confirm drainage paths.

The catchment areas identified in this report are based on the best available data. Most of the catchment areas lie outside what was covered by LiDAR and relied on NRCAN geometric data to map catchments and drainage paths. The lower precision of this data may have impacted some of the drainage analysis. Again, it is strongly recommended that the detailed design include a thorough investigation and survey of the catchment areas impacting this phase of the project.

5.5.1.1.2 Drainage Paths

Phase 2 of the Saskatoon Freeway crosses numerous natural drainage paths which concentrate the runoff from their contributing catchment areas.

Watershed in the north section tends to be parallel to the Freeway until it reaches one of the defined drainage paths which tend to be perpendicular to the Freeway and include: South Saskatchewan River, Small Swale, Northeast Swale, and a local low point that is unlikely to spill. As the proposed alignment turns south it interacts with a constructed drainage ditch that flows north to the Northeast Swale.

South of Highway 41 the Freeway parallels a large ridge to the east and the watershed generally flows from east to west perpendicular to the Freeway. Most runoff concentrates into one of several well-defined drainage paths. After crossing the Freeway the drainage paths on the north end of this section turn north and flow to the Northeast Swale. Drainage paths on the south end of this section continue flowing west towards the CoS and enter several large sloughs. If these sloughs reach a spill point the flow would enter the CoS storm sewer system.

As the Freeway turns back to the southwest it moves away from relatively steep grades along the ridge and into an area of poor drainage dominated by numerous local low points. These low areas result in many sub catchments and substantial natural upstream storage potential. It is expected that the catchments in this area will only yield significant flow during wet years when this storage is full. The drainage paths that could be identified in this area tend to be poorly defined. They often follow a meandering serious of sloughs and wetlands with highly variable storage capacity and spill elevations. Direction of flow can be difficult to determine as many of the connecting water bodies have similar water levels. Flow traveling southeast from this section ends up in one of several terminal basins within the Beaver Creek Terminal Basin which is discussed in more detail in **Section 5.5.1.1.5.4.**

For the purpose of this report drainage paths have been categorized as follows:

- River Direct Drainage (RDD) is a small section which drains directly to the river;
- Small Swale Drainage (SSD) indicates drainage that reaches the Small Swale. The Small Swale appears to have a high point near the Freeway alignment that sends flow both northeast and southwest to the South Saskatchewan River;
- Northeast Swale Drainage (NSD) indicates drainage that reaches the Northeast Swale. The Northeast Swale also appears to have a high point splitting flow direction. However, all flow passing or influenced by the proposed Freeway is expected to travel northeast to the South Saskatchewan River;
- Saskatoon Storm Sewer (SSS) represents any downstream drainage paths that are intercepted by the CoS storm sewer system. In contrast to Phase 1 which interacted with Saskatoons north industrial areas, Phase 2 will interact with residential and commercial land development zones, most notably the Aspen Ridge, Brighton, Briarwood, and Rosewood neighborhoods. In some cases, there is considerable storage capacity between the proposed Freeway and the CoS's system and flow may only reach the storm sewer system during periods of high-water levels;
- Local Low Point (LLP) are areas that don't have well-defined downstream drainage. It is expected that these areas do drain in the wettest years. However, because the drainage is minimal and rare there isn't good evidence of the extent. It is also possible that these locations are terminal basins that no longer drain in our current climate; and

- Beaver Creek Terminal Basin (BCTB) represents numerous low points that spill in wet years as well as several small terminal basins. Refer to **Section 5.5.1.1.5.4**, Beaver Creek Terminal Basin for further information. The area is being considered as a whole because mapping drainage paths and spill elevations in the given terrain would require topographic data with significantly more detail.

5.5.1.1.3 Altered and Dynamic Drainage

Among the challenges with mapping the Phase 2 watershed is accounting for alteration of drainage patterns and dynamic drainage. There are several scenarios where this may be occurring:

- This functional design is recommending three minor alterations to current drainage paths. These are discussed in the Recommendations section and Catchment Area Properties in **Appendix F.** Further drainage analysis during the detailed design will be required to determine the actual drainage and what if any permits are required.
- The most common alteration is caused when roads and rail cross natural drainage paths. Embankments can intercept and concentrate natural overland flow while ditches can collect and convey flow along alternate paths. The absence, presence, and location of culverts has the potential to alter both drainage patterns and storage such that a Freeway culvert may receive more or less flow than expected;
- Constructed drainage ditches are common. It can be assumed that a ditch permitted by the WSA will not significantly alter drainage patterns. However, much of the watershed lies within farmland where the practice of ditching to drain fields is common. In most cases the effect of ditching is a reduction in natural storage, but larger ditches also have the potential to alter drainage paths. Both can increase peak flow rates and the total volume reaching the Freeway culverts. While many of these ditches are considered non-compliant, the WSA will only investigate and correct them if a formal complaint is filed; and
- A dynamic drainage concept was discussed in the Phase 1 report. Only one of these scenarios was identified in Phase 2 where the construction of a new road ditch and culvert appears to have created an alternate drainage path for approximately 25 ha of runoff. This area historically drained to catchment J but the LiDAR suggests it will now follow the new ditch to catchment U and cross the Freeway twice before rejoining catchment J. If the low culvert is obstructed, flow may be split or completely redirected to the other.

During the culvert survey it became evident that the condition of upstream culverts varies greatly. Newer culverts appear to be appropriately sized and installed well. However, many older culverts are damaged and almost completely covered by the road embankment. Most inlets and outlets have significant obstruction from soil and vegetation (**Figure 5.26**). While a plugged culvert can create artificial storage, this can also cause flow to follow a new drainage path or it could overtop the road, washout the culvert, and release all the stored water at once. Both situations could increase the peak flow at a Freeway culvert.

Figure 5.26: Common example of plugged culvert (located in Catchment NN along Range Road 3044, approximately 300 m north of the preferred Freeway alignment)

While most alterations will have little to no impact on the Freeway it is possible for some to significantly change a watershed. The limitations of high-level satellite imagery and topographic data as well as limited culvert location data make it challenging to accurately identify every instance. While a culvert survey was conducted to identify culvert locations, the scope of this functional design did not allow for determination of elevations or a thorough investigation of every potential culvert location in the watershed. Subsequent trips were completed to check several key locations where the absence or presence of culverts would have a significant impact on drainage patterns. Google Earth satellite imagery from May 2012 is among the best visual record of very wet conditions in the area. It was used to help verify mapped catchment boundaries and drainage paths in questionable areas, especially those outside the detailed LiDAR coverage.

To address the potential for altered drainage it is recommended that detailed design include a more thorough investigation of the upstream catchments and consider where altered or dynamic drainage might impact the Freeway.

5.5.1.1.4 Desirable Runoff

In some instances, a roadway ditch will intercept overland sheet flow and divert it to a drainage path prior to its natural concentration point. This may block desirable moisture from reaching agricultural land immediately downstream of the roadway and can reduce the area runoff it is exposed to for infiltration. This may have been the case for much of the land between Highway 41 and Highway 5. However, the proposed Freeway right-of-way through this section is immediately east of existing Range Road 3043 (Llewellyn Road) which is already having this effect on overland watershed from the hills in the east.

Therefore, it is not expected that the Freeway will have any impact on the desirable downstream moisture levels gained from overland sheet flow.

5.5.1.1.5 Catchment Areas

Mapping of the watershed impacting Phase 2 of the Saskatoon Freeway identified 45 separate catchment areas, as shown in **Figure 5.27** and **Figure 5.28**. **Appendix F** summarizes the approximate area, stationing, and general characteristics of each catchment. It also indicates to which of the six drainage paths described above the catchment will drain. This exercise identified several key drainage features, and the following provides additional detail for each.

Saskatoon Freeway

Saskatchewan

SCALE
1: 20 000 HORIZONTAL

REVISIONS						
NO	DATE	SIGNATURE	CS	N/A	TAB NO	A1_01 (P2 N)
			PHOTO DATE	N/A	SHEET	1 OF 1
			DRAWN BY	G. FREMONT	DATE	DRAFT
			DESIGNED BY	AECOM	DATE	DRAFT

NORTH DRAINAGE FIGURE
SASKATOON FREEWAY PROJECT
PHASE 2

LEGEND
- PROPOSED ROADWAY
- EXISTING ROADWAY
- PROPOSED CITY ROADWAY
- ▨ DECOMMISSIONED ROADWAY
- ▨ DYNAMIC CATCHMENT AREA
- ☐ CATCHMENT AREA OUTLINE
- → DRAINAGE FLOW DIRECTION
- ACCESS ROAD REALIGNMENT
- OPTIONAL ACCESS ROAD REALIGNMENT
- ◆ FUTURE INTERCHANGE
- EXISTING CULVERT
- PROPOSED CULVERT
- ▨ DETENTION POND

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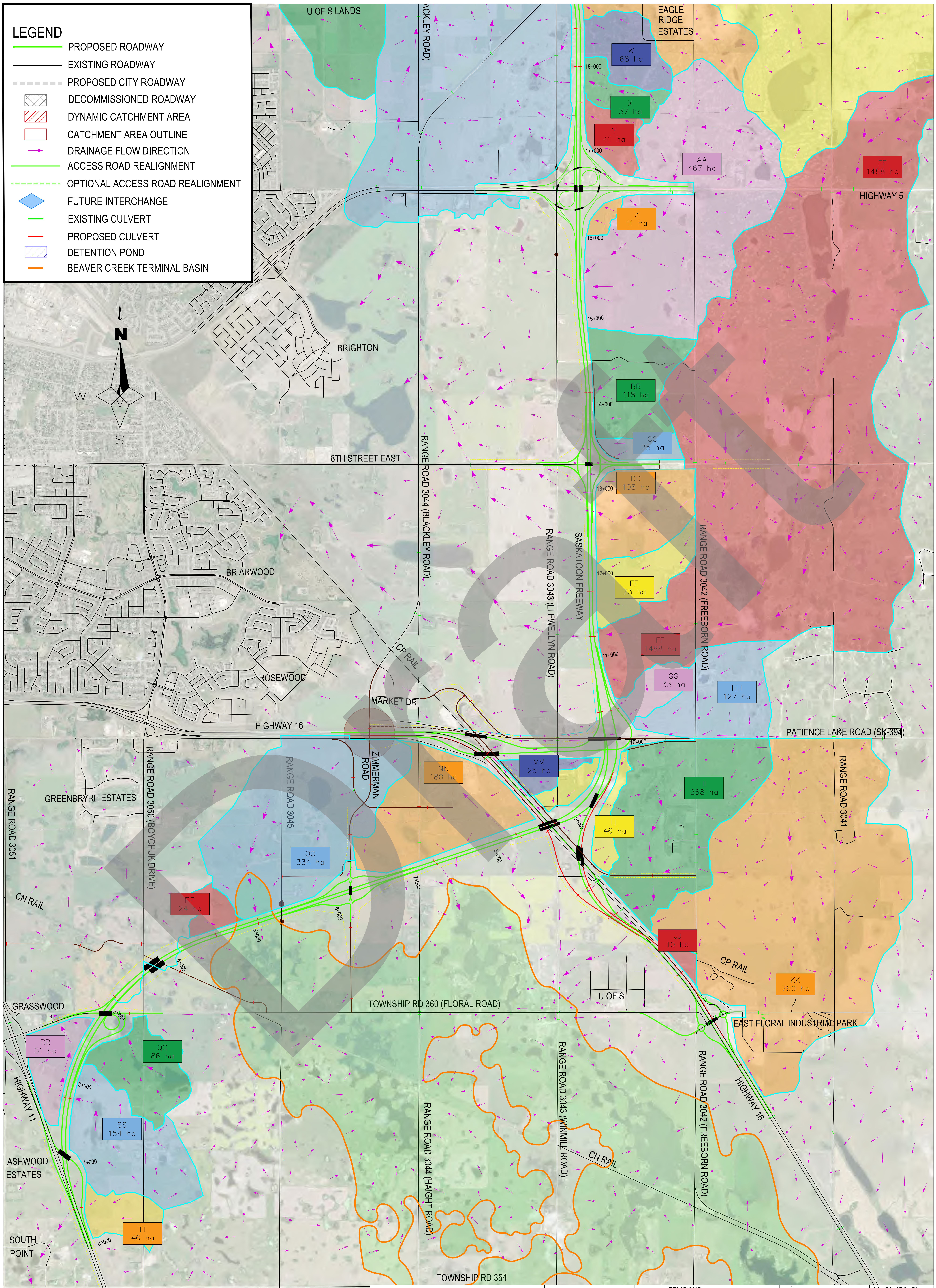

Saskatoon Freeway

Saskatchewan

SCALE
1: 5 000 HORIZONTAL
1: 200 000 VERTICAL

REVISIONS		
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PHOTO DATE	N/A	SHEET	1 OF 1
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DESIGNED BY	AECOM	DATE	DRAFT

SOUTH DRAINAGE FIGURE
SASKATOON FREEWAY PROJECT
PHASE 2

ACAD DWG:
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5.5.1.1.5.1 Northeast Swale Watershed

The Northeast Swale crosses the proposed Freeway alignment at approximately Stn. 24+100. The swale is relatively flat and during wet years much of it is covered in standing water. In dryer years it is comprised of a series of smaller interconnected sloughs and wetlands. Satellite imagery between 2002 and 2004 show the swale almost completely dry with only a handful of small, isolated sloughs. The LiDAR data doesn't cover the entire swale. Although the data is much less detailed, analysis of the NRCAN topographic data for this area suggests a high point approximately 950 m southwest of the McOrmond Drive swale crossing. A review of historic satellite imagery during wet years confirms the absence of flow across this section. Additional evidence of the high point includes a walking trail crossing the area and connecting to the Aspen Ridge trail system. This high point creates a split drainage with the southern portion flowing southwest to the South Saskatchewan River. This south section is not expected to interact with the Freeway drainage.

The north section flows northeast to the South Saskatchewan River. A ridge to the northwest limits the catchment size on that side of the swale with the majority of the runoff coming from the south, east, and northeast. The 950 m section southwest of McOrmond Drive has a relatively small catchment. The section between McOrmond Drive and the proposed Freeway alignment receives inflow from much of the Aspen Ridge development and the U of S Lands East Management Area. Flow from this area follows a constructed ditch to a retention/detention pond in Aspen Ridge before draining to the swale. A large catchment to the east flows north across Highway 41 where it is intercepted by a well-defined drainage path. This path flows southwest and drains to the Northeast swale at roughly the same location as the proposed Freeway crossing. This path intercepts additional flow from the south approximately 500 m before the swale. The flow from the south also comes from a large catchment; much of which crosses, then follows a constructed drainage ditch roughly parallel to the Freeway alignment. Refer to **Section 5.5.1.1.5.3** for detailed discussion on this ditch.

The CoS provided a high-water level of 497.0 meters above sea level (masl) for the Northeast swale. It is measured at a monitoring station between McOrmond Drive and Range Road 3045. However, this elevation is based on the cities own survey control, referred to as "Citywide Local". It is believed that this control is based on older monuments that reference the CGVD28 vertical datum. As the LiDAR data is based on the modern CGVD2013 datum, a correction factor is needed. A subsequent survey was completed to determine this. A GPS configured to the CGVD2013 datum was used to tie in a monument provided by the CoS and a difference was found to be 0.22 m resulting in an adjusted high-water level of 496.78 masl.

Analysis of the LiDAR data along the swale indicated a down stream high point just north of Township Road 374. The spill elevation for this high point was found to be approximately 496.44 masl which is 0.34 m below the adjusted high-water level provided by the CoS. The CoS's monitoring station is approximately 2 km upstream of the high point. Considering a hydraulic grade line over this distance and potential headwater resulting from a narrow drainage path and thick vegetation, the 0.34 m difference seems logical. For the Northeast swale crossing a conservative high-water level estimate of 497.0 masl was applied.

5.5.1.1.5.2 Small Swale Watershed

The Small Swale crosses the proposed Freeway alignment at approximately Stn. 26+800. Similar to the Northeast Swale, the Small Swale is also relatively flat and analysis of the LiDAR data indicates a high point creating split drainage. The proposed Freeway alignment crosses the swale at this high point. The south section flows south along the swale through culverts along McOrmond Drive and what is now referred to as South Grid Road (formally an extension of Central Avenue). From there, flow drains to the South

Saskatchewan River. The north section flows north along the swale then through a culvert on Range Road 3050 before draining into the South Saskatchewan River.

The catchment areas for both sections of the Small Swale are relatively small and consist primarily of natural grassland with some agricultural lands and a few buildings. The swale itself occupies a large portion of the catchment and is made up of numerous interconnected sloughs and wetlands that provide storage. It is expected that the swale only drains in wetter years and satellite imagery indicates that it has been almost completely dry for some years.

With the Freeway crossing at the high point and both sections having grade down to the river it is unlikely there would ever be any significant standing water at the Freeway. Using the LiDAR derived topography, local spill elevations on both the north and south sides were estimated to be around 489.1 masl. These may be conservative given that LiDAR can't see through thick vegetation such as that found in wetlands. Given the small catchment areas feeding both sections of the swale, significant headwater is also unlikely. The elevation of the high point is 489.4 masl and this was used as a conservative high-water level estimate. A detailed topographic survey of the downstream spill points and culverts is recommended for the detailed design phase. It would allow for determination of a more accurate high-water level that could in-turn cut costs with a smaller embankment.

5.5.1.1.5.3 Proposed Drainage Ditch and Major Detention Pond

The proposed Freeway will interact with a considerable portion of the Northeast Swale's watershed, specifically to the southeast. An existing drainage ditch has been established along the natural drainage path and conveys flow from approximately 1700 ha of the watershed. The Saskatoon Freeway will impact the ditch and given the environmental sensitivity of the area it is recommended that the detailed design consider options for managing this flow. In the absence of control structures such as ditch blocks it is expected that the Freeway ditch will intercept flow from this existing drainage ditch and convey it directly to the Northeast swale. Containing the flow within the Freeway ditch will required further analysis during detailed design and due to the potential for substantial peak flows, may not be desirable. The following is justification for design of a more substantial drainage ditch and detention pond along the east side of the proposed Freeway between 21+100 and 23+100. It is expected that this will require collaboration with local stakeholders and the Water Security Agency to formally establish a separate right-of-way and drainage ditch outside of the provincial highway right-of-way. Advantages include better opportunities for other environmental enhancements such as associated wetlands and boundaries, watershed enhancement and possible wetland compensation.

The proposed drainage ditch will replace an existing ditch that follows the natural drainage path. Much of the existing ditch falls within the proposed Freeway right-of-way with the balance being within 200 m. Flow crosses the proposed Freeway alignment from west to east at approximately Stn. 21+100 then continues north roughly 2.2 km where it joins one of the Northeast Swale's natural tributaries. Upstream catchments for this ditch are relatively small but they originate in the hills to the southeast and the grade will encourage increased runoff and faster time of concentration. Several well-defined drainage paths convey this flow across the proposed Freeway alignment from east to west before turning north and combining into a common drainage path. The combined flow passes through a culvert on Township Road 372 (Agra Road) and continues north. At the south edge of NW 16-37-04-W3 flow enters the existing drainage ditch. The WSA indicated that this is not a permitted ditch and was likely constructed by local landowners between 2009 and 2012 (significant flood years). It appears that it was intended to concentrate the natural drainage path into a narrow ditch with improved flow.

The goal of this functional drainage design is to maintain existing drainage patterns. However, flow from catchment U and the upstream dynamic catchment area currently follow Township Road 372 (Agra Road) west across the Freeway to the culvert described above (roughly 700 m west of the Freeway right-of-way). From there, flow only travels 350 m north before re-entering the right-of-way and subsequently crossing back to the east at Stn. 21+100. It is recommended that the runoff from catchment U and the upstream dynamic catchment area be captured by the east Freeway ditch. Doing so does not significantly alter the downstream drainage paths but does prevent flow from "zig-zagging" back and forth across the Freeway.

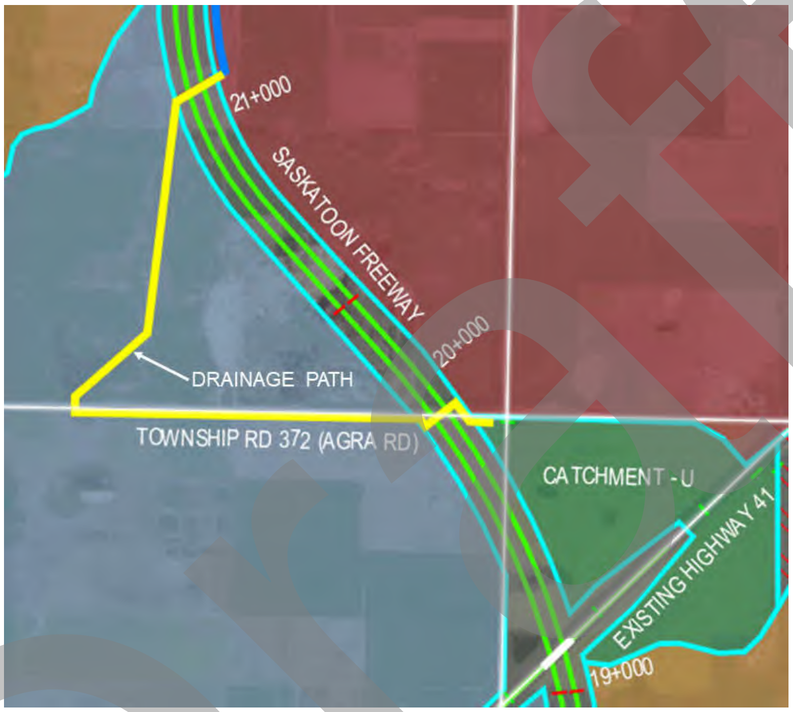


Figure 5.29: Drainage path "zig-zagging" across the Freeway

The proposed culvert at Stn. 21+100 will handle runoff from the Freeway right-of-way between Stn. 16+600 and Stn. 21+100, the north portion of the Highway 5 interchange, and catchments T, U, V, W, X, Y, and Z. Given the increase in impermeable surface area, hillside runoff, and well-defined drainage paths, the peak flows could be substantial. Also, the proposed profile includes a flat section of highway between Stn. 20+600 and Stn 21+800. It is unlikely that the small existing ditch could handle this flow and a 1.2 km flat section is not an ideal location for a detention pond. At approximately Stn 22+400 this concentrated runoff will also need to navigate the proposed Highway 41 interchange and Blackley Road connection before joining the Northeast Swale tributary.

Given the numerous factors described above it is recommended that a more substantial drainage ditch be constructed along the east side of the Freeway between Stn. 21+100 and Stn. 22+400 where a major culvert crossing will be required under the re-aligned Highway 41. A large detention and settlement pond is also recommended on the north side of the re-aligned Highway 41. NW 21-37-04-3M includes the natural confluence of runoff from the south and a tributary from the east. The natural drainage path flows into the Northeast swale approximately 1 km west of the confluence. The tributary caries flow from a large watershed, all of which crosses re-aligned Highway 41 at multiple locations. The proposed ditch and detention pond have several advantages:

- Containment and control of increased peak runoff;
- Manages drainage through the 1.2 km flat section;
- A large shallow detention pond allows for construction of wetlands that will compensate for lost wetlands and storage while helping to filter runoff before it reaches the sensitive Northeast swale;
- A throttled detention pond will allow desirable water to reach the swale without the potential negative impacts of increased peak flows; and
- From a constructability standpoint the proposed Blackley Road overpass and Highway 41 interchange will likely require fill that can be borrowed from this location. Further analysis will be required during the detailed design stage.

5.5.1.1.5.4 Beaver Creek Terminal Basin

Catchments II, JJ, KK, LL, MM, NN, and OO drain across the Freeway into a series of large local low areas. The entire area is characterized by pothole terrain which includes several large shallow sloughs and hundreds of small, isolated wetlands. These local low areas are part of a poorly drained area that could be considered part of the Beaver Creek watershed. However, it is very unlikely the area will ever actually drain to Beaver Creek as a height of land in Section 17-35-04-W3 prevents the area from spilling. To spill, water would need to rise 4-5 m to an elevation of nearly 510.0 masl and flood an area of roughly 2,700 hectares. Satellite imagery from the wetter years of 2012-2015 show no significant increase of water levels for this area ("significant" in comparison to the 4-5 m increase required for water to spill into Beaver Creek). The area can therefore be considered a closed or terminal basin with no natural outlets. Its only natural means of reducing water levels are evaporation and infiltration. The WSA confirmed this classification and indicated that it is comprised of several smaller basins. They were not aware of any formal name for this basin. For the purpose of this report the overall area will be referred to as the "Beaver Creek Terminal Basin".

The entire basin, filled to its spill elevation, would only extend to the proposed alignment in one location, around Stn. 5+000. While water levels of the entire basin are never expected to reach this point, there is a large slough immediately south of the Freeway right-of-way. This slough drains south across Floral Road and CN Rail to a larger slough within the terminal basin. The slough straddles Range Road 3045 and existing culverts could not be confirmed along this section of the grid. Analysis of the LiDAR data indicates a road top spill elevation around 507.9 masl. This corresponds closely to satellite imagery from 2012 which shows a high-water level around 507.7 masl. The proposed Freeway profile elevation of 509.94 masl puts the road surface well above both the spill elevation and high-water level.

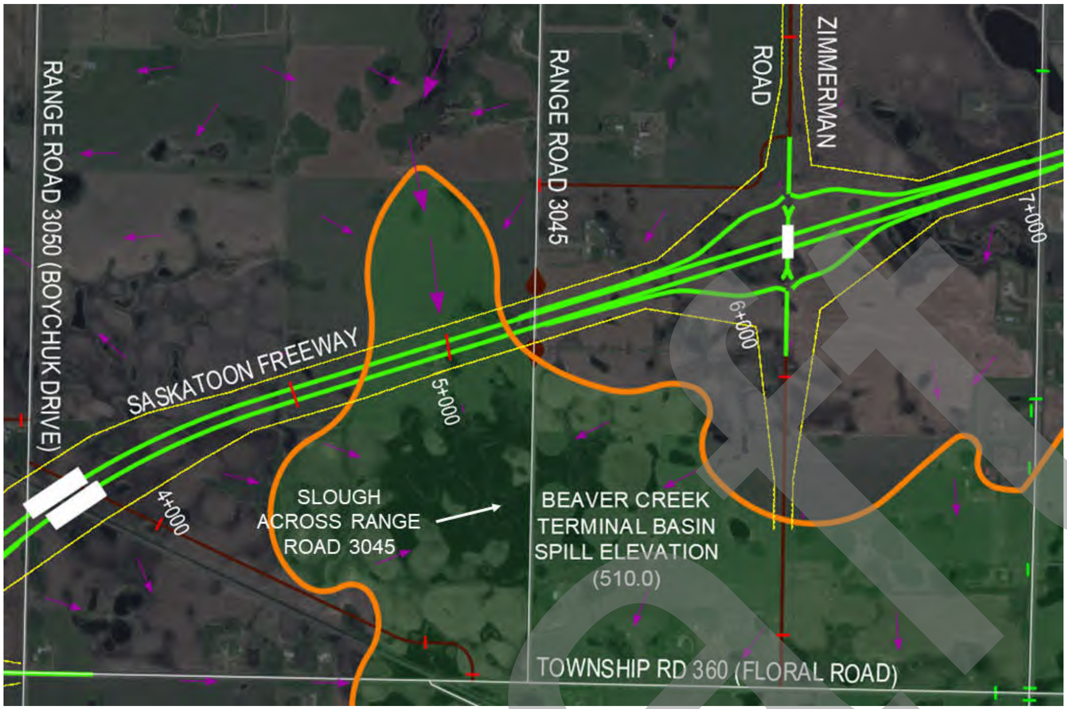


Figure 5.30: Slough extending across Range Road 3045

This area is also characterized by numerous farm and acreage properties. The WSA indicated that funding for flood mitigation was provided to several landowners under the Emergency Flood Damage Reduction Program. They also indicated that The CoS, RM of Corman Park, and several other partners are working on the "Southeast Concept Plan" for this area. It is a high-level plan and the WSA was not aware of any data relevant to the Freeway design. Additional runoff flowing to these basins could increase flood risk around the smaller basins. Approximately 6.9 km of Freeway, interchanges at Highway's 16 and 394, and overpasses for Zimmerman and Floral Roads will all drain into areas of this terminal basin. Asphalt will increase the impermeable surface area while grading will eliminate some of the natural storage; both resulting in an increase to peak flows and the total runoff volume.

- Flooding due to an increase in peak flow can be mitigated with detention ponds or culverts sized to throttle flow to a more natural rate;
- Mitigating flooding due to an increased volume can be achieved by creating retention ponds to intercept and store the increased runoff. Retention ponds are naturally drained through infiltration and evaporation. The effectiveness of both processes is relative to the area covered by the pond. Therefore, large shallow ponds are more effective than deep ponds; and
- Another way to reduce both the peak flow and total volume is to design ditches to the tolerable minimum grade (0.05% outer, 0.10% median). This will reduce peak flow by increasing time of concentration. It will also allow more time for evaporation and infiltration to reduce the total volume.

Given the increased risk of flooding in terminal basins and the history of flooding in this area it is recommended that the detailed design includes some, or all, of these flood mitigation measures. Borrow pits used during construction can be designed as both detention and retention ponds.

5.5.1.1.6 Proposed Culvert Locations

Culverts listed in the following tables are required to maintain existing drainage paths. Several additional culverts were required to maintain the Ministry's standard for maximum culvert spacing of 800 m and have been noted as such. All culverts to be designed according to the Ministry's Hydraulics Manual.

All stations are approximate and subject to change in detailed design. Because the roadways are double lane with median ditches, most locations indicate a pair of culverts (one under each embankment). Some locations will also include culverts under interchange ramps and access roads.

The major and minor culvert sizes are an indication of the expected flow they will need to pass. Generally, a minor culvert will only pass runoff from the roadway and a relatively small local catchment area. Minor culverts are a minimum 800 mm diameter. Major culverts are expected to be around 1,500 mm diameter or multiple 800 mm culverts where cover is an issue. Major culverts are required when they must pass a significant existing drainage course, large or combined catchment areas, or runoff from more than 1600 m of roadway.

Some sections of the Freeway may require back grading or blocking of ditches. Points of Vertical Intersection (PVI) in the proposed Freeway profile do not always align with the natural high and low points within the catchment being crossed. An example is the section between Highway 5 (Stn. 17+000) and the beginning of a flat section (Stn. 20+600). The continuous grade means that maintaining a standard ditch depth could capture flow from all adjacent catchments and convey it all north, along the Freeway ditch. There are two common ways to address this:

- In well graded areas where there is sufficient downstream grade the culverts can be set bellow the minimum ditch depth. This allows the ditches to be graded up from the culvert to the natural catchment boundaries in both directions such that one side is graded to flow opposite the roadway (back grading); and
- In poorly graded areas where there is limited downstream grade the culverts can be set near the catchment boundary with a ditch block at the natural catchment boundary. A ditch block is simply material built up in the ditch to divert the direction of flow such that runoff is conveyed through the culvert rather than continuing to follow the road ditch.

Culvert and drainage details along the Saskatoon Freeway and re-aligned Highway 41 are presented in **Figure F1**, and **Figure F2** (**Appendix F**). Refer to **Section 5.5.1.1.2** for more detail regarding the drainage paths. Details regarding the individual catchments are also provided in **Appendix F**.

The complexity of the Highway 16 interchange and numerous changes to the existing Highway 16 alignment required separate stationing for each embankment. This made it difficult to indicate the location of proposed culverts. Therefore, **Table F3 (Appendix F)** represents distance from Highway 16's intersection with the proposed Freeway alignment. This table includes the proposed adjacent service road on the northeast side of Highway 16 and connectors.

Access roads represent the smaller roadways that will be required to improve or maintain access to existing property and infrastructure that may be cut off by the Freeway as well as CoS and Municipal roads that connect to the Freeway. Separate catchment areas were not delineated for culverts on these roadways. The roads are shown in dark brown on **Figure 5.27** and **Figure 5.28** and include approximate culvert locations. **Table F4 (Appendix F)** presents details regarding culverts along proposed access roads and connectors.

Table F5 (Appendix F) presents the estimated number of culverts required to transfer flow from inside the interchanges to the downstream ditches. Culverts listed in the above tables are not included. All interchange culverts are expected to be minor in regard to size.

5.5.2 Interchange and Freeway Design

From a drainage perspective, the freeway design consists of two typical cross sections:

- Rural – road surface runoff is collected and conveyed by median and outer ditches; and
- Urban – road surface runoff is directed to catch basins by curbs or barriers then conveyed along storm sewer pipe which outlet into ditches.

5.5.2.1 Rural Cross Sections

All the main freeway, portions of the interchanges, and service roads will have a rural cross section. In addition to conveying road runoff, the ditches also intercept existing drainage paths. Ditches are graded so that existing drainage paths are maintained. Flow in the upstream and median ditches will cross the freeway at the proposed culvert locations. The culverts and downstream ditches outlet into existing low areas. The following standards were key design considerations:

- Saskatchewan Highways standard Plan 21010 indicates a desirable ditch depth ≥1.2 m; and
- Table SKS 2.2.8-A.1 from the Saskatchewan Highways Geometric Design Guide Supplement (Interim) indicates the minimum ditch grades, as presented in **Table 5.4**.

Table 5.4: Minimum ditch grades

	OUTER DITCH	MEDIAN DITCH
Desirable Minimum	0.10%	0.20%
Tolerable Minimum	0.05%	0.10%

A detailed review of the Freeway profile from a drainage perspective was not completed for Phase 2. It can be expected that a detailed design will want to review profile elevations to find the most cost-effective balance between height of embankment and drainage considerations. Therefore, reviewing ditch profiles for external drainage will be left for detailed design when the development of detailed surface models will simplify calculation of ditch elevations.

From a drainage perspective, the key profile consideration is ability to drain the low points in ditches. If an embankment is set too low the required minimum ditch depth may result in a section of ditch that cannot drain. There are several ways to address this and some changes to the following variables may also allow the profile to be refined for construction cost savings:

- Raising or moving points of vertical intersection (PVI);
- Using tolerable minimum grades;
- Allowing for some standing water in ditches;
- Purchasing land and draining to lower detention/retention ponds rather than overland drainage; and
- Improving grid road ditches or cutting new overland drainage ditches.

5.5.2.2 Urban Cross Sections

Portions of the interchanges will have curbs or barriers that direct runoff to catch basins. The catch basins are connected to storm sewer pipe which will direct flow to the nearest downstream ditch. The interchanges with urban cross section (curbs/barriers) will include catch basins and storm pipes with outlets to the freeway ditches.

Design and spacing requirements for catch basins fall under TAC Section 2.2.8.3. Subsection 6 indicates that "The spacing of catch basins and drainage inlets is based on the lateral spread objectives described earlier, and vary in accordance with roadway width, longitudinal grades, and the size and nature of the areas that contribute surface drainage to the roadway". These requirements result in catch basin spacing typically in the range of 50 m to 150 m."

5.5.2.3 Drainage Outlets

The six drainage paths described in **Section 5.5.1.1.2** indicate where each section of the freeway or interchange will drain to. More detailed drainage paths are discussed in both the catchment area properties and culvert details in **Appendix F**.

5.5.2.4 Detention/Retention

The goal of runoff detention is to maintain the existing peak flow for a given drainage path. Detention is generally achieved by throttling a drainage outlet using an appropriately sized culvert or other hydraulic structures. The culvert is sized to allow the pre-development flow to pass while additional flow is backed up (detained). Although not a Ministry standard detention/retention may be looked at in certain areas to mitigate drainage issues. For this project, flow can be detained in several locations:

- Upstream outer ditches and median ditches. Ditch blocks can be used to step the flow down and create multiple points of detention;
- Within interchange ramps;
- Borrow pits (dugouts) with access to a lower ditch;
- Ponds constructed in parcels of land that have been cut off by the freeway and are not suitable for future development; and
- Expanding the capacity of existing natural wetlands and water bodies.

In areas where detained flow may result in damage to infrastructure, the use of overflows is recommended. An overflow will cap the detention at a certain elevation and allow all additional flow to pass. Overflows need to weigh the infrastructure being protected against the risk of damaging downstream infrastructure.

During correspondence with the WSA they indicated that *"Along with detention (active) type facilities, it is recommended the design incorporate retention (permanent) type facilities to counteract lost natural storage due to infilling"*. Retention ponds do not have an outlet, so storm water is stored (retained) for a longer duration. Capacity is restored through evaporation, infiltration, and in some cases, it may be pumped. Borrow pits (dugouts) are the most common opportunity to create stormwater retention.

The specific location of detention and retention ponds is subject to numerous factors. Many will not be determined until the detailed design phase. For example, the location and size of borrow pits that can be used for both detention and retention will be based on the cut/fill and mass haul designs, and not necessarily for stormwater storage requirements.

5.5.3 South Saskatchewan River Outlet

The east side bank of the South Saskatchewan River is approximately 15 m lower than the west side bank and features well established trees/vegetation. The proposed Freeway profile slopes down towards the river at varying grades for approximately 4.2 km and the ditch could divert substantial flow directly to the river. However, doing so would not maintain natural drainage paths and would require a major river outfall structure to manage peak flows. Maintaining the natural drainage path for this area would result in only a 500m section of Freeway draining directly to the river (from Stn. 28+100 to Stn. 28+600). The surrounding Catchment A is generally graded parallel to the Freeway. Justification for this is explained in **Section 9.4** Drainage Recommendations. Incorporating stormwater detention along the Freeway ditch in the form of stepped ditch blocks can ensure that the increased runoff can be managed by the River outfall.

The riverbank is steep, dropping roughly 14 m in 65 m (22% grade). While the risk of slope failure due to erosion is less than the west riverbank it remains important to consider and mitigate bank erosion caused by peak flows concentrating in the Freeway ditches. As discussed in the Phase 1 assessment of the west riverbank it is recommended to use the existing natural erosion protection along the banks provided by dense vegetation and avoid construction of a major drop structure. The Freeway ditch will intersect the riverbank at an elevation of approximately 486 m. Vegetation extends to an elevation of approximately 481 m on both sides.

5.5.3.1.1 Advantages of this design:

- Diverting the flows to these natural drainage paths will significantly reduce the cost of constructing a river outfall compared to a major structure;
- The vegetation will capture sediment;
- For storm events more severe than the design return period, flow is directed away from the bridge structure;
- The design should result in more consistent runoff that would promote more vegetation growth and increase the natural erosion protection;
- Trees and vegetation will provide a more naturalized appearance than an engineered structure of concrete or riprap; and
- The ditch blocks discussed below will also provide a crossing for the multiuse pathways.

5.5.3.1.2 Detailed Design Considerations:

- Erosion protection is required in the ditches as they approach the riverbank;
- Rip-rap and geotextile is recommended to be added to the standard ditch section;
- Areas of the steep riverbank section without heavy vegetation would be protected by means such as flexible concrete block mats that are anchored to the bank and allow vegetation to grow between the blocks to provide further anchoring;
- Culverts to direct flow from the median ditch to both outer ditches. This provides redundancy should one be blocked, to provide further protection to the Freeway. Downstream from the culverts, the median will have a ditch block to prevent flow down the riverbank near the bridge;
- In the outer ditches, ditch blocks with culverts will attenuate the flow before it drops down the riverbank. They will limit the peak flow and use the Freeway ditches as detention storage. The ditch blocks will be armored, and the top will provide a spill crest for extreme storm events. The crest elevation is set to ensure roadway freeboard would not be exceeded; and

- Pads and blocks to disperse flow before it reaches the natural vegetation. This will prevent major flows from cutting into the bank.

5.5.3.2 Regulators and Stakeholders

5.5.3.2.1 Water Security Agency

The WSA provided additional information and clarification for several areas of interest along the Phase 2 alignment.

- Regarding Aspen Ridge Neighborhood drainage to the Northeast Swale: The WSA provided several documents related to drainage into the Northeast Swale. Key points include:
    - The WSA concluded that all drainage works for the Aspen Ridge development are within urban boundaries and water management continues along its natural outlet being the Northeast Swale. Therefore, a drainage works permit was not required for the development; and
    - The WSA shared a CoS October 2013 report entitled “Aspen Ridge Neighbourhood Impact on the Northeast Swale Stormwater System” which indicated that the development would have minimal impact on drainage through the swale. The CoS report also recommended increasing the capacity of grid road culverts where the Northeast Swale crosses Range Road 3045 and Township Road 374 within the municipality. AECOM’s desktop review and site survey confirmed the installation of new culverts at these locations. It should also be noted that since the CoS report in 2013 the extension to McOrmond Drive was constructed across the Northeast swale just west of Range Road 3045 and it also has culverts to accommodate flow within the swale;
- Regarding the constructed drainage ditch running along the east side of Sections 16 and 21 TWP 37 RNG 4: The WSA confirmed that this ditch follows a natural run. The ditch has improved the drainage capacity of the channel and reduced flooding on the adjacent lands. Construction of the ditch was not permitted, and it was likely constructed by the local landowners between 2009 and 2012 (2011 and 2012 were significant flood years in the area). The new highway will be required to maintain these natural drainage patterns, but it will not be required to provide positive drainage to local lands. It is desirable that a local drainage authority be established to provide oversight to the establishment of a new and separate channel; and
- Regarding the Beaver Creek Terminal Basin described in **Section 5.5.1.1.5.4**: The WSA confirmed that the area is a closed or terminal basin and has several smaller basins within it that have experienced flooding in the past. The WSA has provided funding to several landowners to construct flood protection works under the emergency flood damage reduction program (EFDRP). The flooding issues ebb and flow with the wet years. The CoS, RM of Corman Park, and several other partners are working on the “Southeast Concept Plan” for this area; it is very high level.

5.5.3.2.2 City of Saskatoon

The CoS provided conceptual crossing locations for utilities including stormwater. The conceptual plan also suggested locations for future stormwater management ponds. While this information was considered the facilities are not yet constructed and some may not be until some time after the Freeway's construction. Since these conceptual locations were provided the original Freeway alignments have been adjusted in some locations. Further, the objective of this functional drainage design is to maintain existing drainage while meeting maximum culvert spacing and ditch design standards. Aligning the Freeway's drainage features with the CoS's proposed locations was not within the scope of this functional design but should be completed during detailed design. The CoS's proposed stormwater crossing are noted in both the culvert and catchment tables.

For Phase 2, correspondence with the CoS included the following:

- The Aspen Ridge development has a substantial stormwater ditch feeding a detention pond that spills into the Northeast Swale. In terms of existing data and analysis the CoS was only able to provide a High-Water Level on the Northeast Swale;
- The east side of Saskatoon's Evergreen Neighborhood borders agricultural land that drains to the Northeast swale. The CoS confirmed that runoff from Evergreen does not flow northeast into the Northeast Swale. Rather, it drains to a wet pond which then drains to the river. They also indicated that there is a channel through the berm along Fedoruk Drive that allows some spillover from the ponding water being stored within the adjacent park space. This pond and "park space" are believed to be part of the Northeast swale but are in the southwest section that drains west to the river. Flow from Evergreen should not affect drainage across the Freeway. The CoS also indicated that Evergreen intercepts runoff from some of the agricultural land to the southeast (refer to Catchment G boundary); and
- Currently, runoff from catchments QQ, RR, and SS appear to be contained in Local Low Points. Some of these low areas will be filled by Freeway embankment so it was important to understand where the water would go if there is no storage compensation. LiDAR suggests it would flow north;
    - The CoS confirmed that Greenbryre Estates is not connected to the CoS storm sewer system. It manages storm water internally via ponds. Online information suggests that these ponds are also used for irrigation of the golf course; and
    - The CoS is not aware of any culverts along Highway 11 between Stonebridge and Greenbryre Estates and future high level servicing plans don't have the area draining to Stonebridge. For this area, the only other potential entry point into the CoS storm system would be the Boychuk Road/Highway 16 interchange.

5.6 Bridge Concepts

5.6.1 Saskatchewan River Bridge Concepts and Functional Designs

The alignment crosses the South Saskatchewan River to the southeast of the Highway 11 interchange with a profile that lowers from the northwest to the southeast at 1.755% grade. As shown on **Figure 5.31**, the profile requires a cut on the northwest bank in order to accommodate the grade lines. The cut will reduce the height of driving force on the northwest bank, but disturbance to the slope is an imperative geotechnical consideration.

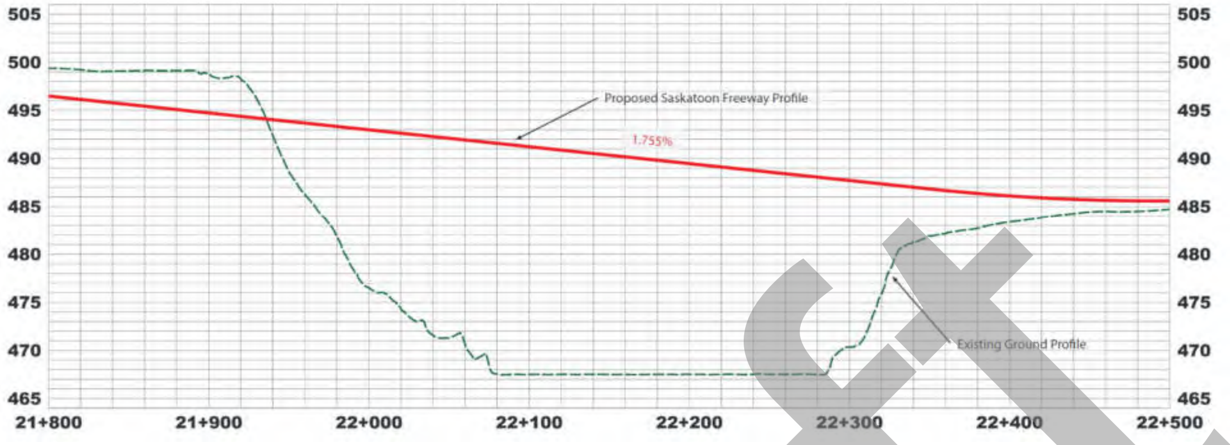


Figure 5.31: South Saskatchewan River Crossing – Gradeline Profile

The laning requirements are to include at initial phase, a minimum of 3-lanes of traffic in the eastbound direction and 2 lanes in the westbound direction. The ultimate configuration based on the Travel Demand Model requires five lanes in both the northwest and southeast direction. The typical initial and ultimate bridge cross sections for the Steel plate Girder and Cable Stay options are shown in **Figure 5.32** and **Figure 5.33**, respectively. Staging details are included in the final project report.

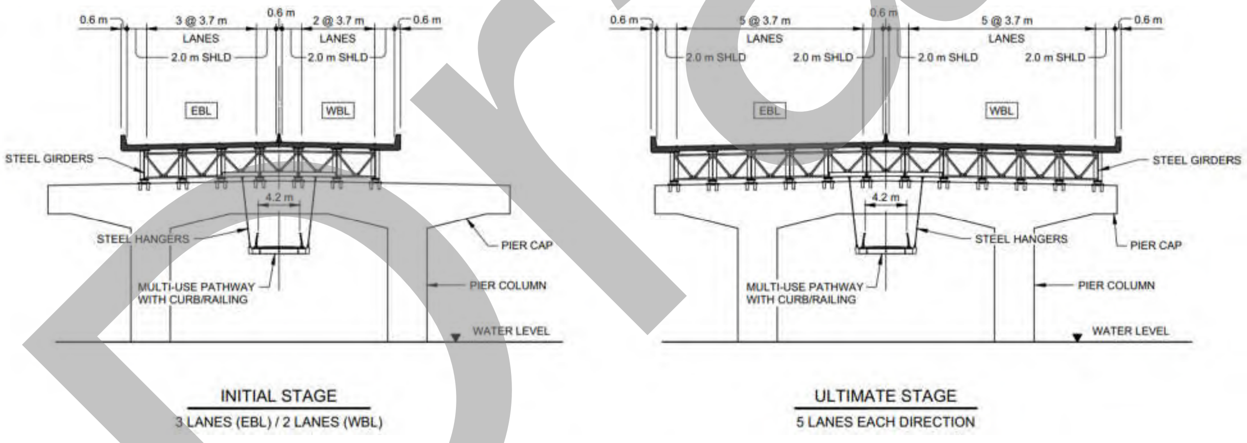


Figure 5.32: Typical initial and ultimate bridge cross sections (steel plate girder)

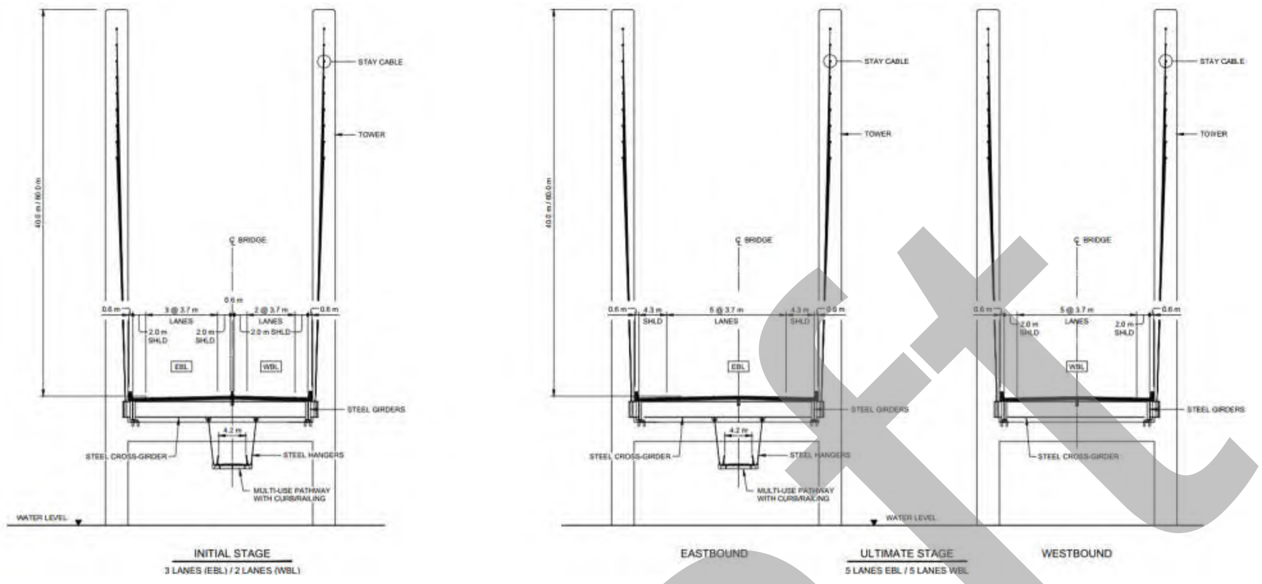


Figure 5.33: Typical initial and ultimate bridge cross sections (cable stay)

The complexity of the river crossing, geotechnical stability risk and limiting environmental factors led to the undertaking of a bridge option study. SNC-Lavalin engaged Leonardt, Andra and Partner (LAP) to complete the bridge option study. Phase 1 of the study included consideration of 15 bridge types detailing the layout and cross section configuration of each. A key driver of geotechnical stability risk and environmental impact is related to the construction. The Phase 1 report also included general information in regard to the intended construction approach. The full study completed by LAP is documented in **Appendix G**.

Engaging the Ministry in evaluation of the options, as noted in subsequent MAE section of the report, the study was consolidated to 4 of the 15 bridge types including:

- Option 2: Steel Composite Girder Bridge;
- Option 6: Through Arch Bridge;
- Option 10: Unsymmetrical Cable Stay Bridge; and
- Option 14: Single Tower Cable Stay Bridge.

Progressing the bridge option study through Phase 1, LAP completed further assessment of the selected bridge options including further structural design, assessment of structural loading and foundation reactions. This information was provided to the project team in order to evaluate foundation options and further defining comparative deep and shallow foundation options for the bridge types. Further explanation of construction means and methods and a matrix of maintenance and durability requirements for each bridge type were also provided. LAP's Phase 2 report including all details of the four bridge types is included in **Appendix G**.

A bridge option workshop was developed and facilitated, including members of the project team and Ministry representatives, in order to review the 4 bridge types. Further details of the MAE process that was followed is provided in subsequent sections of the report. The result of the bridge option workshop concluded 2 bridge types being considered for detailed capital cost estimation. The bridge types are visually depicted in **Figure 5.34**.

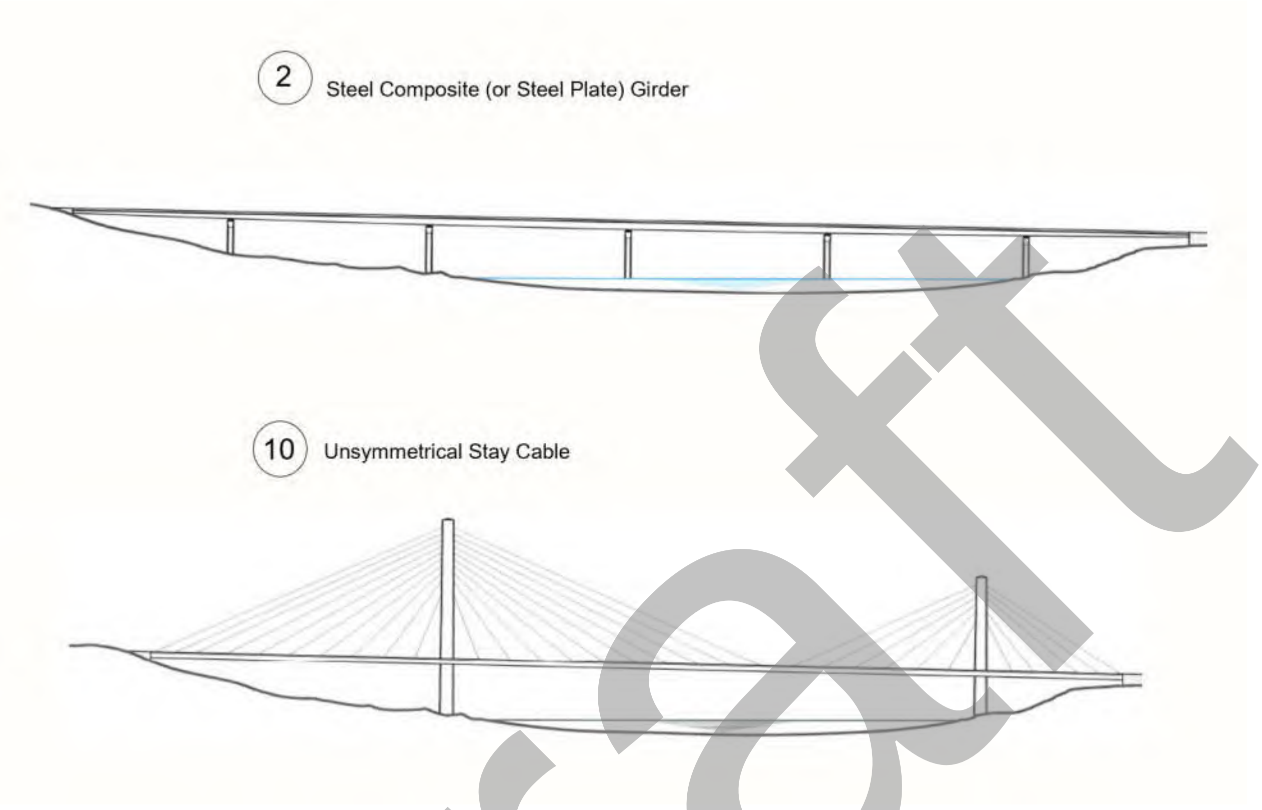


Figure 5.34: Concluded Bridge Types from Phase 1 of the Bridge Option Study

A detailed bill of quantities for each of the bridge type was developed by LAP and presented to SNC-Lavalin for bottom-up cost estimation. The bottom-up cost estimate included, but not limited to, consideration of construction means and methods, materials, equipment, labour, indirect costs and schedule to arrive at final cost for each option. Through the process of quantity definition and assignment of costs, it became apparent that two viable tower options should be considered for the Unsymmetrical Cable Stay Bridge (Option 10) which included steel tower and concrete tower options.

Both the Steel Composite Girder Bridge (Option 2) and the Steel Tower Unsymmetrical Cable Stay Bridge (Option 10) arrived at similar total estimated capital costs. The Steel Composite Girder Bridge (Option 2), being considered the standard bridge type, is escalated in capital construction cost due to the extensive environmental permitting and schedule impacts related to work in the river as well as geotechnical stabilization of the slope as a result of the required pier within the riverbank. Public input on the two bridge options demonstrated preference for the unsymmetrical Stay Cable bridge type. It was subsequently decided to retain both bridge types through to completion of the functional design phase. The Ministry will undertake further assessments in the future to determine how to proceed with one or two bridge types depending on the ultimate delivery model: DBB or DBFOM.

A geotechnical hazards investigation has been completed within the river valley since Phase 1 and is included in **Appendix H** The scope of additional geotechnical investigation is dependent on the river bridge crossing type and as such will be completed at a future date, potentially as part of the detailed design process.

5.6.2 Interchange Bridge Concepts

The development of the interchange bridge concepts was governed by roadway vertical and horizontal alignments. Vertical clearance for the roadway overpasses allows for the use of prestressed concrete (NU girders) or steel girder bridges with a concrete deck, waterproofing membrane and asphalt wearing surface.

The locations of the abutments, piers, straddle bents and MSE retaining walls is dictated by the horizontal alignment of the roadway with respect to the underlying roadway or railway while providing the required lateral clearances.

Constructability issues for bridges located on curved alignments and/or with variable deck widths was considered as part of the development of the bridge concepts. Generally, the use of variable girder spacings, variable deck overhangs and varying the skew angle of adjacent spans would allow for the bridge deck to accommodate the horizontal alignment of the roadway. For bridges on tighter curves, the use of curved steel girders may be necessary.

For highly skewed bridges, the use of straddle bent piers will be necessary to conform to the horizontal clearances specified in the Ministry standards. These highly skewed bridges will also require the use of retaining walls to avoid embankment slopes from spilling onto the underlying roadway. These retaining walls will likely consist of MSE walls running parallel to the underlying roadway and turning back to run parallel to the face of the abutments. Geotechnical input will be necessary to address any issues with the slope stability and settlement of the embankment fills.

5.7 Property Acquisition

As part of the Functional Design process, a new right-of-way will be determined to accommodate the Saskatoon Freeway, interchanges, and associated improvements. Right-of-way widths will at a minimum adhere to the Ministry Standard Plan 21009T and 21010, and will be wide enough to accommodate roadway grading, drainage plus 2-3 m on each side for maintenance purposes. In Phase 2, interchanges are closely spaced with entrance and exit lane tapers, lane drops between interchanges and high fill areas. It is unlikely there will be many consistent width right of ways between interchanges, rather it will be a variable width right of way. A standard 107.4 m right-of-way (101.4 m for a four-lane divided highway with 32 m median + 6 m for maintenance) will be considered as a minimum. Additional property requirements have been identified at Highway 5 to allow for potential slope flattening and at the Central Avenue interchange to allow for the flexibility of constructing a loop ramp in the SE quadrant. Efforts have been made, where appropriate at key locations, to minimize the extent of property required to accommodate the recommended plan. The Ministry will negotiate the transfer of all necessary properties prior to construction. Additional widths for a utility corridor have been provided as discussed in **Section 6.2**.

5.8 Active Transportation

Cyclists and pedestrians will not be accommodated on the Freeway. There are limited opportunities to provide Active Transportation for pedestrians and cyclists along the Saskatoon Freeway or at the complex system interchanges (highway to highway). The cross-sections do not show multi-use paths at highway to municipal road interchanges because the active transportation network is not yet developed in the areas adjacent to the freeway:

- Central Avenue;
- Blackley Road;
- 8th Street; and
- Zimmerman Road.

The staging and details of the multi-use paths should be incorporated in the detailed design phase of the project in accordance with CoS policies (i.e. 3.0 m MUP). ROW widths have been designed to accommodate multi-use paths within the functional design ROW. To maintain access and integrate existing trails along the Northeast and Small Swale, the profile of the Saskatoon Freeway has been designed to accommodate multi-use paths under the Freeway on the east side of the swales.

5.8.1 Saskatoon Freeway Bridge over the South Saskatchewan River

Conceptual plans for the bridge crossing include provisions multi-use paths both eastbound and westbound directions. At the ends of the bridge, the multi-use paths would be interconnected to future trails parallel to the east and west banks of the South Saskatchewan River. The west bank trail would provide a connection to the Wanuskewin Heritage Park to the north, while both east and west bank trails would connect to planned or existing trails in Saskatoon. The exact location and configuration of the interconnections would be determined in consultation with the Meewasin Valley Authority and the Wanuskewin Heritage Park. Concepts for multi-use paths along the east bank have been included but not detailed. This will require further consideration at the time of detailed design.

5.8.2 CN and CP Rail Corridor under the Saskatoon Freeway

The Functional Plan for the Saskatoon Freeway includes bridge crossings over CN Rail and CP Rail. All railway bridges will be constructed to accommodate the existing rail with provisions for accommodating one future additional rail and a CN Access Road/RM road. Additional consultation will be required with Stakeholders to determine connection points north and south of the Saskatoon Freeway.

5.8.3 Flyover Extensions over the Saskatoon Freeway

The Functional Plan for the Saskatoon Freeway includes a future crossing of existing Highway 41 and Patience Lake Road over the Saskatoon Freeway. Provisions for a barrier separated 3.0 m walkway have not been provided given the nature and location of these roads. Additional notations have been included on the roll plan showing other possible flyovers, these flyovers would be determined by the CoS as development occurs in the future.

There may be opportunities to provide multiuse trails on future crossings which have not been functionally designed as part of this study, such as Taylor Street. Additional flyover locations are illustrated on the Roll Plan in **Appendix E**.

6 Utilities

Utility conflicts specific to each interchange, as well as a summary of stakeholder interest of a Transportation Utility Corridor (TUC) are discussed in the following sections.

6.1 Phase 2 Utility Conflicts

The Phase 2 preferred concept will require relocation of several utilities. Relocation will provide increased ground cover to facilitate road construction, avoid interchange footprints, or increase overhead clearance. Utility conflicts for the vicinity of each preferred interchange location are presented in **Table 6.1** and **Table 6.2**. The Phase 2 preferred concept is divided into the North half (Central Avenue, Blackley Road, Realigned Highway 41, Highway 41 Flyover, and Highway 5 interchanges) and South half (8th Street, Highway 16, Zimmerman Road, Floral Road, and Highway 11 interchanges). Utility conflicts and high-level quantity estimates of each utility to be relocated are discussed for each interchange in the following sections. For the purpose of the functional planning study worst case scenarios were assumed for the number of conflicts and relocation distances with the intention of developing conservative relocation quantities. Specific details for each utility crossing location will need to be developed in subsequent design phases.

Table 6.1: Phase 2 utility conflict summary (North)

CENTRAL AVENUE	BLACKLEY ROAD	HIGHWAY 41 RE-ALIGNMENT	HIGHWAY 41 FLYOVER	HIGHWAY 5
SaskEnergy (Distribution)	SaskEnergy (Distribution)	SaskEnergy (Distribution)	SaskEnergy (Distribution)	SaskEnergy (Distribution)
SaskPower (Distribution)	SaskEnergy (TransGas)	SaskPower (Distribution)	SaskEnergy (TransGas)	SaskEnergy (TransGas)
SaskPower (Transmission)	Highway 41 Utility	Highway 41 Utility	SaskPower (Distribution)	SaskPower (Distribution)
SaskTel	SaskTel		SaskTel	SaskTel
			SaskWater	

Table 6.2: Phase 2 utility conflict summary (South)

8TH STREET	HIGHWAY 16	ZIMMERMAN ROAD	FLORAL ROAD	HIGHWAY 11
SaskEnergy (Distribution)	SaskEnergy (Distribution)	SaskEnergy (Distribution)	SaskEnergy (Distribution)	SaskEnergy (Distribution)
SaskPower (Distribution)	SaskEnergy (TransGas)	SaskEnergy (TransGas)	SaskPower (Distribution)	SaskPower (Distribution)
SaskTel	SaskPower (Distribution)	SaskPower (Distribution)	SaskPower (Transmission)	SaskTel
	SaskPower (Transmission)	SaskPower (Transmission)	SaskTel	
	SaskTel	SaskTel	SaskWater	
	Nutrien			

Note: SaskEnergy representatives noted that lines smaller than 2 inch diameter likely exist at various locations; however, SaskEnergy no longer installs lines smaller than 2 inch diameter, and upsize to 4 inch diameter lines whenever possible.

6.1.1 Central Avenue

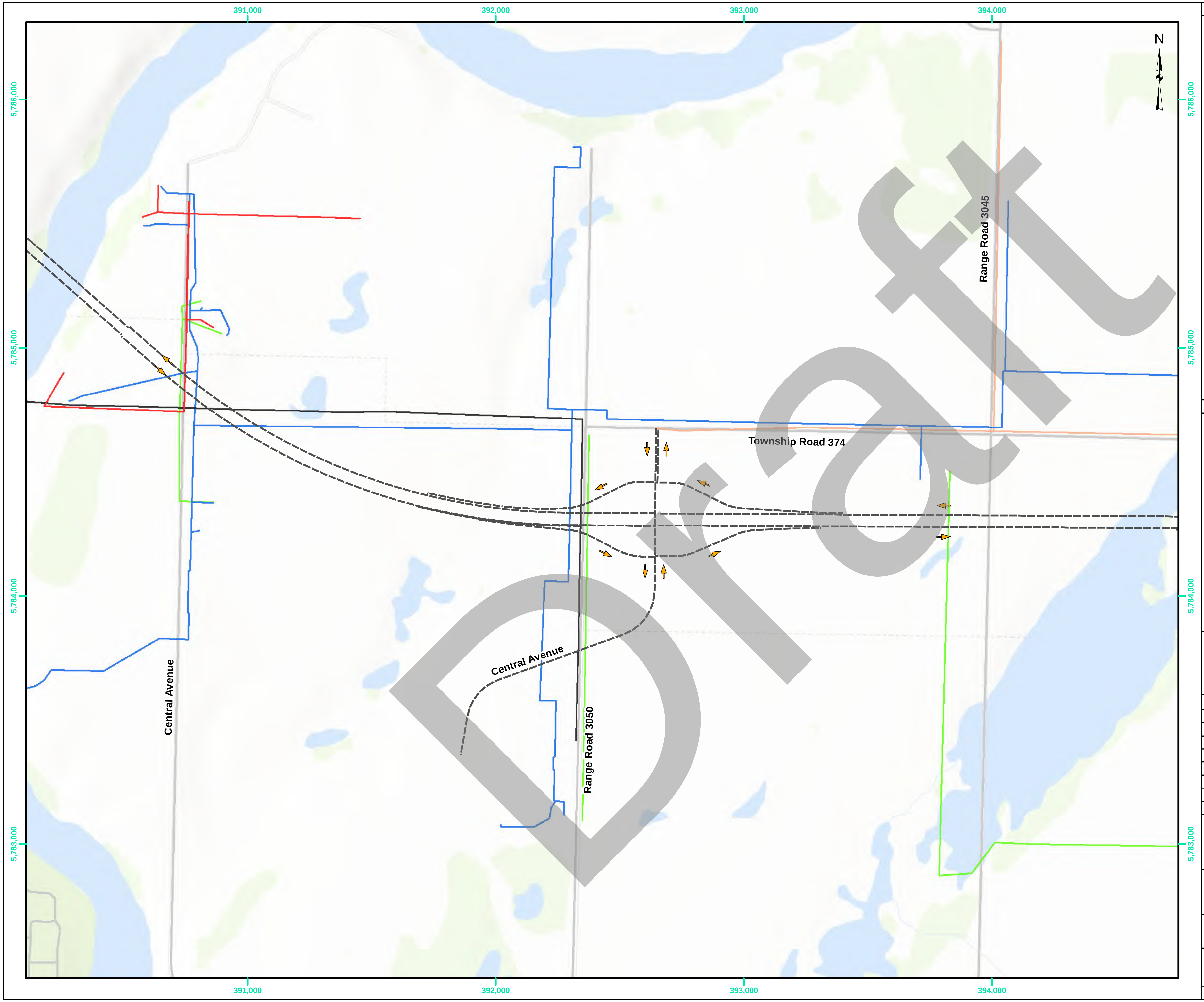
Utility conflicts in and around the preferred Central Avenue interchange location is presented in Figure 6.1.

6.1.1.1 SaskEnergy (distribution)

SaskEnergy operates several distribution lines within the Central Avenue interchange area. Generally, for new road construction increased ground cover would be required over existing facilities. For the purpose of this functional planning study, it is assumed that all SaskEnergy distribution lines crossing the preferred Freeway alignment or located within the preferred interchange footprints will require relocation to a greater depth and perpendicular to the preferred Freeway alignment, or outside the interchange area, respectively, to facilitate Freeway construction.

6.1.1.2 SaskPower (distribution)

SaskPower operates a 14.4 kV overhead cable that crosses the preferred Freeway alignment along range Road 3051 that services nearby residents. This line is not located within the interchange. This line will require realignment across the preferred Freeway alignment footprint.



LEGEND

- ▬ ▬ PHASE 2 ROUTE

UTILITY LINE

- ▬ HWY 41 UTILITY
- ▬ SASKENERGY
- ▬ SASKPOWER DISTRIBUTION (25 kV AND BELOW)
- ▬ SASKPOWER TRANSMISSION (72kV - 230 kV)
- ▬ SASKTEL - COPPER CABLE

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0 125 250 500 METRES

SCALE: 1:15,000

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
CENTRAL AVENUE INTERCHANGE

DATE	2022 05 31	DWG No.	659183-0000-4GDD-0075	FIG No.	6.1	REV	PA

SIZE 11x17

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6.1.1.3 SaskPower (transmission)

A 138 kV overhead transmission line crosses the preferred Freeway alignment west of the Central Avenue Interchange at Range Road 3051, as well as through the Central Avenue interchange footprint. Tower repositioning/realignment may be required to accommodate the Freeway alignment near Range Road 3051. In addition, the vertical grade of Central Avenue is elevated at the interchange location to accommodate an overpass structure over the Freeway. Therefore, relocating the overhead cable will likely be required to provide sufficient overhead clearance between the Central Avenue interchange ramps and the overhead transmission cables.

6.1.1.4 SaskTel

SaskTel operates several copper lines within the Central Avenue interchange area. Generally, for new road construction increased ground cover would be required over existing facilities. Abandonment of the facilities to an unknown extent may be possible in the future; however, for the purpose of this functional planning study it is assumed that all SaskTel distribution lines crossing the preferred Freeway alignment or located within the preferred interchange footprints will require relocation to a greater depth, or outside the interchange area, respectively, to facilitate Freeway construction. No specific concerns regarding utility relocation were raised by SaskTel during the consultation process.

6.1.2 Blackley Road

Utility conflicts in and around the preferred Blackley Road interchange location are presented in **Figure 6.2**.

6.1.2.1 SaskEnergy (distribution)

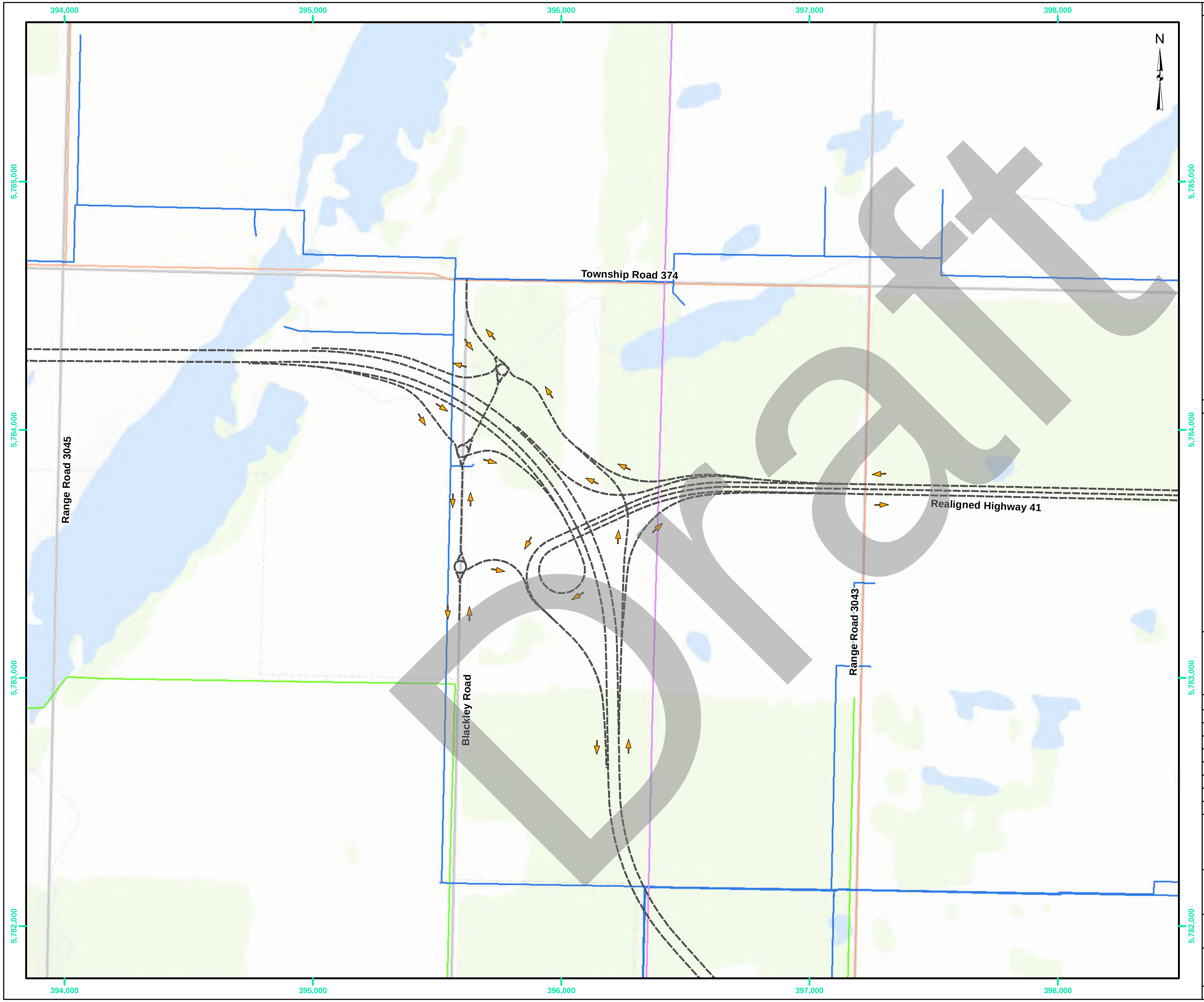
SaskEnergy operates several distribution lines within the Central Avenue interchange area. Generally, for new road construction increased ground cover would be required over existing facilities. For the purpose of this functional planning study it is assumed that all SaskEnergy distribution lines crossing the preferred Freeway alignment or located within the preferred interchange footprints will require relocation to a greater depth and perpendicular to the preferred Freeway alignment, or outside the interchange area, respectively, to facilitate Freeway construction.

6.1.2.2 SaskEnergy (TransGas)

One TransGas NPS 6 pipe runs north-south approximately ½ mile west of Llewellyn Road and crosses the east portion of the preferred Blackley Road interchange footprint. This line will require relocation outside of the interchange footprint.

6.1.2.3 Highway 41 Utility

The Highway 41 Water Utility runs east-west along Township Road 374, turns south along Llewellyn Road and crosses realigned Highway 41, This line will require reinstallation to a lower depth at the realigned Highway 41 crossing location.



LEGEND

- - - - PHASE 2 ROUTE

UTILITY LINE

🟧	HWY 41 WATER UTILITY
🟦	SASKENERGY
🟩	SASKTEL - COPPER CABLE
🟪	TRANSGAS

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SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
BLACKLEY ROAD INTERCHANGE

DATE 2022 05 31 **DWG No.** 659183-0000-4GDD-0076 **FIG No.** 6.2 **REV** PA

SIZE 11x17

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6.1.3 Highway 41

Utility conflicts in and around the preferred Highway 41 interchange location are presented in **Figure 6.3**.

6.1.3.1 SaskEnergy (distribution)

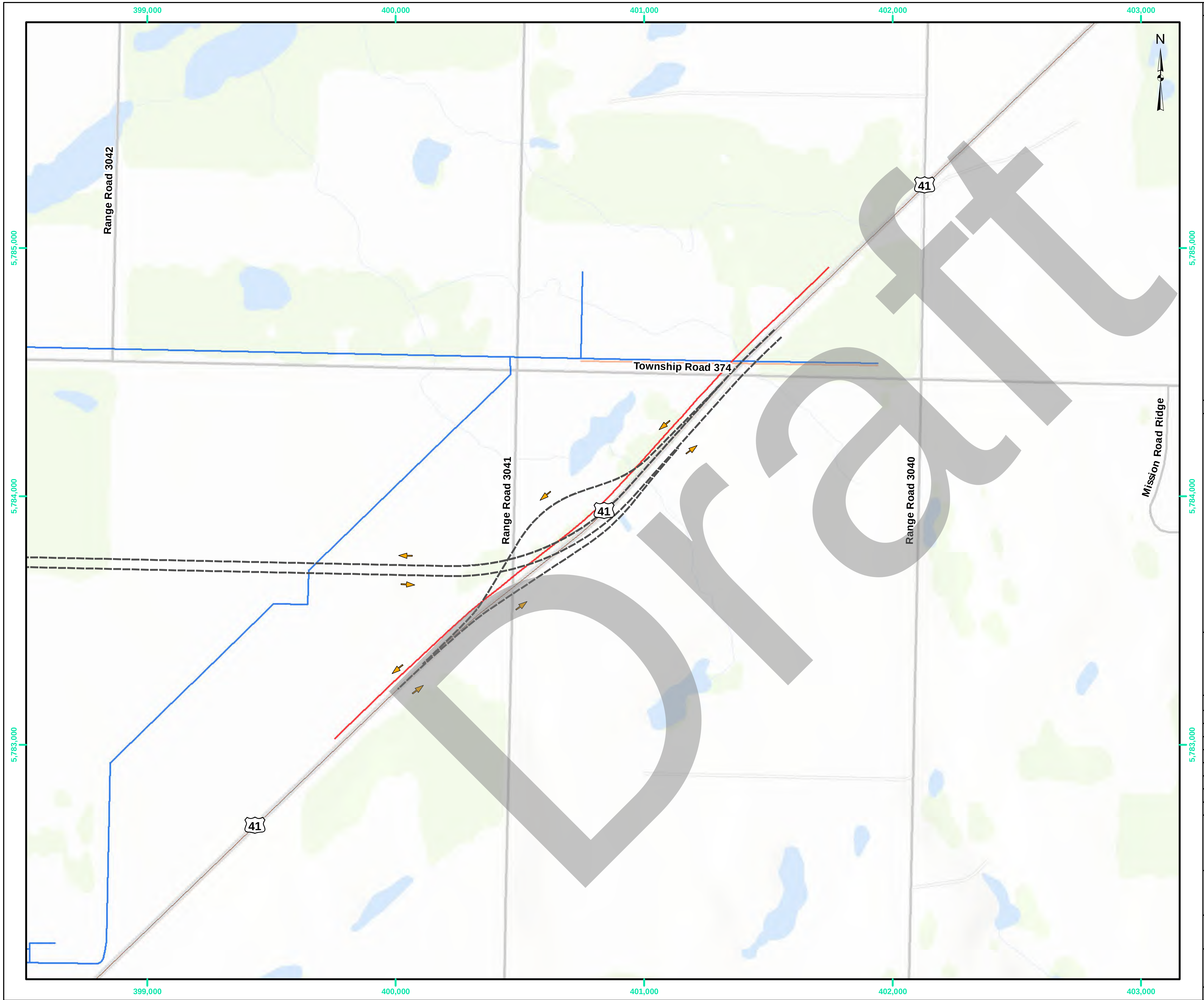
A SaskEnergy distribution line crosses the Highway 41 Realignment approximately mid quarter section between Freeborn Road and Kilmeny Road. Generally, for new road construction increased ground cover would be required over existing facilities. This line also crosses existing Highway 41 north of the proposed Highway 41 interchange location. This line is not located within the interchange footprint, but may require reinstallation to lower depth depending on actual extent of construction of the interchange facility and twinning of Highway 41. For the purpose of this functional planning study, it is assumed that all SaskEnergy distribution lines crossing the preferred Freeway alignment or located within the preferred interchange footprints will require relocation to a greater depth and perpendicular to the preferred Freeway alignment, or outside the interchange area, respectively, to facilitate Freeway construction.

6.1.3.2 SaskPower (distribution)

SaskPower operates a 25 kV overhead cable along the north side of existing Highway 41 that crosses the footprint of the preferred realignment of Highway 41. This line will require relocation outside the interchange footprint.

6.1.3.3 Highway 41 Water Utility

The Highway 41 Water Utility crosses existing Highway 41 north of the preferred Highway 41 interchange location. This line is not located within the interchange footprint but may require reinstallation to lower depth depending on actual extent of construction of the interchange facility and twinning of Highway 41. For the purpose of this functional plan, it is assumed this line will require reinstallation at a lower depth at this location.



LEGEND

▬ ▬ PHASE 2 ROUTE

UTILITY LINE

- 🟧 HWY 41 WATER UTILITY
- 🟦 SASKENERGY
- 🟥 SASKPOWER DISTRIBUTION (25 kV AND BELOW)
- ═ HIGHWAY

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0 125 250 500
METRES

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SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
HIGHWAY 41 INTERCHANGE

DATE 2022 05 31	**DWG No.** 659183-0000-4GDD-0077	**FIG No.** 6.3	**REV** PA

SIZE 11x17

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6.1.4 Highway 41 Flyover

Utility conflicts in and around the preferred Highway 41 Flyover location is presented in **Figure 6.4**.

1.1.1.1 SaskEnergy (distribution)

SaskEnergy operates a distribution line north and south of the preferred Highway 41 flyover location, intersecting the preferred Freeway alignment at two locations:

- North of Township Road 372, between Blackley Road and Llewellyn Road; and
- Township Road 372 and Llewellyn Road.

In addition, the SaskEnergy line runs parallel to the preferred Freeway alignment within the footprint for approximately ½ mile south beginning just south of existing Highway 41. Generally, for new road construction increased ground cover would be required over existing facilities. For the purpose of this functional planning study it is assumed that all SaskEnergy distribution lines crossing or located parallel to the preferred Freeway alignment will require relocation to a greater depth, or outside the footprint area, respectively, to facilitate Freeway construction.

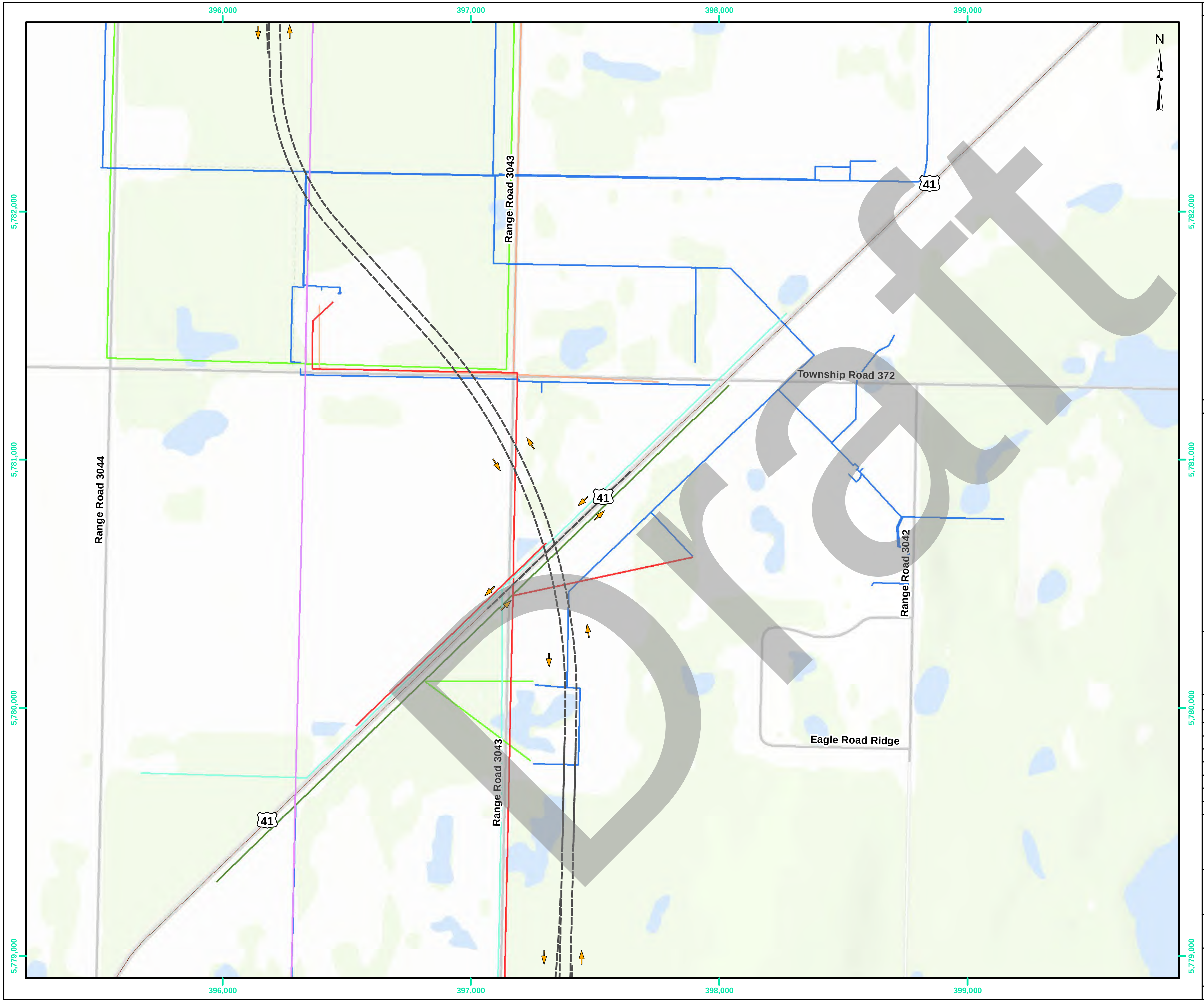
1.1.1.2 SaskEnergy (TransGas)

One TransGas NPS 6 pipe crosses the preferred Freeway alignment north of Township Road 372, between Blackley Road and Llewellyn Road. This line will require both reinstallation to a greater depth and perpendicular horizontal realignment relative to the Freeway.

1.1.1.3 SaskPower (distribution)

SaskPower operates the following three overhead distribution facilities in the vicinity of the Highway 41 Flyover location:

- One 25 kV overhead facility running north-south and crosses the existing Highway 41 along Llewellyn Road, then turns west crossing the Freeway footprint along Agra road;
- One 25 kV overhead facility parallel (north) of existing Highway 41; and
- One 14.4 kV underground facility located south/east of existing Highway 41 at the Flyover location, running slightly skewed to the northeast/southwest across the east-west ¼ section line.



LEGEND

- PHASE 2 ROUTE

UTILITY LINE

- HWY 41 WATER UTILITY
- SASKENERGY
- SASKPOWER DISTRIBUTION (25 kV AND BELOW)
- SASKTEL - COPPER CABLE
- SASKTEL - FIBER
- SASKWATER
- TRANSGAS
- HIGHWAY

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METRES

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SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
HIGHWAY 41 FLYOVER

DATE	DWG No.	FIG No.	REV
2022 05 31	659183-0000-4GDD-0078	6.4	PA

SIZE 11x17

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The north-south/east-west line will require both reinstallation to a greater depth and perpendicular horizontal realignment relative to the Freeway at the two conflict locations. The line parallel to existing highway 41 will require both reinstallation to a greater depth and relocation out of the flyover footprint. The 14.4 kV line will require both reinstallation to a greater depth and perpendicular horizontal realignment relative to the Freeway.

6.1.4.1 SaskTel

SaskTel operates several copper lines within the Flyover area, as well as a fiber line parallel (south) to existing Highway 41. Generally, for new road construction increased ground cover would be required over existing facilities. Abandonment of the copper facilities to an unknown extent may be possible in the future; however, for the purpose of this functional planning study it is assumed that all SaskTel lines crossing the preferred Freeway alignment or located within the preferred Flyover footprint will require relocation to a greater depth, or outside the Flyover area, respectively, to facilitate Freeway construction. No specific concerns regarding utility relocation were raised by SaskTel during the consultation process.

6.1.4.2 SaskWater

SaskWater operates two 8 inch High Density Polyethylene (HDPE) lines along the northeast side of Highway 41 and passes through the location where the preferred Highway 41 flyover crosses the preferred Freeway alignment. These lines will require relocating outside the flyover footprint. One of these 8 inch HDPE lines turns south along the west side of Llewellyn Road. This pipe then crosses the preferred Freeway footprint at Llewellyn Road south of the Flyover location. The pipe will require reinstallation at a greater depth.

6.1.4.3 Highway 41 Utility

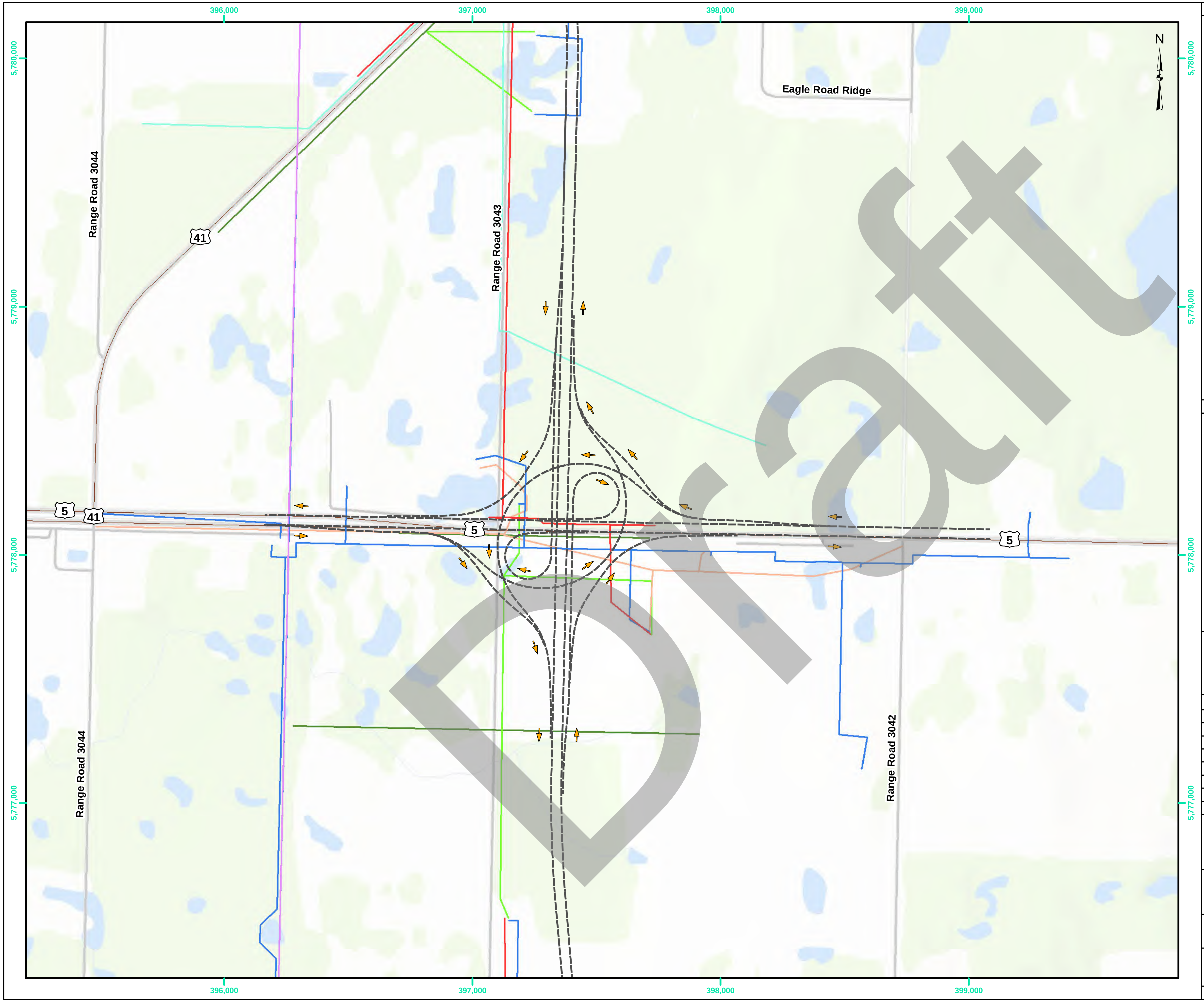
The Highway 41 Water Utility runs east-west along Agra Road and crosses the preferred freeway footprint at Agra Road. This line will require relocation to a greater depth at this location.

6.1.5 Highway 5

Utility conflicts in and around the preferred Highway 5 interchange location is presented in **Figure 6.5**.

6.1.5.1 SaskEnergy (distribution)

SaskEnergy operates an east-west distribution line just south of Highway 5. This line passes through the Highway 5 Interchange footprint and branches of at several locations to service residents on either side of Highway 5, east and west of the interchange. These lines will require relocation out of the interchange footprint.



LEGEND

- PHASE 2 ROUTE

UTILITY LINE

- HWY 41 WATER UTILITY
- SASKENERGY
- SASKPOWER DISTRIBUTION (25 kV AND BELOW)
- SASKTEL - COPPER CABLE
- SASKTEL - FIBER
- SASKWATER
- TRANSGAS
- HIGHWAY

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TITLE
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HIGHWAY 5 INTERCHANGE

DATE	DWG No.	FIG No.	REV
2022 05 31	659183-0000-4GDD-0079	6.5	PA

SIZE 11x17

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6.1.5.2 SaskPower (distribution)

SaskPower operates a 25 kV overhead line that runs along the east side of Llewellyn Road, south up to Highway 5 then T's both east and west along the north side of Highway 5 within the preferred Highway 5 interchange footprint. In addition, a 14.4 kV line branches south from the 25 kV line east of Llewellyn Road and services a nearby acreage. These lines will require relocation from the interchange footprint location.

6.1.5.3 SaskTel

SaskTel operates rural copper network service lines that run within the preferred Highway 5 interchange footprint. One line runs along the east side of Llewellyn Road south of Highway 5. This line branches off to the east and northeast to service 2 acreages within and adjacent to the preferred Highway 5 interchange location. These lines will require relocation from the interchange footprint. Abandonment of the copper facilities to an unknown extent may be possible in the future; however, for the purpose of this functional planning study it is assumed that all SaskTel lines within the interchange footprint will be relocated.

SaskTel also operates two fiber lines in the area with their locations described below:

- An east-west line along the south side of Highway 5; and
- An east-west line parallel to and approximately 1 mile south of Highway 5.

The line located on the south side of Highway 5 will require relocation outside the interchange footprint. The fiber line located further south of Highway 5 will require relocation to a greater depth to facilitate construction of the Freeway.

6.1.5.4 SaskWater

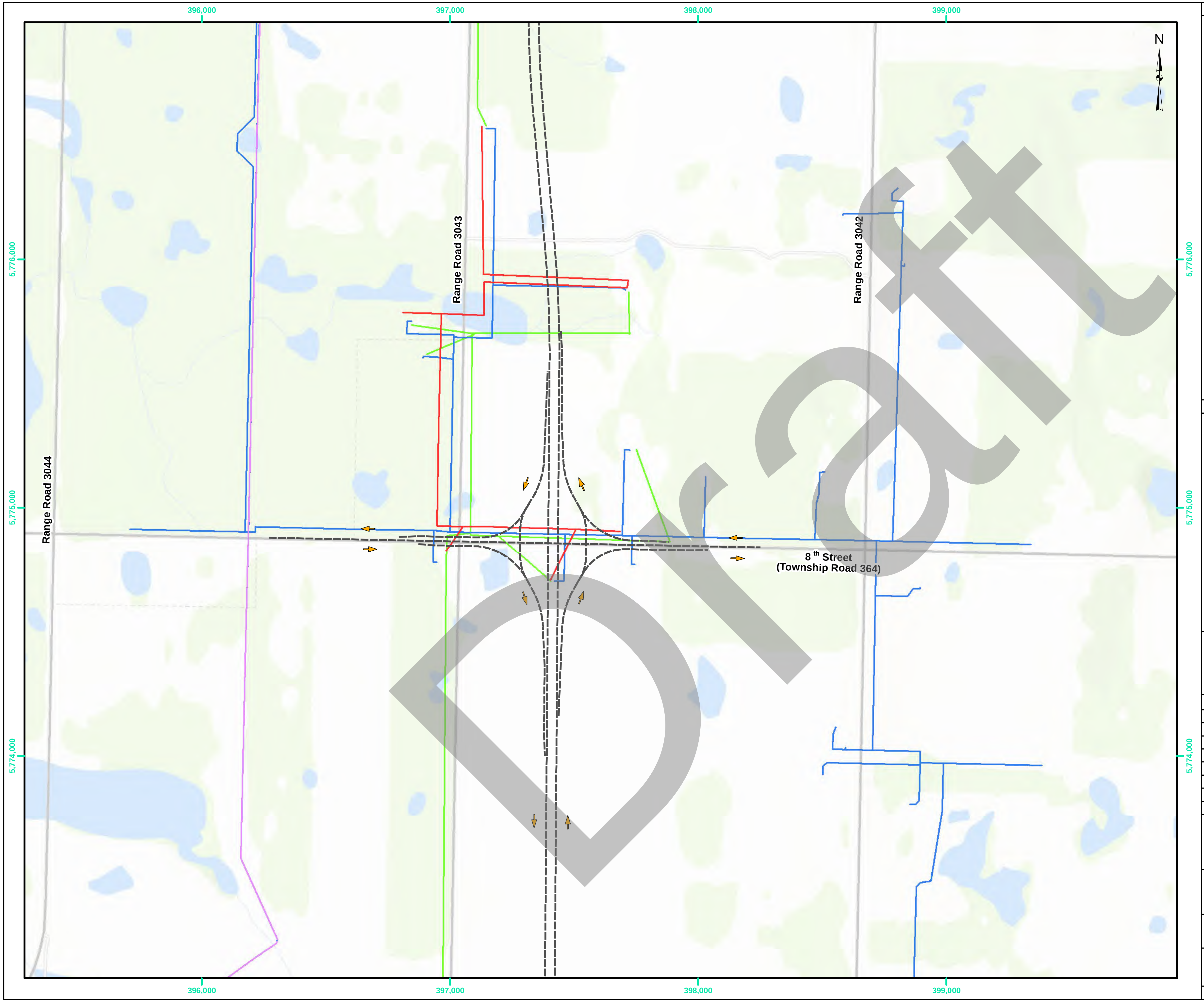
SaskWater operates one 8 inch HDPE potable water line along the west side of Llewellyn Road between the preferred Highway 41 flyover and Highway 5 interchange locations, This pipe changes direction heading southeast at approximately ¾ of a mile north of Highway 5 and outside the preferred Highway 5 interchange footprint location. The pipe will require relocation to a greater depth to facilitate Freeway construction.

6.1.6 8th Street

Utility conflicts in and around the preferred 8th Street interchange location is presented in **Figure 6.6**.

6.1.6.1 SaskEnergy (distribution)

SaskEnergy operates an east-west distribution line just north of 8th Street. This line passes through the 8th Street Interchange footprint and branches of at several locations to service residents on either side of 8th Street, east and west of the interchange. These lines will require relocation out of the interchange footprint. Another line crosses the preferred Freeway alignment approximately just over 1 mile north of 8th Street and outside of the interchange footprint. This line will require relocation to a greater depth to facilitate Freeway construction.



LEGEND

╍╍╍	PHASE 2 ROUTE

UTILITY LINE

🟦	SASKENERGY
🟥	SASKPOWER DISTRIBUTION (25 kV AND BELOW)
🟩	SASKTEL - COPPER CABLE
🟪	TRANSGAS

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METRES

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SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
8th STREET INTERCHANGE

DATE	2022 05 31	DWG No.	659183-0000-4GDD-0080	FIG No.	6.6	REV	PA

SIZE 11x17

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6.1.6.2 SaskPower (distribution)

SaskPower operates a 14 kV overhead north-south line that runs for approximately one mile along Winmill Road, down to the north side of 8th Street, then redirects east-west through the preferred 8th Street interchange footprint. This line will require relocation from the interchange footprint. In addition, a 14 kV underground line that crosses the preferred Freeway alignment approximately one mile north of 8th Street. This line will require relocation to a greater depth to facilitate Freeway construction.

6.1.6.3 SaskTel

A rural copper network line runs north-south along Winmill Road through the preferred 8th Street interchange location footprint. The line also runs east from Winmill Road along the north side of 8th Street, branching off north and south to service two acreages. These lines will require relocation from the interchange footprint. Abandonment of the copper facilities to an unknown extent may be possible in the future; however, for the purpose of this functional planning study it is assumed that all SaskTel lines within the interchange footprint will be relocated. A copper line crosses the preferred Freeway footprint approximately one mile north of 8th Street. This line will require relocation to a greater depth to facilitate Freeway construction.

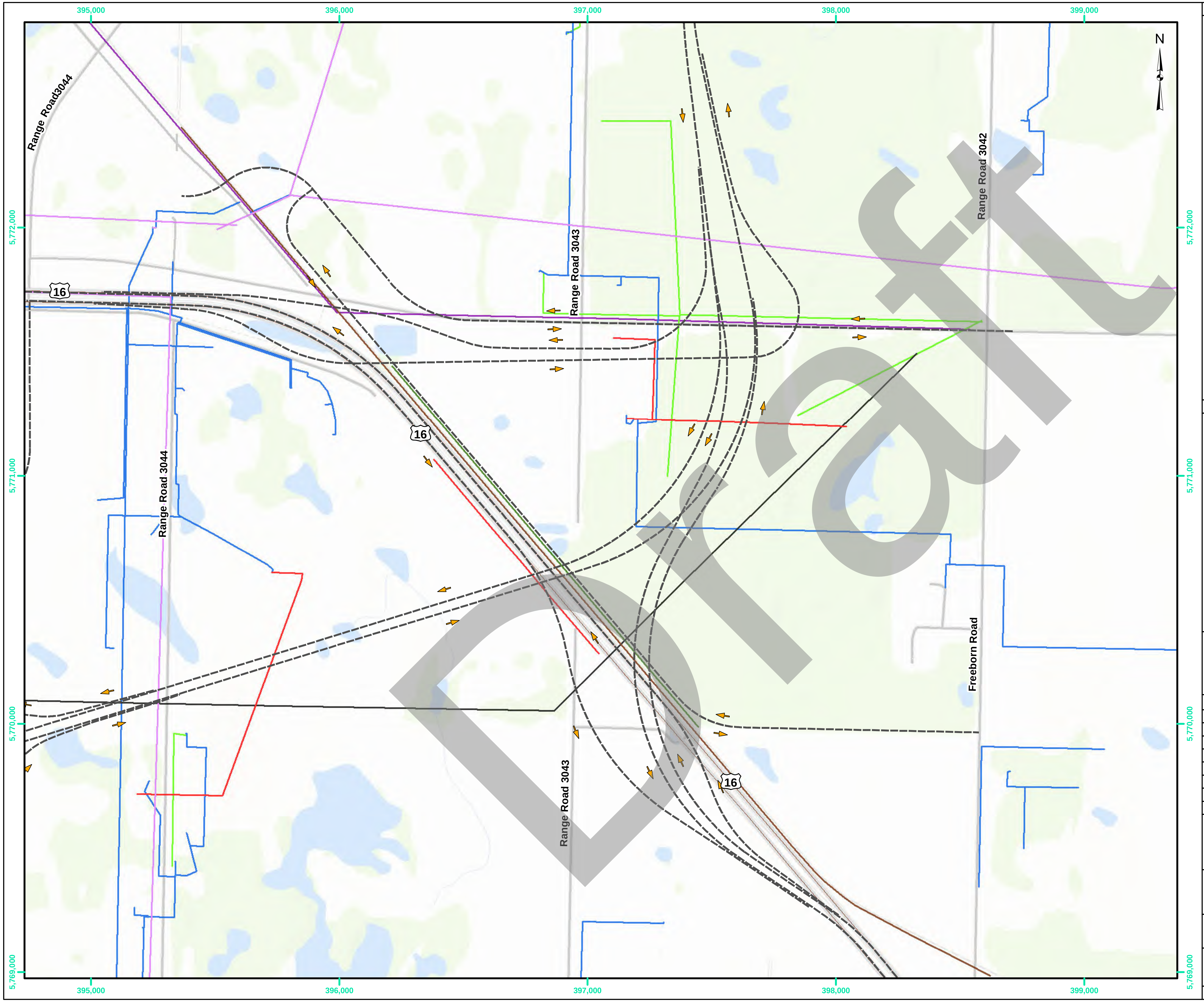
6.1.7 Highway 16

Utility conflicts in and around the preferred Highway 16 interchange location is presented in **Figure 6.7**.

6.1.7.1 SaskEnergy (distribution)

SaskEnergy operates several distribution lines within the Highway 16 interchange area from just north of Patience Lake Road to northeast of the existing Highway 16 alignment. There will be embankment fill for the majority of the Freeway and Patience Lake Road alignments through this area and the SaskEnergy lines will require relocation from the interchange footprint.

Several lines also exist southwest of the existing Highway 16 alignment around Height Road. These lines are out of the Highway 16 interchange footprint but will require relocation to a greater depth and perpendicular to the preferred Freeway alignment.



LEGEND

- ▬ ▬ PHASE 2 ROUTE

UTILITY LINE

- 🟪 NUTRIEN RAW WATER LINE
- 🟦 SASKENERGY
- 🟥 SASKPOWER DISTRIBUTION (25 kV AND BELOW)
- ⬛ SASKPOWER TRANSMISSION (72kV - 230 kV)
- 🟩 SASKTEL - COPPER CABLE
- 🟩 SASKTEL - FIBER
- 🟫 TELUS AND BELL FIBERS
- 🟪 TRANSGAS
- ▭ HIGHWAY

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SCALE: 1:15,000

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CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
HIGHWAY 16 INTERCHANGE

DATE 2022 05 31	**DWG No.** 659183-0000-4GDD-0081	**FIG No.** 6.7	**REV** PA

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6.1.7.2 SaskEnergy (TransGas)

Two TransGas pipes (one NPS 6 and one NPS 12) cross the realigned Patience Lake Road just east of the CP rail line, east of Costco, and one NPS 6 line crosses existing Circle Drive east of the future Zimmerman/Circle Drive interchange. The infrastructure at these locations will require relocation to a greater depth to facilitate road construction.

6.1.7.3 SaskPower (distribution)

SaskPower operates the following distribution lines within the preferred Highway 16 interchange area:

- 25 kV underground line along the south side of Patience Lake Road. This line turns south about ¼ of a mile east of Winmill Road to service a local farm. This line will be located within the Patience Lake Road flyover embankment fill and will need to be relocated outside the fill footprint;
- 14.4 kV overhead east-west line located approximately ½ mile south of Patience Lake Road. This line crosses the preferred Freeway alignment. The height of this line may need to be increased to provide sufficient clearance over the Freeway;
- 25 kV overhead and 14.4 kV underground lines parallel (west) to Highway 16. Due to conflicts with multiple structures and access ramps these lines will require relocation from the interchange footprint; and
- 14.4 kV underground line crosses the preferred Freeway footprint between Haight Road and Highway 16 servicing acreages north and south of the preferred Freeway alignment. This line will require realignment to be perpendicular to the Saskatoon Freeway.

6.1.7.4 SaskPower (transmission)

Two 230 kV overhead lines cross the preferred Highway 16 interchange footprint. The Saskatoon Freeway vertical grade is elevated at this location to accommodate an overpass over the CP rail tracks. As such this wire will require relocation as there will be insufficient overhead clearance between the Saskatoon Freeway road surface and the overhead transmission wire.

6.1.7.5 SaskTel

SaskTel operates rural copper network lines that runs parallel to and crosses Patience Lake Road within the preferred Patience Lake Flyover and Highway 16 interchange footprints to service acreages and farm yards. The lines are located in areas of embankment fil and will therefore require relocation from the flyover and interchange footprint areas. Abandonment of the copper facilities to an unknown extent may be possible in the future; however, for the purpose of this functional planning study it is assumed that all SaskTel lines crossing the preferred Freeway alignment or located within the preferred flyover and interchange footprints will require relocation outside the footprint areas.

6.1.7.6 Nutrien Raw Water Line

A water line operated by Nutrien is located along Patience Lake Road. The water line provides freshwater from the South Saskatchewan River to the Patience Lake mine site and currently operates as a 12 inch HDPE pipe. The line is located on the north side of Patience Lake Road, then crosses under the Patience Lake Road near the east side of the CP railway. Nutrien representatives also mentioned that are remnants of the original steel line in some places when the line was replaced with the HDPE pipe. The current HDPE water line will be located within the footprint of the proposed embankment fills for the Patience Lake Road flyovers and will require relocation out of the interchange footprint.

6.1.8 Zimmerman Road

Utility conflicts in and around the preferred Zimmerman Road interchange location is presented in **Figure 6.8**.

6.1.8.1 SaskEnergy (distribution)

SaskEnergy operates one distribution line that crosses the preferred Freeway alignment west of the preferred Zimmerman Road interchange location. For the purpose of this functional planning study, it is assumed that all SaskEnergy distribution lines crossing the preferred Freeway alignment or located within the preferred interchange footprints will require relocation to a greater depth and perpendicular to the preferred Freeway alignment, or outside the interchange area, respectively, to facilitate Freeway construction.

6.1.8.2 SaskEnergy (TransGas)

One NPS 6 line crosses the preferred Freeway alignment between the preferred Zimmerman Road interchange location and existing Haight Road. This line will require relocation to a greater depth and pedicular realignment to the Freeway to facilitate road construction.

6.1.8.3 SaskPower (distribution)

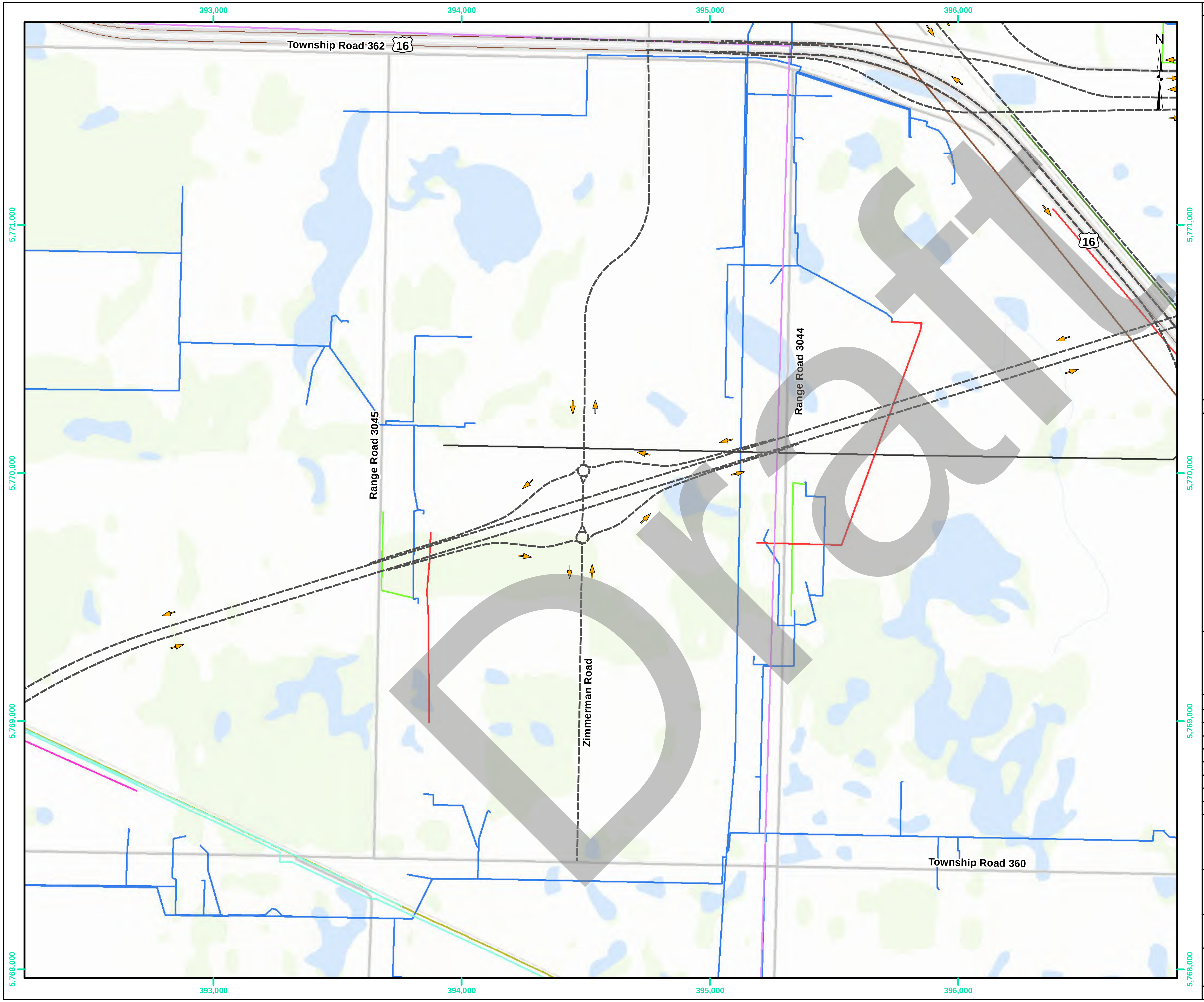
SaskPower operates a 14 kV overhead line that crosses the ramp terminals on the west side of the preferred Zimmerman Road interchange. It is assumed that the overhead line will need to be relocated outside of the preferred interchange footprint for the purpose of this functional planning study.

6.1.8.4 SaskPower (transmission)

A SaskPower transmission corridor crosses the preferred Freeway footprint just east of the preferred Zimmerman Road interchange, as well as across the northern edge of the preferred Zimmerman Road interchange footprint. There are two overhead 230 kV lines and one 72 kV line, as well as one underground communication circuit within the corridor. The Freeway vertical grade is elevated at these locations to accommodate the overpass over the proposed Freeway alignment. As such the overhead wires will require relocation as there will be insufficient overhead clearance between the Zimmerman Road overpass surface and the overhead transmission wire. The underground wire within this corridor will need to be relocated outside of the interchange footprint and realigned perpendicular to the Freeway.

6.1.8.5 SaskTel

SaskTel operates a rural copper network line that crosses the preferred Freeway alignment west of the preferred Zimmerman Road interchange location at Range Road 3045. Abandonment of the facilities to an unknown extent may be possible in the future; however, for the purpose of this functional planning study it is assumed that all SaskTel distribution lines crossing the preferred Freeway alignment or located within the preferred interchange footprints will require relocation to a greater depth and perpendicular to the preferred Freeway alignment, or outside the interchange area, to facilitate Freeway construction. No specific concerns regarding utility relocation were raised by SaskTel during the consultation process.



LEGEND

- PHASE 2 ROUTE

UTILITY LINE

- CITY OF SASKATOON
- ROGERS FIBER
- SASKENERGY
- SASKPOWER DISTRIBUTION (25 kV AND BELOW)
- SASKPOWER TRANSMISSION (72kV - 230 kV)
- SASKTEL - COPPER CABLE
- SASKTEL - FIBER
- SASKWATER
- TELUS AND BELL FIBERS
- TRANSGAS
- HIGHWAY

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METRES

SCALE: 1:15,000

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
ZIMMERMAN ROAD INTERCHANGE

DATE	DWG No.	FIG No.	REV
2022 05 31	659183-0000-4GDD-0082	6.8	PA

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6.1.9 Floral Road

Utility conflicts in and around the preferred Floral Road interchange location is presented in **Figure 6.9**.

6.1.9.1 SaskEnergy (distribution)

SaskEnergy distribution lines are located north-south, just west of Prairie View Road, and east-west, just south of Floral Road. The north-south line intersects the preferred Freeway alignment west of Prairie View Road and the east-west line runs through the interchange footprint. There is also a relatively short branch from the north-south line that runs east to Prairie View Road along Floral Road. For the purpose of this functional planning study, it is assumed that all SaskEnergy distribution lines crossing the preferred Freeway alignment or located within the preferred interchange footprints will require relocation to a greater depth and perpendicular to the preferred Freeway alignment, or outside the interchange area, respectively, to facilitate Freeway construction.

6.1.9.2 SaskPower (distribution)

SaskPower operates a 14 kV underground north-south line that intersects the preferred Freeway alignment, just west of Prairie View Road Drive. This line will require realignment to be perpendicular to the Saskatoon Freeway.

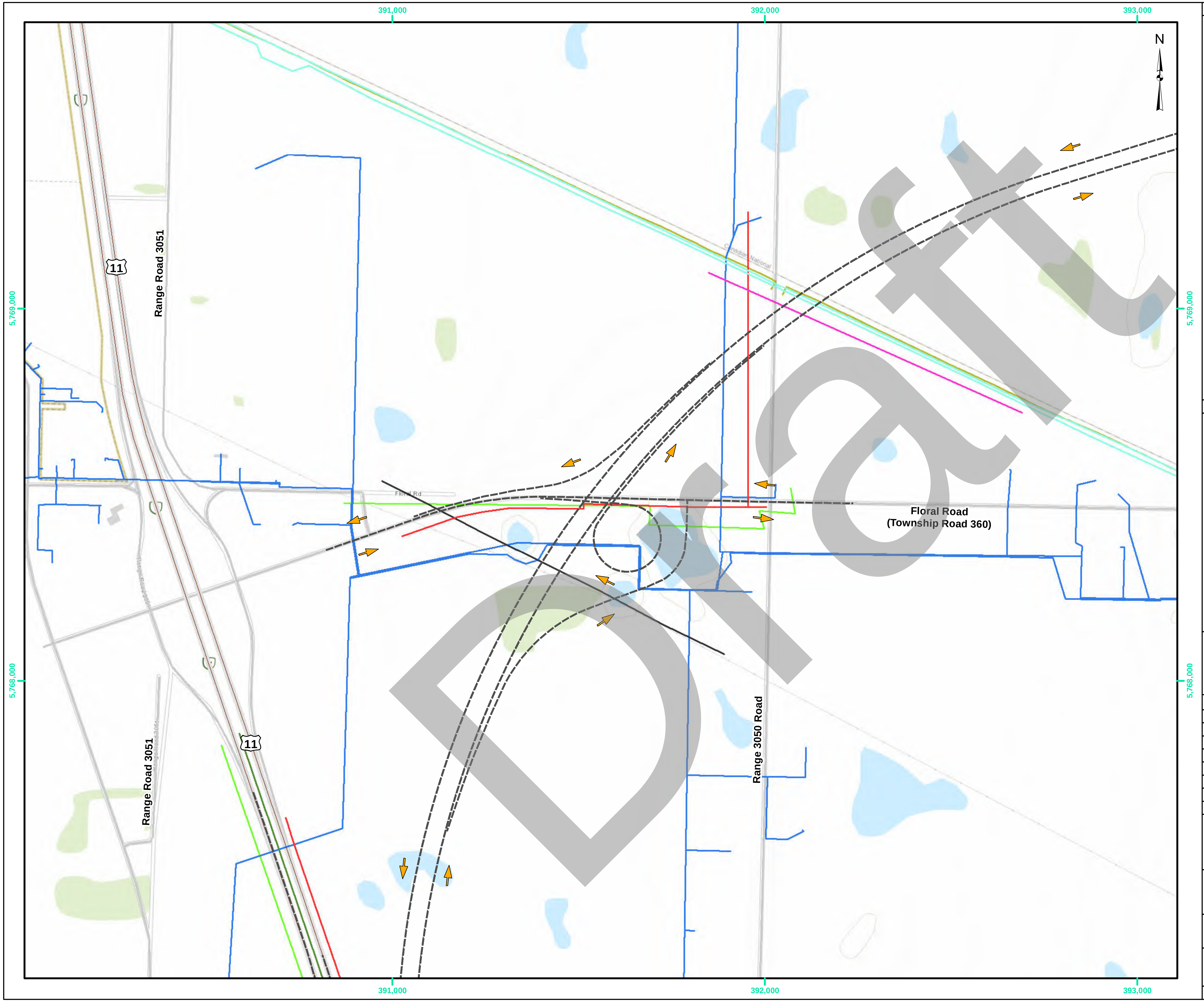
SaskPower also operates a 25 kV overhead line that runs east-west through the interchange footprint along existing Floral Road. It is assumed that the overhead line will need to be relocated outside of the preferred interchange footprint for the purpose of this functional planning study.

6.1.9.3 SaskPower (transmission)

A SaskPower 138 kV overhead line that crosses the preferred Freeway alignment just inside the interchange footprint south extent. The Saskatoon Freeway vertical grade will be greater than the existing ground surface. As such this wire will require relocation as there will be insufficient overhead clearance between the Freeway road surface and the overhead transmission wire.

6.1.9.4 SaskTel

SaskTel operates a rural copper network line that runs through the interchange footprint along Floral Road. Abandonment of the facilities to an unknown extent may be possible in the future; however, for the purpose of this functional planning study it is assumed that all SaskTel distribution lines crossing the preferred Freeway alignment or located within the preferred interchange footprints will require relocation to a greater depth and perpendicular to the preferred Freeway alignment, or outside the interchange area, to facilitate Freeway construction. No specific concerns regarding utility relocation were raised by SaskTel during the consultation process.



LEGEND

- - - PHASE 2 ROUTE

UTILITY LINE

🟪	CITY OF SASKATOON
🟨	ROGERS FIBER
🟦	SASKENERGY
🟥	SASKPOWER DISTRIBUTION (25 kV AND BELOW)
⬛	SASKPOWER TRANSMISSION (72kV - 230 kV)
🟩	SASKTEL - COPPER CABLE
🟩	SASKTEL - FIBER
⬜	SASKWATER
═	HIGHWAY

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OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
FLORAL ROAD INTERCHANGE

DATE	2022 05 31	**DWG No.**	659183-0000-4GDD-0083	**FIG No.**	**6.9**	**REV**	PA

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6.1.9.5 SaskWater

SaskWater operate a 14 inch PVC potable water line and a 9 inch HDPE raw water line along the west side of the CN rail line that cross the preferred Freeway alignment at the CN rail overpass location. These lines are located in the footprint of the overpass embankment and will require relocation from the embankment footprint. SaskWater also noted that one 12 inch steel line as abandoned at this location.

6.1.10 Highway 11

Utility conflicts in and around the preferred Floral Road interchange location is presented in **Figure 6.10**.

6.1.9.1 SaskPower (distribution)

SaskPower operates the following distribution lines within the preferred Highway 16 interchange area:

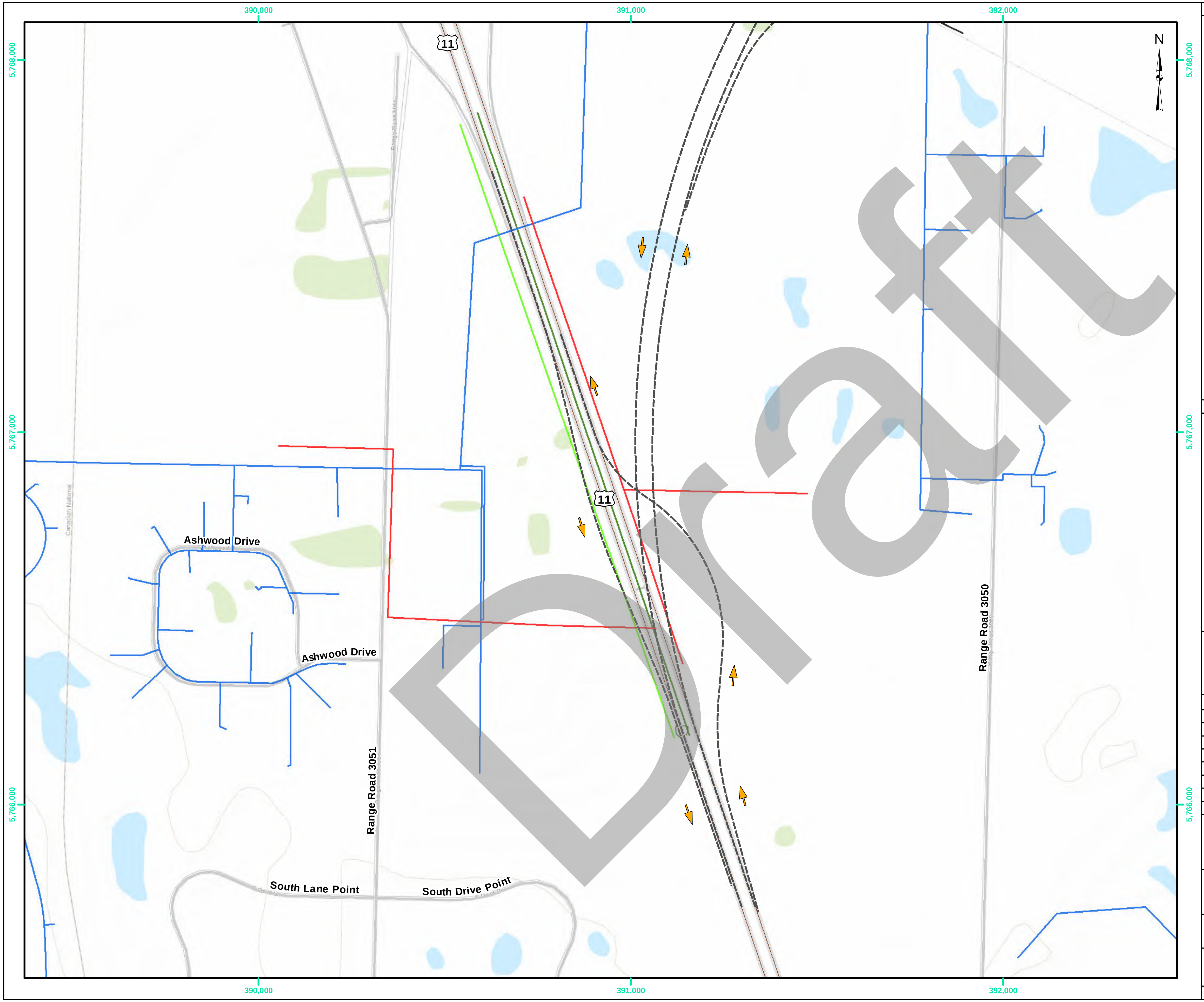
- 25 kV overhead line that runs along the east side of Highway 11 through the preferred Highway 11 interchange footprint. This line will need to be relocated outside of the preferred interchange footprint;
- 14 kV overhead line that runs east from Highway 11, approximately 1 mile south of Floral Road. This line is located within the preferred interchange footprint and will require relocation; and
- 14 kV overhead line that runs west from Highway 11, approximately 1¼ mile south of Floral Road. This line is located within the preferred interchange footprint and will require relocation.

6.1.9.1 SaskTel

A SaskTel fiber line runs parallel to existing Highway 11, within the existing Highway 11 ROW, through the preferred Highway 11 interchange footprint. This line will require relocation from the interchange footprint. SaskTel also noted that a copper line runs along the west side of Highway 11 through the interchange footprint, but that mitigation will not be required as this line can be abandoned in the future.

6.1.11 Quantity Estimates

Quantity estimates for the utilities to be relocated in Phase 1 and Phase 2 will be presented in SFFPS Final Report.



LEGEND

- ▬ ▬ PHASE 2 ROUTE

UTILITY LINE

- 🟦 SASKENERGY
- 🟥 SASKPOWER DISTRIBUTION (25 kV AND BELOW)
- ▬ SASKPOWER TRANSMISSION (72kV - 230 kV)
- 🟩 SASKTEL - COPPER CABLE
- 🟩 SASKTEL - FIBER
- ═ HIGHWAY

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SASKATOON FREEWAY

TITLE
UTILITY CONFLICTS
HIGHWAY 11 INTERCHANGE

DATE	2022 05 31	DWG No.	659183-0000-4GDD-0084	FIG No. 6.10	REV	PA

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6.2 Transportation Utility Corridor

At the request of the Ministry of Highways (Ministry), utility stakeholders were consulted for interest in a Transportation Utility Corridor (TUC) along the preferred Freeway alignment. Consultation was completed during Phase 1 if the functional planning Study (SNC-Lavalin, 2021). Interest by stakeholders is summarized in **Table 6.3**. The TUC is currently highly conceptual and will require ongoing discussion with stakeholders and further refinement at the detailed design phase.

Table 6.3: TUC Interest Summary Phase 2

STAKEHOLDER	WIDTH REQUESTED (METERS)	WIDTH PLANNED (METERS)	INSIDE/OUTSIDE OF FREEWAY	SECTION(S) OF FREEWAY
SaskEnergy (Distribution)	10	10	Inside	Entire corridor
SaskEnergy (TransGas)	30	30	Either side	Entire corridor
SaskPower (Distribution)	10	10	Unknown	Entire corridor
SaskPower (Transmission)	30 to 110	40	Either side	Entire corridor
SaskTel	10	10	Either side	Entire Corridor
Rogers Communications Inc.	1.5	1.5	Either Side	Entire Corridor
SaskWater	15	15	Outside	Phase 2
CoS Water and Sewer	12 to 50	15	Varies	Phase 1 and Phase 2

The total corridor width varies between 127 m to 165 m based on the feedback from utility stakeholders. It is understood that some utilities could share the corridor with other utilities and others cannot. These agreements would likely reduce the required TUC width; however, the details of these agreements are beyond the scope of this functional planning study. In the interest of creating a conservative estimate of potential land required for the TUC it is assumed that there would be no sharing of the corridor between utilities.

The corridor widths requested by the CoS are based on accommodating conventional excavation methods during installation of the utilities (N. Kahn, personal communication, May 28, 2020). Once installation is complete the final requirement for a corridor would be approximately 15 m. According to the CoS alternative installation technics (e.g. tunnelling) are less desirable than conventional excavation and installation due to cost and issues meeting specifications for small gradients.

SaskPower transmission corridor requested widths would vary depending on the line voltages installed within the corridor (30 m for 72 kV, 30 m to 40 m for 138 kV, and 40 m for 230 kV transmission lines). According to SaskPower (R. Lu, personal communication, June 2, 2020), it is conceptually possible to utilize multi-circuit structures to install multiple circuits in the same corridor, if logistics are satisfied. This would potently limit the required corridor width to 40 m. As it is unknown at this time on the line voltages and number of lines to be installed, and it is possible to install multiple circuits in a 40 m corridor, SaskPower transmission width of 40 m was assumed.

Generally, TransGas requires a 30 m corridor; however, this may be able to be reduced within a TUC due to limited public exposure to the utility.

For Phase 1, the requested location of the TUC by utility stakeholders was considered, but location of the presented TUC in Phase 1 was predominantly determined by current development around Highway 16 and Highway 12, as well as the Wanuskewin Heritage Park buffer. For Phase 2, a TUC would be limited to the outside of the Freeway. SaskEnergy expressed preference for the inside of the Freeway as their distribution lines would require several crossing locations with the Freeway in order to service costumers inside the Freeway. The TUC preliminary concept is presented on the Phase 1 and Phase 2 Combined Roll Plan (**Appendix E**).

7 Multiple Account Evaluation

Multiple Account Evaluation (MAE) processes were used to assess shortlisted interchange functional plan concepts, river crossing options, and mainline alignments. A modified Delphi method was used to assess concepts.

A process of identifying improvement alternatives and then evaluating them is fundamental to many levels of road infrastructure development and operation: planning, design, construction, maintenance, and operations. Road infrastructure planning has evolved to consider a broad spectrum of elements (Elements) which can be categorized into accounts (Accounts). Common Accounts and respective Elements typically used by road authorities are presented in **Figure 7.1**.

Financial Account

- Capital Construction Cost
- Maintenance Cost
- Operating Cost
- (Optional Revenue a negative cost)

Road User Account (Customer Account)

- Travel Time
- Vehicle Operating Costs
- Safety Costs

Environmental and Heritage Account

- Green House Gas Emissions
- Biophysical
- Natural Resource
- Heritage

Social Account

- Alignment to Road Network Plans
- Alignment to Social Interests

Economic Account

- Direct Employment During Construction
- Indirect Employment Resulting from Construction
- Local Economy

Figure 7.1: Multiple Account Evaluation Accounts and Elements (Evaluation Criteria)

These Accounts and Elements can be standardized to address a specific road authority’s mandate and/or modified to suit a specific project’s needs.

These accounts and elements can be standardized to address a specific road authority’s mandate and/or modified to suit specific project attributes. Accounts and their respective Elements (evaluation criteria) were developed and tailored to suit the Saskatoon Freeway Functional Planning Study (SFFPS) – Phase 2: Roadways and the Phase 2 mainline alignment.

In its simplest form MAE can be completed using a modified Delphi method where a group of subject matter experts considers a range of criteria, respective weightings, ratings, and resulting evaluation points. Each participant provides their assessment of weightings and ratings anonymously. The weightings and rating points are typically averaged and the alternative which exhibits the greatest number of points can be established as the preferred alternative. This structured communication process leads to a collective decision which inherently removes some of the bias potential of individual participants. The following is a brief description of the original Delphi process for easy reference:

> The Delphi method, also known as Estimate-Talk-Estimate (ETE) is a structured communication technique or method, originally developed as a systematic, interactive forecasting method which relies on a panel of experts. The technique can also be adapted for use in face-to-face meetings and is then called mini-Delphi or ETE. Delphi has been widely used for business forecasting and has certain advantages over another structured forecasting approach. Delphi is based on the principle that forecasts (or decisions) from a structured group of individuals are more accurate than those from unstructured groups. The experts answer questionnaires in two or more rounds. After each round, a facilitator or change agent provides an anonymized summary of the experts' forecasts from the previous round as well as the reasons they provided for their judgments. Thus, experts are encouraged to revise their earlier answers in light of the replies of other members of their panel. It is believed that during this process the range of the answers will decrease, and the group will converge towards the "correct" answer. Finally, the process is stopped after a predefined stop criterion (e.g., number of rounds, achievement of consensus, stability of results), and the mean or median scores of the final rounds determine the results.
>
> (https://en.wikipedia.org/wiki/Delphi_method)

MAE can also be undertaken using a detailed and complex analysis of each evaluation criteria (Element) and their respective cost streams over a planning horizon period. For example, road network macro modeling software can be used to determine total travel times for future network alternatives. A respective travel time cost can be determined through a detailed analysis of driver time costs of various types of vehicles. The future cost details can be calculated for an existing network where no changes are made (Base Case) and an alternative future state involving network changes (Alternative). This enables Net Present Values (NPV) and Benefit to Cost (B/C) ratios to be calculated; the Alternative cost is subtracted from the Base Case cost. The NPV can be normalized by dividing it by the capital cost for the Alternative resulting in a B/C ratio, as presented below.

- *Net Present Value (NPV) = Discounted Base Case - Discounted Alternative*
- *B/C = NPV/Capital Cost - 1*

MAE can also be used for portfolio management where NPV's are plotted considering different time horizons. This leads to an analysis of optimum timing for infrastructure investments. MAE can be based on volumes of traffic moved and/or on volumes of people moved. The latter considers an analysis of vehicle occupancy rates on road networks thereby enabling analysis of different modes of travel to move people (e.g. freeways versus light rail).

The Delphi method approach to MAE is a suitable level of analysis for functional planning. Functional plans can be changed or refined through the remaining phases of the delivery life cycle thus detailed analysis is typically not warranted early in the development process.

7.1 Mainline Alignment Through the Swales Area Multiple Account Evaluation

It is important to note that the SFFPS scope did not include re-evaluation of the freeway corridor route determined in previous location studies.

A detailed quantitative MAE analysis was not used for the SFFPS because of uncertainties associated with the travel demand model (TDM) assumptions: time horizon and population growth, employment growth, etc. The TDM assumptions are described in **Section 4.1** of this report. In addition, the functional concepts for each interchange location are similar; therefore, a detailed analysis is not warranted. This is highlighted by some of the evaluation criteria (MAE Elements) noted as “Equivalent” in the weighting process.

The modified Delphi method was used for Phase 2 of the SFFPS to assess alternative alignment concepts through the northern portion of the Phase 2 mainline, focussing on the route through the Swales and access to Highway 41. The Delphi method was further modified where account weighting was completed by the Environmental and Heritage TWG experts prior to the actual MAE process. These experts also weighted the elements within the Environmental Account at the same time. This method was used to ensure adequate consideration was given to environmental factors associated with the Small and Northeast Swales.

Details of the MAE for northern mainline alignment for Phase 2 of the Saskatoon Freeway Functional Planning Study are included in **Appendix I**.

Alignment functional plan concepts were evaluated using the following order of activities:

1. Three northern alignment (through the Swales) concepts were developed through multiple public consultation sessions. Two concepts for re-aligning Highway 41 were also developed; however, only one of these concepts was carried forward to the MAE because it was better suited to local land uses and was better aligned to the travel patterns confirmed in TDM analysis (multiple TDM runs);

2. An Excel workbook was developed and used specifically for the Northern Alignment MAE. The workbook included worksheets for completing the weighting and rating processes, data input worksheets to capture input from each participant, and a summary work sheet;

3. The applicable elements were determined for the four alignment concepts;

4. The weighting for each element was determined by each MAE participant by allotting values to each account and subsequently to each element, with a greater value suggesting greater importance. For example, an element could be weighted 0 if it was not applicable, or 7 if it was important. The sum of the elements weightings within each account equaled the predetermined account weighting. For example, if the Financial Account weighting was predetermined to be 13, the 4 elements within this account could be weighted 7, 0, 4, and 2 (or any other variation of non-negative numbers that add up to 13);

5. The weightings were averaged for each element. As an example, Participant 1, Participant 2, and Participant 3 might weight the importance of Travel Time differently considering the array of elements being considered. Average weightings were calculated as a means of capturing the overall group of

participants weighting minimizing potential bias for a specific concept. Note the weighting of the elements was completed in advance of participant ratings. This was also done to minimize the potential for bias when completing the weighting process;

6. Participants rated each of the elements on a scale of 0 to 4 (0 = Unacceptable, 1 = Marginally Acceptable, 2 = Acceptable, 3 = Excellent, 4 = Exemplary);

7. The final MAE results were reviewed by the Ministry. The executive team members and subject matter experts met with the Ministry to further discuss the top two rated concepts;

8. The Environmental and Heritage TWG provided comments and/or challenges to the initial results which ultimately led to a refinement of a north route added outside of the initial 500 m general location corridor; and

9. The preferred interchange functional plan concept was selected.

7.2 North and South Interchange Concepts Multiple Account Evaluation

A quantified detailed MAE analysis was not used for the SFFPS because of uncertainties associated with the travel demand model (TDM) assumptions: time horizon and population growth, employment growth, etc. The TDM assumptions are described in **Section 4.1** of this report. In addition, the functional concepts for each interchange location are similar; therefore, a detailed analysis is not warranted. This is highlighted by some of the evaluation criteria (MAE Elements) noted as “Equivalent” in the weighting process.

The modified Delphi method was used for Phase 2 of the SFFPS to assess design concepts at each interchange location along the entire Phase 2 alignment.

Details of the MAE for the north and south interchange concepts for Phase 2 of the SFFPS are included in **Appendix I**.

Interchange design functional plan concepts were evaluated using the following order of activities:

1. Multiple concepts were developed for each location: Central Avenue (2 concepts), Highway 41 (2 concepts), Blackley Road (2 concepts), Highway 5 (2 concepts), 8th Street (2 concepts), Highway 16 (3 concepts), and Highway 11 (2 concepts). Zimmerman Road interchange was not included in the MAE as there was only one reasonable option: a diamond interchange. Floral Road west was added to the alignment primarily as a way to address Floral Road eastbound traffic access to the Saskatoon freeway to avoid U-turns on Highway 11 from Grasswood. The concepts incorporated ultimate system level, hybrid, and service level interchange features. Interim staging concepts were also considered as part of the qualitative review;

2. Background data was compiled for each shortlisted concept in preparation for an initial MAE session by the project team executive members. For example, high level parametric construction cost estimates were determined or each interchange concept allowing the MAE participants to make an informed judgement on how they might rate the alternative;

3. Excel workbooks were developed and used for each location. The workbooks included worksheets for completing the weighting and rating processes, data input worksheets to capture input from each participant, and a summary work sheet;

4. The applicable elements were determined for each location. Some elements were not applicable or were considered equal for each of the concepts at a specific location. For example, an assessment of the impact to the swales was not applicable for the interchanges south of the swales. In other words, each MAE was tailored to the specifics of each location; however, the same set of elements was used;

5. The weighting for each element was determined by each MAE participant by first allotting values to each account and subsequently to each element, with a greater value suggesting greater importance. For example, an element could be weighted 0 if it was not applicable, or 7 if it was important. The sum of the elements weightings within each account equaled the predetermined account weighting. For example, if the Financial Account weighting was predetermined to be 13, the 4 elements within this account could be weighted 7, 0, 4, and 2 (or any other variation of non-negative numbers that add up to 13). The established weighting were applied to all interchange configurations;

6. The weightings were averaged for each account and element. As an example, Participant 1, Participant 2, and Participant 3 might weight the importance of the Customer Account and the element Travel Time differently considering the array of elements being considered. Average weightings were calculated as a means of capturing the overall group of participants weighting minimizing potential bias for a specific concept. Note the weighting of the accounts and elements was completed in advance of participant ratings. This was also done to minimize the potential for bias when completing the weighting process;

7. Participants rated each of the elements on a scale of 0 to 4 (0 = Unacceptable, 1 = Marginally Acceptable, 2 = Acceptable, 3 = Excellent, 4 = Exemplary);

8. Results of the MAE were reviewed with each Technical Working Group to ensure an opportunity for feedback prior to finalizing the preferred interchange configurations; and

9. The final MAE results were determined and used for selection of the preferred interchange functional plan concepts.

8 Multi-Phase Supporting Information

8.1 Geotechnical Investigation

8.1.1 Geotechnical Investigation

The Phase 2 geotechnical investigation field program was completed winter 2022. This section of the report summarizes the Phase 2 geotechnical investigation. Detailed laboratory testing results are included with a detailed description of the Phase 2 geotechnical investigation in the Phase 2 Factual Geotechnical Data report (**Appendix J**).

The collection of reliable geotechnical information is a key component of a functional design. The geotechnical investigations will provide factual data to understand subsurface conditions along the freeway alignment, as well as at the proposed locations for interchanges, railway crossings, South Saskatchewan River crossing, and swale crossings.

The geotechnical investigation and testing plan was based on Ministry standards and the experience of SNC-Lavalin on projects similar in nature. Optimization of the field investigation has been completed through detailed geological review and consideration of existing boreholes within the project extent. The geotechnical investigation included drilling of preliminary, stratigraphic, and foundation boreholes as outlined below.

Preliminary Boreholes: Preliminary boreholes were drilled along the general roadway alignment and will be used to delineate surficial materials and define engineering properties of the subgrade. Drilling of preliminary boreholes was completed in accordance with specification CM 303-01, as outlined in the Ministry Construction Manual for Soils Testing (1997) and were completed to a minimum depth of 4.6 m (15 feet) below existing ground surface. The information obtained from preliminary boreholes will be used for pavement design, route confirmation and soft soil delineation. Through review of existing borehole information, SNC-Lavalin identified significant amounts of soft soils along the alignment including several wetlands. The presence of which increase the value of the data that will be collected through the completion of preliminary boreholes.

Stratigraphic Boreholes: Stratigraphic boreholes were drilled along the general roadway alignment and will be used to obtain soil stratigraphy and engineering properties of the subgrade and deeper foundation materials. Drilling of stratigraphic boreholes was completed in accordance with specification STP 1041 as outlined in the Ministry Standard Test Procedures Manual for Stratigraphic Holes (1992) and specification CM 303-01 as outlined in the Construction Manual for Soils Testing (1997). Stratigraphic boreholes were drilled to a minimum depth of 13.5 m (45 feet) below existing ground surface. The information obtained from completion of stratigraphic boreholes will be used to interpolate the stratigraphy of the area, determine the engineering properties of the subgrade and foundation along the alignment, and determine the type and quality of expected adjacent borrow sources.

Foundation Boreholes: Foundation boreholes were drilled at bridge/overpass locations in order to define the soil horizons and material properties of the supporting ground. Drilling of foundation boreholes was completed in accordance with the specifications as outlined in the Ministry Construction Manual for Soils Testing (CM 303-01) and were completed to a minimum depth of 24.4 m (80 feet) below existing ground surface. Proposed Cone Penetration Testing (CPTu) was not completed during the Phase 2 geotechnical investigation due to consistently unsuccessful attempts during the Phase 1 geotechnical investigation. SNC-Lavalin and the Ministry decided to remove CPTu testing from the Phase 2 geotechnical investigation because soil type in the Saskatoon Freeway area is not conducive to successful CPTu results. A sufficient number of conventional drilled foundation borehole at each structure were completed in order to collect soil samples for laboratory testing. Visual inspection of the soils encountered was also completed at each borehole. The information obtained from the completion of foundation boreholes will be used to define soil capacities for design of structural foundations.

Foundation Boreholes for the South Saskatchewan River Crossing: Foundation boreholes were proposed to be drilled for the South Saskatchewan River crossing targeting abutment and pier locations as defined by the selected structure type. Deep stratigraphic boreholes were completed at the west and east abutment locations to depths of 100.25m (330 feet) and 100.45 m below existing ground surface, respectively. The proposed Foundation borehole at the pier location on the west bank of the river could not be completed due to access restrictions. Additional safety and environmental protection measures will be required during detailed design phases if drilling at this location is required. For pier locations within the river, drilling was proposed to be completed via barge during the summer months. Due to extremely low water levels in the river in 2021, barge access was not possible, and drilling could not be completed at pier locations within the river. Boreholes drilled at the river crossing were completed using mud rotary methods due to depth and complexity. Geophysical logging was also completed on the deep stratigraphic foundation boreholes at the South Saskatchewan River. The boreholes were geophysically logged using a Mount Sopris MGX II digital logging system and Matrix software. Natural gamma (NG), single-point resistance (SPR), and spontaneous potential (SP) readings were collected at each abutment. The information obtained from the completion of foundation boreholes at the South Saskatchewan River crossing will be used to define soil capacities for design of structural foundations.

- Drill supervisors determined the final location of boreholes based on site conditions and oversaw the drilling operation. Prior to any ground intrusive investigation, appropriate permits and utility clearances were obtained. For each borehole, the drill supervisor documented soil descriptions, collected soil samples, and completed in-situ field testing. Standard Penetration Testing (SPT) and Shelby tube sampling was performed at select stratigraphic depths where soil conditions allowed. Soil samples collected during the field investigation are being tested at the time of this report to determine the geotechnical parameters of the soils. The following tests will be performed on selected samples:
- Natural water content (ASTM D2216);
- Atterberg limits (ASTM D4318);
- Wash sieve analysis (ASTM C117);
- Hydrometer and sieve test (ASTM D7928 and C136);
- Group index and classification (MHI STP 205-2);
- Unconfined compression strength (for select Shelby tube samples, ASTM D2166);
- Unit weight (for select Shelby tube samples, ASTM D7263);
- Carbonate content (for select glacial till samples, ASTM D4373); and,
- Organic content (for organic soil samples only, AASHTO T267).

As assumed, groundwater was encountered during the drilling investigation. Due to the anticipated large fills at the interchanges and railway crossing locations, installation and monitoring of Vibrating Wire (VW) piezometers has been completed as part of the geotechnical investigation. During drilling, the location and depth of piezometers was determined based on the soils encountered and groundwater observed. Slope inclinometer (SI) casing was installed during the drilling investigation at both the east and west abutments of the South Saskatchewan River crossing. This SI casing was installed in order to monitor horizontal displacement of the valley slope and will also determine any potential slip surfaces that will require consideration for slope stability modelling.

Upon completion, each borehole locations was surveyed using a handheld GPS unit. Additional survey using a real time kinematic (RTK) surveying system was completed for boreholes containing instrumentation. Preliminary and stratigraphic boreholes (up to 13 m) were backfilled with the cuttings and/or bentonite chips. A cement/bentonite slurry mixture was used to backfill deeper stratigraphic boreholes, boreholes with instrumentation installed, and boreholes with groundwater or environmental concerns.

9 Recommendations

9.1 Interchange Design

9.1.1 Central Avenue

Based on the findings from the MAE and feedback from the Public Workshop, Concept 1 was selected as the preferred concept at Central Avenue. Full access will be provided at the Central Avenue interchange with a diamond configuration with two lane ramps to/from the west and single lane ramps to/from the east. The Saskatoon Freeway will have five lanes in each direction west of Central Avenue and four lanes in each direction east of Central Avenue. A lane will be added/dropped at Central Avenue through use of the two lane N/S-W ramp and the two lane W-N/S ramp.

While the initial concept included two lanes in each direction along Central Avenue and two-lane roundabouts at the terminal intersections, updated traffic modelling showed the need for three lanes in each direction. As such, roundabouts are no longer considered feasible and signalized intersections are recommended at the ramp terminal intersections. The Central Avenue alignment will also be shifted to the east to increase separation between the Small Swale and the Central Avenue interchange. A new single structure will be constructed for Central Avenue over the Saskatoon Freeway. Range Road 3051, Range Road 3050, and Range Road 3045 will be closed with cul-de-sacs. Central Avenue will provide future access north and south of the Saskatoon Freeway.

A summary of key geometrics for the Central Avenue Interchange is provided in **Table 9.1** and the preferred interchange configuration is presented below in **Figure 9.1**. Functional Design plan and profiles for the interchange are presented in **Appendix K**.

Table 9.1: Central Avenue interchange geometrics.

GEOMETRIC DESIGN STANDARD		CENTRAL AVENUE	RAMP W-N/S	RAMP N/S-E	RAMP N/S-W	RAMP E-N/S
Design Speed (km/h)		70	60	60	60	60
Number of Lanes		6	2	1	2	1
Lane Width (m)		3.7	3.7	4.8	3.7	4.8
Shoulder Width (m)	Left	0.5	1.0	1.0	1.0	1.0
	Right	0.5	2.5	2.5	2.5	2.5
Minimum Radius (m)		190	130	190	130	130
Maximum Grade (%)		4.0	3.5	3.0	2.0	2.0
Minimum "K" Factor	Crest	25	50	100	N/A	N/A
	Sag	12	30	30	60	100

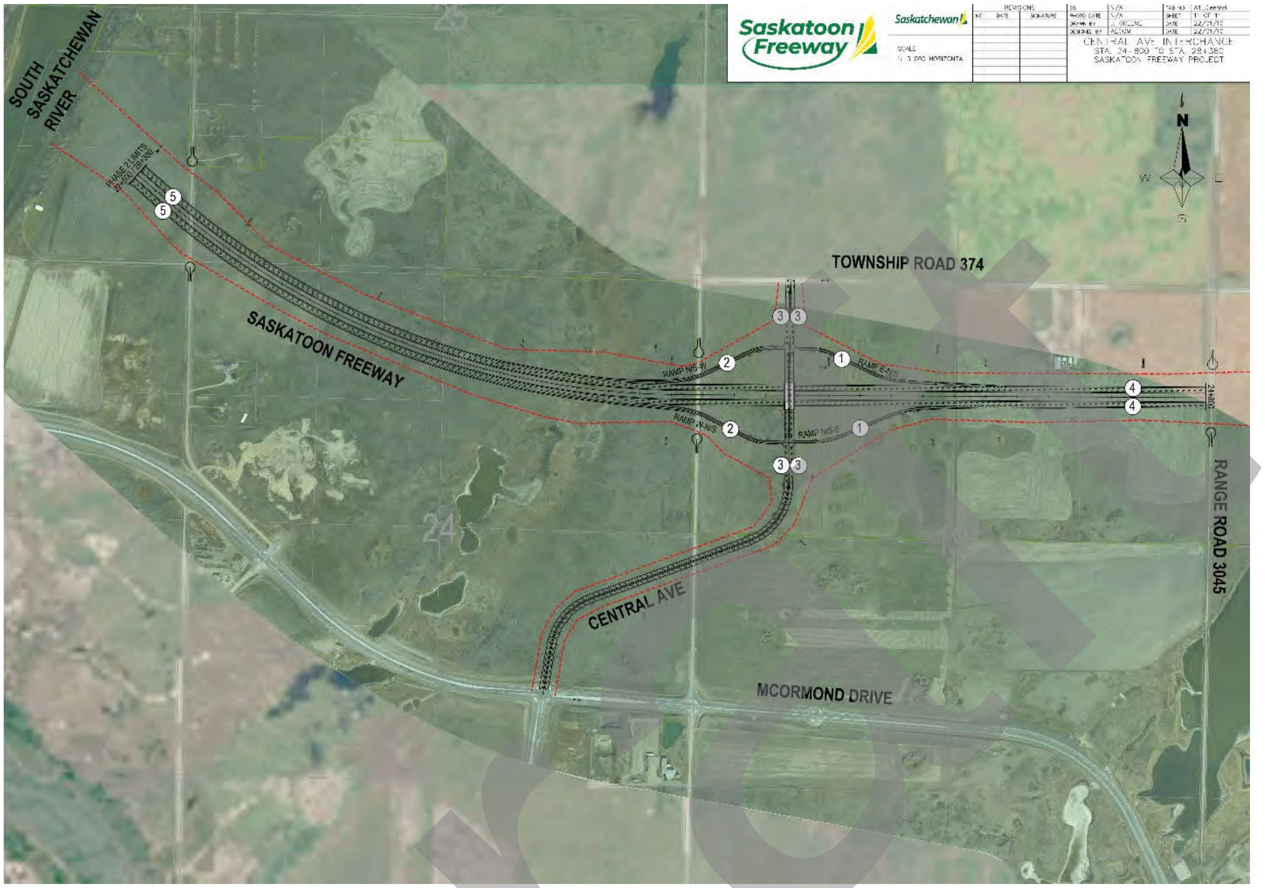


Figure 9.1: Central Avenue recommended interchange configuration

9.1.2 Highway 41/Blackley Road

As discussed in **Section 5.2.1**, Freeway Concept 3 was selected as the preferred mainline alignment as it minimizes impacts to the Northeast Swale. As such, the Highway 41 Realignment Concepts 1/2 were carried forward as they better align with Freeway Concept 3. Based on the MAE, Highway 41 realignment interchange Concept 2 was preferred as it provided direct freeway access from Blackley Road and more direct/free-flow movements to/from Highway 41. Additionally, Concept 2 required fewer intersections along Highway 41 compared to Concept 1.

Following selection of Highway 41 Realignment interchange Concept 2 as the preferred concept, and based on feedback from the Public Workshop and TWG Meetings, the following minor modifications were made to the Highway 41/Blackley Road interchange configuration:

- Combined interchange footprint was reduced by shifting Blackley Road to the east and replacing the Parclo ramps with direct ramps;
- Replaced signalized intersections with roundabouts (3) for more direct access which allows for a more curvilinear alignment of Blackley Road;
- Minor geometry changes to optimize spacing between merge/diverge points and roundabout entry/exit points;

- Provided separate structures for Ramp E-S and Ramp N-E for improved road geometry;
- Eliminated redundant ramp/structure for Blackley Road S-E Ramp; and
- Modified Ramp S-N/S profile to go under Ramp E-S, N-E, and E-N instead of going over.

New structures will be constructed for Blackley Road over the Saskatoon Freeway (one structure), Ramp E-S over the Saskatoon Freeway and Ramp S-N/S (two structures), Ramp N-E over the Saskatoon Freeway and Ramp S-N/S (two Structures), and Ramp E-N over Ramp S-N/S (one structure).

As part of this interchange concept, Highway 41 will be realigned to the east and run parallel to and south of Township Road 374. The realigned section of Highway 41 will be twinned (4-lane divided cross-section) and maintain a 130 km/h design speed outside of the CoS limits. The existing section of Highway 41 west of Kilmeny Road will be maintained as a lower speed roadway and cross the Saskatoon Freeway with a flyover structure (one structure). As such, no access to/from the Saskatoon Freeway will be provided at the existing Highway 41 flyover.

North of the Saskatoon Freeway, a new interchange will be required to connect the realigned section of Highway 41 with the existing section of Highway 41. This interchange will be designed to promote use of the Highway 41 realignment by requiring southbound vehicles to 'exit' Highway 41 via the N-S ramp to continue straight on existing Highway 41. In the northbound direction, vehicles using the existing Highway 41 will need to merge onto the new/realigned section of Highway 41 via the S-N ramp. A new structure will carry Ramp N-S over the Highway 41 realignment (one structure).

A summary of key geometrics for the Highway 41/Blackley Road interchange and the Highway 41 Realignment are provided in **Table 9.2** and **Table 9.3**, respectively. The recommended interchange configurations are presented below in **Figures 9.3, 9.4**, and **9.5**. Functional Design plan and profiles for the interchange are presented in **Appendix K**.

Table 9.2: Highway 41/Blackley Road interchange geometrics

GEOMETRIC DESIGN STANDARD		BLACKLEY ROAD	RAMP N-N/S	RAMP N/S-E	RAMP N/S-N	RAMP S-N/S	RAMP N/S-S
Design Speed (km/h)		80	70	60	70	70	50
Number of Lanes		4	1	1	2	1	1
Lane Width (m)		3.7	4.8	4.8	3.7	4.8	4.8
Shoulder Width (m)	Left	0.5	1.0	1.0	1.0	1.0	1.0
	Right	0.5	2.5	2.5	2.5	2.5	2.5
Minimum Radius (m)		90	40	130	190	130	130
Maximum Grade (%)		3.0	4.0	5.0	5.0	1.8	1.9
Minimum "K" Factor	Crest	30	20	25	20	50	50
	Sag	30	25	25	25	150	15

Table 9.3: Blackley Road interchange geometrics

GEOMETRIC DESIGN STANDARD		HWY 41 REALIGNMENT	HWY 41	RAMP E-N/S	RAMP E-S	RAMP N-E	RAMP S-E	RAMP N-S	RAMP S-N
Design Speed (km/h)		130	80	80	60	50	90	100	100
Number of Lanes		4	2	1	1	1	1	1	1
Lane Width (m)		3.7	3.7	4.8	4.8	4.8	4.8	4.8	4.8
Shoulder Width (m)	Left	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.0
	Right	2.5	2.0	2.5	2.5	2.5	2.5	2.5	2.5
Minimum Radius (m)		950	N/A	350	165	90	340	440	810
Maximum Grade (%)		3.0	4.0	5.0	3.0	5.5	2.6	3.0	2.50
Minimum "K" Factor	Crest	60	26	26	40	15	60	55	55
	Sag	75	30	30	30	25	35	45	75

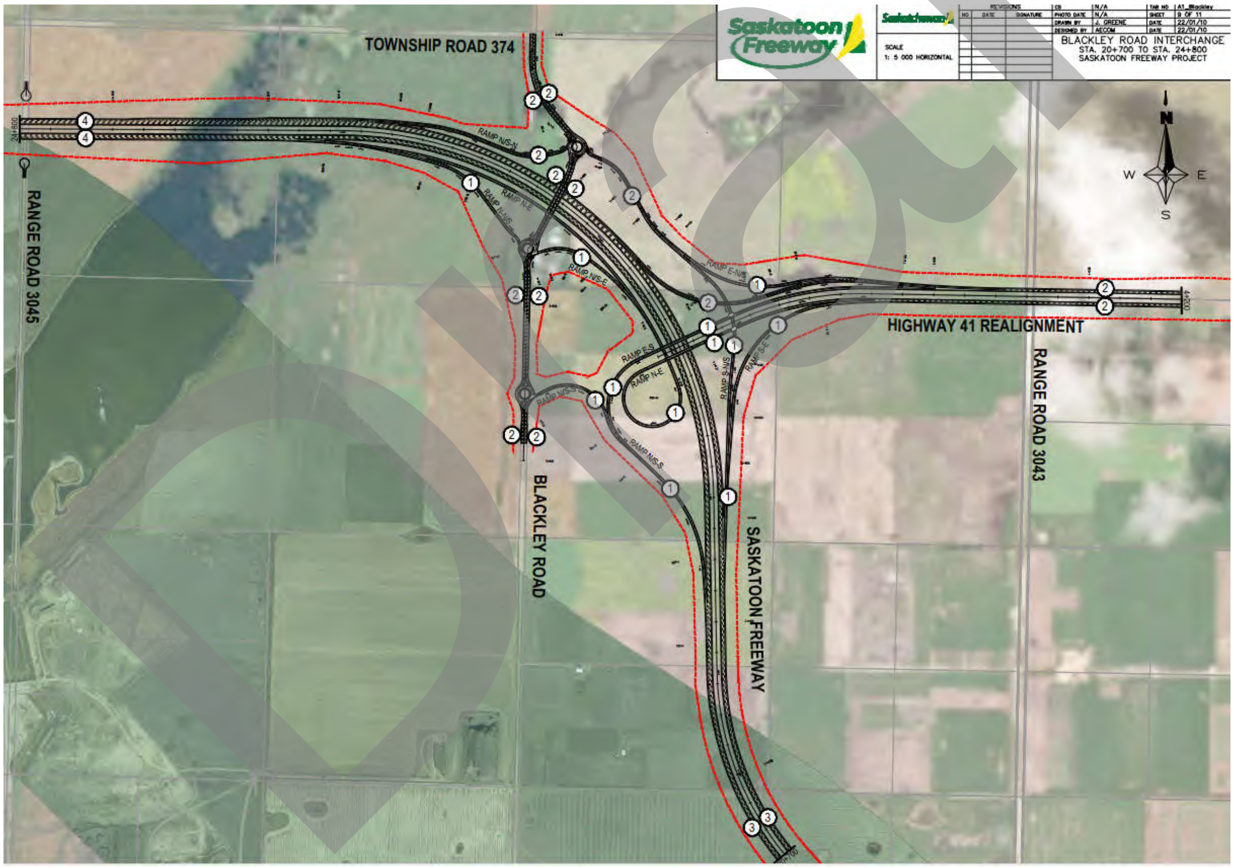


Figure 9.2: Blackley Road/Highway 41 recommended interchange configuration

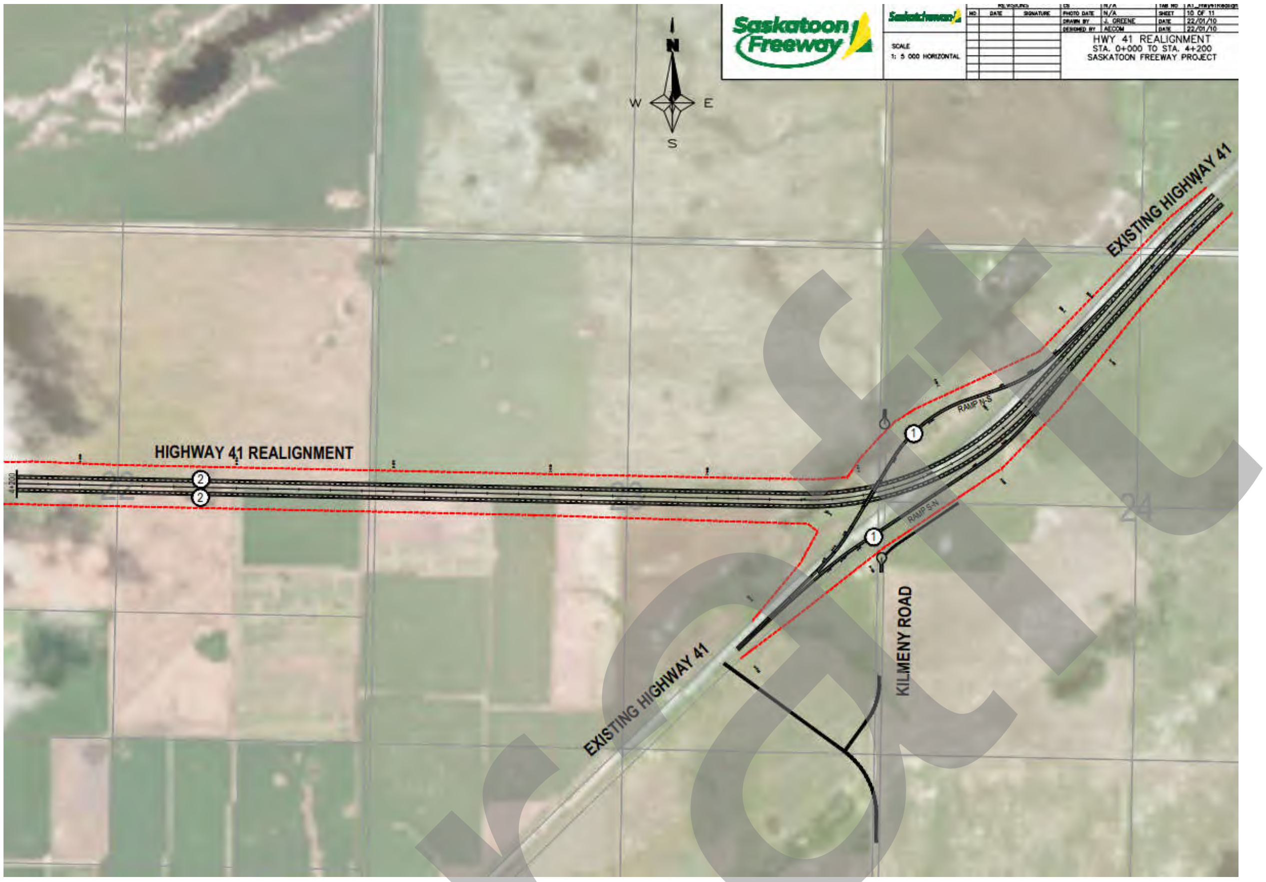


Figure 9.3: Highway 41 realignment recommended interchange configuration

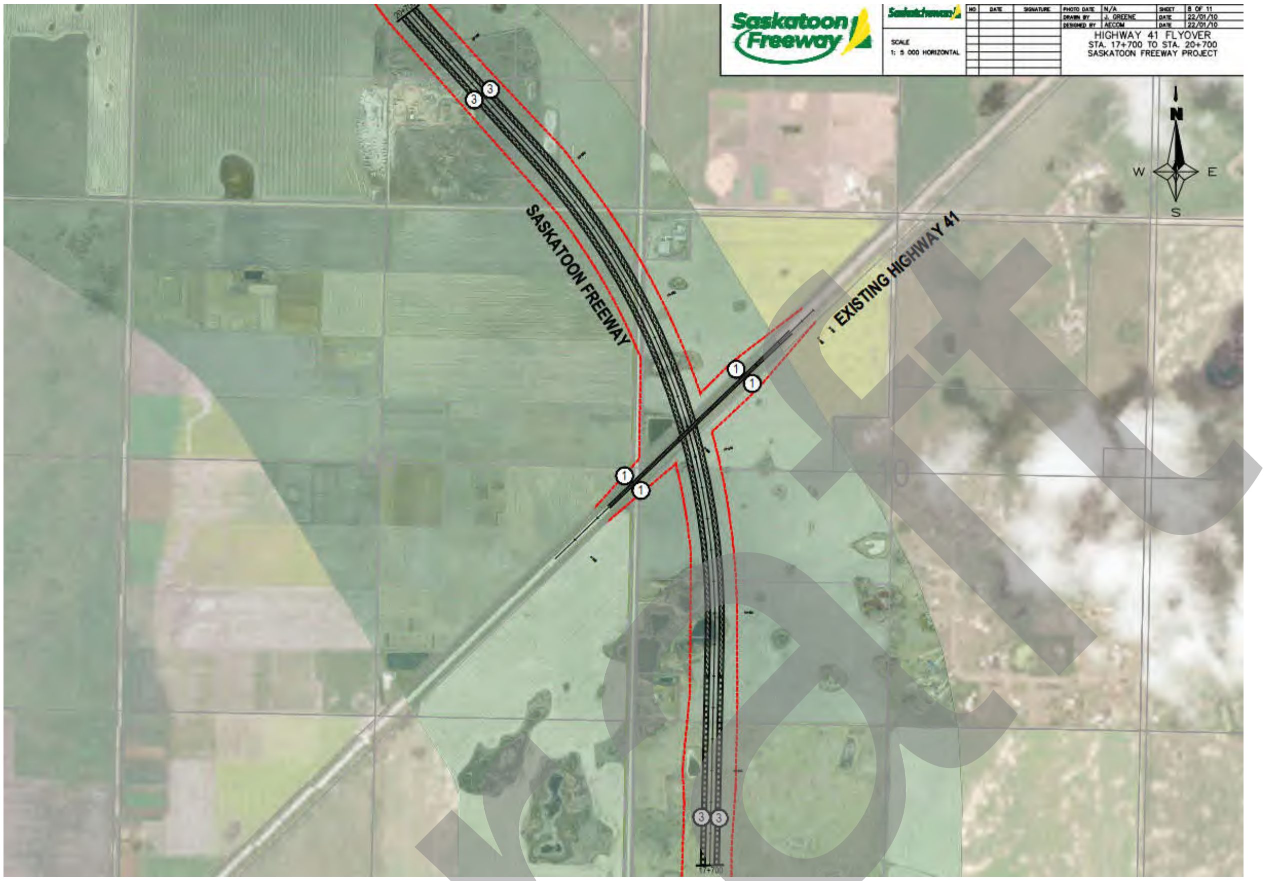


Figure 9.4: Flyover at existing Highway 41

9.1.3 Highway 5

Based on the findings from the MAE and feedback from the Public Workshop, Concept 1 was selected as the preferred concept at Highway 5. This configuration will provide full access to/from Highway 5 and would be completely free-flowing without requiring signalized intersections.

The Saskatoon Freeway will have a 6-lane cross-section (3-lanes in each direction) through the Highway 5 interchange, with a design speed of 130 km/h. All ramps at this interchange will be single-lane ramps with a 90 km/h design speed. Direct ramps will be provided for the W-S, S-E, E-N, and N-W ramps with a flyover for the W-N and E-S ramp. Loop ramps will be provided for the N-E and S-W ramps. A C-D road will be used in the northbound direction to combine the S-E and S-W ramps exits. In the southbound direction, a C-D road will combine the N-W and N-E ramp exits. Structures will carry the Saskatoon Freeway traffic over Highway 5 (two structures), Ramp N-E over Highway 5 (one structure), Ramp S-W over Highway 5 (one structure), Ramp W-N over Ramp E-S, the Saskatoon Freeway, and Highway 5 (three structures), and Ramp E-S over Ramp W-N, the Saskatoon Freeway, and Highway 5 (three structures).

A summary of key geometrics for Highway 5 is provided in **Table 9.4** and the recommended interchange configuration is presented below in **Figure 9.5**. Functional Design plan and profiles for the interchange are presented in **Appendix K**.

Table 9.4: Highway 5 interchange geometrics

GEOMETRIC DESIGN STANDARD		HWY 5	RAMP N-W	RAMP N-E	RAMP W-S	RAMP W-N	RAMP S-E	RAMP S-W	RAMP E-S	RAMP E-N
Design Speed (km/h)		130	90	90	90	90	90	90	90	90
Number of Lanes		4	1	1	1	1	1	1	1	1
Lane Width (m)		3.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Shoulder Width (m)	Left	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Right	3.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Minimum Radius (m)		N/A	340	90	230	340	340	90	340	250
Maximum Grade (%)		4.3	4.4	6.0	3.1	4.5	3.3	4.2	3.9	5.0
Minimum "K" Factor	Crest	195	60	30	60	60	60	25	60	60
	Sag	85	35	15	35	35	35	35	35	40

Figure 9.5: Highway 5 recommended interchange configuration

9.1.4 8th Street

Based on the findings from the MAE and feedback from the Public Workshop, Concept 1 was selected as the preferred concept at 8th Street. Full access will be provided at the 8th Street interchange with a diamond configuration with single lane ramps in all directions. The initial TDM runs indicated that two lane ramps may be required in some locations. Upon refinement of the TDM, 2063 projections confirmed that single lane ramps are sufficient for all movements.

8th Street is assumed to be a six-lane urban cross section with 6 m wide concrete median at the ultimate stage, in accordance with CoS long term plan. The Saskatoon Freeway will have 3 lanes in each direction through 8th Street. The ramp terminal intersections will be signalized but could be staged with stop signs at initial construction depending on development rates east of Saskatoon. Service roads are proposed to provide access to existing yard sites east of the interchange.

A summary of key geometrics for the 8th Street Interchange is provided in **Table 9.5** and the preferred interchange configuration is presented below in **Figure 9.6**. TAC GDG design standards are followed for the ramps as they are connecting to a CoS street. Higher than minimum K values are provided when possible. Functional Design plan and profiles for the interchange are presented in **Appendix K**.

Table 9.5: 8th Street interchange geometrics

GEOMETRIC DESIGN STANDARD		8TH STREET	RAMP S-E/W	RAMP S-E	RAMP E/W-N	RAMP E-N	RAMP N-W/E	RAMP N-W	RAMP W/E-S	RAMP W-S
Design Speed (km/h)		80	90	70	90	70	90	70	90	70
Number of Lanes		6	1	1	1	1	1	1	1	1
Lane Width (m)		3.7	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Shoulder Width (m)	Left	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	Right	3.0	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Minimum Radius (m)		N/A	340	190	340	190	340	190	340	190
Maximum Grade (%)		2.75	3.75	3.2	3.5	3.2	3.0	2.75	3.0	2.75
Minimum "K" Factor	Crest	85	40	40	40	30	40	25	35	40
	Sag	85	45	-	45	80	45	60	45	-

Figure 9.6: 8th Street recommended interchange configuration

9.1.5 Highway 16

Concept 3 is the recommended configuration for the Highway 16 interchange. Design speeds on Highway 16 are 130 km/h. This requires significant embankments over the CP rail line to provide 10 m clearance. The southbound Highway 16 lanes also overpass the northbound mainline lanes while the northbound Highway 16 lanes merge at-grade with the mainline. This results in a staggered cross section with the southbound lanes profile being as much as 9 m above the northbound lanes. The alignments are spaced to avoid retaining walls. This approach requires slightly more property, and will result in a reduced construction cost.

A major fork will be constructed southbound to diverge Highway 16 and the Freeway mainline. For northbound traffic on Highway 16, the connection is shown as a right-hand entrance rather than a major connector. The difference is that the right-hand entrance follows typical lane balance practice and carries three lanes following the merger of two lanes with two lanes. A major connector would not drop a lane and would carry four lanes. Given the traffic volumes on the mainline and that the two-lane eastbound to northbound ramp merges with the mainline about 1 km north, a right-hand entrance was recommended to reduce the number northbound lanes between Highway 16 and 8th Street. Five lanes are not required in this location based on the TDM. Dropping a lane will also reduce the bridge lengths on the eastbound to northbound ramp and Patience Lake Road over the mainline.

A lane drop is shown on the 8th Street functional plan near Stn. 12+000. This lane could be carried to the 8th Street interchange and dropped as a “forced exit” rather than the tangent section lane drop as shown.

Alternate options for northbound laning could be considered during detailed design if desired:

- Use a major connector, i.e. four lanes north of merging mainline with Highway 16. To avoid carrying five lanes, drop one lane on the eastbound to northbound ramp prior to the mainline gore point and use a typical single lane entrance ramp design to drop the second lane. The TDM indicates that the peak 2063 volumes are near the capacity threshold between 1 and 2 lanes on this ramp, so this may be a valid option depending on development rates; and
- Use a major connector, i.e. four lanes north of merging mainline with Highway 16. Carry five lanes north of the merge with the eastbound to northbound ramp from Circle Drive. Drop a lane on the tangent section and drop a second lane as a “forced exit” at the 8th Street interchange.

An alternate alignment is shown for Patience Lake Road (**Figure 9.8**). This alignment would require fewer bridges and may be preferred by the RM for this reason. The final configuration of Patience Lake Road will be subject to further consultation. Note, the existing railway crossing at Patience Lake Road is to be moved to the new crossing location.

There are several potential municipal access roads shown in brown which includes basket weave ramps for connections to Circle Drive as part of a future Zimmerman Road/Circle Drive interchange. Although the design of the Zimmerman Road/Circle Drive interchange is outside the scope of this study, the basket weave concept is an example of how conflicts with the Circle Drive ramps connection to the Freeway mainline could be eliminated. Other access roads are shown in black, as these will be required to maintain legal access to some parcels.

A summary of key geometrics for the Highway 16 Interchange is provided in **Table 9.6** and the preferred interchange configuration is presented below in **Figure 9.7** and **Figure 9.8**. Functional Design plan and profiles for the interchange are presented in **Appendix K**.

Table 9.6: Highway 16 interchange recommended geometry

GEOMETRIC DESIGN STANDARD		HWY 16 S-N	HWY 16 N-S	RAMP S-W	RAMP W-S	RAMP W-N	RAMP N-W	PATIENCE LAKE RD
Design Speed (km/h)		130	130	100	110	70	90	80
Number of Lanes		2	2	2	2	2	2	2
Lane Width (m)		3.7	3.7	3.7	3.7	3.7	3.7	3.7
Shoulder Width (m)	Left	1.0	1.0	1.0	1.0	2.0	2.0	2.0
	Right	3.0	3.0	3.0	3.0	2.0	2.0	2.0
Minimum Radius (m)		950	950	600	600	190	340	250
Maximum Grade (%)		2.65	2.8	0.45	0.9	3.75	4.5	5.0
Minimum “K” Factor	Crest	195	195	195	125	55	40	40
	Sag	75	75	N/A	125	45	40	50

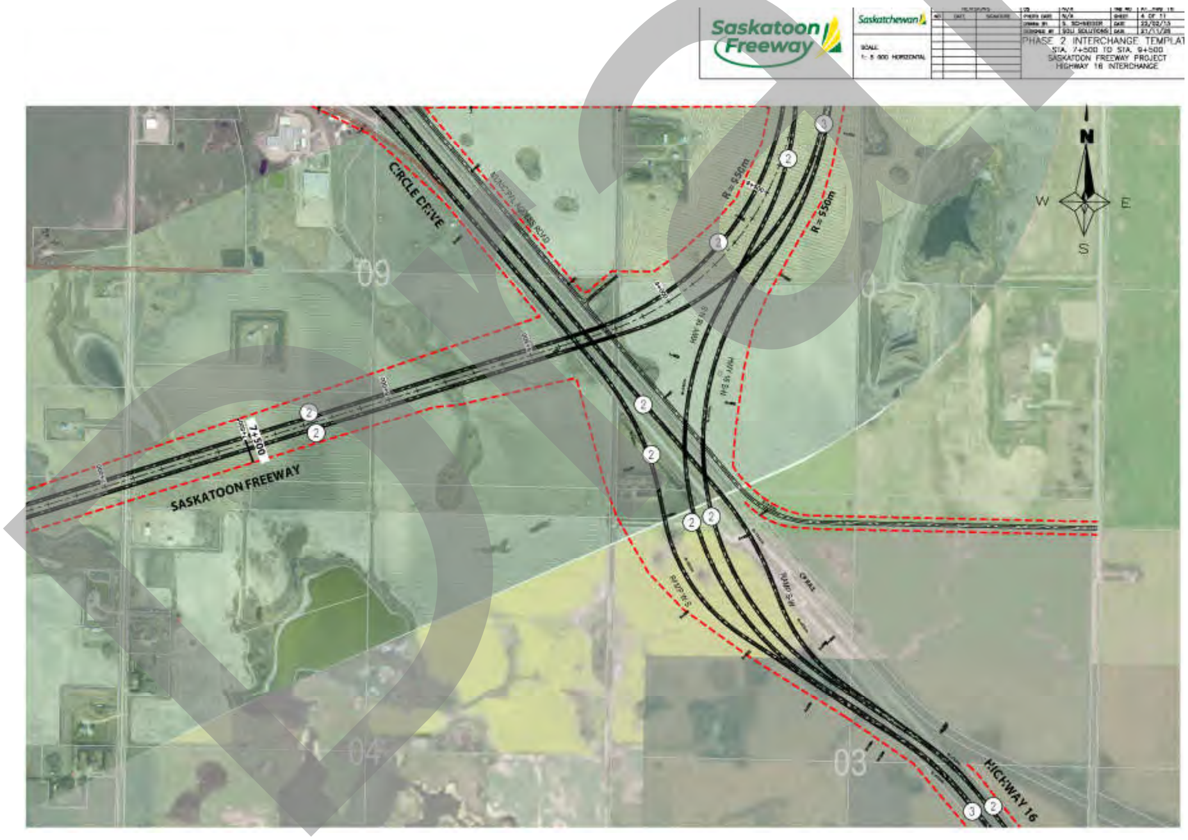


Figure 9.7: Highway 16 recommended interchange

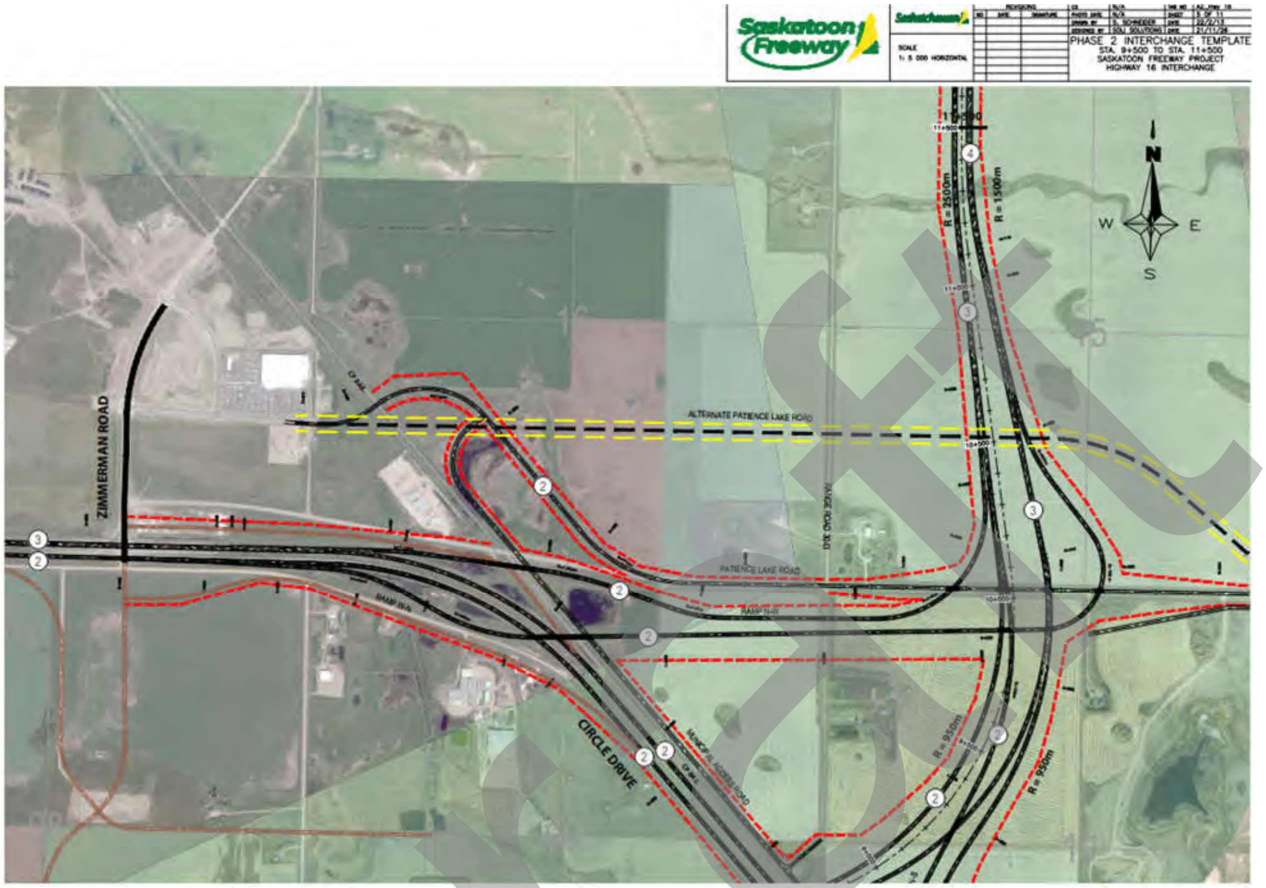


Figure 9.8: Highway 16 recommended interchange

9.1.6 Zimmerman Road

A diamond interchange is the recommended configuration for the Zimmerman Road interchange. Full access will be provided at the 8th Street interchange with a diamond configuration with single lane ramps in all directions.

The future Zimmerman Road extension is assumed to be a two-lane rural cross section. The Saskatoon Freeway will have 2 lanes in each direction through the interchange. The ramp terminal intersections are shown as roundabouts, although this can be modified during future design stages if desired. Ramp terminal spacing is 105 m as per Saskatchewan Ministry of Highways (Ministry) standards for diamond interchange configurations.

A summary of key geometrics for the Zimmerman Road Interchange is provided in **Table 9.7** and the preferred interchange configuration is presented below in **Figure 9.9**. Functional Design plan and profiles for the interchange are presented in **Appendix K**.

Table 9.7: Zimmerman Road interchange geometrics

GEOMETRIC DESIGN STANDARD		ZIMMERMAN ROAD	RAMP N/S-W	RAMP N/S-E	RAMP E-N/S	RAMP W-N/S
Design Speed (km/h)		90	80	80	80	80
Number of Lanes		2	1	1	1	1
Lane Width (m)		3.7	4.8	4.8	4.8	4.8
Shoulder Width (m)	Left	2.0	1.0	1.0	1.0	1.0
	Right	2.0	2.5	2.5	2.5	2.5
Minimum Radius (m)		N/A	250	250	250	250
Maximum Grade (%)		4.0	2.25	4.0	3.75	4
Minimum "K" Factor	Crest	40	40	40	40	40
	Sag	40	80	45	45	45

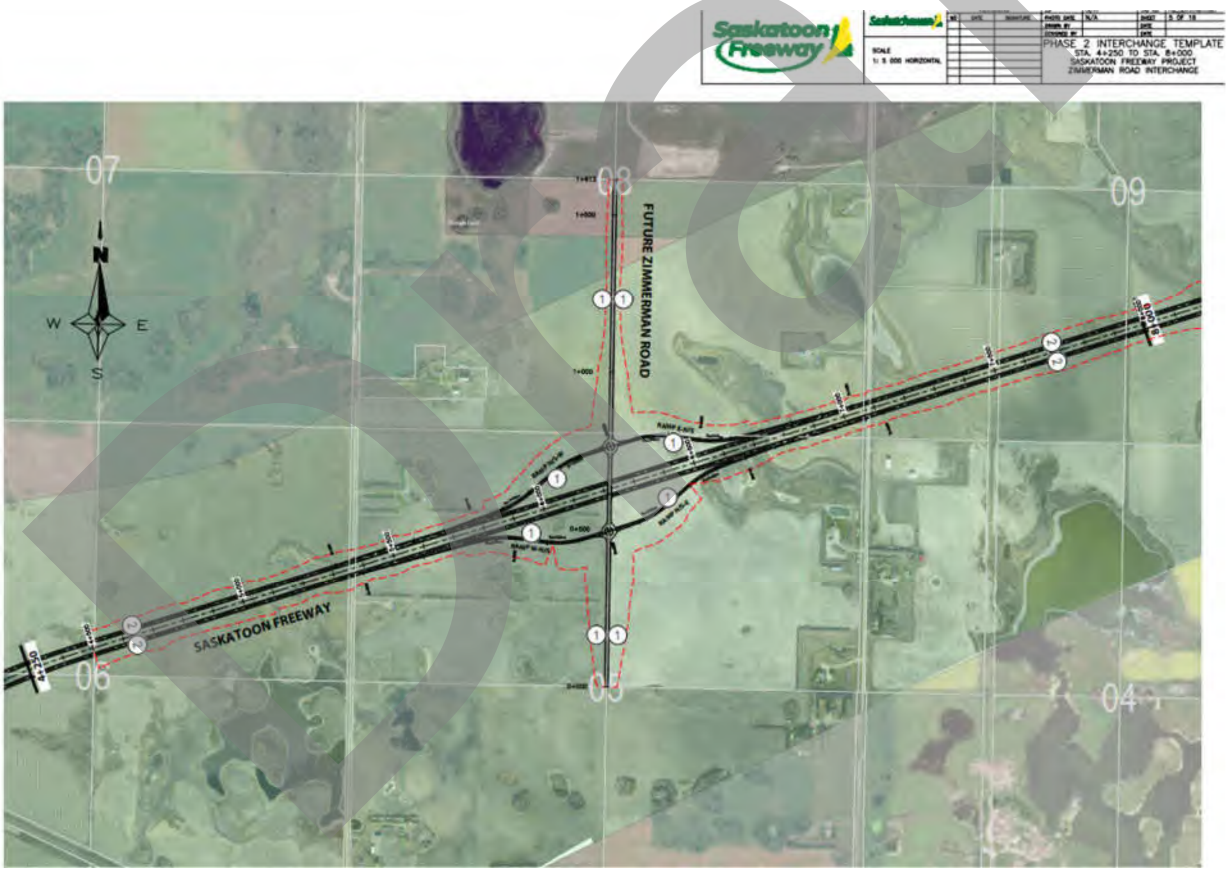


Figure 9.9: Zimmerman Road recommended interchange configuration

9.1.7 Floral Road

The Floral Road interchange allows for an additional connection for traffic originating or terminating at the Grasswood commercial centre to access the Freeway. The Floral Road intersection provides key movements that cannot be conveniently provided at adjacent interchanges. The eastbound to northbound loop ramp has a design speed of 50 km/h. The northbound to eastbound/westbound ramp has an intersection with Floral Road. This intersection was shown as a roundabout in early concept sketches, but was ultimately changed to a stop controlled or signalized intersection given the relative volumes of through traffic on Floral Road versus the ramp.

The southbound to westbound directional ramp merges with Floral Road prior to an existing access point, however the spacing to this access point is only about 50 m. Depending on future development in the area, this access point may need to be relocated to the west at the time of construction.

A summary of key geometrics for the Floral Road Interchange is provided in **Table 9.8** and the preferred interchange configuration is presented below in **Figure 9.10**. Functional Design plan and profiles for the interchange are presented in **Appendix K**.

Table 9.8: Floral Road interchange recommended geometrics

GEOMETRIC DESIGN STANDARD	FLORAL ROAD		RAMP N-W	RAMP W-N	RAMP S-E/W
Design Speed (km/h)	80		90	50	60
Number of Lanes	2		1	1	1
Lane Width (m)	3.7		4.8	4.8	4.8
Shoulder Width (m)	Left	2.0	1.0	1.0	1.0
	Right	2.0	2.5	2.5	2.5
Minimum Radius (m)	N/A		340	90	130
Maximum Grade (%)	4.0		3.5	2.85	3.4
Minimum "K" Factor	Crest	40	150	40	45
	Sag	40	35	55	45

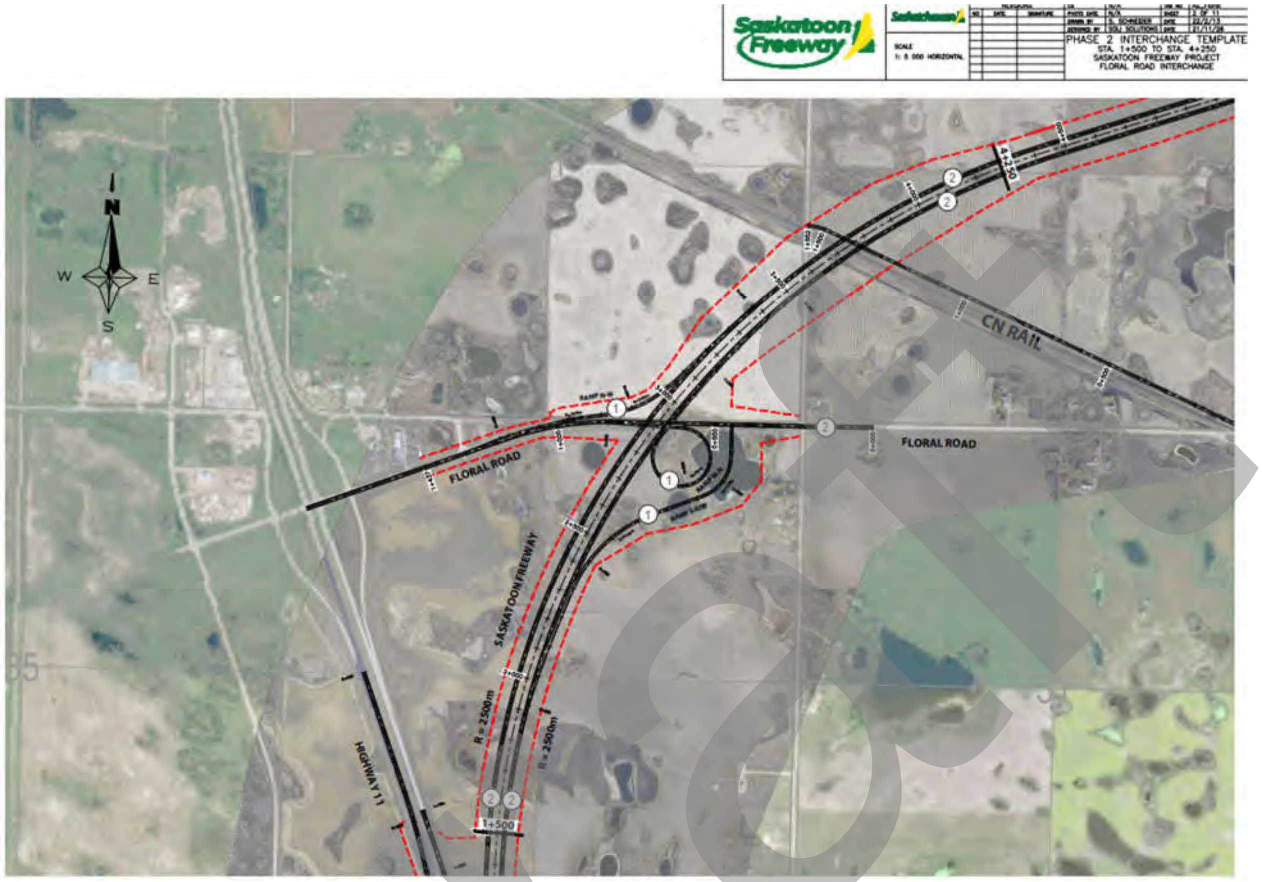


Figure 9.10: Floral Road recommended interchange configuration

9.1.8 Highway 11

Concept 1 is the recommended concept for the Highway 11 interchange. The angle of the northbound exit ramp to existing Highway 11 inbound to Saskatoon was increased during development of the functional design to reduce the crossing angle with the Freeway mainline and to reduce the bridge skew. This requires more property but reduces the bridge length significantly. The curve radii for this ramp are gradually reduced along the alignment from 800 m to 450 m to 320 m. The southbound lanes of existing Highway 11 will need to be shifted slightly west to accommodate the bridge embankment and the mainline lanes, which will require reconstruction of approximately 2 km of Highway 11.

A summary of key geometrics for the Highway 11 Interchange is provided in **Table 9.9** and the preferred interchange configuration is presented below in **Figure 9.11**. Functional Design plan and profiles for the interchange are presented in **Appendix K**.

Table 9.9: Highway 11 interchange recommended geometrics

GEOMETRIC DESIGN STANDARD	HIGHWAY 11 N-S		RAMP S-N
Design Speed (km/h)	110		80
Number of Lanes	2		2
Lane Width (m)	3.7		3.7
Shoulder Width (m)	Left	1.0	2.0
	Right	3.0	2.0
Minimum Radius (m)	2,000		320
Maximum Grade (%)	0.5		3.0
Minimum "K" Factor	Crest	300	60
	Sag	150	40

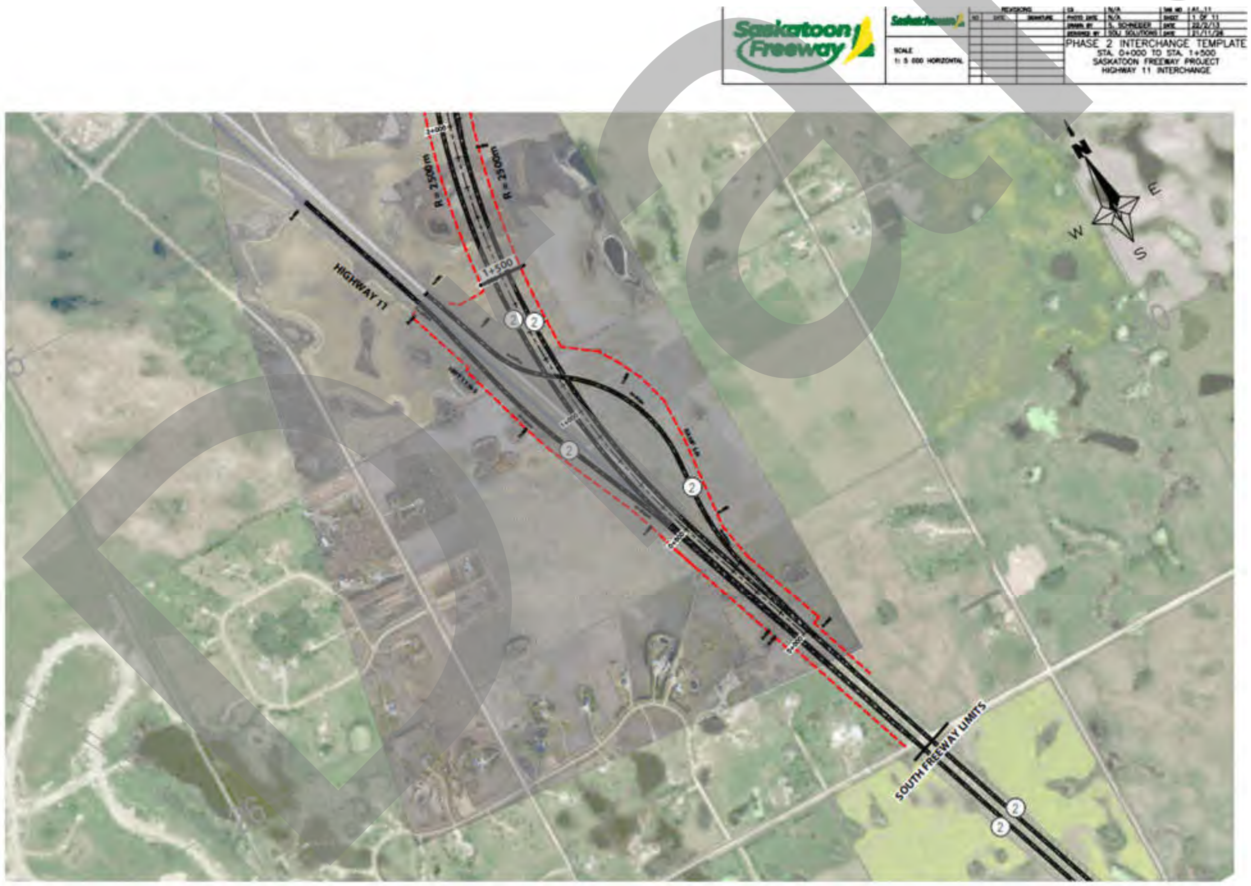


Figure 9.11: Highway 11 recommended interchange configuration

9.2 Mainline Alignment

Phase 2 of the study includes new construction of approximately 28.4 km of the Saskatoon Freeway from Highway 11 in the south to east of the South Saskatchewan River. The Saskatoon Freeway will be designed to a 130 km/h design speed and in accordance with the design standards provided in **Section 5.1**.

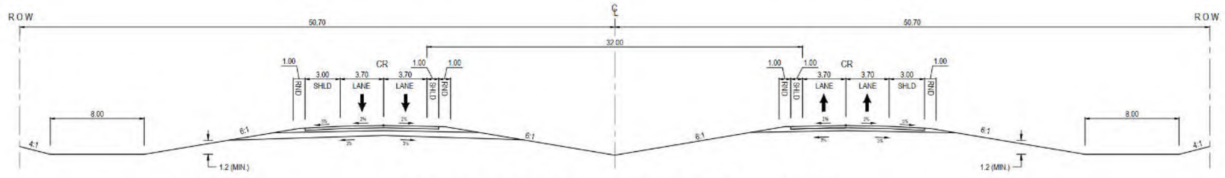
Based on the MAE and feedback from the Public Workshop, it is recommended that the mainline alignment be shifted further north as illustrated in North Section Concept 4. As part of this concept, Highway 41 will be realigned to the north to allow for interchanges at Central Avenue, Highway 5, and a combined interchange at Blackley Road and Highway 41 Realignment 'B'. A flyover with no freeway access would be provided at the existing Highway 41 location and the remaining sections of existing Highway 41 would become an arterial road, with lower speeds.

Within the overall Phase 2 limits, there are nine horizontal curves along the Saskatoon Freeway mainline, with an additional curve required to facilitate a widened median at Highway 16. The minimum horizontal curves along the mainline have a radius of 950 m and occur east of Highway 16 and between Highway 41 and Highway 41/Blackley Road. This meets the minimum requirements for a 130 km/h freeway design speed. A horizontal curve with a radius of 1,200 m occurs at the Blackley Road interchange. All other horizontal curves are above 2,000 m radius.

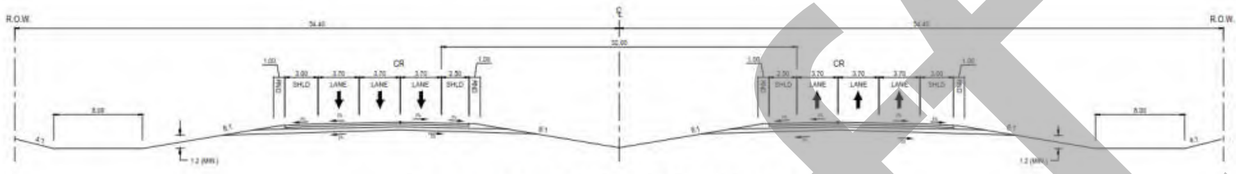
In general, the profile of the Saskatoon Freeway follows the existing ground profile while providing a minimum grade of 0% for rural cross sections and 0.5% grades at structures. A maximum vertical grade of 3.0% is required west of Highway 16 to ensure adequate clearance for the CP Rail track adjacent to Highway 16. Additional vertical curves between 2-3% are required along the Saskatoon Freeway for clearance of the CN Rail line east of Floral Road and for the future twinned Highway 5.

A standard median width of 32 m will be provided throughout the corridor with a minor flare of the eastbound lanes at the Highway 16 interchange to accommodate the geometry required for a major fork design. The ultimate configuration of the Saskatoon Freeway will have a typical 4-lane cross-section between Highway 11 and Highway 16, a 6-lane cross-section between Highway 16 and Highway 41/Blackley, an 8-lane cross-section between Highway 41/Blackley and Central Avenue, and a 10-lane cross-section between Central Avenue and the South Saskatchewan River.

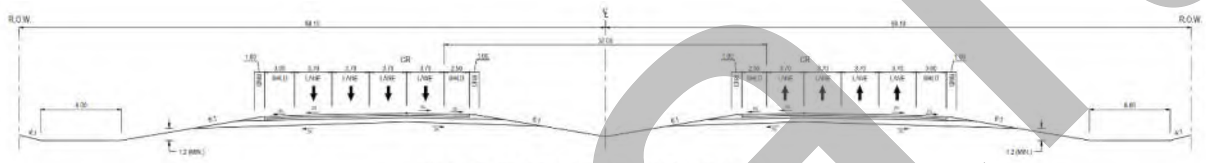
Additional auxiliary lanes will be provided within the interchange limits to facilitate deceleration or acceleration. The typical cross-section of the Saskatoon Freeway is provided below in **Figure 9.12**. Functional Design plan and profiles for the Saskatoon Freeway are presented in **Appendix K**.



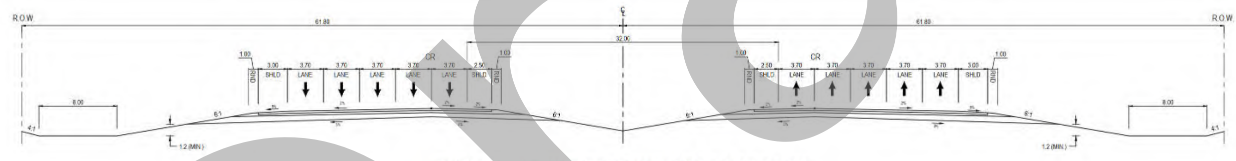
TYPICAL 4-LANE FREEWAY CROSS-SECTION



TYPICAL 6-LANE FREEWAY CROSS-SECTION



TYPICAL 8-LANE FREEWAY CROSS-SECTION



TYPICAL 10-LANE FREEWAY CROSS-SECTION

Figure 9.12: Typical Saskatoon Freeway Cross-Section

9.3 Secondary Roads

Secondary Roads are defined as all roads which are not designated as freeway, interchange ramps and numbered provincial highways. Secondary roads that intersect the Saskatoon Freeway are typically the responsibility of the adjacent Rural Municipality (RM) of Corman Park and the CoS. This report recommends a general alignment of all secondary roads that are directly impacted by the proposed freeway or where land remnants are land locked. However, it is acknowledged that there will be considerable new development adjacent to the proposed freeway right-of-way before the freeway is opened to traffic. Future development may result in changes to the alignment of secondary roads.

When property is acquired for the freeway over the next 5-10 years, remnant parcels of land may be created. All parcels of land require some form of legal land access to a road right-of-way. The property acquisition process should consider the cost of creating legal access to all remnant parcels created during the acquisition process. Property acquisition decisions could affect the recommended plan for secondary roads impacted by the freeway.

Functional plans are provided for each of the cross roads at interchanges in **Appendix K**. Conceptual access schemes are also included for other access roads (municipal roads) and are illustrated on the Roll Plan in **Appendix F**.

9.4 Drainage

Recommendation details are outlined in **Section 5.1.5** Drainage Design Criteria and on **Table F6** (**Appendix F)**. Catchment areas are in **Figure 5.27** and **Figure 5.28**.

A primary goal of this design was to maintain existing drainage patterns. Some minor exceptions to this goal have been recommended. It is recommended that any changes to natural drainage paths be done in consultation with the Water Security Agency (WSA). The CoS provided drainage information based on their recent studies which has been incorporated into the design.

- Catchment B (**Figure 9.13**) appears to be part of a local low area with no historical evidence of external drainage or significant ponding. The Freeway will cut off an approximately 26 ha area that would naturally flow northeast within the local low area. At this point the proposed Freeway profile is grading down towards the river valley. The Freeway ditch will capture runoff from the 26 ha area to the south and likely a little runoff from the north. Any flow captured by the ditch will be diverted directly to the South Saskatchewan River. Attempting to maintain drainage patterns for this area would require raising the Freeway profile which would impact bridge design.

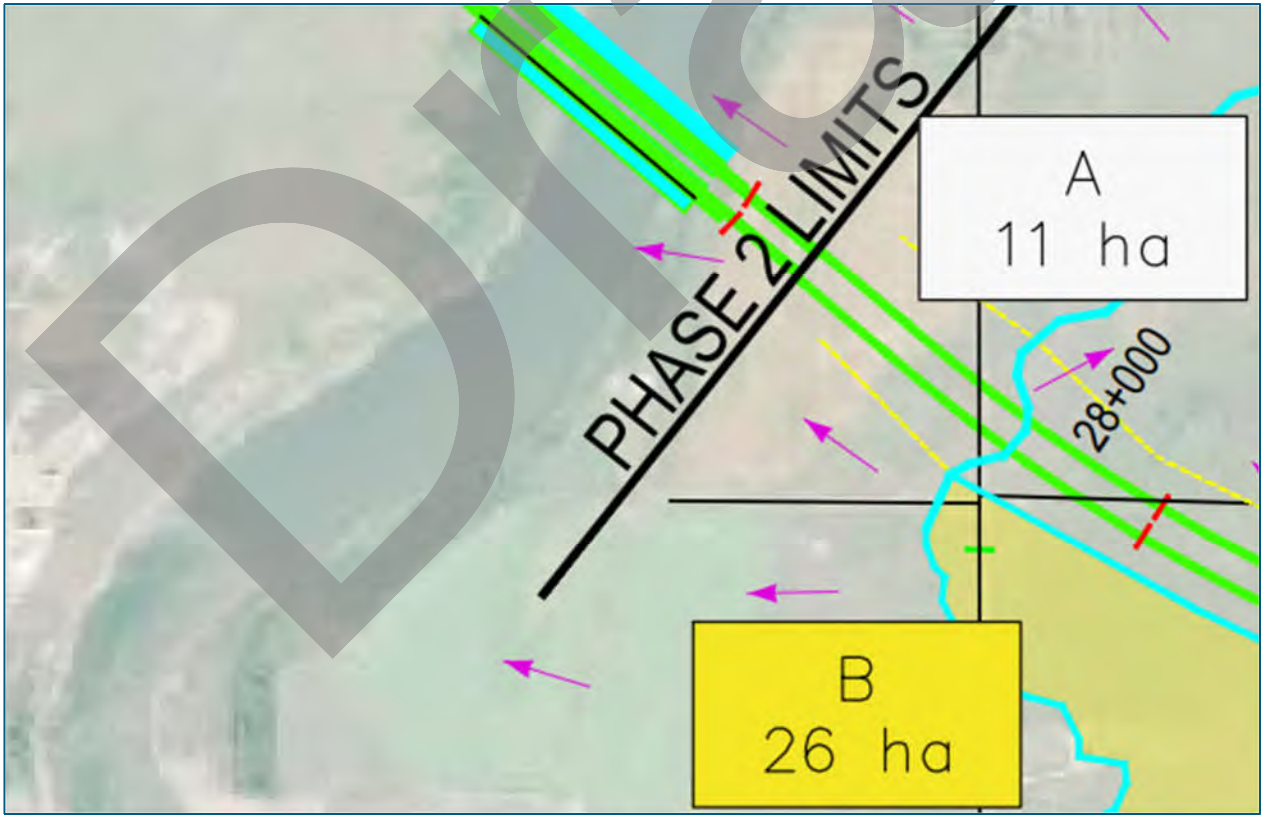


Figure 9.13: Potential exception to maintaining existing drainage –River Crossing (from Figure 5.27)

- Catchment H (**Figure 9.14**) includes flow from catchments J through Z. Between Stn. 23+200 and Stn. 23+800 there are several well-defined drainage paths criss-crossing the proposed alignment from both the north and south. This occurs along the edge of the Northeast Swale and within the proposed Freeway Right-of-Way. It is recommended that the Freeway ditches intercept this flow and convey it directly to the Northeast Swale. This prevents the potentially significant flow of catchment H from crossing the Freeway twice and eliminates unnecessary culverts.

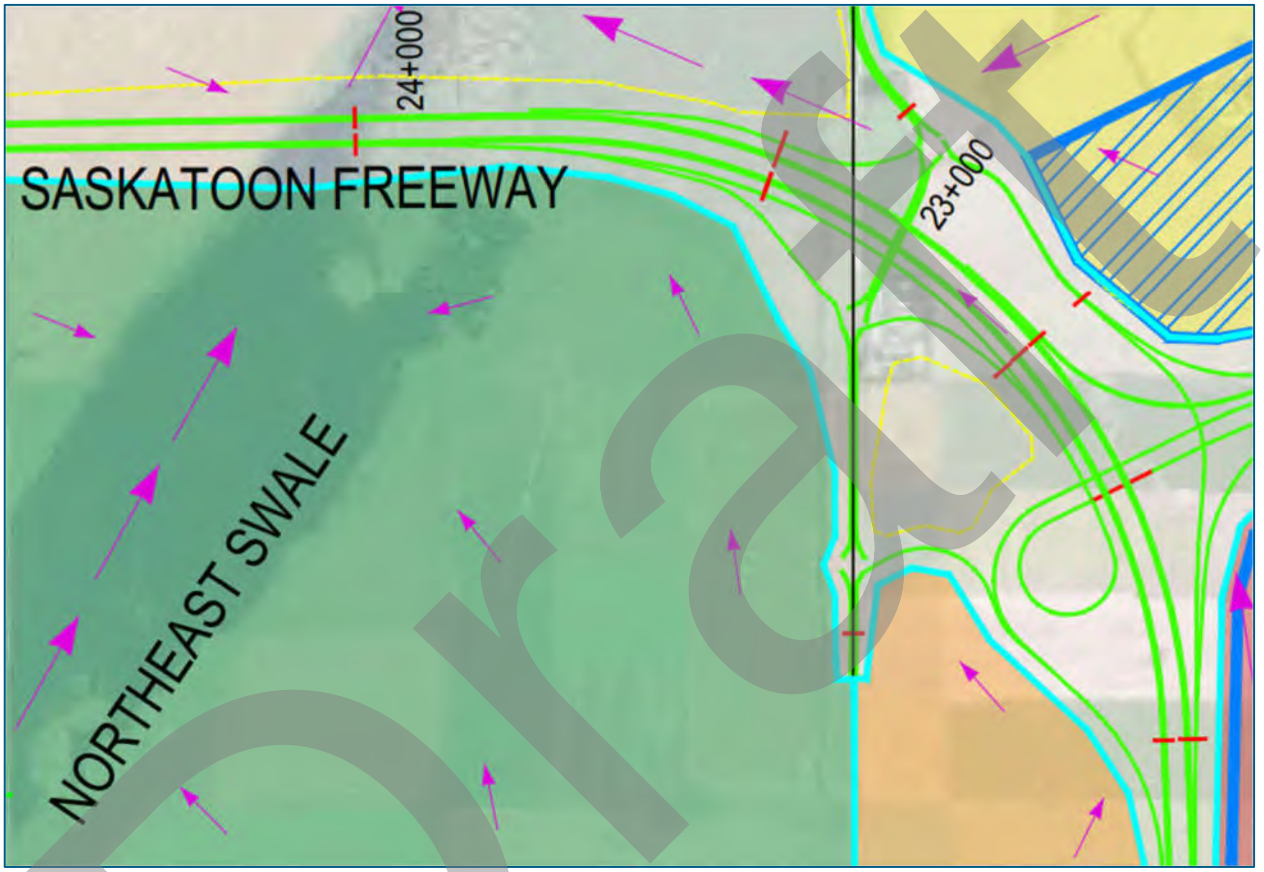


Figure 9.14: Potential exception to maintaining existing drainage – Blackley Road Interchange (from Figure 5.27)

- Catchment Z (**Figure 9.15**) naturally drains northwest as part of the Northeast Swale watershed. Directing runoff from this area across the Highway 5 interchange may be challenging. Detailed design may want to consider directing this catchment to the south and compensating for increase runoff volume with a retention pond.

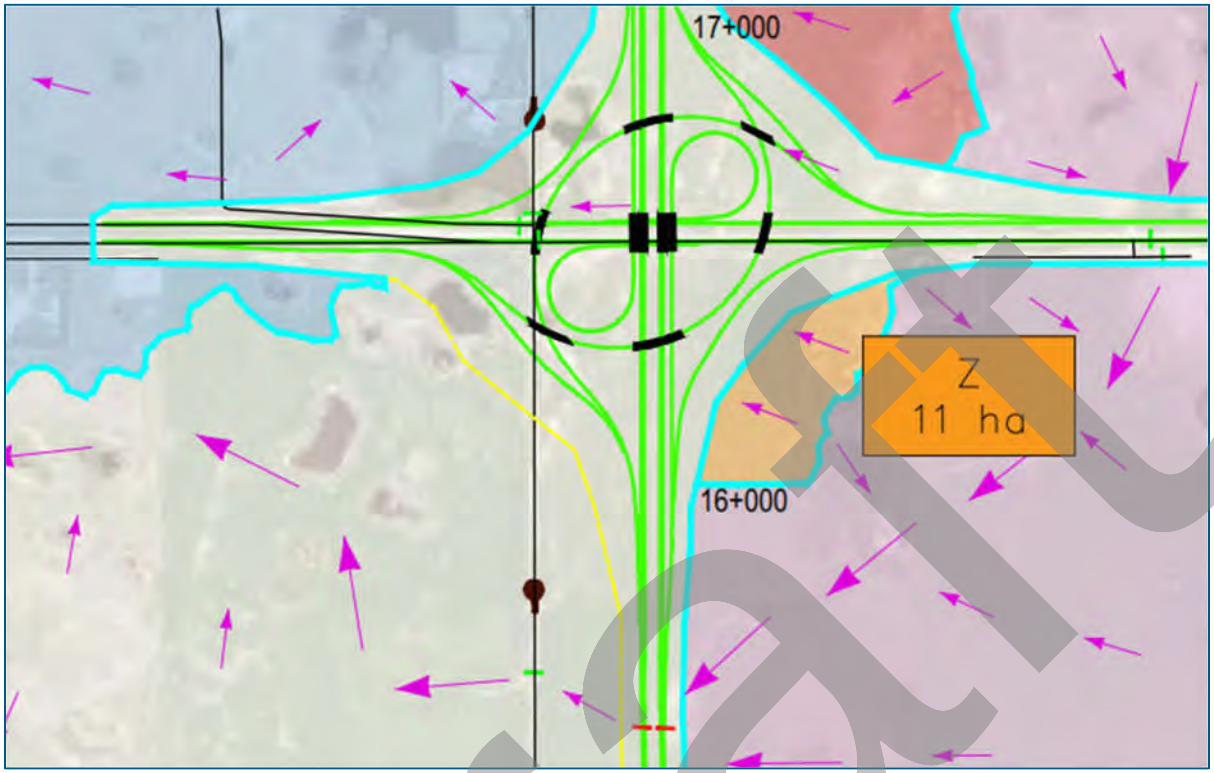


Figure 9.15: Potential exception to maintaining existing drainage – Highway 5 Interchange (from Figure 5.28)

- It is believed that a pair of proposed culverts southeast of the Floral Road and Highway 16 interchange will restore the natural drainage path (**Figure 9.16**). This could be a consideration for a future functional design. Currently flow reaching the Highway 16 ditch is traveling 700 m southeast to an existing pair of culverts. These culverts are filling a large slough in SW 26-35-4-W3. The NRCAN topographic data suggests that restoring this natural drainage path would send flow to the large slough in NE 27 and SE 34-35-4-W3. Further investigation and consideration are recommended for detailed design.

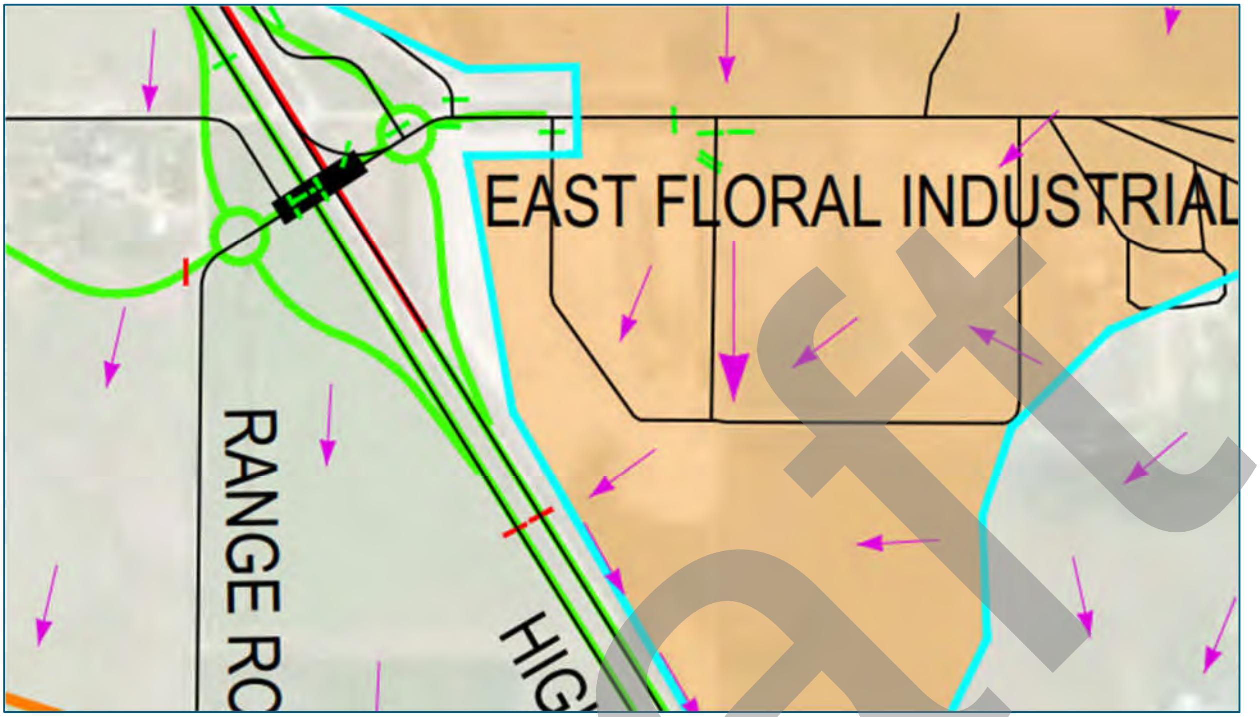


Figure 9.16: Potential exception to maintaining existing drainage – Highway 16 at Floral Road (from Figure 5.28)

The proposed Freeway alignment crosses the Small Swale at a natural high point. Catchment C-1 drains to the south section of the swale while catchment C-2 drains to the north section. It is recommended that the drainage be altered such that flow from these catchments does not cross the Freeway. The swale has some storage capacity and during periods of high-water levels both sections will spill south and north to the South Saskatchewan River. Much of the catchment boundary separating the south and north sections resides within the Freeway right-of-way. Culverts would only be required to drain the median ditch. Discussions with the Saskatchewan Water Security Agency (WSA) are recommended during the detailed design phase to finalize the drainage design for the C-2 catchment area.

The catchment areas and drainage paths identified in this report are based on the best available data. The topographic data acquired from Natural Resources Canada is dated and generally does not have sufficient detail to accurately define upstream catchment boundaries in the undulating hills or the drainage patterns in the large flat downstream areas characterized by potholes, sloughs, and wetlands. While most crossing drainage paths are clear and well-defined with both LiDAR and satellite imagery, many of the upstream catchment areas were not clear; especially those outside the limits of the LiDAR data. Additionally, the culvert surveys were limited to relatively brief investigations at key locations. Submerged, covered, and crushed culverts may have been missed. As in Phase 1, the watershed in Phase 2 is complex and influenced by ongoing development. It is therefore recommended that detailed design include comprehensive survey and mapping of all drainage paths and catchment areas to address the following:

- The potential for altered and dynamic drainage paths discussed in **Section 5.5.1.1.3**;
- Determination of a more accurate high-water level in the Small Swale as discussed in **Section 5.5.1.1.5.2**; and

- Improved delineation of all catchment boundaries and drainage paths. Especially in catchments BB, KK, LL, OO, and RR.

The detention of increased peak runoff can often be achieved within the Freeway ditches using an appropriately sized culvert to throttle the outflow. It is recommended that the increased peak flow from each interchange be similarly detained within the interchange ramps. In areas where detained flow may result in damage to infrastructure, the use of high-water-level overflows is recommended.

During Phase 1 the WSA also recommended retention facilities to counteract loss of natural storage. As in Phase 1, the borrow pits required to construct this phase will provide substantial retention capacity. It is recommended that retention within these borrow pits be considered during the detailed design phase. Due to the significant loss of storage and anticipated sensitivity to flooding of neighboring developments, retention ponds are specifically recommended in Catchments QQ and RR.

Design and construction of a drainage ditch between Stn. 21+100 and Highway 41 and a detention pond northeast of the Highway 41 interchange are recommended. The approximate proposed locations are shown in **Figure 5.27**. To prevent flow from “zig-zagging” across the Freeway it is also recommended that the runoff from catchment U and the upstream dynamic catchment area be captured by the east Freeway ditch and conveyed north to the proposed drainage ditch. Refer to **Section 5.5.1.1.5.3** for details on these recommendations.

Recommended locations of culverts have been analysed and described in the Proposed Culvert Location section of this report. The standard maximum culvert spacing of 800 m was not necessary to achieve functional drainage. Most of the proposed Phase 2 Freeway alignment is already within or adjacent to CoS limits. Culverts increase the number of points where future CoS storm sewers will need to intercept flow. It is therefore recommended that the specific location of additional culverts required to meet this standard be identified during the detailed design phase in consultation with the CoS.

Given the deep cuts through the riverbank and the relatively small catchment sizes, it is recommended that the area northwest of Stn. 28+100 follows the Freeway ditches to the river. To reduce the risk of bank erosion near the bridge structure culverts are recommended to direct flow from the median ditch to the outside ditches and utilize existing natural drainage routes on either side. Specific recommendations regarding the control of flow to the river and protection of the infrastructure are detailed in the South Saskatchewan River Outlet section of this report.

- The uncertainty associated with varied vertical datums, geoids, and unknown LiDAR quality makes it difficult to validate the predicted watershed patterns. If the P4G LiDAR continues to be used by the Ministry, an adjustment of approximately - 0.3 m is recommended;
- The Dynamic Drainage paths discussed in the Design Concept are an important consideration and demonstrate the impact that changing conditions can have on drainage paths in this relatively flat terrain; and
- The grid road system and ongoing land development in the area has significantly altered natural drainage patterns. Whether intentional or not, future development and drainage projects may alter the size and drainage path of catchment areas, which may impact the flow intersected by the Saskatoon Freeway.

Several locations were identified where watershed may be desirable. Landowner consultation and consultation with the Water Security Authority is recommended for the following locations:

- NE 31-37-05-3. A field ridge appears to be directing overland flow to a dugout south of the freeway. Most of this flow will be cut off by the Saskatoon Freeway. If feeding the dugout is desirable ditch grades can be adjusted accordingly. Refer to Catchment D in Figure 5.27 for more detail;
- NW 32-37-05-3. An access road and treeline at 15+560 seems to be directing runoff into a wetland and dugout to the south. If the dugout is desired the freeway ditch grades can be adjusted accordingly. Refer to Catchment E in **Figure 5.27** for more detail;
- SW 31-37-05-3. An area of agricultural land, roughly 24 ha, will be cut off from natural overland flow from the northwest. Refer to Catchment C in **Figure 5.27** for more detail; and
- NE 31-37-05-3. An area of agricultural land, roughly 9 ha will be cut off from natural overland flow. Refer to Catchment F in **Figure 5.27** for more detail.

Recommended locations of culverts have been analysed and described in the Proposed Culvert Location section of this report. The standard maximum culvert spacing of 800 m was not necessary to achieve functional drainage. It is recommended that the location of additional culverts required to meet this standard be identified in the detailed design phase. However, the section between Highway 12 and Highway 16 required additional culverts to accommodate the overland sheet flow.

The detention of increased peak runoff can be achieved within the freeway ditches using an appropriately sized culvert to throttle the outflow. It is recommended that the increased peak flow from each interchange be similarly detained within the interchange ramps. In areas where detained flow may result in damage to infrastructure, the use of high-water-level overflows is recommended. Flow following Drainage Path 3 through the Hudson Bay swale may require some additional detention at the Hudson Bay swale. Several potential locations have been recommend as described in **Section 5.5.2.4** (Detention/Retention) and shown in **Figure 5.27**.

Given the deep cuts through the riverbank and the relatively small catchment sizes, it is recommended that the area southeast of Stn. 21+200 follows the freeway ditches to the South Saskatchewan River. To reduce the risk of bank erosion near the bridge structure, culverts are recommended to direct flow from the median ditch to the outside ditches and utilize existing natural drainage routes on either side. Specific recommendations regarding the control of flow to the river and protection of the infrastructure are provided in the South Saskatchewan River Outlet section of this report.

9.5 Access Management Plan

Based on comments received from adjacent municipalities and the general unknown nature of development abutting the freeway, minimizing the construction of new roads is the most prudent. Access schemes are included in the Roll Plan in **Appendix E**. However; it is very likely to require amendments as future developments will occur prior to freeway construction and may require different roadway connections.

9.6 Bridges

The recommended bridge structures are summarized in **Table L1** in **Appendix L**. A bridge numbering plan, as well as general plan and elevation drawings for all structures (ten interchanges) are also provided in **Appendix L**.

9.7 Other Design Components

9.7.1 Intelligent Transportation System (ITS)

The Ministry has a key action to "Advance the use of field devices and new technologies in project and service delivery through the Ministry's Intelligent Transportation System (ITS) plan." (Saskatchewan Ministry of Highways and Infrastructure, 2019).

The Saskatoon Freeway Functional Planning Study incorporates ITS concepts. The high-level concept plan was updated during Phase 2. The updated ITS plan includes Phase 2 (**Figure 9.17**, **Figure 9.18**, and **Figure 9.19**). Additional discussion is included in the Final Report addressing Phase 1, Phase 2, and Phase 3 concepts, as well as functional standards.

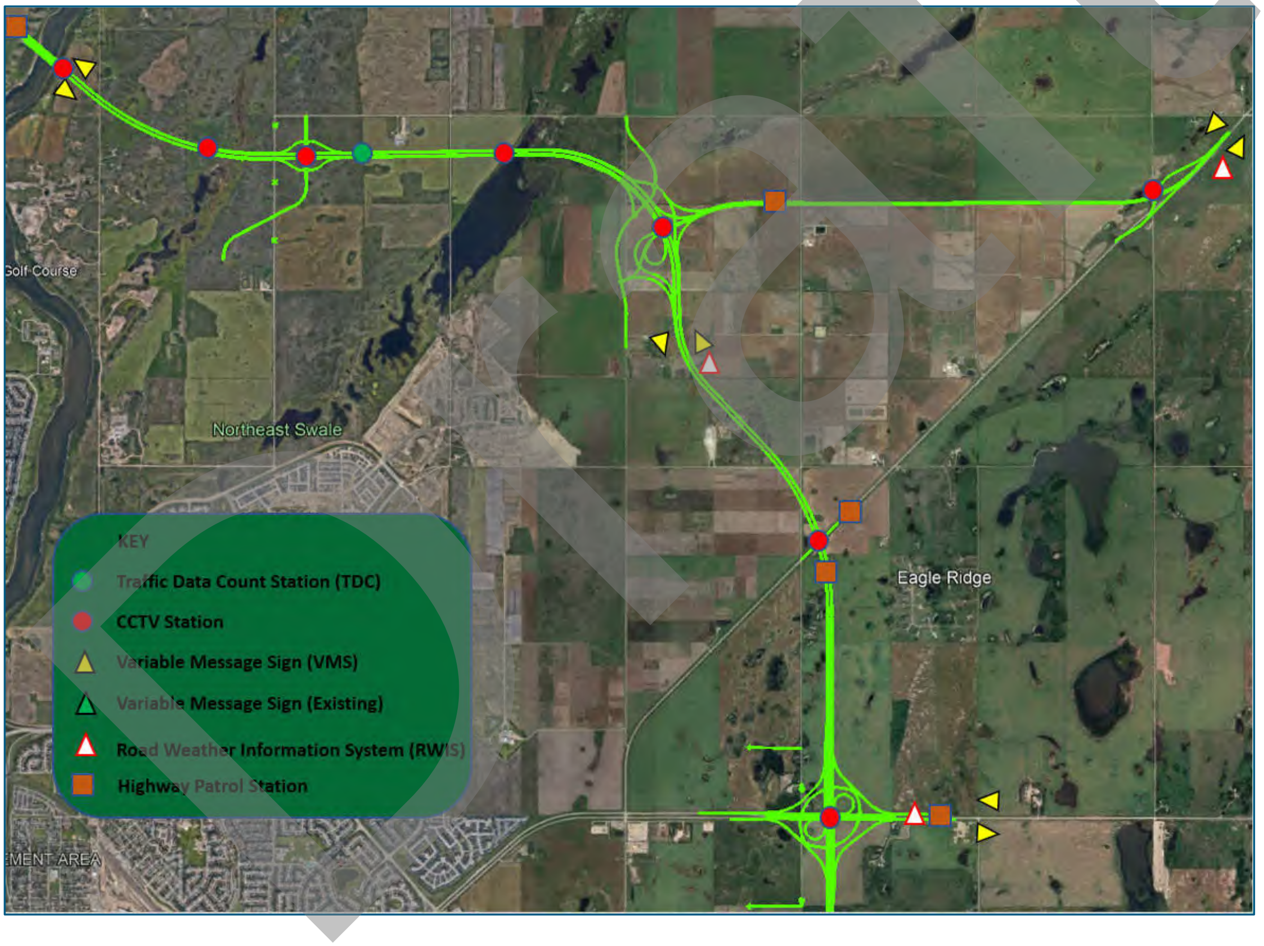


Figure 9.17: Draft ITS concept plan – Phase 2 North

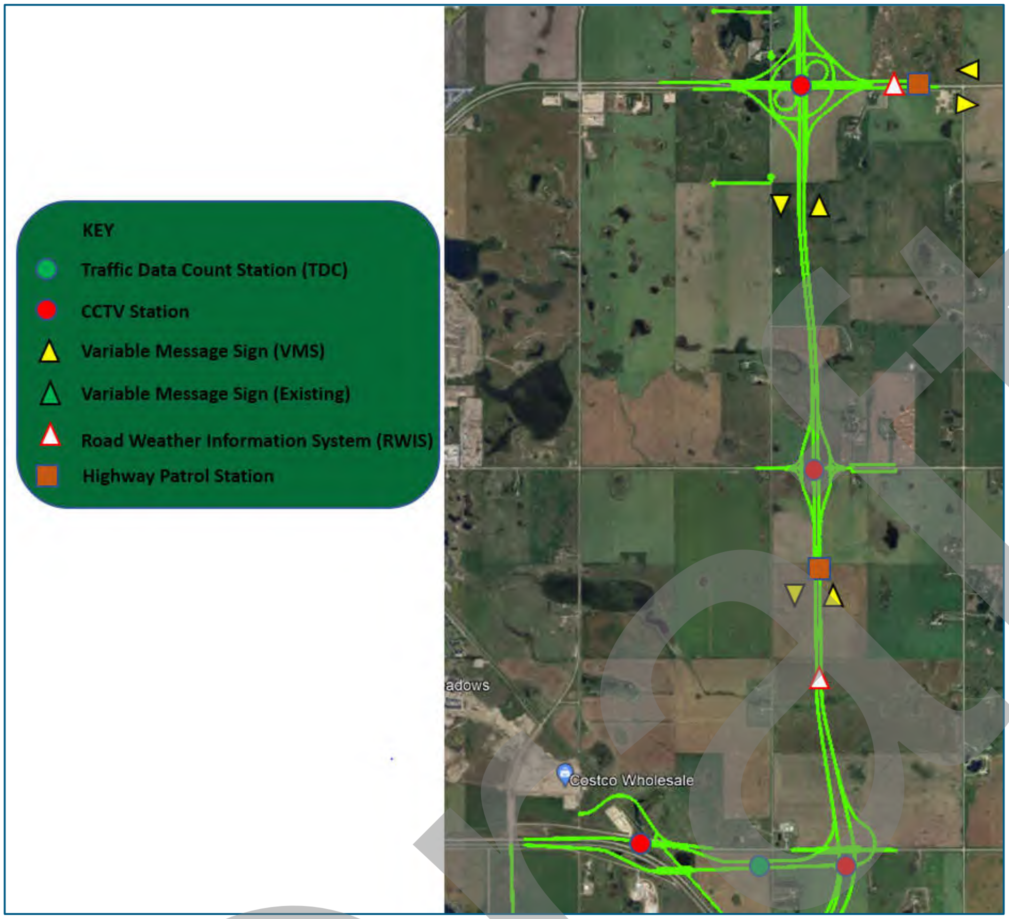


Figure 9.18: Draft ITS concept plan – Phase 2 South part 1

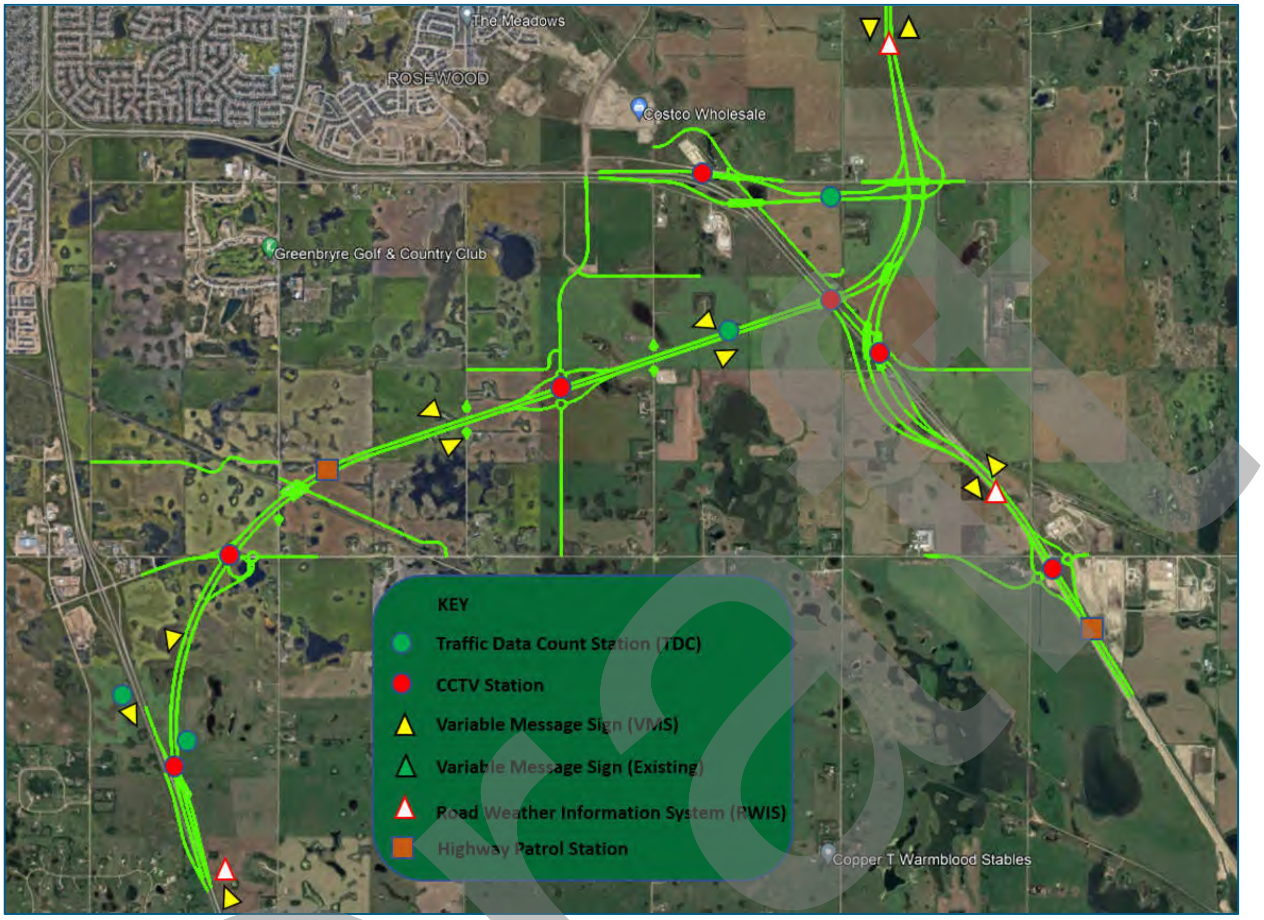


Figure 9.19: Draft ITS concept plan – Phase 2 South part 2

9.7.2 Sound

A sound study was undertaken as part of the functional design to assess noise impacts from the freeway to adjacent property. The functional design work included a jurisdictional scan of guidelines shown in **Table 9.10**.

Table 9.10: Noise level criteria of various jurisdictions

Criteria Considered			Noise Limit
Canada Mortgage and Housing Corporation - CMHC	Road and Rail Noise: Effects on Housing	1981	55 dBA LAeq24h
City of Regina	Public Report PWI19-7 Noise Attenuation	April 18, 2019	65 dBA Ldn
City of Saskatoon Council Policy	Number C07-028	February 27, 2017	65 dBA Ldn
Federal Highway Administration (US) - FHWA	Highway Traffic Noise Analysis and Abatement Policy and Guidance FHWA Noise Regulations	August 24, 2017	67 dBA LAeq1h
Ontario – Ministry of the Environment	Environmental Noise: Guideline - Stationary and Transportation Sources - Approval and Planning - Publication NPC-300	August, 2013	55 dBA LAeq 16h (day) 45 dBA LAeq 8h (night)
Québec – Ministry of Transport	Traffic Noise Politic	March 1998	55 dBA LAeq24h for new roads 65 dBA LAeq24h for existing roads
Saskatchewan Highways and Transportation	DM 2050-3 Design Manual Section: Traffic Noise Subject: Noise Measurements	August 1, 1991	Noise attenuation is generally considered when noise levels exceed 60 or 65 dBA (Ldn)
World Health Organization - WHO	Environmental Noise Guidelines for the European Region	2018	53 dBA Lden and 45 dBA Lnight

As the WHO guidelines are the most recently developed and based on health considerations, and given the study evaluates noise in the long term (2063) it is possible that WHO guidelines may be adopted by authorities prior to the timing of the detailed design. A table of definitions is included in **Appendix M.**

SNC-Lavalin completed numerical modelling on the functional design to develop noise level contours. The plan (**Appendix M**) is based on the current CoS criteria presented in **Table 9.10** and shows the contour line for 65 dBA Ldn. Noise mitigation should be included in the detailed design phase for residences identified during this study within the 65 dBA Ldn (**Appendix M**).

9.7.3 Lighting

Dark-sky lighting is where light is directed to the ground and not up to the sky where it can contribute to light pollution. The intent is that interchanges will have full lighting (dark-sky compliant) with sections between the interchanges and the river crossing will not be lighted.

9.7.4 Over Height/Over Dimension Route

Providing an over height/over dimension (OD) route using the Saskatoon Freeway; most importantly the new South Saskatchewan River bridge, would provide a significant economic benefit by decreasing travel time (relative to the existing over height routes) and reduce requirements for additional roadways or improvements to existing roadways for over height route use. For example, current over height loads which wish to travel from the west side of the CoS to the east side may be directed to the South Saskatchewan River bridge located at Outlook. It is, therefore, critical to ensure OD loads can gain access to the Saskatoon Freeway and cross the river bridge. Both South Saskatchewan River bridge types shortlisted in this study will not have any over height restrictions and given the number of lanes across the bridge will generally not have any width limitations. This includes potential staging scenarios as well.

Further discussion regarding the OD route options is included in the Final Report because the options span Phase 1 and Phase 2.

9.8 Property Acquisition

9.8.1 Road Right of Way

The Functional Plans (**Appendix K**) illustrate the general requirements for road right of way. Road alignments and interchange layouts were selected with consideration to minimizing the need to acquire property occupied by residents or businesses. Setting property requirements also took into account potential changes in future development or road function that may require additional property in the future. Property requirements were also influenced by efforts to minimize environmental impacts. The following considerations were included in the recommended property requirements:

- Regarding the Central Avenue interchange, if required, additional property has been identified allowing for a W-N loop ramp. The Central Avenue interchange was shifted eastward to minimize impacts to the Small Swale;
- The selected alignment through the Northeast Swale and Small Swale was located south of Township Road 374 to minimize impacts to the swales. It should be noted that a route on top of Township Road 374 would have necessitated another corridor to accommodate local traffic and ultimately development traffic;

- The alignment through Cindercrete was selected to ensure the main complex was not cut off from their property and future resources to the west. There may be an opportunity to acquire severe land to the north as a borrow source;
- A detention pond is proposed at the Blackley Road/Realigned Highway 41 interchange in the northeast quadrant. This will serve two purposes: reducing impact to the drainage system in the vicinity of the swales; and reducing environmental impacts. The detention pond has not been explicitly included in the ROW plans given that detailed design is required as well as clarity on the future municipal road network; and
- When this project is eventually constructed, it may be delivered by alternate delivery methods such as design-build. Sufficient property has been designated to allow flexibility for future D-B consortiums to reverse the over/under grade separations for the freeway and intersecting highway without the need for additional property purchase;

Purchasing property for a proposed freeway will create remnant parcels of land that are excess to what is required for the freeway. These remnant parcels can be sold and consolidated into other existing adjacent parcels or, if there are ancillary needs, the excess property may be used for detention areas, borrow sources or utility corridors.

All remnant parcels created through the purchase and dedication of land to road right of way must have legal access to road right of way. Parcels can not exist without access. During negotiations with landowners, consideration should be given to acquiring land that creates parcels of land without legal access. The cost of providing legal access should be considered when preparing legal plans. It may be more efficient to consolidate remnant parcels with adjacent parcels or road right of way to eliminate the need to provide legal access.

9.8.2 Drainage

In most cases the increased peak runoff can be detained within interchanges and the Freeway ditch using appropriately sized culverts to throttle flow out of these areas. Borrow pits developed during construction may also be used for detention; however, several locations have been identified where additional area may be required to retain, detain, or convey increased flow.

- As discussed in **Section 5.5.1.1.5.3**, a 1,500 m drainage ditch is recommended east of the Freeway between Stn. 21+100 and the first culverts east of the Highway 41 interchange;
- A retention/detention pond is recommended immediately north and east of the Highway 41 interchange. This pond will serve to detain flow coming from the proposed drainage ditch and all flow crossing re-aligned Highway 41;
- It is recommended that retention/detention ponds be used to manage all flow into the Beaver Creek Terminal Basin. As in other locations this can be achieved with the borrow pits used during construction but strategically planning their location and size may be more important; and
- Retention ponds were also specifically recommended for catchments QQ and RR.

10 Environmental Summary

10.1 General Environmental Recommendations

10.1.1 Wildlife and Species of Conservation Concern

A large diversity of wildlife, including SOCC and SAR, were identified within the proposed freeway corridor options. Additional species and occurrences of SOCC and SAR are likely to be identified as more surveys are completed during the EA process. The majority of wildlife and bird species in Saskatchewan are protected by provincial and federal legislation, hence, where possible, routing should be done to minimize effects to areas of important wildlife habitat. There are additional legal protections for wildlife SOCC and SAR. Where routing cannot avoid crossing into habitat utilized by wildlife and SOCC/SAR, the following mitigations should be considered to reduce impacts:

- Consider the Environment and Climate Change Canada (ECCC) avoidance guidelines for breeding birds when scheduling construction activities;
- Conduct breeding bird surveys prior to and during construction during the general nesting period;
- Consider design measures that employ strategies to preserve wildlife movement corridors;
- Acquire permits for relocation or removal of wild species, if appropriate;
- Construction activities should consider the restricted activity timing windows for the protection of fish and fish habitat outlined by Fisheries and Oceans Canada (DFO 2013);
- Conduct pre-construction surveys in areas where SOCC/SAR have potential to be found;
- Establish setbacks around wildlife and plant SOCC occurrences prior to construction in accordance with the Saskatchewan ARGs. Contact ENV or ECCC if project activities fall within listed setback distances;
- Implement construction options that minimize loss of SOCC/SAR habitat, such as bridging over sensitive habitat;
- Consider intelligent transportation system measures such as animal detection systems (animal deterrent systems and/or driver advisory systems;
- Implement wildlife crossings in areas where they will be best utilized by animals to maintain a naturalized connection between habitat on either side of the proposed freeway, and reduce the risk of wildlife mortality; and
- Consider implementing design options that reduce sensory impacts to wildlife (noise, light pollution), such as reduce lighting, dark-sky compliant lighting, sound barriers, etc.

10.1.1.1 Future Wildlife Studies

In addition, species-specific detection surveys will be required during the EA process, taking into account the results from previously completed surveys. It is recommended that species-detection surveys area completed throughout all three phases of the Saskatoon Freeway Project. The following surveys will likely be required:

- Auditory amphibian surveys;
- Grassland bird surveys;
- Yellow rail surveys;
- Common nighthawk surveys;
- Short-eared owl surveys;
- Prairie raptor surveys;
- Burrowing owl surveys;
- Sharp-tailed grouse surveys;
- Additional snow track surveys; and
- Additional surveys may be required as potential habitat is identified.

10.1.1.2 Surface Water and Wetlands

Wetlands are abundant throughout the project corridor and serve as important habitat for wildlife and vegetation. Wetlands are protected in Saskatchewan and proponents are required to compensate for the loss of wetland habitat. Hence, where possible, routing aims to minimize the total area of wetland habitat affected. For areas where impacts to wetlands are unavoidable, the following mitigations will be considered and implemented to reduce impacts:

- Localized drainage plans may likely be required to prevent adverse impacts to the ecological function of undisturbed areas;
- Ancillary roads and laydown areas have been sited to avoid wetland habitat where possible;
- An Aquatic Habitat Protection Permit (AHPP) in accordance with *The Environmental Management and Protection Act, 2010* should be obtained for works within the bed, bank, or boundary of a waterbody/wetland, or discharge with adverse effects on water;
- Wetland classification surveys should be completed where disturbance to wetlands cannot be avoided;
- A Drainage Permit may be required for effects to drainage;
- Erosion and sediment control measures have been implemented to protect adjacent wetland areas and the river valley;
- Pre-construction species detection surveys for SOCC (e.g. northern leopard frog and rare plant surveys) should be conducted in wetlands with the potential to support SOCC, followed by suitable mitigation where required; and
- Proponents are required by federal and provincial regulations to compensate for the loss of wetland habitat where it can not be avoided. Typically, a 3:1 wetland compensation ratio will be required for projects of this type, but that final compensation value will be determined in consultation with ENV.

10.1.1.3 Native Grasslands

Unseeded grassland is present within Phase 2 and provides important habitat for a variety of wildlife species. Much of these grassland is located in the upland areas adjacent to the Northeast and Small Swales. Proponents in Saskatchewan may be required to compensate for the loss of grassland habitat (i.e. compensation has been a condition in some recent ministerial decisions), hence, where possible, routing should attempt to minimize the total area of grassland habitat affected. For areas where impacts to grasslands are unavoidable, the following mitigations should be considered to reduce impacts:

- Disturbed areas should be restored to grassland habitat using native species and following Ministry and the Ministry of Environment policies on revegetation and seeding; and
- The footprint of roadway has been reduced as much as possible through unseeded/uncultivated grassland;
- Fragmentation of grassland has been reduced as much as possible; The roadway is as close as possible to other developments to leave larger patches of intact grassland in place;
- Wildlife crossings (**Section 10.1.3)** have been implemented into the design of the project to maintain a naturalized connection between habitat on either side of the proposed freeway;
- Fencing to restrict wildlife access to the freeway to reduce wildlife mortality has been implemented into project design;
- Design options that reduce sensory impacts to wildlife (e.g. noise, light pollution, reduced speed limits), such as reduce lighting, dark-sky compliant lighting, sound barriers, etc. have been implemented into the freeway design;
- Depending on the regulatory regime in place at the time of construction, compensation for impacts to this feature may be required; and
- Species specific surveys for SOCC should be conducted in these areas during the EA phase of the project and prior to disturbance and suitable mitigation measures should be developed based on the results. HRIAs should also be completed where required by the Heritage Conservation Branch.

10.1.1.4 Heritage Resources

The proposed freeway corridor passes through areas that have the potential to contain heritage resources, ranging from the earliest occupations to more recent homestead sites. The presence of a concentration of important heritage resources at Wanuskewin Heritage Park, in addition to some located in the small swale highlights the potential of some portions of the proposed freeway route to encounter heritage resources. Some of these heritage resources may be sufficiently significant to require extensive mitigation, which can affect both the project detailed design and timetable. A referral to the Heritage Conservation Board will be required prior to construction, and it is likely that a Heritage Resources Impact Assessment will be required at many locations throughout Phase 2 of the project. HRIAs are often required in the undeveloped locations (such as uncultivated landscapes), as these are where heritage resources are most likely still intact.

10.1.2 Phase 2 Specific Environmental Recommendations

10.1.2.1 South Saskatchewan River Crossing

The South Saskatchewan River crossing is the interface between Phase 1 and Phase 2 of the project. The South Saskatchewan River valley is an ecologically important feature, serves as a natural corridor for wildlife movement, habitat for fish species, and has a high potential for archaeological finds. As such, the location of the crossing has been chosen to minimize disturbance to the channel and banks as much as possible. The following mitigations have been implemented into the design of the project to reduce potential impacts:

- Bridge elevation will preserve wildlife movement through the river valley is preserved;
- Placement and size of bridge abutments have been placed and reduced as much as practical so that disturbance to the banks is reduced;
- Placement and size of the piers has been selected to limit impacts to fish habitat within the river channel. Compensation for disturbance to fish habitat will likely be required once the final design of the piers and construction plans are known;
- Measures to protect the water quality in the river (i.e. as a result of spills and/or road salt/gravel application) have been considered in bridge designs;
- Species specific surveys and fish salvages for SOCC should be conducted in the river valley prior to disturbance and suitable mitigation measures should be developed based on the results; and
- Construction activities will consider the restricted activity timing windows for the protection of fish and fish habitat outlined by Fisheries and Oceans Canada (DFO 2013).

10.1.2.2 Small Swale and Northeast Swale

The Northeast Swale and small swale are both ecologically sensitive features that have been identified as important areas within the CoS. As a result on this, project designs should consider minimizing direct impacts to these features where possible. Should impacts to the swales be unavoidable the following mitigations should be employed:

- The footprint of roadway has been reduced as much as possible through sensitive areas;
- Measures to preserve drainage patterns (i.e. culverts, bridges, etc.) in unimpacted areas of the swales have been implemented into project design;
- The swale will form part of the road drainage network and measures should be taken to ensure that surface water inputs into the swale do not cause adverse impacts to the ecological function. This will include pre-treatment of road runoff using forebay systems and installation of permanent erosion and sediment control measures;
- Wildlife crossings have been implemented into project design to maintain a naturalized connection between habitat on either side of the proposed freeway;
- Fencing to restrict wildlife access to the freeway to reduce wildlife mortality has been implemented into project design;
- Design options that reduce sensory impacts to wildlife (e.g. noise, light pollution, reduced speed limits), such as reduce lighting, dark-sky compliant lighting, sound barriers, etc. have been implemented into the freeway design;
- Proponents are required by federal and provincial regulations to compensate for the loss of wetland habitat where it can not be avoided. Typically, a 3:1 wetland compensation ratio will be required for projects of this type, but that final compensation value will be determined in consultation with ENV; and

- Species specific surveys for SOCC should be conducted in the swale prior to disturbance and suitable mitigation measures should be developed based on the results.

Wildlife crossings will be required to be placed along the freeway to provide wildlife with a path to safely cross the road, connect habitats, and mitigate wildlife-vehicle collisions (WVC). These should be placed in locations where wildlife are mostly likely to utilize these crossing, within the Northeast and small swales, and along the South Saskatchewan River's banks. There are various types wildlife crossing structures, each with their own advantages and disadvantages. According to the *Wildlife Crossing Structure Handbook Design and Evaluation in North America* (Clevenger and Huijser 2011), wildlife crossing structures can be divided into 11 different designs:

- Overpass, which can be subdivided into four different designs:
  - Landscape bridge – large structures designed exclusively for wildlife use. The large size allows a large diversity of wildlife to use;
  - Wildlife overpass – a structure designed exclusively for wildlife use, similar to landscape bridges but is generally smaller;
  - Multi-use overpass – structure that is designed for wildlife and human use. This structure is generally the smallest type of overpass and is best implemented in human disturbed areas, where it will benefit generalist type species; and
  - Canopy overpass – structures that are designed exclusively for semi-arboreal and arboreal species that commonly use canopy cover for travel;
- Underpass, which can be subdivided into seven different designs:
  - Viaduct/flyover – largest type of underpass with a wide span and vertical clearance, which allows for use by a wide range of wildlife. However, this type of structure is usually not built exclusively for wildlife use;
  - Large mammal underpass – smaller than viaducts but is considered the largest underpass type structure that is designed exclusively for wildlife use. Although this type of structure is designed for use by large mammals, smaller mammals will use the structure as well;
  - Multi-use underpass – this structure is similar to large mammal underpasses (albeit smaller) but is designed for mixed use between wildlife and humans. Large mammals may also use the underpass, if the passageway is sufficiently large enough for them to pass through. If riparian habitat or cover is retained within the underpass, small- and medium-sized may also use this type of structure;
  - Small- to medium-sized mammal underpass – one of the smallest types of underpass, this structure is designed for small- and medium-sized mammals and often restricts large mammals from using it. Use of this type of structure is dependent on how the structure has been modified to fit the species' specific crossing needs (i.e. vegetation);
  - Modified culvert – these structures are designed for riparian habitats or irrigation canals, which are used by small-sized wildlife and sometimes medium-sized wildlife, if the passageway is sufficiently large enough for them to pass through; and
  - Amphibian and reptile tunnels – these structures are designed amphibian and reptile use due to the warm and damp environment inside the tunnel. Other small- and medium-sized mammals may also use these structures.

Some wildlife crossings utilize structures or methods to guide and coax wildlife to use the crossings. Fences are commonly used to prevent wildlife from walking off the crossing and onto the road or railway. Occasionally, bait may be used during the first post-construction years to coax wildlife towards the wildlife crossings (Bissonette and Cramer 2008). Culverts and underpasses may implement wildlife shelves to allow small and medium wildlife to cross when passages are wet (Foresman 2001; 2003) or smaller tunnels to allow reptiles and amphibians to cross (Dodds et al. 2004). Shrubs, logs, and woody debris may be placed around the passageway of crossings to lead wildlife towards the crossing and away from the road or railway (Roof and Wooding 1996).

10.1.3 Wildlife Crossings

10.1.3.1 Structure Dimensions

The size and dimensions of wildlife crossing structures vary depending on various factors including environmental and cost limitations. Ungulates tend to use underpasses that are short in length, relatively wide, and high in vertical clearance (Cramer 2012; Clevenger and Barrueto 2014). This is because it allows wildlife to spend less time in the underpass, allows more wildlife to pass through simultaneously (especially those that travel in groups/packs), and allow larger individuals to use the passage. In terms of importance for improving wildlife crossing effectiveness, shortening the length of the underpass is considered the most important, followed by widening the underpass, and finally raising the height of the underpass (Cramer 2012). Studies have reported varying recommendations for effective structural dimensions, as each species tend to have varying preferences for underpass dimensions (Donaldson 2007; Cramer 2012). **Table 10.1** presents a summary of recommended wildlife crossing structure dimensions for effective use.

Table 10.1: Recommended dimensions for wildlife crossing

Crossing Type	Usage	Target Species Group	Minimum Dimensions	Recommended Dimensions
Landscape bridge	Wildlife Only	All wildlife species Amphibians (if adapted)	W: 230 ft (70 m)	W: >330 ft (>100 m)
Wildlife overpass	Wildlife Only	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Small mammals Reptiles and amphibians (if adapted)	W: 130–165 ft (40–50 m)	W: 165–230 ft (50–70 m)
Multi-use overpass	Mixed use: Wildlife & Human activities	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Small mammals Reptiles and amphibians (if adapted)	W: 32 ft (10 m)	W: 50–130 ft (15–40 m)

Crossing Type	Usage	Target Species Group	Minimum Dimensions	Recommended Dimensions
Canopy crossing	Wildlife Only	Semi-arboreal mammals	none	none
Viaduct or flyover	Multi-purpose	All wildlife species	none	none
Large mammal underpass	Wildlife only	Large mammals High-mobility, medium-sized mammals Low mobility, medium-sized mammals Semi-arboreal & semiaquatic mammals (adapted) Small mammals Amphibians (adapted) Reptiles	W: 23 ft (7 m) H: 13 ft (4 m)	W: >32 ft (>10 m) H: >13 ft (>4 m)
Multi-use underpass	Mixed use: Wildlife & Human activities	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Semi-arboreal & semiaquatic mammals (if adapted) Small mammals Amphibians (if adapted) Reptiles	W: 16.5 ft (5 m) H: 8.2 ft (2.5 m)	W: >23 ft (>7 m) H: >11.5 ft (>3.5 m)
Underpass with waterflow	Wildlife and Drainage	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Semi-arboreal mammals (if adapted) Semi-aquatic mammals Small mammals &	W: 6.5 ft path (2 m) H: 10 ft (3 m)	W: >10 ft (>3 m) H: >13 ft (>4 m)

Crossing Type	Usage	Target Species Group	Minimum Dimensions	Recommended Dimensions
		amphibians Semi-arboreal mammals & reptiles (if adapted)		
Small to medium-sized mammal underpass	Wildlife and seasonal drainage	High-mobility medium-sized mammals (if adapted) Low mobility medium-sized mammals Semi-aquatic mammals (if adapted) Small mammals Amphibians (if adapted) Reptiles	W: 1-4 ft (0.3–1.2 m) H: 1-4 ft (0.3–1.2 m) OR 1 – 4 ft diameter (0.3–1.2 m) Size selection is based on the target species needs or connectivity objective at the site.	W: 1-4 ft (0.3–1.2 m) H: 1-4 ft (0.3–1.2 m) OR 1 – 4 ft diameter (0.3–1.2 m)
Modified Culvert	Wildlife and drainage	High-mobility medium-sized mammals (if adapted) Low mobility medium-sized mammals Semi-aquatic mammals Small mammals Reptiles (if adapted) Amphibians	W: 1.5 ft (0.5 m) Clearance: >3 ft (>1 m)	W: >3 ft (1 m) Clearance: >4 ft (>1.5 m)
Amphibian and reptile tunnel	Wildlife Only	Amphibians Low mobility medium-sized mammals (if adapted) Semi-aquatic (if adapted) Small mammals & reptiles (if adapted)	Dimensions vary depending on target species or taxa or local conditions. Tunnels range from 1–3 ft (0.35–1 m) in diameter	Dimensions vary depending on target species or taxa or local conditions. Tunnels range from 1–3 ft (0.35–1 m) in diameter

(Clevenger and Huijser 2011)

10.1.4 Effectiveness

Various factors will determine the location and type of wildlife crossing structure (overpass, box culvert, etc.) to use. The effectiveness of crossing structures is also heavily dependent on the wildlife within the area. Large ungulates (moose, deer, elk), for instance, are more likely to use overpasses due to the openness of the structure, as opposed to underpass structures (e.g. box culverts) which have a limiting vertical clearance that restricts and deters larger species from using the structure (Clevenger and Waltho 2003; Clevenger et al. 2009; Clevenger and Barrueto 2014). However, some of these species can and do use underpasses if the opening is sufficiently large enough for them to pass through. Previous research suggests a strong tendency for moose to almost exclusively use overpasses, however this preference may be more influenced by the presence of favourable habitat than openness of the passage (Clevenger and Barrueto 2014).

Small and medium-sized mammals, such as skunks and raccoons, are more likely to use enclosed culverts (Servheen et al. 2003). The two attributes that influence small and medium-sized mammal use of underpass-type structures are structural dimensions (length, width, and height) and landscape, specifically vegetation cover (**Table 10.1**) (McDonald and St. Clair 2004; Clevenger and Barrueto 2014). Small mammals are less likely to use overpasses possibly because they are more vulnerable to terrestrial and aerial predators (McDonald and St. Clair 2004).

Amphibians and reptiles tend to make up a relatively greater percentage of road kills presumably due to their ecology and life history. Mortality rates tend to peak for amphibian species that move from terrestrial or aquatic hibernacula to aquatic breeding habitats by crossing roads and other barriers during their spring migration period (COSEWIC 2012; Bennett 2017). Each year, a large number of snakes are killed on roads after emerging from their hibernaculum (Government of Saskatchewan 2020f). They tend to be slow-moving and may not be easily observed by a vehicle traveling on the road (and thus likely to be contacted by a vehicle) compared to larger mammals.

While amphibian and reptiles can utilize most wildlife crossing types (**Table 10.1**), crossings that are used exclusively have been developed and used in other provinces, including Alberta and Ontario (Ontario Ministry of Natural Resources and Forestry 2016). These amphibian/reptile-specific crossings are underpasses built under or sometimes into the road, and may feature modifications that allow these species to pass, such as amphibian walls or drift fences. Amphibians and turtles require warm and damp passages due to their high skin permeability and vulnerability to water loss (Ontario Ministry of Natural Resources and Forestry 2016). Drainage culverts that are designed to drain or equalize water may be used by amphibians and reptiles when they are wet or dry.

Vegetation is also important as many wildlife species rely on it for cover (Cramer 2012). Vegetation also simulates the natural habitat that has been fragmented due to roads or other structures, which may lead wildlife towards the crossing.

The project has incorporated two distinct large mammal wildlife crossings, one in the Northeast Swale and one in the Small Swale. Additional underpass crossings should also be implemented into the final bridge design to allow for continued movement along the South Saskatchewan River. Although the exact requirements for these crossing are not yet determined, the topography is suitable for either underpass or overpass crossings. Multiple small mammal crossings (dry culverts) will likely be installed throughout the roadway. Culverts meant to maintain hydrology will also be suitable for aquatic species in Swales and wetland areas. Underpass crossings have been incorporated into the current design. As part of the design, eastbound and westbound lanes will be separate underpasses as this shortens the length of each underpass and allows natural light to pass between the structures, which should improve wildlife crossing usage.

Additional wildlife mitigation measures, such as fencing has also been incorporated into the design to ensure large wildlife interactions with the roadway and traffic are minimized. The fences should direct wildlife either away from the roadway, or towards crossing structures.

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APPENDIX A

Phase 2 Biological Assessment

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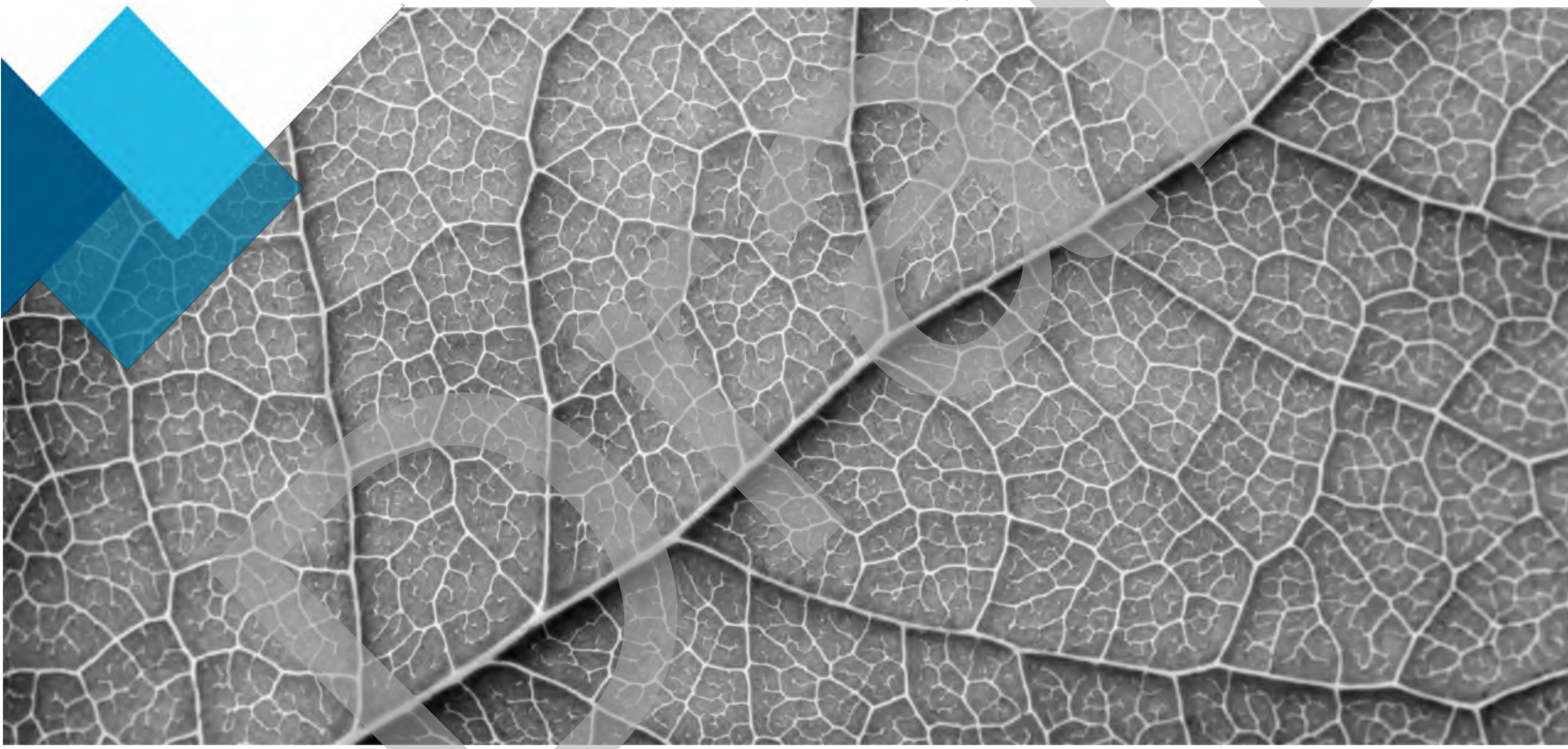
Phase 2 Biological Assessment

Saskatoon Freeway Functional Planning Study

Saskatchewan Ministry of Highways



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Executive Summary

SNC-Lavalin Inc. (SNC-Lavalin) conducted a Biological Assessment in support of the Ministry of Highways (the Ministry) Saskatoon Freeway Functional Planning Study (SFFPS): Phase 2. The Ministry continues to conduct a functional planning study to determine how the Saskatoon Freeway will look and operate. This report serves as an addendum to the 2020 SFFPS Environmental and Regulatory Review. This assessment and report focus primarily on the area between the Northeast Swale and the South Saskatchewan River, as these areas were identified by stakeholders as areas of concern and biological significance.

A large number of options were initially presented as potential routes in the area as a result of extensive stakeholder consultations and opportunities for environmental expert input. These concepts are described below and included in **Figure 1-2**.

- Freeway Concept 1, which follows the initially proposed general location (red) freeway concept first introduced in the 2020 SFFPS Environmental and Regulatory Review and determined in the Saskatchewan Ministry Highways and Transportation, (November 2017) Final Report – South Saskatoon Freeway General Location Study by Associated Engineering;
- Freeway Concept 2 (yellow) shifts the freeway approximately 250 m north to avoid the most sensitive areas of the Small and Northeast Swales; and
- Freeway Concept 3 (dark blue) shifts the freeway further north to further reduce environmental impacts associated with the Northeast Swale, and to minimize the length of water crossing.

Freeway Concept 4 (blue) is built on Freeway Concept 3 with a slight shift to the north minimizing open water crossing in the Northeast Swale and includes an east-west realignment of Highway 41 (light blue) as illustrated in **Figure 1-3**.

SNC-Lavalin conducted a wildlife and wildlife habitat study and a preliminary vegetation study as part of the Biological Assessment for Phase 2. These surveys were completed in 2020 and 2021 between the Northeast Swale and the South Saskatchewan River. The surveys also included the Small Swale, as well as some cropland, grassland, and riparian habitat between these landmarks. The following surveys were completed:

- snow tracking surveys;
- sharp-tailed grouse (*Tympanuchus phasianellus*) lek surveys;
- auditory amphibian surveys;
- common nighthawk (*Chordeiles minor*) and short-eared owl (*Asio flammeus*) surveys;
- yellow rail (*Coturnicops noveboracensis*) surveys;
- incidental wildlife observations; and
- a preliminary vegetation study.

A review of desktop resources, including databases and previous reports found a total of 36 wildlife SOCC within the 2021 desktop study area, 20 of which are considered SAR. A total of 114 wildlife species were observed during the 2020 and 2021 species detection surveys, 13 of which were identified as SOCC (Of the SOCC observed during species detection surveys, 11 were birds, one was a mammal, and one was an amphibian. Six of those species are SAR, including the American badger, barn swallow, common nighthawk, horned grebe, northern leopard frog, and short-eared owl. Some significant wildlife features, such as a new previously undiscovered sharp-tailed grouse lek were also discovered in the small swale. A total of 981 wildlife sign observations were made during the 2020 snow tracking surveys in the Phase I study area, and 3924 wildlife sign observations were made during the 2020 and 2021 snow tracking surveys in the Phase 2 study area.

A search of HABISask produced records of nine plant SOCC within the 2021 vegetation study area. No plant SAR element occurrences or lands requiring additional environmental protections or conservation easements were identified within the 2021 vegetation study area. A total of 371 vascular plant taxa were identified during the 2020 and 2021 field vegetation surveys. A total of 13 plant SOCC and 124 plant SOCC occurrences were detected and documented during the vegetation surveys.

Concept 1 (centered within the original General Location Study 500 m corridor) has the shortest road distance of all concept options considered. The proximity of this concept to McOrmond Drive will create small areas of fragmented wetland and native prairie habitat between the two roadways in the Northeast Swale while allowing a large area of land north of the corridor to remain intact. Noise and visual disturbance to wildlife and wildlife habitat may be reduced (in terms of total area affected by sensory disturbance) by selecting this concept, which is close to an existing source of noise pollution. Concept 1 would require the longer crossing structure (bridge, embankment, etc.) to traverse the open water portion Northeast Swale wetland complex. For the Small Swale, the route will cross over an open water portion of the wetlands in that swale, but also impact some of the potential vegetation and wildlife habitat located on the slopes and upland portions of the Small Swale.

Concept 2 is located between Freeway concept 1 and Freeway concept 3 and 4. The proximity of this Concept to McOrmond Drive will create moderately sized areas of fragmented wetland and native prairie habitat between the two roadway. Noise and visual disturbance to wildlife and wildlife habitat may be intermediate compared to other concepts (in terms of total area affected by sensory disturbance). The concept is located just over 400 m from a sharp-tailed grouse lek adjacent to the Small Swale, which is the recommended setback distance for this permanent sensitive wildlife feature (ENV 2017). The concept will also cross a sizeable portion of the Northeast Swale, including the largest open water section of all Concepts. This concept avoids the open water portions of the Small Swale, but still may impact some portions of the vegetation and wildlife habitat located within the slopes and upland portions of the small swale. The concept also crosses marl wetland habitat within the Small Swale, which supports several plant SOCC.

Concept and 3 and concept 4 are discussed together, as they overlap for the main route of the Freeway. Freeway Concept 4 (a derivative of Concept 3) minimizes the amount of the open-water in Northeast Swale wetland complex that would be covered by the proposed freeway. However, the location of the concept will result in wetland and native prairie habitat fragmentation in the Swales. The concept is located just over 400 m from a sharp-tailed grouse lek, which is the recommended setback distance for this permanent sensitive wildlife feature (ENV 2017). The concept also crosses marl wetland habitat within the Small Swale, which supports several plant SOCC. This concept avoids the open water portions of the small swale, but still may impact some portions of the vegetation and wildlife habitat located within the slopes and upland portions of the small swale. Noise and visual disturbance to wildlife and wildlife habitat may be increased (in terms of total area affected by sensory disturbance) by selecting this concept, as this area is closer to areas of previously undisturbed locations. This concept requires the shortest crossing structure over the Northeast Swale wetland complex, reducing costs and leaving a larger section of open-water swale available for wildlife which utilize the area. There are fewer challenges with wildlife crossing placement here as the topography is suitable for overpass construction compared to other concepts. Although concept 4 will disturb more area to make way for the Highway 41 realignment, this realignment passes over primarily cultivated land.

Wildlife crossings are incorporated in the freeway design and placed along the freeway to provide wildlife with a path to safely cross the road, connect habitats, and mitigate wildlife-vehicle collisions (WVC). These will be placed in locations where wildlife are mostly likely to utilize these crossing, within the Northeast and small swales, and along the South Saskatchewan River's banks.

Future wildlife and vegetation studies conducted in support of a Technical Proposal (TP) and/or Environmental Impact Statement/Assessment (EIS/EIA) should include grassland bird and prairie raptor surveys, and vascular plant surveys. It may also be necessary (depending on timeline of the project) to repeat surveys that were previously completed in this assessment. Future biological studies performed within the Phase 2 area may wish to consider the following recommendations based on the results of the 2020 SFFPS Environmental and Regulatory Review and the Phase 2 Biological Assessment. The areas studied in this report represent areas with likely the greatest environmental significance in the area, but other smaller areas that were not assessed as part of Phase II still may have regulatory and environmental significance.

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Appendices

1 Introduction

SNC-Lavalin Inc. (SNC-Lavalin) was retained by the Saskatchewan Ministry of Highways (SMH) to continue environmental baseline work on the Saskatoon Freeway Functional Planning Study (SFFPS). As part of this work, SNC-Lavalin and the Meewasin Valley Authority (MVA) have collaborated to produce the SFFPS Phase 2 Biological Assessment. SNC-Lavalin's contributions to the assessment are presented in this report, which serves as an addendum to the 2020 SFFPS Environmental and Regulatory Review. This report focuses primarily on the area between the Northeast Swale and the South Saskatchewan River, as these areas were identified by stakeholders as areas of concern and biological significance.

1.1 Project Overview

The Ministry is currently conducting the functional planning study to determine a series of potential routes for the Saskatoon Freeway and its associated infrastructure, interchanges, and supporting roadworks. The study is scheduled to be completed in 2022.

Once constructed, the freeway is expected to be a minimum four-lane, 56-kilometre freeway that will be routed around the City of Saskatoon, with roadway connections at eight provincial highways as well as some municipal roads. The planned route begins at Highway 11 south of Saskatoon and is routed counter-clockwise around the City connecting with Highway 7 west of the city (**Figure 1-1**). It will potentially consist of 16 interchanges, five railway overpasses, a minimum of two flyovers and a bridge crossing the South Saskatchewan River.

The environmental portion of functional planning study began with the review of a 500 m wide corridor that was identified in preceding general location studies. Information gained within the functional planning study is used to determine where the centre line of the freeway will be and will define interchange concepts, service roads and access points on and off the freeway. When complete, the functional planning study will more precisely identify the amount of land required for construction and allow for a more precise cost estimate for the construction phase. The study is broken into three phases including (**Figure 1-1**):

- Phase 1: North of Saskatoon between the South Saskatchewan River and Highway 16;
- Phase 2: East of Saskatoon between the South Saskatchewan River and Highway 11 (southeast terminus of the Saskatoon Freeway corridor); and
- Phase 3: West side of Saskatoon between Highway 16 and Highway 7 (southwest terminus of the Saskatoon Freeway corridor).

Completion of Phase 3 of the functional planning study has been deferred to a future date. The timing for detailed design and construction has not yet been determined.

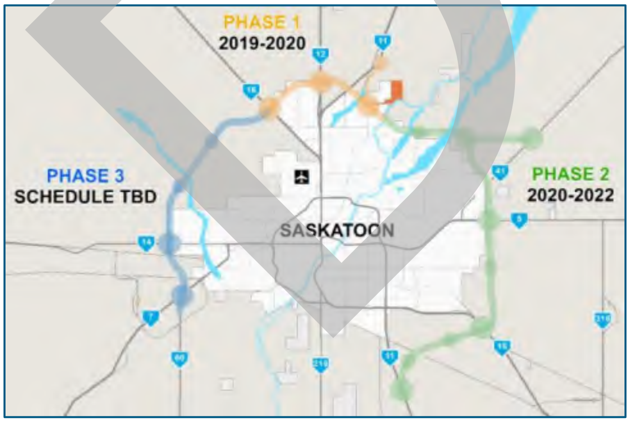


Figure 1-1: Saskatoon Freeway Phases

There is potential for environmental constraints throughout the proposed freeway route, but much public concern has been directed towards the areas immediately adjacent to the South Saskatchewan River, the Small Swale, and the Northeast Swale to the northeast of the City of Saskatoon. This report aims to better determine the environmental constraints that are present in these areas of concern, all found within Phase 2 of the project.

1.2 Study Objective

The objectives of the Phase 2 Biological Assessment are:

- Identify potential routing constraints within the proposed Phase 2 freeway concept corridors with a focus on three areas of public concern: the Northeast Swale, Small Swale, and the South Saskatchewan River valley. Potential constraints include Species of Conservation Concern (SOCC), sensitive wildlife features, and sensitive habitat;
- Recommend potential design and operational mitigations to avoid or reduce impacts; and
- Inform future biological studies conducted in support of a Technical Proposal and/or Environmental Impact Assessment for the proposed project.

1.3 Proposed Phase 2 Freeway Concept Corridors

Various routing concepts through the Northeast Swale and Small Swale have been proposed through discussions between representatives of SMH, MVA, AECOM, SNC-Lavalin, the City of Saskatoon, local environmental groups, landowners, and residents. These options take into consideration various concerns including sensitive environmental features, construction costs, overall road length; accessibility; and usability.

A large number of options were initially presented as potential routes in the area as a result of extensive stakeholder consultations and opportunities for environmental expert input. The shortlisted alignment concepts are described below and presented in **Figure 1-2**. Concept 4 (**Figure 1-3**) was determined to be the preferred route by means of a Multiple Account Evaluation (MAE). Details of the MAE can be found in **Section 5.1.1** of this report.

- Freeway Concept 1 (red), which follows the initially proposed General Location Study freeway alignment first identified in 2005, and described in the 2020 SFFPS Environmental and Regulatory Review;
- Freeway Concept 2 (yellow) shifts the freeway approximately 250 m north to avoid the most sensitive areas of the Small and Northeast Swales; and
- Freeway Concept 3 (purple) shifts the alignment north, and travels west and parallel to Township Road 374 from approximately the Small Swale to Blackley Road. From Blackley road, the alignment turns south to meet up with the remainder of the alignment for Phase 2.

Freeway Concept 4 (blue) is founded on Freeway Concept 3 with a slight shift to the north minimizing open water crossing in the Northeast Swale and includes an east-west realignment of Highway 41 (light blue) as illustrated in **Figure 1-3**.

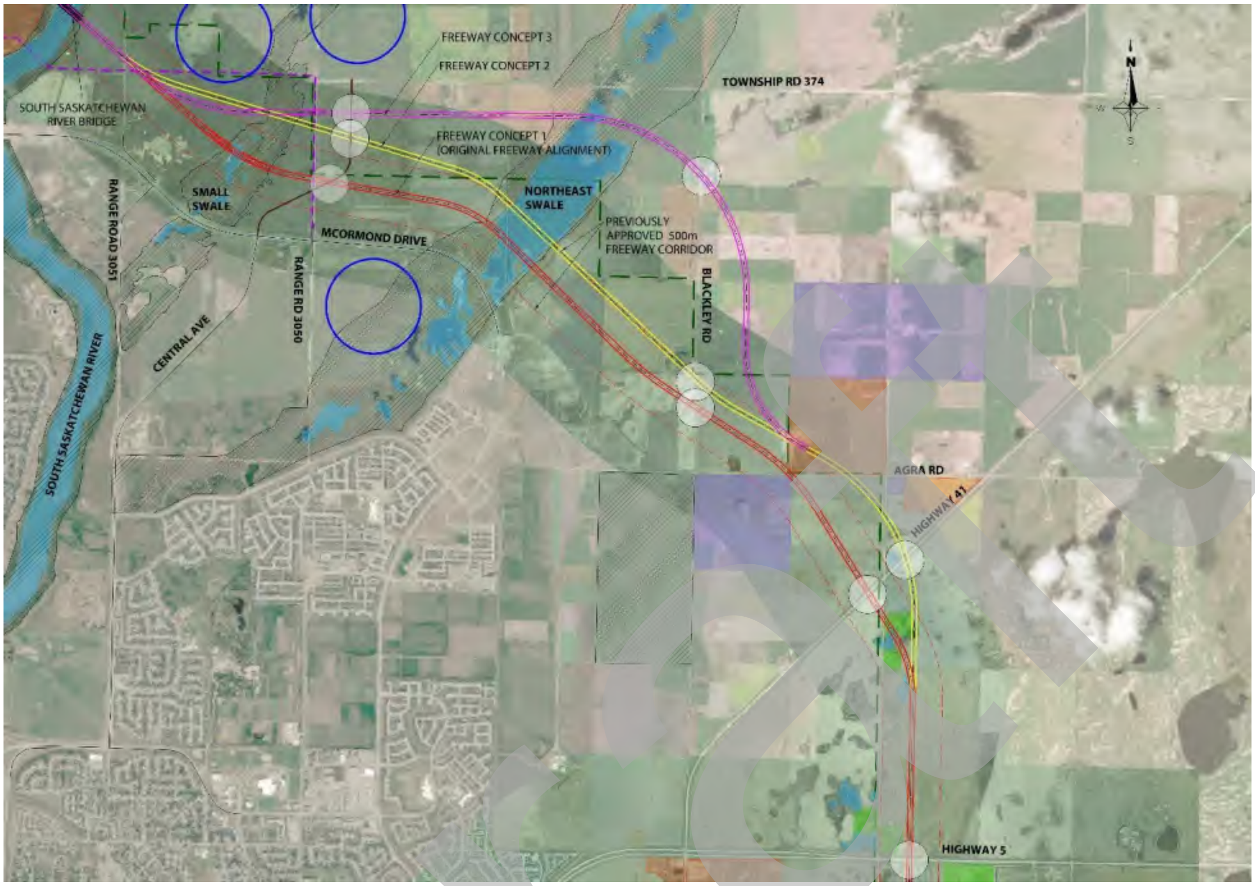


Figure 1-2: Proposed Saskatoon Freeway Phase 2 route alternatives

Concept 4 geometry was developed through consultations with Stakeholders as noted above. Key considerations included:

- Retaining Township Road 374 (Berghiem Road) to service existing and future developments between the Saskatoon Freeway and the grid road;
- Minimizing open water crossings; thereby, minimizing fill into the Northeast Swale and Small Swale;
- Utilizing existing disturbed land at the Small Swale where an existing trail was identified;
- Locating the freeway at the high point across the Small Swale; thereby, minimizing impacts on localized drainage;
- Complying with standard separation distances between interchanges; and
- Realigning Highway 41 recognizing there was a significant travel pattern between the northeast side of future development and the commercial/industrial areas north of the City of Saskaoon.

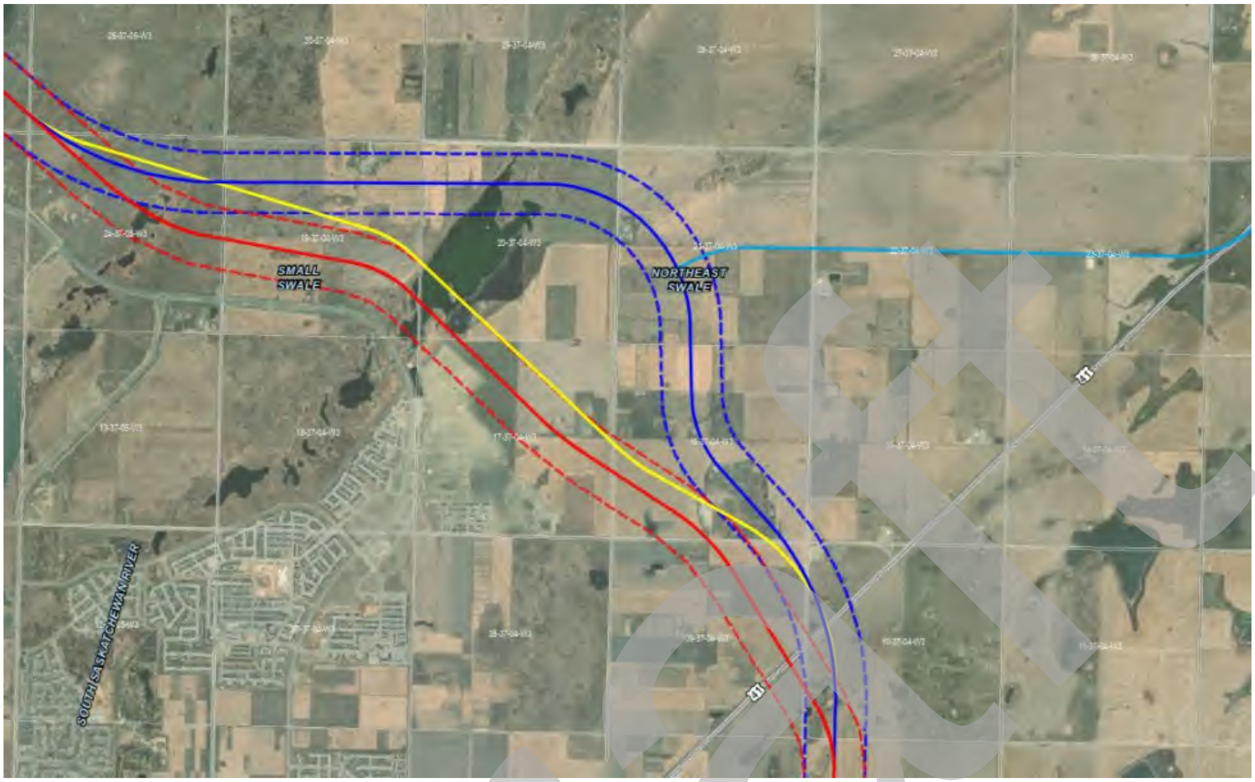


Figure 1-3: Freeway Concept 4

2 Regulatory Considerations

The following section describes: the federal and provincial assessment processes; potential federal, provincial, and municipal regulatory approvals / permits that may be required; and key environmental legislation relevant to the proposed project. The information is based on current legislation.

2.1 Environmental Assessment

2.1.1 Federal

The federal environmental assessment process is legislated by the *Impact Assessment Act*. The Physical Activities Regulations (SOR/2019-285) identify the physical activities that constitute the designated projects that may require a federal environmental assessment. Under the regulations, “the construction, operation, decommissioning and abandonment of a new all-season public highway that requires a total of 75 km or more of new right of way” is considered a designated project. The proposed freeway does not meet the 75 km threshold.

Under the *Impact Assessment Act*, the Minister of Environment and Climate Change has the power to designate projects, if in the Minister’s opinion the project may cause adverse effects within federal jurisdiction or adverse direct or incidental effects, or public concerns related to those effects warrants a designation. A designation request to the Minister may come from various sources, including the public, an Indigenous group, a non-governmental organization, a federal authority, the Agency, another jurisdiction, the project proponent or the Minister may decide to designate a project on his or her own.

Provincially, *The Environmental Assessment Act* provides a coordinated review of developments in Saskatchewan and provides an approval-in-principle that is not intended to duplicate regulatory programs but acts as an umbrella to ensure all relevant impacts for a project are addressed (ENV 2018). The Saskatchewan environmental assessment process begins with the submission of a Technical Proposal (TP) to the Saskatchewan Ministry of Environment (ENV). The TP is intended to provide ENV with enough information to determine regulatory requirements, including whether the project is considered a development pursuant to *The Environmental Assessment Act*. If the project is not considered a development, the project may proceed as proposed, subject to any conditions and applicable provincial regulatory requirements. If the project is considered a development, it will require ministerial approval and be subject to an Environmental Impact Assessment (EIA). The Act defines a development to mean any project, operation or activity, or any alteration or expansion of any project, operation or activity, which is likely to:

- Influence any unique, rare, or endangered feature of the environment;
- Substantially utilize any provincial resource, and in doing so, pre-empt the use, or potential use of that resource for any other purpose;
- Cause the emission of any pollutants or create by-products, residual or waste products which require handling and disposal in a manner that is not regulated by any other Act or regulation;
- Cause widespread public concern because of potential environmental changes;
- Involve a new technology that is concerned with resource utilization and that may induce significant environmental change; and/or
- Have a significant impact on the environment or necessitate a further development, which is likely to have a significant impact on the environment.

The proposed project has the potential to influence a unique, rare, or endangered feature of the environment (e.g., the Northeast and Small Swales) and has the potential to cause widespread public concern because of potential environmental changes, hence, will likely require submission of a TP to determine if the project is subject to an EIA.

Developments subject to an EIA must submit an Environmental Impact Statement (EIS) to the Environmental Assessment and Stewardship Branch (EASB) of ENV for review and approval. The EIS is then reviewed by the Saskatchewan Environmental Assessment Review Panel (SEARP), a multidisciplinary panel consisting of representatives from various provincial ministries and agencies with environmental and socioeconomic interests or responsibilities. If the EIS does not contain all the required information, ENV will issue Technical Review Comments and direct the proponent to provide additional information to address deficiencies. Once the EIS is complete, it will be made available for public review. Following the completion of the public review period, the EASB will make a recommendation to the Minister for a decision on whether the project can proceed with conditional approval. Conditions may include, among other things, a requirement to compensate for lost wetland and grassland habitat. Once approval is granted, the proponent can apply for additional permits and approvals.

2.1.2 Meewasin Valley Authority

The MVA is a conservation agency dedicated to conserving the cultural and natural resources of the South Saskatchewan River valley. The MVA has the power to coordinate or control the development of public land in accordance with the Development Plan as per section 10 of *The Meewasin Valley Authority Act*. The Saskatoon Freeway is located, in part, on lands under the jurisdiction of the MVA (Schedule A of the Act) however the Province is exempt from the MVA Development Review process and not subject to Development Review by the Authority. MVA is a key member of the Technical Working Group (TWG) for Environment and Heritage established as part of the Project Team and has been contracted by the Ministry to collect baseline environmental data within the Northeast Swale and surrounding area (including the Small Swale). As part of the TWG, MVA has participated in mitigation planning for the freeway design through environmentally sensitive areas to ensure that changes made to the river channel within their jurisdiction are compatible with the Authority's Development Plan.

2.2 Regulatory Approvals / Permits and Requirements

Numerous other environmental federal and provincial approvals / permits may be required for development of the proposed project. The project will also be subject to various environmental legislation. **Table 2.1** provides a list of potential approvals / permits and key legislation, however, this list is not inclusive and there may be other applicable approvals / permits and legislation. The Ministry will continue to engage with provincial and municipal agencies as the project progresses and once the layout is determined to discuss applicable approvals and permits.

Table 2.1: Potential environmental permits / approvals and key legislation

Permit and/or Approval	Description	Agency	Applicable Legislation or Regulation
Federal			
Migratory Birds Damage or Danger Permit	The Act prohibits the disruption or loss of active migratory nests, or harm or loss of eggs, young, and breeding adults. Under section 26(1) of the regulations, permits are required: to scare or kill migratory birds; for the collection, destruction, and disposal of eggs of migratory birds; for the removal, relocation, and/or destruction of birds/nests/eggs.	Environment and Climate Change Canada (ECCC)	› *Migratory Birds Convention Act, 1994* › Migratory Birds Regulations
n/a	The *Species at Risk Act* (SARA), provides legal protection of species listed in Schedule 1 to prevent them from becoming extirpated or extinct, and to provide necessary actions for the recovery of a species. Key considerations under SARA include protection of species' critical habitat (Sections 52 and 58); prohibition of killing, harming or taking of species at risk (Section 32); and prohibition of damage or destruction of residences of Species at Risk (Section 33).	ECCC	› *Species at Risk Act*
Fisheries Act Self Assessment / Review / Authorization	The Act requires that projects avoid causing the death of fish [Section 34.4(1)], as well as the avoiding the harmful alteration, disruption or destruction of fish habitat [Section 35(1)] unless authorized by the Minister of Fisheries and Oceans Canada (DFO). This applies to work being conducted in or near almost all waterbodies in Canada. Activities within the South Saskatchewan River and other watercourses will be subject to a request for review to DFO before proceeding and is expected to require an authorization. The Act also prohibits the deposition of deleterious substances in a waterway [section 36(1) to 36(6)].	Fisheries and Oceans Canada (DFO)	› *Fisheries Act*
Approval for a Major Work	An owner who proposes to construct, place, alter, rebuild, remove or decommission a major work in, on, over, under, through or across any navigable water must make an application for an approval to the minister.	Transport Canada	› *Canadian Navigable Waters Act*

Permit and/or Approval	Description	Agency	Applicable Legislation or Regulation
Provincial			
n/a	This Act protects the air, land, and water resources of Saskatchewan through the regulation and control of potentially harmful activities and substances. It regulates activities and materials that may affect the environment, including hazardous substances, hazardous waste, industrial waste, sewage and sewage works and waterworks. EMPA sets out permitting/approval processes; environmental protection plans, corrective action plans, reporting responsibilities; and consequences/penalties.	ENV	› *The Environmental Management and Protection Act, 2010* › The Environmental Management and Protection (Saskatchewan Environmental Code Adoption) Regulations › The Hazardous Substances and Waste Dangerous Goods Regulations
Aquatic Habitat Protection Permit (AHPP)	Section 38(4) of the Act prohibits the direct or indirect alteration of any waterbody or wetland without express authorization to do so. Aquatic habitat alteration may be allowed if authorization has been provided via a permit, a previously accepted environmental protection plan, or the Environmental Code (section 38(5)). Authorizations are not required if the watercourse or waterbody is wholly contained within the boundaries of land owned by the person carrying out the alteration and the surface water does not flow directly or indirectly into other surface water that is not wholly contained within the boundaries of that land (section 38(6)).	ENV	› *The Environmental Management and Protection Act, 2010*
n/a	This Act protects wildlife and wild species at risk in Saskatchewan (including most migratory and non-migratory birds that are not protected federally) from being disturbed, collected, harvested, captured, killed, sold or exported without a permit (Sections 31, 32 and 33). In addition, the den, nest, dam, or usual place of habitation of wildlife and wild species at risk is also protected from disturbance and destruction.	ENV	› *The Wildlife Act, 1998* › The Wildlife Regulations
Research Permit	Section 21(2) of the Act requires permits for surveys, research or other activity to detect or observe any species, wild species or wild species at risk, or assess the habitat of any species, wild species at risk, for a commercial, scientific, academic or other purpose prescribed in the regulations without a licence issued by the director.	ENV	› *The Wildlife Act, 1998* › The Wildlife Regulations
Special Collection Permit	This Act protects fish, crustaceans, molluscs, and aquatic invertebrates in Saskatchewan. It also protects the eggs or sperm from these species, as well as the individual parts of these species. This includes species not considered SOCC. Under Section 13 of this Act "*No person shall fish or acquire, raise, possess, use, culture, import, introduce, process, package, market, carry or transport any fish or dispose of any fish or allow any fish to be*	ENV	› *The Fisheries Act, 1994*

Permit and/or Approval	Description	Agency	Applicable Legislation or Regulation
	wasted except in accordance with any licence or any provisions of this Act or the Fisheries Act (Canada) or its regulations."		
n/a	This Act concerns the spread and propagation of Prohibited, Noxious, and Nuisance Weeds. Section 26(1) outlines requirements for machines to be thoroughly cleaned, inside and out, to ensure the removal or destruction of any prohibited or noxious weeds before the machine is moved. Permits would be required if chemicals were to be used near waterbodies/watercourses.	n/a	› *The Weed Control Act, 2010*
n/a	These Acts concern the spread and propagation of pests that may affect the environment. Sections 5 to 7 require that every person take measures to destroy pests, soils, or any other matter that may contain pests. Requirements for training and certification associated with the application of of pest control products are also stipulated.	n/a	› *The Pest Control Act* › *The Pest Control Products (Saskatchewan) Act*
Water Rights Licence	Under section 50 of the Act a licence is required for the right to use water (surface water or groundwater).	WSA	› *The Water Security Agency Act*
Approvals to Construct / Operate Drainage Works	Under section 59 of the Act and section 11 of the regulations, approval is required for the construction, extension, alteration and operation of drainage works.	WSA	› *The Water Security Agency Act* › The Water Security Agency Regulations
Heritage Property Act Clearance / Heritage Resource Impact Assessment (HRIA) Permit / Mitigation / Research Investigation Permit	If an operation or activity which may be undertaken is likely to result in the alteration, damage or destruction of heritage property, the minister may require under section 63(that person to: (a) carry out an assessment to determine the effect of the proposed operation or activity on that heritage property; (b) prepare and submit to the minister a report containing the assessment mentioned in clause (a); and (c) undertake any salvage, preservation or protective measures, or any other action, that the minister may specify. A Research Permit is required under section 67 to: (a) carry out a survey; (b) make collections; or (c) conduct excavations or other activities; which may disturb or dislocate archaeological or palaeontological objects on a heritage property.	MPCS	› *The Heritage Property Act, 1980*
Utility Crossing Agreements	Agreements with utility companies to regarding movement of existing utilities to accommodate the freeway.	Various utility and oil and gas companies	n/a

n/a - denotes no permit/approval required

3 Meewasin Valley Authority Habitat Evaluations

The MVA conducted a number of parallel studies to evaluate the habitat along the proposed Saskatoon Freeway through the Northeast Swale and Small Swale to the South Saskatchewan River in the northeast sector of Saskatoon in 2020 and 2021. The evaluation included desktop evaluation and field investigation in these areas (Grilz and Hooey 2020 and 2021). The desktop evaluation included habitat cover assessment mapping; and screening through citizen scientist databases, provincial databases, and Meewasin records. The habitat cover assessment identified approximately 83% of MVA's study area (the Northeast Swale and Small Swale areas) is classified as ecological environment, which includes aquatic habitat, naturalized grasslands, and hayfields. Compilation of data from various databases indicated that numerous rare plant and wildlife species have been historically observed in the area, including several rare plant, mammal, amphibian, and bird species in the Northeast Swale and Small Swale. The data from these reports has also been incorporated into the desktop review sections and figures of this report in **Section 4**.

The field investigations included monitoring using wildlife cameras, wildlife tracking, water quality sampling, and dark-sky light pollution monitoring. Observations through the wildlife cameras indicated that white-tailed deer and mule deer were abundant in the Northeast Swale and Small Swale areas, with mule deer more common in the Northeast Swale and white-tailed deer more abundant in the Small Swale. Other wildlife observed through the wildlife cameras include coyotes, porcupines, weasels, and moose. Wildlife tracking could not be completed due to concerns with COVID-19, but citizen scientists reported observations of white-tailed deer at the Small Swale and mule deer at the Northeast Swale. Water quality samples were collected to supplement the development of a baseline understanding of wetland water quality within the Small Swale, while the City of Saskatoon has conducted water quality monitoring at the Northeast Swale which provides a baseline for long-term monitoring of the wetlands in the area. Both swale areas have a similar amount of artificial sky glow (i.e., light pollution), which are significantly lower than the amount of artificial sky glow in urban and suburban environments.

MVA also notes concerns with the freeway alignment and how it may impact sensitive habitat in the Northeast Swale, Small Swale, South Saskatchewan River, and other areas along the proposed route. The main concern with the alignment that intersects with these areas is that the freeway causes habitat fragmentation and prevents wildlife from safely moving between habitats. Installing wildlife crossings along the freeway would contribute to habitat connectivity and allow wildlife to move between habitats by passing under or over the freeway (Grilz and Hooey 2020). Additional considerations to reduce the impacts from vehicles and project infrastructure (lighting, etc.) related to noise and light should also be incorporated into project design.

Based on the results of their habitat evaluations, MVA provided considerations for short-term monitoring and long-term monitoring. Short-term monitoring considerations include conducting breeding bird surveys, bat surveys, amphibian surveys, rare vascular plant surveys, and sharp-tailed grouse lek surveys from 2020 to 2021. Some of these recommendations will be carried forward and completed during the EA phase of the project. Long-term monitoring considerations include continuing ongoing species at risk surveys, dark sky monitoring, water quality monitoring, wildlife monitoring, and noise monitoring to aid in the development of mitigation strategies.

4 Biological Studies

SNC-Lavalin conducted a wildlife and wildlife habitat study and a preliminary vegetation study as part of the Phase 2 Biological Assessment. These studies were conducted over the course of two years, beginning in 2020 and ending in 2021.

4.1 Regulatory Context

4.1.1 Species of Conservation Concern (SOCC) and Species at Risk (SAR)

The following biological studies give particular attention to plant and wildlife Species of Conservation Concern (SOCC), breeding birds, sensitive wildlife features, and other environmental sensitivities that may be present in the study area. For the purpose of this study, an SOCC is defined as any plant or wildlife species that meets one or more of the following criteria:

- Listed under Schedule 1, Schedule 2, or Schedule 3 of the federal *Species at Risk Act* (SARA) as *Endangered*, *Threatened*, or *Special Concern*;
- Currently under consideration for addition to Schedule 1 of SARA;
- Assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) as *Endangered*, *Threatened*, or *Special Concern*;
- Listed as a designated species in *The [Saskatchewan] Wildlife Act*, *1998*;
- Ranked as *S1*, *S2*, *S3*, or tracked by the Saskatchewan Data Conservation Centre (SKCDC); and/or
- Assessed as a sensitive species or feature under The Saskatchewan Ministry of Environment (ENV) Saskatchewan Activity Restriction Guidelines (ARGs) for Sensitive Species (ENV 2017).

For the purposes of this assessment, a Species at Risk (SAR) is defined as species that meets one or more of the following criteria, representing a small subset of the SOCC:

- Listed under Schedule 1 of SARA as *Endangered*, *Threatened*, or *Special Concern*; and/or
- Listed as a designated species in *The [Saskatchewan] Wildlife Act, 1998*.

Explanations of federal and provincial SOCC and SAR rankings are provided in Appendix A.

4.1.2 Breeding Birds

Aside from a few non-native and/or common species, all migratory and resident breeding birds and their nests are protected under federal and/or provincial legislation. For the purpose of this study, breeding bird species are defined as those with legislative protection that meet one or more of the following criteria:

- Identified under the federal *Migratory Birds Convention Act, 1994* and Migratory Birds Regulations; and/or,
- Identified under *The [Saskatchewan] Wildlife Act, 1998* and The [Saskatchewan] Wildlife Regulations, 1981.

4.1.3 General Wildlife and Sensitive Wildlife Features

The *[Saskatchewan] Wildlife Act, 1998* provides protection for the majority of wildlife in Saskatchewan (1998, c.W-13.12, s.32.). This legislation also provides protection for sensitive wildlife features such as dens, hibernacula, leks, nests, setts (badger residences), etc. Some non-native and nuisance species are exempt from this legislation, such as most rodent species.

4.2 Wildlife and Wildlife Habitat Study

SNC-Lavalin conducted the SFFPS Phase 2 wildlife and wildlife habitat study between the South Saskatchewan River and Northeast Swale to identify wildlife SOCC and sensitive wildlife features within the proposed freeway alignment corridors. The study consisted of the following desktop and field-level investigations:

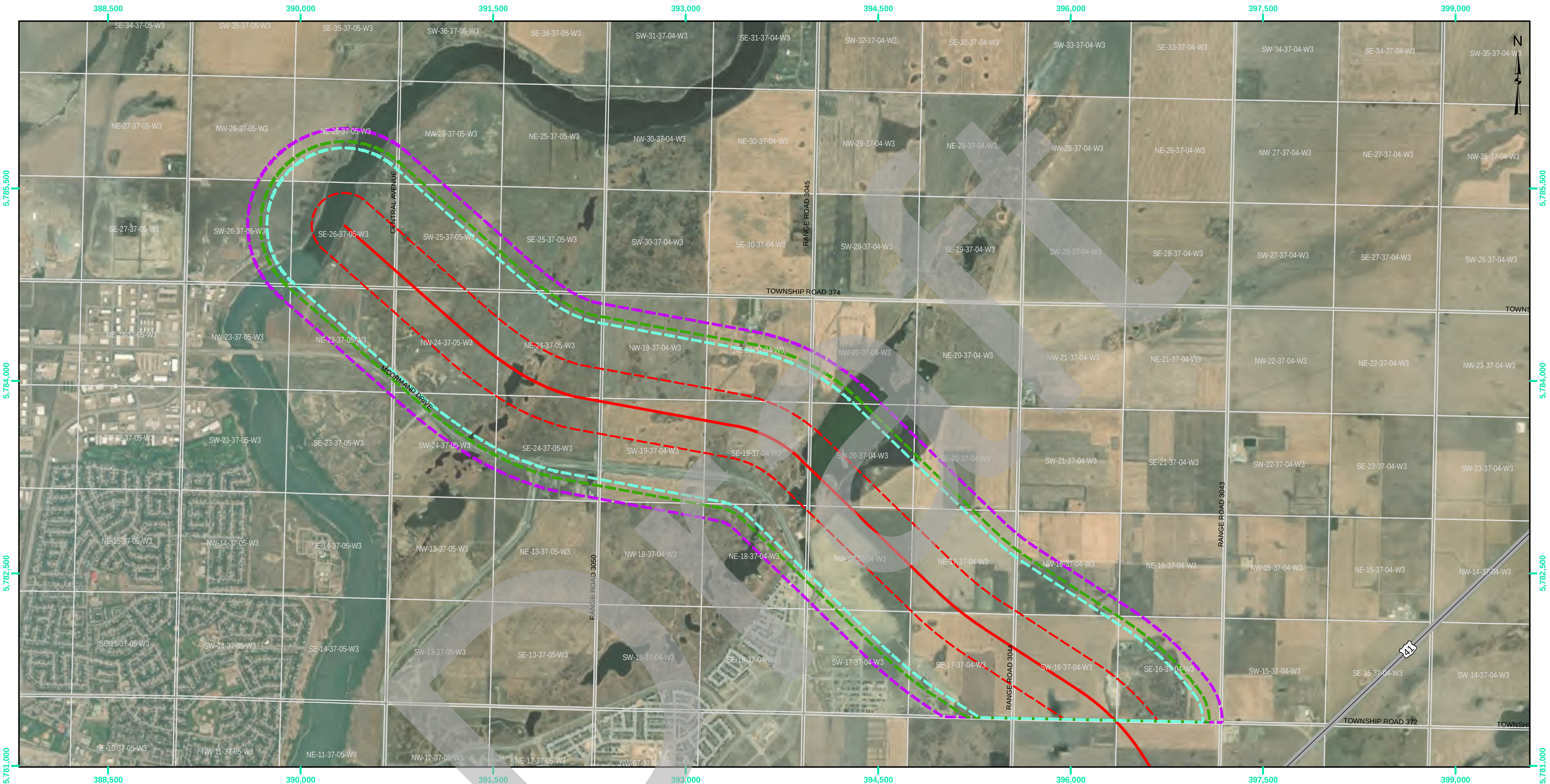
- A desktop wildlife SOCC screening exercise to identify wildlife SOCC occurrences, sensitive wildlife features, and potential wildlife SOCC habitat within the 2021 desktop wildlife study area, including occurrences that may not have been captured by the 2020 SFFPS Environmental and Regulatory Review (SNC-Lavalin 2020);
- Field-level species detection surveys for wildlife SOCC and sensitive wildlife features within the corresponding wildlife study areas; and
- Incidental observations of wildlife SOCC and sensitive wildlife features made during the field program.

The results of the wildlife and wildlife habitat study may be used to inform biological studies conducted in support of a TP and/or EIA for the proposed project. For the purpose of this study, wildlife includes fish, bird, mammal, amphibian, reptile, and insect species.

4.2.1 Wildlife Study Areas

The SFFPS Phase 2 wildlife and wildlife habitat study was designed to target areas of sensitive wildlife habitat intersected by the Phase 2 freeway concepts, including portions of the Northeast Swale, Small Swale, South Saskatchewan River valley, and surrounding lands under private ownership. The 2020 wildlife species detection surveys follow the original freeway concepts 1 and 2 between the eastern bank of the South Saskatchewan River (Phase 2 boundary) and Township Road 372 (**Figure 4.1**), while the 2021 species detection surveys focused on the 500 m wide corridor surrounding Concept 3 and 4 (**Figure 4.2**). The realignment of Highway 41 was not included in these studies as it did not contain as much high-value habitat, but future work during the EA phase of the project may be required in this area.

ENV Species Detection Survey Protocols (2014a, 2014b, 2017, 2020a to 2020d) suggest that wildlife study areas include the proposed project footprint as well as the largest applicable setback distance based on the Saskatchewan Activity Restriction Guidelines (ARGs) for Sensitive Species (ENV 2017). According to these guidelines, road construction falls under the high disturbance category. Recommended setback distances for high disturbance activities were applied to the Concept 1 corridor to create customized study areas for the 2020 wildlife species detection surveys (**Table 4.1**). Study areas for the 2021 wildlife species detection surveys were created by applying these same setback distances to the Concept 3 corridor. A desktop study area for the 2021 wildlife SOCC screening exercise was selected based on the largest buffer distance identified by this exercise: 1,000 m.



- 🟥 ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- ▬ HIGHWAY
- ⬚ GENERAL LOCATION CORRIDOR (PHASE 2)
- ⬚ 2020 AMPHIBIAN AUDITORY AND COMMON NIGHTHAWK/SHORT-EARED OWL STUDY AREA
- ⬚ 2020 SHARP-TAILED GROUSE LEK STUDY AREA
- ⬚ 2020 YELLOW RAIL STUDY AREA

NOTES

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0 190 380 760 1,140 1,520 Metres

SCALE: 1:30,000

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REV	DATE	DESCRIPTION	DES	DRN	CHK	APP

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DWG No.	DESCRIPTION

CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020 WILDLIFE STUDY AREAS

DATE	DWG No.	FIG No.	REV
2021 11 30	659183-0000-4EDD-0062	4.1	00

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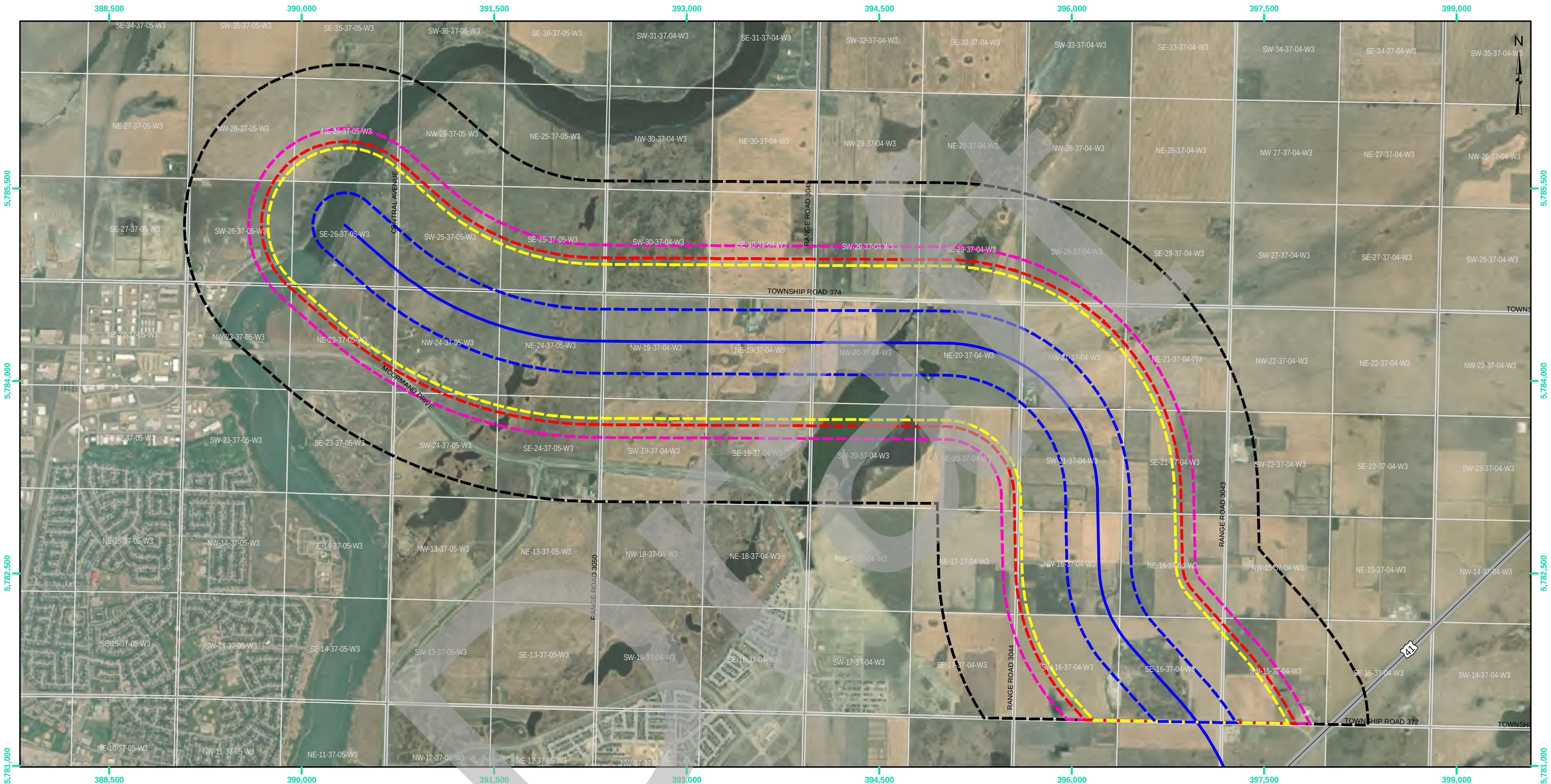

- ROUTE CONCEPT 3
- HIGHWAY
- 2021 STUDY AREA
- 2021 SHARP-TAILED GROUSE LEK STUDY AREA
- 2021 AMPHIBIAN AUDITORY AND COMMON NIGHTHAWK/SHORT-EARED OWL STUDY AREA
- 2021 YELLOW RAIL STUDY AREA
- 2021 DESKTOP STUDY AREA

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0 190 380 760 1,140 1,520 Metres

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CLIENT
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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2021 WILDLIFE STUDY AREAS

DATE 2021 11 30 **DWG No.** 659183-0000-4EDD-0070 **FIG No.** 4.2 **REV** 00

SIZE 11x17

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Table 4.1: Wildlife study areas

Species Detection Survey	Target Species with the Largest Applicable Setback Distance	Associated Wildlife Feature Requiring a Setback	Buffer Applied to Corridor (m)	2020 Study Area Size (ha)	2021 Study Area Size (ha)
amphibian auditory	northern leopard frog	breeding and overwintering habitat	500	1,175	1,471
common nighthawk and short-eared owl	short-eared owl	breeding bird activity	500	1,175	1,471
desktop SOCC screening	multiple bird species	breeding bird activity, nest sites, nesting colonies	1,000	n/a*	2,508
sharp-tailed grouse	sharp-tailed grouse	lek	400	1,010	1,273
snow track	n/a	n/a	n/a	n/a	n/a
yellow rail	yellow rail	breeding bird activity	350	928	1,175

*Desktop SOCC screening was previously conducted as part of the 2020 SFFPS Environmental and Regulatory Review
Source: (ENV 2014a, 2014b, 2017, 2020a to 2020d).

Three mammal species assessed as sensitive under the Saskatchewan ARGs (ENV 2017) may be detected using the ENV Snow Track Survey Protocol (2014a): black-footed ferret (*Mustela nigripes*), black-tailed prairie dog (*Cynomys ludovicianus*), and swift fox (*Vulpes velox*). The proposed freeway concept corridors fall outside of the current ranges of the black-tailed prairie dog and swift fox as well as the historical range of the black-footed ferret, which is believed to be extirpated from the province (COSEWIC 2009a, 2010a, and 2011; SKCDC 2021a). For this reason, snow track study areas were not established using setback distances provided by the Saskatchewan ARGs for Sensitive Species. The 2020 snow track survey followed the original proposed freeway corridor down the centreline and outer limits (250 m buffer) of the proposed corridor, and the 2021 survey followed the Concept 3 corridor down the centreline and along the outer limits (250 m buffer) of the proposed corridor.

4.2.2 Methods

4.2.2.1 Desktop Wildlife SOCC Screening

A desktop screening exercise was conducted to identify wildlife SOCC occurrences, sensitive wildlife features, and potential wildlife SOCC habitat within the 2021 desktop study area, including occurrences that may not have been captured by the 2020 SFFPS Environmental and Regulatory Review (SNC-Lavalin 2020). This data was obtained from the following sources:

- The HABISask tool (Government of Saskatchewan 2021) for a (i) list of wildlife SOCC occurrences and animal assemblages that were previously detected within the study area (known as element occurrences), (ii) the locations of federal and/or provincial lands requiring environmental protection, and (iii) predictive distribution models for wildlife SOCC;
- Available studies in the region with data less than ten years old and with spatial wildlife SOCC data that could be readily extracted (e.g., presented on maps or with UTM coordinates), including:
    - North Commuter Parkway – Baseline Terrestrial and Aquatic Field Studies, and Heritage Resource Impact Assessment (Stantec 2013a),
    - 2020 SFFPS Environmental and Regulatory Review (SNC-Lavalin 2022);
    - North Central/North East Natural Area Screening Study, City of Saskatoon (Stantec 2013b), and

- MVA Habitat Evaluation of the Saskatoon Freeway Project Through the Northeast and Small Swale Complexes, 2020 Report (Grilz and Hooey 2020) and MVA Habitat Evaluation of the Saskatoon Freeway Project Through the Northeast and Small Swale Complexes, 2021 Report (Grilz and Hooey 2021).

Current federal and provincial species rankings were provided by the SARA Public Registry (Government of Canada 2021) and the SKCDC (2021a and 2021b) (Appendix A).

4.2.2.2 Species Detection Surveys

SNC-Lavalin completed wildlife surveys during the winter, spring, and summer of 2020 and 2021 between the Northeast Swale and the South Saskatchewan River. The surveys also included the Small Swale, as well as some cropland, grassland, and riparian habitat between these landmarks. The following surveys were completed:

- snow tracking surveys;
- sharp-tailed grouse (*Tympanuchus phasianellus*) lek surveys;
- auditory amphibian surveys;
- common nighthawk (*Chordeiles minor*) and short-eared owl (*Asio flammeus*) surveys;
- yellow rail (*Coturnicops noveboracensis*) surveys; and
- incidental wildlife observations.

Species detection surveys were conducted in accordance with ENV Species Detection Survey Protocols. Research permits for species detection surveys were obtained from ENV (Appendix B). As a condition of these permits, survey results were submitted to ENV using the most recent data submission loadforms (ENV 2021a).

Land access permissions were not required for access from public roads. Form A letters were sent out via registered mail to inform landowners and occupants of the intent to access private land for on-foot assessments. SNC-Lavalin also provided notification in the form of a phone call or voice message which was delivered prior to accessing the land (if requested).

4.2.2.2.1 Snow Tracking Surveys

SNC-Lavalin completed snow track surveys to identify mammal species presence and travel pathways within the study area in accordance with the ENV Snow Track Survey Protocol (2014a).

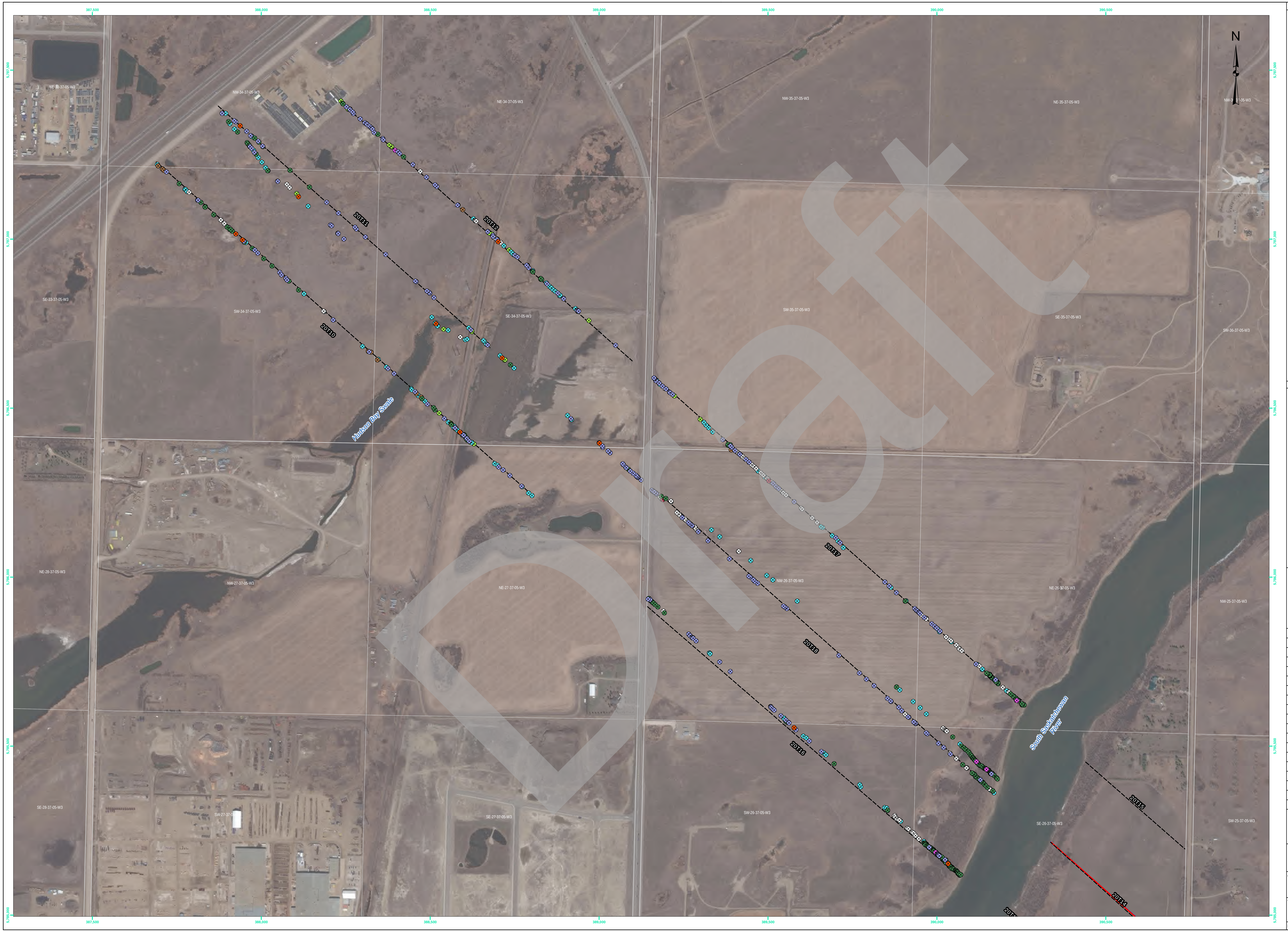
The first year of snow track surveys were conducted between 29 January and 4 April 2020 along 18 transects. Additional winter tracking surveys were also completed in the Phase 1 area, along the Hudson Bay Swale in 2020. Methodology for the winter tracking completed in 2020 is detailed in the Environmental and Regulatory Review (SNC-Lavalin 2020). (**Figures 4.3** to **4.5; Table 4.2**).

In 2021, snow track surveys were completed along nine transects the first visit and 12 the second visit. Transects were split in two as warm weather prevented crossing the frozen portion of the Northeast Swale. Surveys were conducted between 19 February and 19 March 2021 (**Figure 4.6; Table 4.2)**. Transects were located between the Northeast Swale and the Hudson Bay Swale. Transect locations were based on the original proposed freeway corridor for 2020 and on the Concept 3 for 2021. Transect locations in 2021 were selected to cover areas that had not been previously assessed by snow tracking efforts. An assessment of ancillary roads that may be associated with the freeway was not completed. All transects followed the proposed corridor concepts as below:

- On the centreline of the proposed corridor;
- On the northern edge of the proposed corridor (approximately 250m north of the centreline); and
- On the southern edge of the corridor (approximately 250m south of the centreline).

The ENV Snow Track Survey Protocol (2014a) recommends that repeat surveys be completed where diverse and sensitive taxa are anticipated, with surveys being at least four weeks apart. Each transect was surveyed two to four times. Transect lengths varied between transects due to topographic barriers (e.g. waterbodies, roads), ranging from 390 m to 1,770 m. Snow track surveys were completed two to four days following a snow-obliterating event across various habitat types and land uses. A field crew of two qualified personnel completed transects on-foot, recording identifiable wildlife tracks, feces, feathers, regurgitation pellets, wing patterns, and residences using a digital collection application (Survey123 – Esri software) (ENV 2014a). Where species or taxa could not be determined from tracks, the tracks were followed off-transect until identifying features were detected. No attempt to distinguish between mule deer and white-tailed deer was completed due to track similarities. Detection results for the snow track surveys were compiled and mapped (**Figures 4.2** to **4.5**).

Most of the surveys were completed when at least 75% of the ground was covered by snow (only one transect was completed when snow coverage was only 50-74%). Snow textures in the survey were primarily crust and powder, and snow depth varied between 5 cm to 40 cm deep.



LEGEND

SPECIES DETECTED

- ⊗ BIRD
- ⊗ COYOTE
- ⊗ GROUSE
- ⊗ HARE / RABBIT
- ⊗ PORCUPINE
- ⊗ RED FOX
- ⊗ SMALL RODENT
- ⊗ WEASEL
- ⊗ WHITE-TAILED DEER / MULE DEER

- - - SNOW TRACK SURVEY TRANSECT

— ROUTE CONCEPT 1
(BASE CASE/ORIGINAL ALIGNMENT)

NOTES

1. COORDINATE SYSTEM: NAD 1983 UTM ZONE 13N.
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SCALE: 1:5,000

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CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

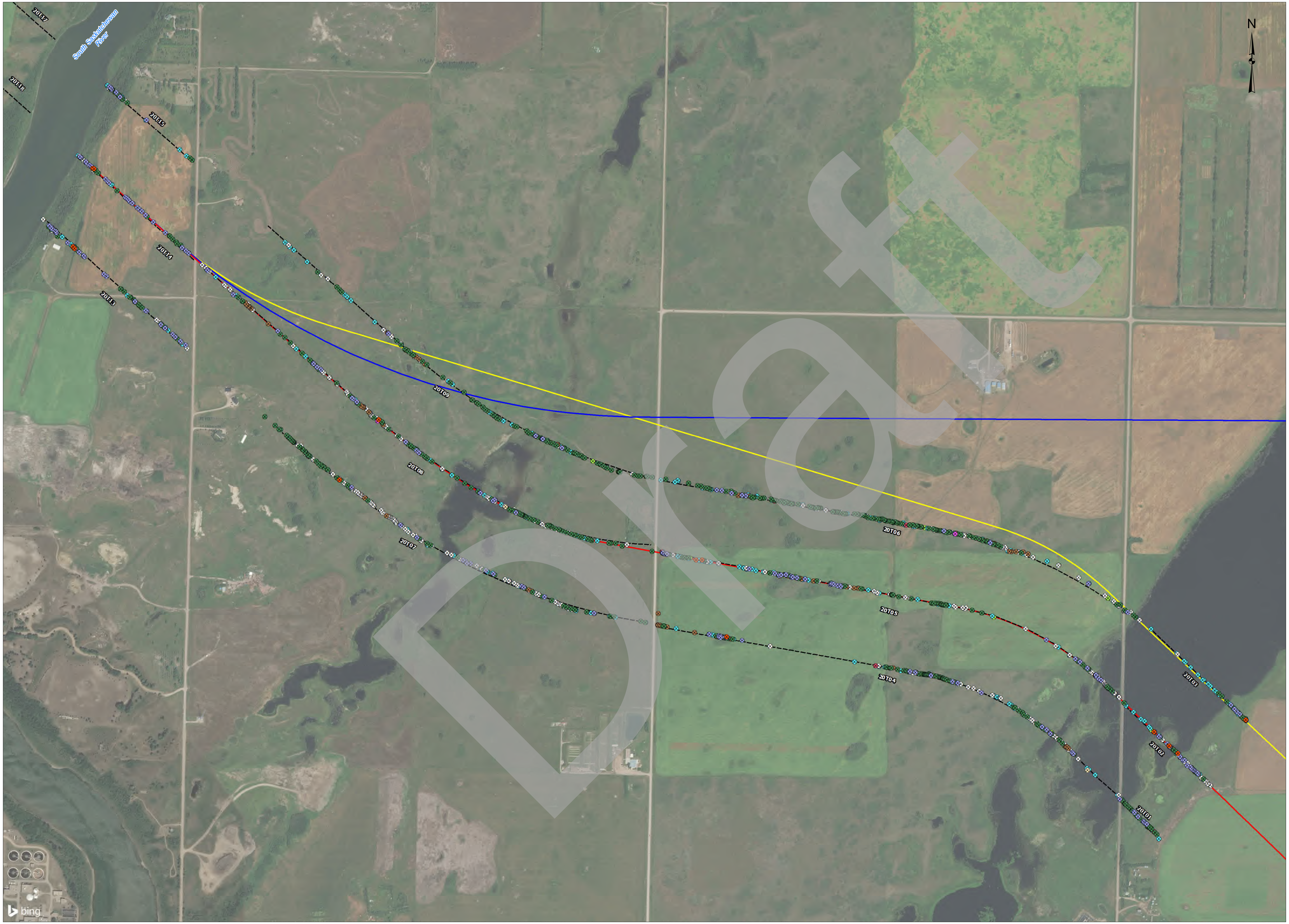
PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020 PHASE 1 SNOW TRACK SURVEY TRANSECTS AND DETECTION RESULTS

DATE 2022 03 17 **DWG No** 659183-0000-4EDD-0074 **FIG No.** 4.3 **REV** 00

SIZE 22 x 34

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0074 2020 West Snow Track Survey 22BY34.mxd



LEGEND

SPECIES DETECTED

- ⊗ BEAVER
- ⊗ BIRD
- ⊗ COYOTE
- ⊗ GROUSE
- ⊗ HARE / RABBIT
- ⊗ MUSKRAT
- ⊗ PORCUPINE
- ⊗ RED FOX
- ⊗ SMALL RODENT
- ⊗ WEASEL
- ⊗ WHITE-TAILED DEER / MULE DEER

- - - - SNOW TRACK SURVEY TRANSECT

🟥 ROUTE CONCEPT 1
(BASE CASE/ORIGINAL ALIGNMENT)

🟨 ROUTE CONCEPT 2

🟦 ROUTE CONCEPT 3

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SCALE: 1:6,000

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SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON FREEWAY

TITLE
2020 SNOW TRACK SURVEY TRANSECTS AND DETECTION RESULTS

DATE	2020 08 09	DWG No	659183-0000-4EDD-0038	FIG No.	4.4	REV	00

SIZE 22 x 34

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LEGEND

SPECIES DETECTED

⊗	BEAVER
⊗	COYOTE
⊗	MUSKRAT
⊗	PORCUPINE
⊗	RED FOX
⊗	WEASEL
⊗	WHITE-TAILED DEER / MULE DEER
- - -	SNOW TRACK SURVEY TRANSECT
🟥	ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
🟨	ROUTE CONCEPT 2
🟦	ROUTE CONCEPT 3

SIZE 22 x 34

NOTES

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TITLE

2020 SNOW TRACK SURVEY TRANSECTS AND LARGE MAMMAL WILDLIFE DETECTION RESULTS

DATE	DWG No	FIG No.	REV
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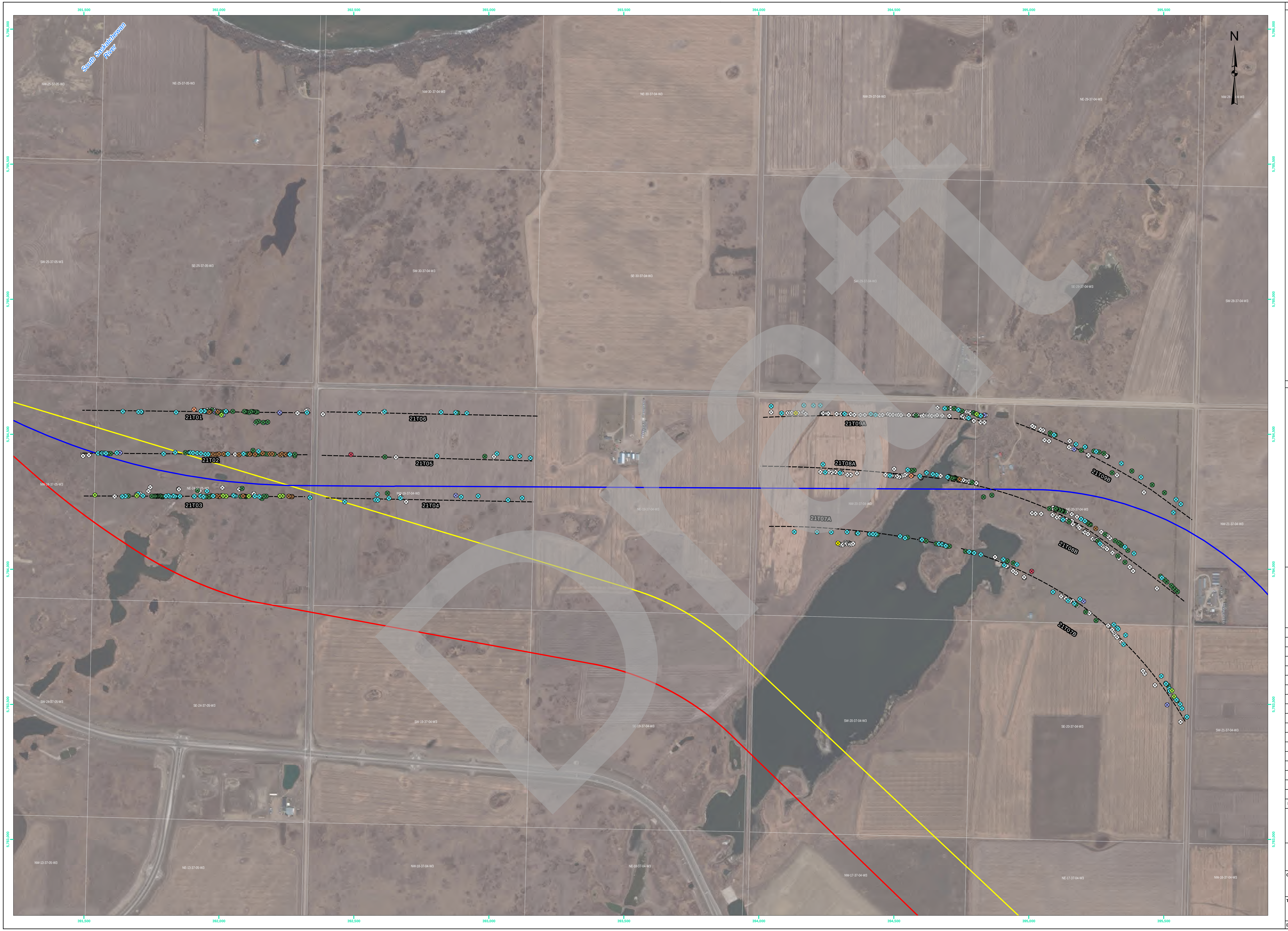

LEGEND

SPECIES DETECTED

- ⊗ BEAVER LODGE
- ⊗ BIRD
- ⊗ COYOTE
- ⊗ GOOSE
- ⊗ GROUSE
- ⊗ HARE / RABBIT
- ⊗ MOOSE
- ⊗ RED FOX
- ⊗ SMALL RODENT
- ⊗ WEASEL
- ⊗ WHITE-TAILED DEER / MULE DEER

- - - - SNOW TRACK SURVEY TRANSECT

ROUTE CONCEPT 1
(BASE CASE/ORIGINAL ALIGNMENT)

ROUTE CONCEPT 2

ROUTE CONCEPT 3

SIZE 22 x 34

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAY	SASKATOON FREEWAY

TITLE
2021 SNOW TRACK SURVEY TRANSECTS
AND DETECTION RESULTS

DATE	DWG No	FIG No.	REV
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Table 4.2: 2020/2021 Snow track survey transect starting and end locations

Transect ID	Starting UTM (13U)		Ending UTM (13U)	
	Easting	Northing	Easting	Northing
20T01	393958	5782971	394086	5782859
20T02	394271	5783021	393961	5783318
20T03	394397	5783251	393973	5783641
20T04	392352	5783580	393949	5782992
20T05	392363	5783844	393955	5783336
20T06	393953	5783643	392354	5784091
20T07	392315	5783595	391042	5784257
20T08	390766	5784839	392325	5783865
20T09	390992	5784975	392326	5784097
20T10	387689	5787229	388803	5786242
20T11	387869	5787397	388678	5786678
20T12	389099	5786639	388234	5787406
20T13	390215	5785000	390716	5784544
20T14	390735	5784856	390336	5785216
20T15	390725	5785195	390437	5785456
20T16	389143	5785913	390064	5785117
20T17	390253	5785623	389165	5786592
20T18	390167	5785368	389160	5786263
21T01	392158	5784595	391491	5784589
21T02	391489	5784424	392322	5784426
21T03	392331	5784269	391417	5784274
21T04	392389	5784266	393168	5784249
21T05	393153	5784404	392367	5784423
21T06	392391	5784583	393177	5784565
21T07a	394005	5784178	394443	5784151
21T07b	394747	5784080	395566	5783540
21T08a	394629	5784349	394005	5784379
21T08b	395579	5783877	394756	5784311
21T09a	393997	5784573	394828	5784559
21T09b	395602	5784185	394961	5784541

4.2.2.2.2 Sharp-tailed Grouse Lek Surveys

SNC-Lavalin completed Sharp-Tailed Grouse Lek surveys in accordance with the ENV Sharp-Tailed Grouse Survey protocol (2020a). These surveys were completed to determine the occupancy (detected/not detected) of sharp-tailed grouse and their leks. Sharp-tailed grouse leks (mating grounds) are protected under *The Wildlife Act*, *1998*.

Five transects spaced approximately 250 m apart and were chosen based on the proposed freeway corridor in 2020. An additional four transects spaced approximately 250 m apart were chosen based on Concept 3 in 2021. (**Figure 4.7**; **Table 4.3**). Fewer transects were required in 2021, as the southern sections of the 2021 study area overlapped with the 2020 corridor. Each transect included 9 to 15 survey points, spaced approximately 300 m to 400 m apart from each other. This spatial design was selected so that any sharp-tailed grouse lek could be detected up to 400 m from the proposed freeway corridor. Additionally, two sharp-tailed grouse leks that were previously detected just outside the proposed corridor and study areas were visited during survey efforts to determine if they were still active. Suitable lekking grounds include open grassland and shrubland habitats therefore these habitats were targeted for survey. Higher elevation habitats were also surveyed as leks are commonly situated on higher ground with good visibility of the surrounding area (Government of Saskatchewan 2020a).

Leks are most active in the mornings, but sharp-tailed grouse are active throughout the day and will begin gathering at leks in the evenings. Each survey was conducted in a two-part program. Survey points were first visited in the evening, approximately two hours prior to sunset until sunset, to identify potential lek sites and grouse habitat. If promising habitat or a gathering of sharp-tailed grouse were observed, the survey point was revisited the subsequent morning, one hour before sunrise to approximately two or three hours after, to scan for lekking activity. Air temperature and wind speed were recorded using an anemometer (Kestrel 2000 Pocket Wind Meter) prior to commencing each survey. Surveys were not completed during heavy rain events or other adverse weather, as lekking activity is reduced during these times. Each transect was completed twice, separated by a period of at least three days to reduce the risk of a lek being missed on any single occasion. Surveys were completed for each survey point between 27 April and 8 May 2020, and 15 April and 5 June 2021. Surveys started within the recommended survey window of mid-March to mid-May (ENV 2020a) but continued later as lekking activity was still observed past the survey window. Some points were not surveyed twice if the point was determined not likely to contain suitable lekking habitat.

Sharp-tailed grouse occupancy was assessed by personnel who positioned themselves in a location where lekking activity could be observed from a distance without disturbing the grouse. Grouse were observed using both binoculars and spotting scopes. The number of individuals, and if possible, the sex of each individual was recorded. Survey personnel spent approximately 15 to 20 minutes observing active lek locations to identify the number of individual grouse present. Upon survey completion, detection results were compiled and mapped (**Figure 4.7**).

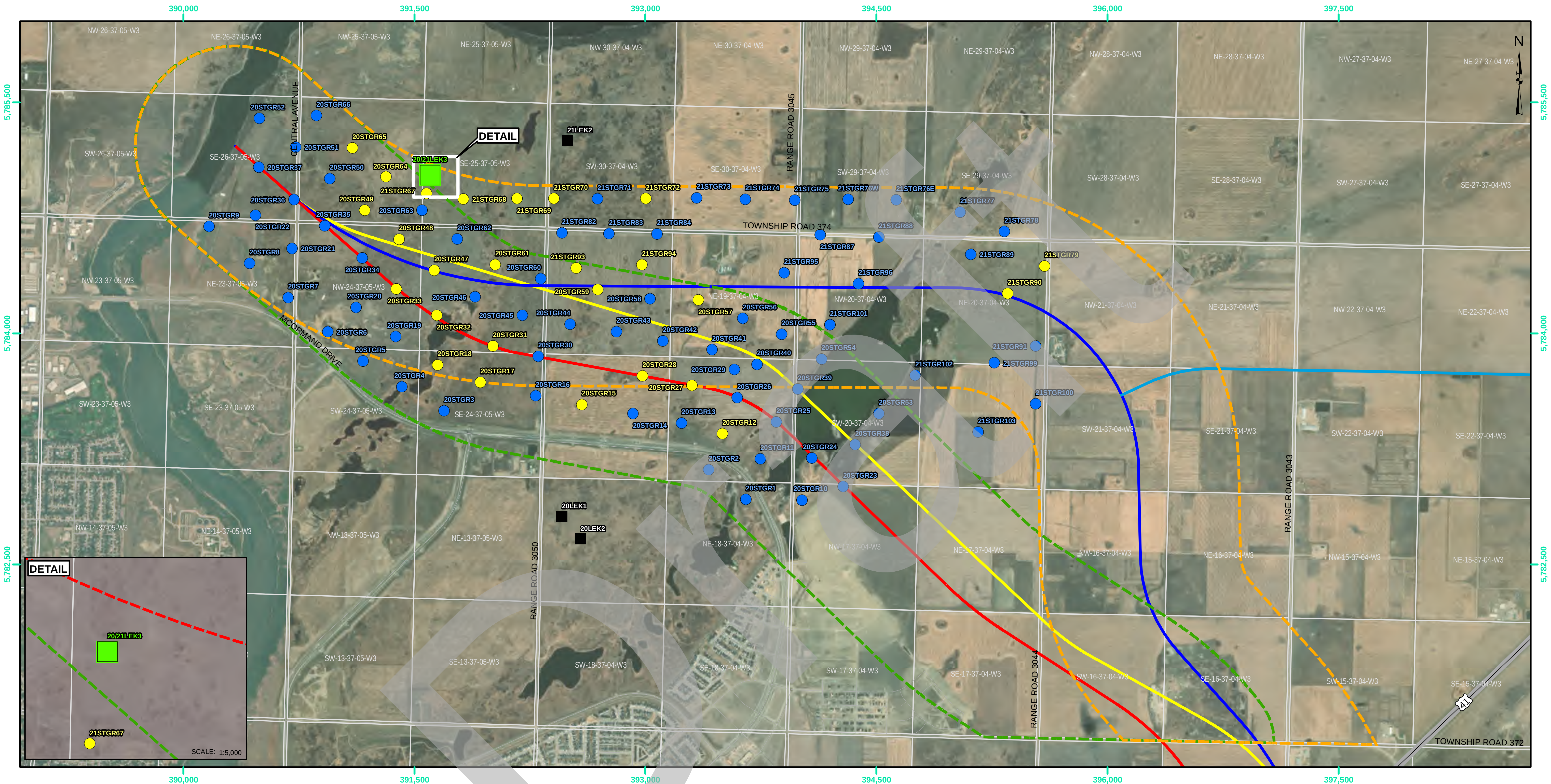
Table 4.3: 2020/2021 Sharp-tailed grouse lek survey stations and lek sites

Survey Point	Transect ID	UTM (13U)	
		Easting	Northing
20STGR01	5	393651	5782920
20STGR02	5	393411	5783114
20STGR03	5	391692	5783496
20STGR04	5	391419	5783653
20STGR05	5	391166	5783820
20STGR06	5	390936	5784009
20STGR07	5	390679	5784232
20STGR08	5	390428	5784454
20STGR09	5	390167	5784693
20STGR10	4	394016	5782916
20STGR11	4	393745	5783184
20STGR12	4	393499	5783348
20STGR13	4	393234	5783417

Survey Point	Transect ID	UTM (13U)	
		Easting	Northing
20STGR14	4	392922	5783477
20STGR15	4	392586	5783536
20STGR16	4	392288	5783594
20STGR17	4	391927	5783682
20STGR18	4	391650	5783794
20STGR19	4	391378	5783979
20STGR20	4	391121	5784168
20STGR21	4	390703	5784551
20STGR22	4	390467	5784767
20STGR23	3	394283	5783004
20STGR24	3	394079	5783190
20STGR25	3	393850	5783422
20STGR26	3	393594	5783582
20STGR27	3	393301	5783662
20STGR28	3	392980	5783723
20STGR29	3	392684	5783783
20STGR30	3	392303	5783849
20STGR31	3	392016	5783918
20STGR32	3	391644	5784115
20STGR33	3	391382	5784288
20STGR34	3	391160	5784488
20STGR35	3	390917	5784698
20STGR36	3	390717	5784867
20STGR37	3	390489	5785078
20STGR38	2	394360	5783276
20STGR39	2	393989	5783638
20STGR40	2	393723	5783798
20STGR41	2	393431	5783894
20STGR42	2	393113	5783949
20STGR43	2	392812	5784010
20STGR44	2	392509	5784058
20STGR45	2	392199	5784116
20STGR46	2	391894	5784236
20STGR47	2	391628	5784409
20STGR48	2	391400	5784611
20STGR49	2	391177	5784798
20STGR50	2	390950	5785005
20STGR51	2	390728	5785210
20STGR52	2	390492	5785396
20STGR53	1	394514	5783477
20STGR54	1	394142	5783833
20STGR55	1	393884	5783994

Survey Point	Transect ID	UTM (13U)	
		Easting	Northing
20STGR56	1	393632	5784097
20STGR57	1	393341	5784160
20STGR58	1	393029	5784224
20STGR59	1	392689	5784284
20STGR60	1	392320	5784354
20STGR61	1	392023	5784446
20STGR62	1	391777	5784612
20STGR63	1	391549	5784799
20STGR64	1	391315	5785016
20STGR65	1	391098	5785203
20STGR66	1	390862	5785414
21STGR67	6	391578	5784908
21STGR68	6	391817	5784872
21STGR69	6	392166	5784876
21STGR70	6	392405	5784876
21STGR71	6	392688	5784874
21STGR72	6	393003	5784876
21STGR73	6	393333	5784880
21STGR74	6	393649	5784871
21STGR75	6	393969	5784865
21STGR76E	6	394627	5784867
21STGR76W	6	394315	5784870
21STGR77	6	395044	5784787
21STGR78	6	395330	5784661
21STGR79	6	395591	5784436
21STGR82	7	392457	5784652
21STGR83	7	392763	5784647
21STGR84	7	393074	5784646
21STGR87	7	394135	5784640
21STGR88	7	394515	5784625
21STGR89	7	395112	5784513
21STGR90	7	395351	5784259
21STGR91	7	395533	5783917
21STGR93	8	392550	5784424
21STGR94	8	392977	5784446
21STGR95	8	393901	5784393
21STGR96	8	394383	5784322
21STGR99	8	395265	5783808
21STGR100	8	395534	5783542
21STGR101	9	394198	5784056
21STGR102	9	394751	5783727
21STGR103	9	395160	5783359

Survey Point	Transect ID	UTM (13U)	
		Easting	Northing
20LEK1*	Previously Detected Lek	392838	5782765
20LEK2*	Previously Detected Lek	392578	5782665



ABUNDANCE OF INDIVIDUALS AT LEKS

☐ 1 TO 5

☐ 5 TO 10

☐ 10 TO 15

☐ 15 TO 20

ACTIVE LEK

■ NO*5

🟩 YES

● SHARP-TAILED GROUSE SURVEY STATION - NOT DETECTED

● SHARP-TAILED GROUSE SURVEY STATION - DETECTED

— HIGHWAY

— ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)

— ROUTE CONCEPT 2

— ROUTE CONCEPT 3

— ROUTE CONCEPT 4

▭ 2020 SHARP-TAILED GROUSE LEK STUDY AREA

▭ 2021 SHARP-TAILED GROUSE LEK STUDY AREA

NOTES

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4. SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY.
5. INACTIVE LEKS WERE PREVIOUSLY RECORDED LEK OCCURENCES BY OTHER OBSERVERS. SNC-LAVALIN RE-ASSESSED THESE LEKS IN 2021, BUT DID NOT OBSERVE LEKKING BIRDS.

0 160 320 640 960 1,280 Metres

SCALE: 1:25,000

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CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 SHARP-TAILED GROUSE LEK SURVEY STATIONS AND DETECTION RESULTS

DATE 2021 11 30 **DWG No.** 659183-0000-4EDD-0065 **FIG No.** 4.7 **REV** 00

SIZE 11x17

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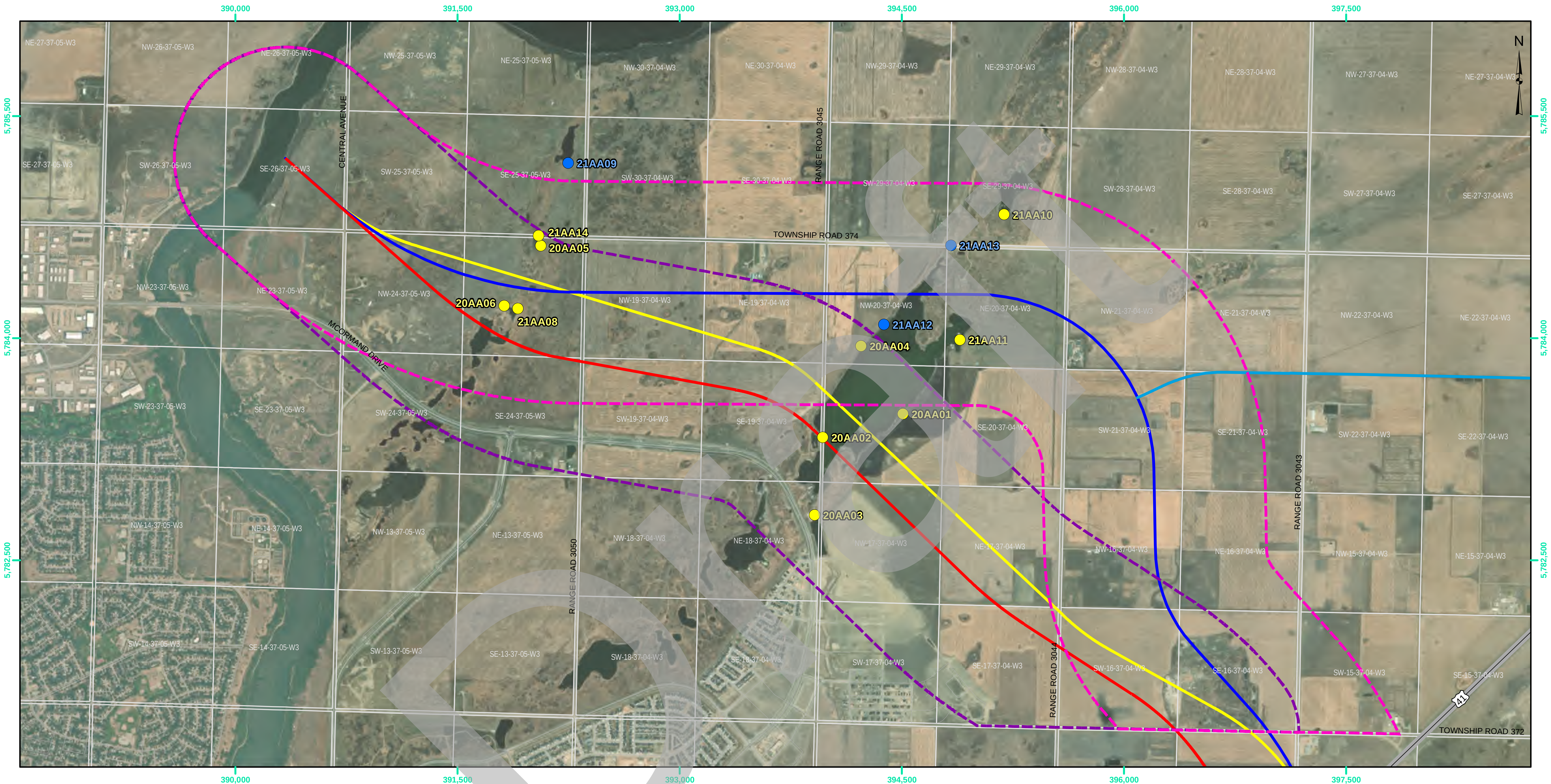
4.2.2.2.3 Amphibian Auditory Surveys

SNC-Lavalin completed amphibian surveys in accordance with ENV Amphibian Auditory Survey Protocol (2020b) to determine occupancy (detected/not detected) of northern leopard frogs (*Lithobates pipiens)* and other amphibian species within the study area. The surveys were focused on detecting northern leopard frogs as they are a SAR; listed as a Schedule 1, *Special Concern* species under SARA.

Surveys targeted suitable amphibian breeding habitat and survey stations were selected based on known habitat and satellite imagery (**Figure 4.8**; **Table 4.4**). Survey stations were not revisited after initial visits if their habitats were deemed unlikely to contain amphibians (e.g.: drained wetlands, burned wetlands, etc.). Suitable habitat for northern leopard frogs includes semi-permanent and permanent water bodies with abundant vegetation, and shallow water nearby for breeding (COSEWIC 2009a).

Two rounds of surveys were completed between 15 May 2020 and 9 June 2020 at each survey station over the course of the calling season. A third round of surveys, as recommended by ENV Amphibian Auditory Survey Protocol (2020b), could not be completed due to poor weather conditions after the second round of surveys. Three rounds of surveys were completed in 2021 on 5 May, 14 May, and 4 June. If northern leopard frogs were detected at a survey station, the species was considered present, and the station was not surveyed again. Surveys were repeated with a minimum of seven days between each other to increase the likelihood of detecting all amphibian species present throughout the calling season.

A field crew of two qualified personnel completed surveys at each survey station. Air temperature and wind speed were recorded using an anemometer (Kestrel 2000 Pocket Wind Meter) prior to commencing each survey. Surveys were conducted between 30 minutes after sunset and no later than 01:00, during peak calling times for amphibians in Saskatchewan (ENV 2020b). Surveys were not completed during heavy rain events or high winds as these conditions make it challenging to aurally detect and identify calling amphibians. Amphibian presence was assessed by qualified personnel who positioned themselves within the potentially suitable breeding habitat and listened for amphibians over a three-minute period. Amphibian abundance was determined using a calling index as counting individual amphibians can be difficult, especially when multiple species are calling (Mossman et al. 1998; **Table 4.5**). Upon survey completion, detection results were compiled and mapped (**Figure 4.7**).



🔵 AMPHIBIAN AUDITORY SURVEY STATION - NOT DETECTED

🟡 AMPHIBIAN AUDITORY SURVEY STATION - DETECTED

ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)

ROUTE CONCEPT 2

ROUTE CONCEPT 3

ROUTE CONCEPT 4

HIGHWAY

2020 AUDITORY AMPHIBIAN STUDY AREA

2021 AUDITORY AMPHIBIAN STUDY AREA

NOTES

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CLIENT
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SASKATOON FREEWAY

TITLE
2020/2021 AMPHIBIAN AUDITORY SURVEY STATIONS AND DETECTION RESULTS

DATE 2021 11 30 **DWG No.** 659183-0000-4EDD-0066 **FIG No.** 4.8 **REV** 00

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Table 4.4: 2020/2021 Amphibian auditory survey stations

Station ID	UTM (13U)	
	Easting	Northing
20AA01	394508	5783488
20AA02	393965	5783329
20AA03	393910	5782805
20AA04	394224	5783946
20AA05	392061	5784624
20AA06	391813	5784219
20AA07	391422	5783667
21AA08	391908	5784200
21AA09	392247	5785182
21AA10	395191	5784835
21AA11	394892	5783988
21AA12	394488	5784089
21AA13	394832	5784626
21AA14	392047	5784693

Table 4.5: Amphibian abundance index

Calling Index	Calling Description
0	no amphibians calling
1	individual calls, not overlapping (estimate of one to five individuals calling at a site)
2	calls are overlapping, but individuals are still distinguishable (estimate of six to10 individuals calling at a site)
3	numerous calls can be heard; chorus is constant and overlapping (estimate of > 10 individuals)

Source: Mossman et al. 1998

4.2.2.2.4 Common Nighthawk and Short-eared Owl Surveys

SNC-Lavalin completed common nighthawk and short-eared owl species detection surveys simultaneously as the timing and survey styles allow for overlap. Surveys were completed in accordance with ENV Common Nighthawk Survey Protocol (2020c) and Short-eared Owl Survey Protocol (2020d) to determine the occupancy (detected/not detected) of the species. Both species are considered SAR; the common nighthawk is listed as Schedule 1, *Threatened* and the short-eared owl as Schedule 1, *Special Concern* under SARA.

A total of nine survey stations in 2020 and ten in 2021 were selected in suitable habitats where common nighthawk and/or short-eared owl activity may occur (**Table 4.6**). Survey stations were selected along roadways, points of high elevation, flat land, and other locations with unobstructed views of tree lines and open grasslands where individuals could be easily detected (COSEWIC 2018).

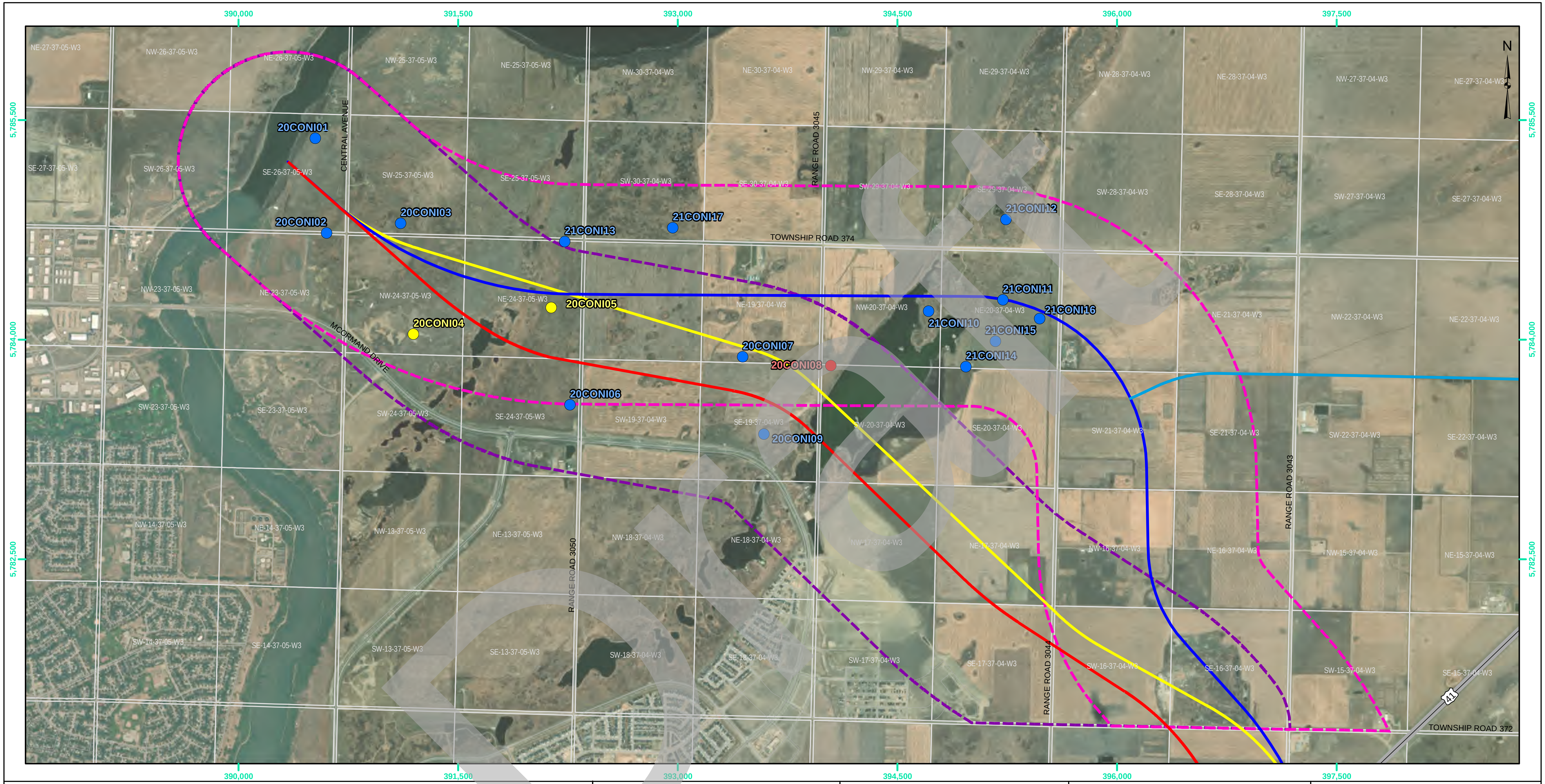
Table 4.6: 2020/2021 Common nighthawk and short-eared owl survey stations

Station ID	UTM (13U)	
	Easting	Northing
20CONI01	390528	5785388
20CONI02	390162	5784778
20CONI03	391099	5784787
20CONI04	391190	5783969
20CONI05	391959	5784282
20CONI06	392287	5783535
20CONI07	393170	5784120
20CONI08	394041	5783827
20CONI09	393719	5783088
21CONI10	394713	5784195
21CONI11	395220	5784271
21CONI12	395240	5784821
21CONI13	392227	5784669
21CONI14	394967	5783815
21CONI15	395170	5783989
21CONI16	395471	5784144
21CONI17	392966	5784764
21CONI18	400501	5783778
21CONI19	401215	5784492

Two rounds of common nighthawk surveys and three rounds of short-eared surveys were completed at each station. Common nighthawk surveys were completed between 8 June and 2 July 2020, and in conjunction with short-eared owls between 14 June and 1 July 2021. If the species were detected at a survey station, the species were considered present, and no further surveys were completed at that location. A minimum separation of 10 days between subsequent common nighthawk surveys and five days for subsequent short-eared owl surveys was observed to increase the likelihood of species detection.

A field crew of one or two qualified personnel completed surveys at each survey station. Air temperature and wind speed were recorded using an anemometer (Kestrel 2000 Pocket Wind Meter) prior to commencing each survey. Surveys were completed between one hour before sunset and 30 minutes after sunset, the peak activity times for common nighthawks (due to increased aerial insect activity) and for short-eared owls. Surveys were not completed during adverse weather conditions, including heavy rain events or high winds where detection would be limited and bird activity is reduced.

Common nighthawk surveys involved the use of a call-playback system (FOXPRO Spitfire Game Caller with a TX-24 remote). Upon arriving at a survey station, the surveyor(s) located an optimal vantage and broadcasting point. The call-playback system was situated above ground and directed towards areas where common nighthawk activity was anticipated. Conspecific common nighthawk calls were then broadcasted while surveyors listened and scanned for activity and vocalizations. Each survey consisted of a passive three-minute silent survey followed by three minutes of calling (30 seconds of calling followed by 30 seconds of listening, repeated three times). Each survey lasted approximately six minutes. Common nighthawk occupancy was recorded as detected/not detected for each survey. Upon survey completion, detection results were compiled and mapped (**Figure 4.9**). Short-eared owl surveys were point-count style surveys where upon arrival at a station, personnel turned off vehicles and lights, and waited two minutes to allow sounds to settle. Once the waiting period was finished, personnel listened for vocalizations and scanned the area with binoculars for three minutes. Each survey lasted five minutes and short-eared owl occupancy was recorded as either detected/not detected. Survey results were compiled and mapped alongside the common nighthawk results (**Figure 4.9**).



● COMMON NIGHTHAWK AND SHORT-EARED OWL SURVEY STATIONS - NOT DETECTED

● COMMON NIGHTHAWK AND SHORT-EARED OWL SURVEY STATIONS - SHORT-EARED OWL DETECTED

● COMMON NIGHTHAWK AND SHORT-EARED OWL SURVEY STATIONS - COMMON NIGHTHAWK DETECTED

— ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)

— ROUTE CONCEPT 2

— ROUTE CONCEPT 3

— ROUTE CONCEPT 4

— HIGHWAY

▭ 2020 AUDITORY AMPHIBIAN STUDY AREA

▭ 2021 AUDITORY AMPHIBIAN STUDY AREA

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0 165 330 660 990 1,320 Metres

SCALE: 1:26,000

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CLIENT

SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION

SASKATOON FREEWAY

TITLE

2020/2021 COMMON NIGHTHAWK AND SHORT-EARED OWL SURVEY STATIONS AND DETECTION RESULTS

DATE 2021 11 30 **DWG No.** 659183-0000-4EDD-0068 **FIG No.** 4.9 **REV** 00

SIZE 11x17

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4.2.2.2.5 Yellow Rail Surveys

SNC-Lavalin completed yellow rail surveys in accordance with ENV Yellow Rail Survey Protocol (2014b) to determine the occupancy (detected/not detected) of yellow rails. Yellow rails are SAR listed as Schedule 1, *Special Concern* under SARA. Yellow rails are rarely detected incidentally due to their secretive nature and nocturnal habits, so targeted surveys are required to determine occupancy (ENV 2014b). The detection of breeding behaviour such as calling is sufficient evidence to determine that yellow rails are present in an area.

A total of eight survey stations were selected to target potential yellow rail breeding habitat in 2020. (**Figure 4.10**; **Table 4.7**). An additional six survey stations were added in 2021. The survey stations were mainly placed around the Small Swale and Northeast Swale complexes, specifically in areas dominated by sedges and other emergent aquatic vegetation (COSEWIC 2009b).

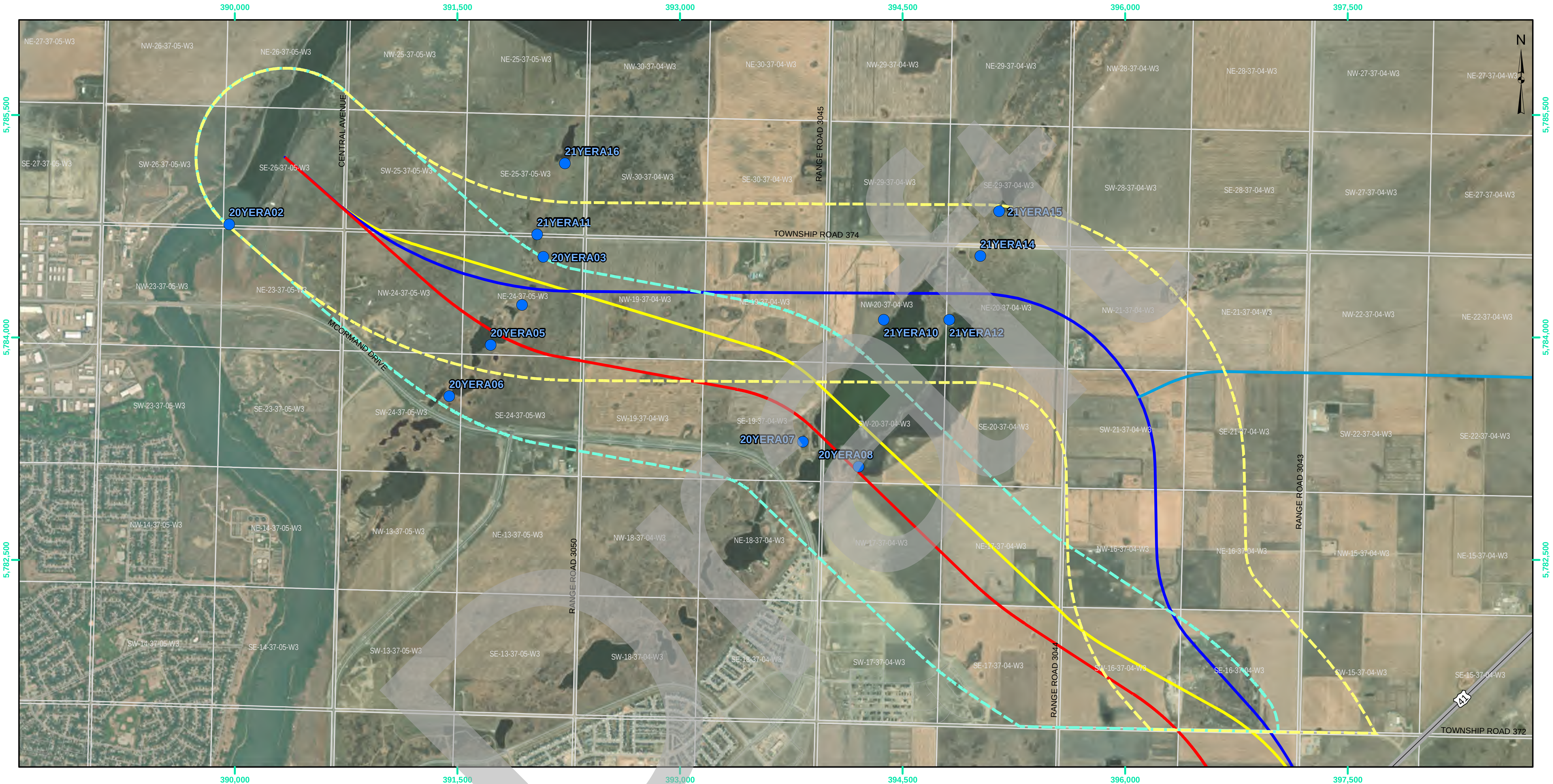
Table 4.7: 2020/2021 Yellow rail survey stations

Station ID	UTM (13U)	
	Easting	Northing
20YERA01	390248	5785000
20YERA02	389976	5784769
20YERA03	392074	5784531
20YERA04	391937	5784220
20YERA05	391668	5783892
20YERA06	391451	5783591
20YERA07	393765	5783326
20YERA08	394206	5783125
21YERA10	394373	5784120
21YERA11	392037	5784695
21YERA12	394814	5784119
21YERA14	395024	5784548
21YERA15	395151	5784850
21YERA16	392225	5785173

Two to three separate surveys were conducted at each survey station between 8 June and 3 July 2020, and between 14 June and 3 July 2021. Surveys were repeated with a minimum of four days between each survey to increase the likelihood of detecting yellow rails.

The surveys were completed by a field crew of two qualified personnel. Air temperature and wind speed were recorded using an anemometer (Kestrel 2000 Pocket Wind Meter) prior to commencing each survey. Surveys were conducted primarily between 23:00 and 02:30. Surveys were not completed during heavy rain events or other adverse weather conditions which may temporarily reduce yellow rail activity.

Yellow rail surveys involved the application of a call-playback system (FOXPRO Spitfire Game Caller with a TX-24 remote). Upon arriving at each survey station, the call-playback system was situated approximately one metre above ground and directed toward the central zone of the targeted wetland (ENV 2014b). A yellow rail male attraction call was then broadcasted while surveyors aurally observed for yellow rail activity. The survey commenced with a passive five-minute silent survey followed by three minutes of call-playback broadcasting (five seconds of calling followed by five seconds of listening, repeated for three minutes), and concluded with a passive two-minute silent survey. The total survey was approximately 10 minutes in duration. Yellow rail occupancy was recorded as detected/not detected for each survey. Upon survey completion, detection results were compiled and mapped (**Figure 4.10**).



● YELLOW RAIL SURVEY STATION - NOT DETECTED

● YELLOW RAIL SURVEY STATION - DETECTED

ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)

ROUTE CONCEPT 2

ROUTE CONCEPT 3

ROUTE CONCEPT 4

HIGHWAY

2020 YELLOW RAIL STUDY AREA

2021 YELLOW RAIL STUDY AREA

NOTES

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SASKATCHEWAN MINISTRY
OF HIGHWAYS

PROJECT LOCATION

SASKATOON FREEWAY

TITLE

2020/2021 YELLOW RAIL SURVEY STATIONS
AND DETECTION RESULTS

DATE 2021 11 30 **DWG No.** 659183-0000-4EDD-0067 **FIG No.** 4.10 **REV** 00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0067 2021 YERA.mxd

4.2.2.3 Incidental Wildlife Observations

SNC-Lavalin recorded all incidental observations of wildlife SOCC, previously undetected wildlife species, and sensitive wildlife features such as nests, leks, dens, setts, and hibernacula. Surveyors gathered incidental observations during the 2020 and 2021 field programs while conducting species detection surveys. Surveyors used a GPS-enabled Apple iPad equipped with a digital data collection application (Survey123 for ArcGIS – Esri Software) to collect incidental occurrence data, including abundance, residence and breeding evidence, habitat descriptions, and other pertinent information.

Following the completion of the 2020 and 2021 field programs, all incidental wildlife and wildlife feature observations were compiled and submitted to ENV using standardized data submission loadforms. Incidental SOCC and sensitive wildlife feature observations were also mapped.

4.2.3 Results

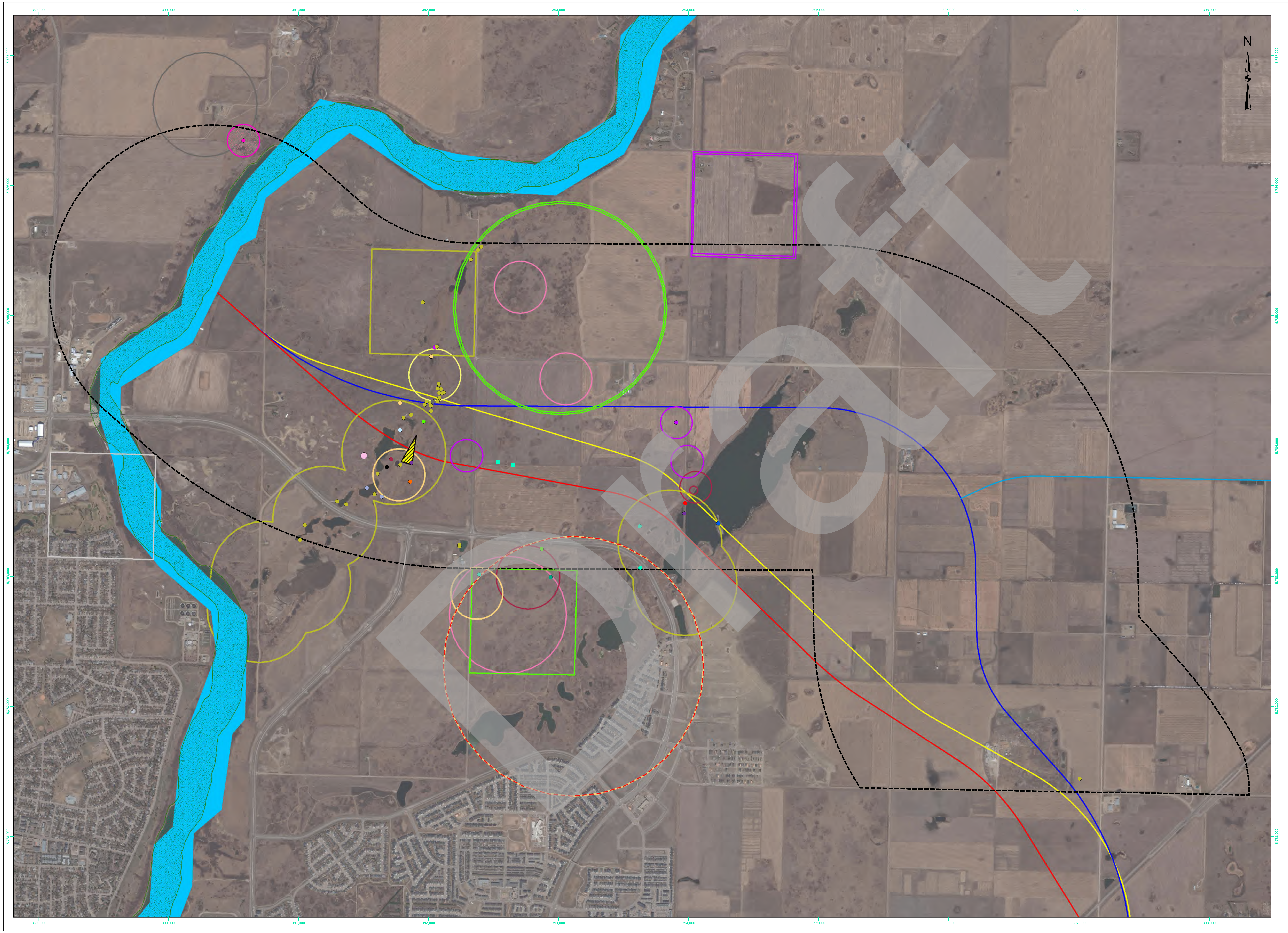
4.2.3.1 Desktop Wildlife SOCC Screening

A review of desktop resources, including databases and previous reports found a total of 36 wildlife SOCC within the 2021 desktop study area, 20 of which are considered SAR (Government of Saskatchewan 2021) (**Table 4.8**). Sixty wildlife-related element occurrences are located within the study area. Subdivided by occurrence type, this total includes 54 vertebrate SOCC occurrences, two invertebrate SOCC occurrences, three sensitive wildlife features, and one migratory bird concentration site (**Figure 4.11)**. The concentration site follows the South Saskatchewan River and is locally significant for thousands of staging waterfowl during the spring and fall migration season. No federal or provincial lands requiring additional environmental protections or conservation easements were identified within the study area. However, significant stakeholder concerns revolve around the Northeast and Small Swales. HABISask's predictive distribution model identified potentially suitable habitat for 16 wildlife SOCC (including 15 SAR) within the study area (**Table 4.9**). Explanations of federal and provincial species rankings are provided in Appendix A and an inventory of all 60 element occurrences can be found in Appendix C.

A review of previous studies conducted within the region produced records of ten wildlife SOCC (including eight SAR) and 40 wildlife-related occurrences within the 2021 desktop study area (Grilz and Hooey 2020; Stantec 2013a and 2013b) (**Table 4.8**). Subdivided by occurrence type, this total includes 38 vertebrate SOCC occurrences and two sensitive wildlife features (**Figure 4.11**).

4.2.3.2 Species Detection Surveys

A total of 114 wildlife species were observed during the 2020 and 2021 species detection surveys, 13 of which were identified as SOCC (**Table 4.10;** Appendix D). Of the SOCC observed during species detection surveys, 11 were birds, one was a mammal, and one was an amphibian. Six of those species are SAR, including the American badger, barn swallow, common nighthawk, horned grebe, northern leopard frog, and short-eared owl.



LEGEND

🟥	ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
🟨	ROUTE CONCEPT 2
🟦	ROUTE CONCEPT 3
🟦	ROUTE CONCEPT 4
⬚	2021 DESKTOP STUDY AREA
ANIMAL ASSEMBLAGE	
▨	MIGRATORY BIRD CONCENTRATION SITE
INVERTEBRATE	
🟧	GOLDENROD GALL FLY
▨	YELLOW-BANDED BUMBLE BEE*
VERTEBRATE	
🟩	AMERICAN BADGER*
▨	BAIRD'S SPARROW*
🟪	BANK SWALLOW*
☐	BARN SWALLOW*
🟦	BLACK-NECKED STILT
⬛	BOBOLINK*
🟦	GREAT BLUE HERON
⬚	HORNED GREBE*
🟦	LAKE STURGEON*
☐	LOGGERHEAD SHRIKE*
☐	NORTHERN LEOPARD FROG*
🟩	NORTHERN SHRIKE
🟪	OSPREY
🟦	PEREGRINE FALCON*
☐	RUSTY BLACKBIRD*
☐	SHORT-EARED OWL*
☐	TURKEY VULTURE
☐	WHOOPING CRANE*
☐	YELLOW RAIL*
WILDLIFE FEATURE	
🟫	AMERICAN BADGER DEN
☐	SHARP-TAILED GROUSE LEK *

*** DENOTES SPECIES AT RISK**

SIZE 22 x 34

NOTES

1. COORDINATE SYSTEM: NAD 1983 UTM ZONE 13N.
2. BASE CADASTRAL DATA ADAPTED FROM HER MAJESTY IN RIGHT OF SASKATCHEWAN OR INFORMATION SERVICES CORPORATION OF SASKATCHEWAN, SASKADMIN2016, SASKGRID2016.
3. CADASTRAL BOUNDARIES ARE FOR INFORMATIONAL PURPOSES ONLY AND SHOULD NOT BE CONSIDERED SUITABLE FOR LEGAL, ENGINEERING, OR SURVEYING PURPOSES.
4. TOPOGRAPHIC FEATURES OBTAINED FROM CANVEC V12.0 DATASET, NATURAL RESOURCES CANADA EARTH AND SCIENCES SECTOR CENTRE FOR TOPOGRAPHIC INFORMATION, 2013-09-30.
5. HIGHWAYS AND ROADS OBTAINED FROM THE NATIONAL ROAD NETWORK SASKATCHEWAN EDITION 11.0 DATASET, 2020-06-18.
6. RAILWAYS OBTAINED FROM THE NATIONAL RAILWAY NETWORK SASKATCHEWAN EDITION 2.0 DATASET, 2019-07-25.
7. RARE SPECIES INFORMATION OBTAINED FROM HABISASK COLLECTED BY THE SASKATCHEWAN CONSERVATION DATA CENTRE, MEEWASIN VALLEY AUTHORITY (GRILZ AND HOOEY 2020); NORTH COMMUTER PARKWAY – BASELINE TERRESTRIAL AND AQUATIC FIELD STUDIES, AND HERITAGE RESOURCE IMPACT ASSESSMENT (STANTEC 2013A); AND NORTH CENTRAL/NORTH EAST NATURAL AREA SCREENING STUDY, CITY OF SASKATOON (STANTEC 2013B). INFORMATION IS SENSITIVE AND INTENDED FOR CONSERVATION PURPOSES ONLY. ONLY SPECIES WITHIN STUDY AREA ARE SHOWN.

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REFERENCE DRAWINGS

DWG No	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
00	2022 10 06	ISSUED FOR INFORMATION	HR	KVG	HY	JP

0 125 250 500 Metres

SCALE: 1:13,000

SNC · LAVALIN

CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON FREEWAY

TITLE

DESKTOP WILDLIFE SOCC SCREENING RESULTS

DATE	DWG No	FIG No.	REV
2021 12 20	659183-0000-4EDD-0063	4.11	00

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0063 2021 Desktop Wildlife Study Area_.mxd

Table 4.8: Wildlife SOCC with documented occurrences in the 2021 desktop study area

Common Name	Scientific Name	Taxonomic Group	SKCDC Ranking	COSEWIC Status	SARA Status	SAR	ARG for Species or Feature	Source
American badger	*Taxidea taxus taxus*	mammal	S3; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a	HABISask, MVA
Baird's sparrow	*Centronyx bairdii*	bird	S4B; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a	HABISask, Stantec
bank swallow	*Riparia riparia*	bird	S4B, S5M; tracked	Threatened	Schedule 1, Threatened	✓	n/a	HABISask, MVA
barn swallow	*Hirundo rustica*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	✓	n/a	HABISask, MVA
black-necked stilt	*Himantopus mexicanus*	bird	SNA; tracked	No Status	No Status		n/a	HABISask
brown creeper	*Certhia americana*	bird	S4B, S3N, S4M	No Status	No Status		n/a	MVA
Canada warbler	*Cardellina candensis*	bird	S4B, S3M	Special Concern	Schedule 1, Special Concern	✓	n/a	MVA
Cooper's hawk	*Accipiter cooperii*	Bird	S4B, S2N, S2M	Not at Risk	No Status		n/a	MVA
bobolink	*Dolichonyx oryzivorus*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	✓	n/a	HABISask
goldenrod gall fly	*Eurosta solidaginis*	insect	S3; tracked	No Status	No Status		n/a	HABISask
great blue heron	*Ardea herodias*	bird	S5B, S5M; tracked	No Status	No Status		nesting colony	Stantec
Harris's sparrow	*Zonotrichia querula*	Bird	SUB, S5M	Special Concern	No Status		n/a	MVA
hooded merganser	*Lophodytes cucullatus*	Bird	S4B, S3M	No Status	No Status		n/a	MVA
horned grebe	*Podiceps auritus*	bird	S5B, S5M; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a	HABISask, MVA
lake sturgeon	*Acipenser fulvescens*	fish	S2; tracked	Endangered	No Status		selected waters*	HABISask
lesser yellowlegs	*Tringa flavipes*	bird	S4B, S4M	Threatened	No Status	✓	n/a	MVA
loggerhead shrike	*Lanius ludovicianus*	bird	S2B, S2M; tracked	Threatened	Schedule 1, Threatened	✓	breeding bird	HABISask, MVA
northern leopard frog	*Lithobates pipiens*	amphibian	S3; tracked	Special Concern	Schedule 1, Special Concern	✓	breeding and overwintering habitat	HABISask, MVA, Stantec
northern shrike	*Lanius borealis*	bird	S1B, S4N, S4M; tracked	No Status	No Status		n/a	HABISask
olive-sided flycatcher	*Contopus cooperi*	bird	S4B, S4M	Special Concern	Threatened	✓	n/a	MVA
osprey	*Pandion haliaetus*	bird	S2B, S2M; tracked	No Status	No Status		nest site	HABISask
peregrine falcon	*Falco peregrinus anatum*	bird	S1B, SNRM; tracked	Not at Risk	Schedule 1, Special Concern	✓	nest site	HABISask
pileated woodpecker	*Dryocopus oryzivorus*	bird	S3	No Status	No Status		n/a	MVA
red-necked phalarope	*Phalaropus lobatus*	bird	S3B, S3M	Special Concern	No Status	✓	n/a	MVA
rusty blackbird	*Euphagus carolinus*	bird	S3B, SUN, S3M; tracked	Special Concern	Schedule 1, Special Concern	✓	breeding bird	HABISask
sharp-tailed grouse	*Tympanuchus phasianellus*	bird	S5; tracked	No Status	No Status		lek	HABISask
short-eared owl	*Asio flammeus*	bird	S3B, S2N, S3M; tracked	Threatened	Schedule 1, Special Concern	✓	breeding bird	HABISask, MVA

surf scoter	*Melanitta perspicillata*	bird	S3B, S3M	No Status	No Status		n/a	MVA
Townsend’s solitaire	*Myadestes townsendi*	bird	S3B, S3M	No Status	No Status		n/a	MVA
turkey vulture	*Cathartes aura*	bird	S3B, S3M; tracked	No Status	No Status		n/a	HABISask, Stantec
western grebe	*Aechmophorus occidentalis*	bird	S3B, S3M	Special Concern	Schedule 1, Special Concern	✓		MVA
white-winged crossbill	*Loxia leucoptera*	bird	S4B, S3N	No Status	No Status		n/a	MVA
white-winged scoter	*Melanitta deglandi*	bird	S5B, S3M	No Status	No Status		n/a	MVA
whooping crane	*Grus americana*	bird	SXB, S1M; tracked	Endangered	Schedule 1, Endangered	✓	staging area	HABISask
yellow rail	*Coturnicops noveboracensis*	bird	S3B, S3M; tracked	Special Concern	Schedule 1, Special Concern	✓	breeding bird	HABISask
yellow-banded bumble bee	*Bombus terricola*	insect	S4; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a	HABISask

*Proponent is required to contact the Department of Fisheries and Oceans (DFO) if the project is located in or near: the waters of the North Saskatchewan, South Saskatchewan, and Saskatchewan Rivers (including large connected waters such as the Torch River), and the waters of the Churchill River below the confluence of the Reindeer River.

Source: (ENV 2017; Grilz and Hooey [MVA] 2020 and 2021; Government of Saskatchewan 2021; Stantec 2013a and 2013b; SKCDC 2021a and 2021b)

Table 4.9: HABISask wildlife SOCC habitat predictive distribution model results

Common Name	Scientific Name	Taxonomic Group	SKCDC Ranking	COSEWIC Status	SARA Status	SAR	ARG for Species or Feature
American badger	*Taxidea taxus taxus*	mammal	S3; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a
Baird's sparrow	*Centronyx bairdii*	bird	S4B; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a
bank swallow	*Riparia riparia*	bird	S4B, S5M; tracked	Threatened	Schedule 1, Threatened	✓	n/a
bobolink	*Dolichonyx oryzivorus*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	✓	n/a
burrowing owl	*Athene cunicularia*	bird	S2B, S2M; tracked	Endangered	Schedule 1, Endangered	✓	breeding bird
chestnut-collared longspur	*Calcarius ornatus*	bird	S3B; tracked	Endangered	Schedule 1, Threatened	✓	breeding bird
common nighthawk	*Chordeiles minor*	bird	S4B, S4M; tracked	Special Concern	Schedule 1, Threatened	✓	breeding bird
ferruginous hawk	*Buteo regalis*	bird	S3B; tracked	Special Concern	Schedule 1, Threatened	✓	nest site
golden eagle	*Aquila chrysaetos*	bird	S3B, S3N, S4M; tracked	Not at Risk	No Status		nest site
horned grebe	*Podiceps auritus*	bird	S5B, S5M; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a
loggerhead shrike	*Lanius ludovicianus*	bird	S2B, S2M; tracked	Threatened	Schedule 1, Threatened	✓	breeding bird
monarch	*Danaus plexippus plexippus*	insect	S2B, SNRM; tracked	Endangered	Schedule 1, Special Concern	✓	n/a
northern leopard frog	*Lithobates pipiens*	amphibian	S3; tracked	Special Concern	Schedule 1, Special Concern	✓	breeding and overwintering habitat
piping plover	*Charadrius melodus circumcinctus*	bird	S3B, S3M; tracked	Endangered	Schedule 1, Endangered	✓	high-water mark
short-eared owl	*Asio flammeus*	bird	S3B, S2N, S3M; tracked	Threatened	Schedule 1, Special Concern	✓	breeding bird
Sprague's pipit	*Anthus spragueii*	bird	S3B, S3M; tracked	Threatened	Schedule 1, Threatened	✓	breeding bird

Source: (ENV 2017; Government of Saskatchewan 2021; SKCDC 2021a and 2021b)

Table 4.10: Wildlife SOCC observed during species detection surveys

Common Name	Scientific Name	Taxonomic Group	SKCDC Ranking	COSEWIC Status	SARA Status	SAR	ARG for Species or Feature
American badger	*Taxidea taxus taxus*	mammal	S3; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a
American white pelican	*Pelecanus erythrorhynchos*	bird	S5B, S5M	Not at Risk	No Status		nesting colony
barn swallow	*Hirundo rustica*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	✓	n/a
common nighthawk	*Chordeiles minor*	bird	S4B, S4M; tracked	Special Concern	Schedule 1, Threatened	✓	breeding bird
black-crowned night heron	*Nycticorax nycticorax*	bird	S4B	No Status	No Status		nesting colony
double-crested cormorant	*Phalacrocorax auritus*	bird	S5B, S5M	Not at Risk	No Status		nesting colony
great blue heron	*Ardea herodias*	bird	S5B, S5M; tracked	No Status	No Status		nesting colony
horned grebe	*Podiceps auritus*	bird	S5B, S5M; tracked	Special Concern	Schedule 1, Special Concern	✓	n/a
northern leopard frog	*Lithobates pipiens*	amphibian	S3; tracked	Special Concern	Schedule 1, Special Concern	✓	breeding and overwintering habitat
prairie falcon	*Falco mexicanus*	bird	S3B, S3N, S3M; tracked	Not at Risk	No Status		nest site
sharp-tailed grouse	*Tympanuchus phasianellus*	bird	S5; tracked	No Status	No Status		lek
short-eared owl	*Asio flammeus*	bird	S3B, S2N, S3M; tracked	Threatened	Schedule 1, Special Concern	✓	breeding bird
trumpeter swan	*Cygnus buccinator*	bird	S3B, S3M; Tracked	Not at Risk	No Status		breeding bird

Source: (ENV 2017; Government of Saskatchewan 2021; SKCDC 2021a and 2021b)

4.2.3.2.1 Snow Tracking Surveys

A total of 981 wildlife sign observations were made during the 2020 snow tracking surveys in the Phase I study area (**Figure 4.3**). Hares/rabbits (299), small rodents (239), deer (189), and coyotes (156) were the most frequently observed wildlife signs (

Table 4.11). This data was previously reported in the Environmental and Regulatory Review (SNC-Lavalin 2020), but the figure was not previously presented. Two active American badger excavations (*Taxidea taxus taxus),* an SOCC, were observed during the surveys. Observations were found throughout the transects, but the greatest concentrations of tracks were recorded on the west bank of the South Saskatchewan River, and at several locations within the Hudson Bay swale.

Table 4.11: 2020 Snow tracking survey wildlife observations, Phase 1

Species/Taxa	Scientific Name	Number of wildlife sign observations
American badger	*Taxidea taxus taxus*	2
bird spp.	*n/a*	56
coyote	*Canis latrans*	156
Canada Goose	*Branta canadensis*	1
Deer (white-tailed or mule)[a]	*Odocoileus virginianus/hemionus*	189
hare/rabbit (snowshoe hare or white-tailed jackrabbit)[a]	*Lepus spp.*	299
Hungarian partridge	*Perdix perdix*	13
Red fox	*Vulpes vulpes*	2
Sharp-tailed grouse	*Tympanuchus phasianellus*	15
small rodent[a]	*Mus/Microtus spp.*	239
Weasel[a] (Stoat, least weasel, etc.)	*Mustela spp*	11

At least 12 wildlife species were observed in the surveys, including at least nine mammal species and two bird species (**Figure 4-4** to **Figure 4-6**; **Table 4.12**). A considerable majority of tracks were made by rabbits/hare, deer species, and coyotes Due to the similarity in some tracks (e.g. mule deer [*Odocoileus hemionus*] and white-tailed deer [*Odocoileus virginianus*]), tracks were grouped together for similar species. Only one SAR species, the American badger (*Recurvirostra americana*), was observed during surveys . The American badger is listed as Schedule 1 Special Concern under SARA and COSEWIC.

Table 4.12: 2020/2021 Snow tracking survey wildlife observations results, Phase II

Common Name	Scientific Name	Taxonomic Group	Number of Unique Track Sets or Signs
American badger	*Taxidea taxus taxus*	mammal	2
coyote	*Canis latrans*	mammal	624
gray partridge	*Perdix perdix*	bird	8
moose	*Alces alces*	mammals	2
muskrat	*Ondatra zibethicus*	mammal	2
North American beaver	*Castor canadensis*	mammal	2
North American porcupine	*Erethizon dorsatum*	mammal	8
rabbit/hare	*Lepus sp.*	mammal	1241

red fox	*Vulpes vulpes*	mammal	11
sharp-tailed grouse	*Tympanuchus phasianellus*	bird	184
weasel	*Mustela sp.*	mammal	27
white-tailed deer / mule deer	*Odocoileus sp.*	mammal	1195
small unknown rodent species	n/a	various	618

4.2.3.2.2 Sharp-Tailed Grouse Lek Surveys

The sharp-tailed grouse lek surveys identified 57 sharp-tailed grouse at 16 stations sites in 2020 and 47 sharp-tailed grouse at 12 station in 2021. However, upon revisiting, most of these grouse were only observed foraging in the area and were not subsequently found as part of a lek (**Table 4.13**). One previously undiscovered active lek site was identified north of survey points 20STGR63 and 21STGR67. The two leks, 20LEK1 and 20LEK2, were previously identified leks in HABISask (Element occurrences 9999102837 and 9999114727) and were investigated due to their proximity to the project footprint. No sharp-tailed grouse were observed at the two previously known lek sites south of McOrmond Road, and lekking activity was not observed (**Figure 4.7**).

Table 4.13: 2020/2021 Sharp-tailed grouse lek survey results

Station ID	Survey	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Sharp-Tailed Grouse Detected (Y/N)	Lek Detected (Y/N)
20STGR01	1	2020-05-05	20:29	15	1 - Light Air	N	N
20STGR03	1	2020-04-30	18:15	27	3 - Gentle Breeze	N	N
	2	2020-05-07	18:27	18	1 - Light Air	N	N
20STGR04	1	2020-04-30	18:36	27	3 - Gentle Breeze	N	N
	2	2020-05-07	18:44	18	1 - Light Air	N	N
20STGR05	1	2020-04-30	18:54	27	3 - Gentle Breeze	N	N
	2	2020-05-07	18:59	18	1 - Light Air	N	N
20STGR06	1	2020-04-30	19:07	27	3 - Gentle Breeze	N	N
	2	2020-05-07	19:10	18	1 - Light Air	N	N
20STGR07	1	2020-04-30	19:25	25	2 - Light Breeze	N	N
	2	2020-05-07	19:19	18	1 - Light Air	N	N
20STGR08	1	2020-04-30	19:39	25	2 - Light Breeze	N	N
	2	2020-05-07	19:30	18	1 - Light Air	N	N
20STGR09	1	2020-04-30	19:51	25	2 - Light Breeze	N	N
20STGR10	1	2020-04-28	20:19	18	2 - Light Breeze	N	N
	2	2020-05-06	20:16	17	2 - Light Breeze	N	N
20STGR11	1	2020-04-28	17:49	18	3 - Gentle Breeze	N	N
	2	2020-05-06	17:54	19	3 - Gentle Breeze	N	N
20STGR12	1	2020-04-28	18:02	18	3 - Gentle Breeze	Y	N
	2	2020-05-06	18:08	19	3 - Gentle Breeze	N	N
20STGR13	1	2020-04-28	18:16	18	3 - Gentle Breeze	N	N
	2	2020-04-29	7:55	7	2 - Light Breeze	N	N
	3	2020-05-06	18:18	19	3 - Gentle Breeze	N	N
20STGR14	1	2020-04-28	18:29	18	3 - Gentle Breeze	N	N

Station ID	Survey	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Sharp-Tailed Grouse Detected (Y/N)	Lek Detected (Y/N)
	2	2020-04-29	8:05	7	2 - Light Breeze	N	N
	3	2020-05-06	18:30	19	3 - Gentle Breeze	N	N
20STGR15	1	2020-04-28	18:44	18	3 - Gentle Breeze	Y	N
	2	2020-05-06	18:40	18	3 - Gentle Breeze	N	N
20STGR16	1	2020-04-27	17:37	16	3 - Gentle Breeze	N	N
	2	2020-05-06	21:00	17	2 - Light Breeze	N	N
20STGR17	1	2020-04-27	17:48	16	3 - Gentle Breeze	Y	N
	2	2020-05-06	20:45	17	2 - Light Breeze	N	N
20STGR18	1	2020-04-27	17:56	16	3 - Gentle Breeze	Y	N
	2	2020-04-29	7:33	7	2 - Light Breeze	Y	Y
	3	2020-05-06	20:30	17	2 - Light Breeze	Y	Y
20STGR19	1	2020-04-27	18:06	16	3 - Gentle Breeze	N	N
	2	2020-05-06	20:15	17	2 - Light Breeze	N	N
	3	2020-05-08	7:05	4	1 - Light Air	N	N
20STGR20	1	2020-04-27	18:14	16	3 - Gentle Breeze	N	N
	2	2020-05-06	20:00	17	2 - Light Breeze	N	N
20STGR21	1	2020-04-27	18:26	16	3 - Gentle Breeze	N	N
	2	2020-05-06	19:45	17	2 - Light Breeze	N	N
20STGR22	1	2020-04-27	18:42	15	3 - Gentle Breeze	N	N
	2	2020-05-06	19:30	17	2 - Light Breeze	N	N
20STGR23	1	2020-05-06	20:29	17	2 - Light Breeze	N	N
20STGR25	1	2020-04-28	19:58	18	2 - Light Breeze	N	N
	2	2020-05-06	19:53	17	2 - Light Breeze	N	N
20STGR26	1	2020-04-28	19:50	18	2 - Light Breeze	N	N
	2	2020-05-06	19:43	18	3 - Gentle Breeze	N	N
20STGR27	1	2020-04-28	19:35	18	2 - Light Breeze	Y	N
	2	2020-05-06	19:21	18	3 - Gentle Breeze	N	N
20STGR28	1	2020-04-28	19:16	18	2 - Light Breeze	Y	N
	2	2020-05-06	19:12	18	3 - Gentle Breeze	N	N
20STGR29	1	2020-04-28	19:03	18	2 - Light Breeze	N	N
	2	2020-05-06	18:58	18	3 - Gentle Breeze	N	N
20STGR30	1	2020-04-27	20:25	15	3 - Gentle Breeze	N	N
20STGR31	1	2020-04-27	20:13	15	3 - Gentle Breeze	Y	N
	2	2020-05-06	17:45	18	3 - Gentle Breeze	N	N
20STGR32	1	2020-04-27	19:54	15	3 - Gentle Breeze	N	N
	2	2020-05-06	18:00	18	3 - Gentle Breeze	Y	N
	3	2020-05-08	7:24	4	1 - Light Air	N	N
20STGR33	1	2020-04-27	19:39	15	3 - Gentle Breeze	Y	N
	2	2020-05-06	18:15	18	3 - Gentle Breeze	N	N
20STGR34	1	2020-04-27	19:27	15	3 - Gentle Breeze	N	N
	2	2020-05-06	18:30	18	3 - Gentle Breeze	N	N

Station ID	Survey	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Sharp-Tailed Grouse Detected (Y/N)	Lek Detected (Y/N)
20STGR35	1	2020-04-27	19:17	15	3 - Gentle Breeze	N	N
	2	2020-05-06	18:45	18	3 - Gentle Breeze	N	N
20STGR36	1	2020-04-27	19:03	15	3 - Gentle Breeze	N	N
	2	2020-05-06	19:00	18	3 - Gentle Breeze	N	N
20STGR37	1	2020-04-27	18:52	15	3 - Gentle Breeze	N	N
	2	2020-05-06	19:15	18	3 - Gentle Breeze	N	N
20STGR38	1	2020-05-06	20:38	17	2 - Light Breeze	N	N
20STGR39	1	2020-04-28	20:00	17.5	2 - Light Breeze	N	N
	2	2020-05-05	20:05	15	1 - Light Air	N	N
20STGR40	1	2020-04-28	19:45	17.5	2 - Light Breeze	N	N
	2	2020-05-05	19:51	15	3 - Gentle Breeze	N	N
20STGR41	1	2020-04-28	19:30	17.5	2 - Light Breeze	N	N
	2	2020-05-05	19:34	15	3 - Gentle Breeze	N	N
20STGR42	1	2020-04-28	19:15	17.5	2 - Light Breeze	N	N
	2	2020-05-05	19:22	15	3 - Gentle Breeze	N	N
20STGR43	1	2020-04-28	19:00	17.5	2 - Light Breeze	N	N
	2	2020-05-05	19:07	17	3 - Gentle Breeze	N	N
20STGR44	1	2020-04-28	18:45	17.5	2 - Light Breeze	N	N
	2	2020-05-05	18:54	18	3 - Gentle Breeze	N	N
20STGR45	1	2020-04-27	20:40	16	3 - Gentle Breeze	N	N
	2	2020-05-04	20:51	14	1 - Light Air	N	N
20STGR46	1	2020-04-27	20:30	16	3 - Gentle Breeze	N	N
	2	2020-05-04	20:44	14	1 - Light Air	N	N
20STGR47	1	2020-04-27	20:15	16	3 - Gentle Breeze	N	N
	2	2020-05-04	20:35	14	1 - Light Air	Y	N
20STGR48	1	2020-04-27	20:00	16	3 - Gentle Breeze	N	N
	2	2020-05-04	20:26	14	1 - Light Air	Y	N
20STGR49	1	2020-04-27	19:45	16	3 - Gentle Breeze	Y	N
	2	2020-05-04	20:18	14	1 - Light Air	Y	N
20STGR50	1	2020-04-27	19:30	16	3 - Gentle Breeze	N	N
	2	2020-05-04	20:10	14	0 - Calm	N	N
20STGR51	1	2020-04-27	19:15	16	3 - Gentle Breeze	N	N
	2	2020-05-04	19:52	14	0 - Calm	N	N
20STGR52	1	2020-05-04	19:40	14	0 - Calm	N	N
20STGR53	1	2020-05-06	20:46	17	2 - Light Breeze	N	N
20STGR54	1	2020-04-28	20:15	17.5	2 - Light Breeze	N	N
	2	2020-05-05	17:40	17	2 - Light Breeze	N	N
20STGR55	1	2020-04-28	17:30	18	3 - Gentle Breeze	N	N
	2	2020-05-05	17:52	17	2 - Light Breeze	N	N
20STGR56	1	2020-04-28	17:45	18	3 - Gentle Breeze	N	N
	2	2020-05-05	18:00	17	2 - Light Breeze	N	N

Station ID	Survey	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Sharp-Tailed Grouse Detected (Y/N)	Lek Detected (Y/N)
20STGR57	1	2020-04-28	18:00	18	3 - Gentle Breeze	Y	N
	2	2020-05-05	18:14	17	2 - Light Breeze	N	N
20STGR58	1	2020-04-28	18:15	18	3 - Gentle Breeze	N	N
	2	2020-05-05	18:30	17	2 - Light Breeze	N	N
20STGR59	1	2020-04-28	18:30	18	3 - Gentle Breeze	Y	N
	2	2020-05-05	18:40	17	2 - Light Breeze	N	N
20STGR60	1	2020-04-27	17:30	18	3 - Gentle Breeze	N	N
	2	2020-05-04	18:10	14	2 - Light Breeze	N	N
20STGR61	1	2020-04-27	17:45	16	3 - Gentle Breeze	N	N
	2	2020-05-04	18:21	14	2 - Light Breeze	N	N
20STGR62	1	2020-04-27	18:00	16	3 - Gentle Breeze	N	N
	2	2020-05-04	18:31	14	2 - Light Breeze	Y	N
20STGR63	1	2020-04-27	18:15	16	3 - Gentle Breeze	N	N
	2	2020-05-04	18:49	14	2 - Light Breeze	N	N
20STGR64	1	2020-04-27	18:30	16	3 - Gentle Breeze	Y	N
	2	2020-05-04	19:00	14	1 - Light Air	Y	N
20STGR65	1	2020-04-27	18:45	16	3 - Gentle Breeze	Y	N
	2	2020-05-04	19:14	14	1 - Light Air	N	N
20STGR66	1	2020-04-27	19:00	16	3 - Gentle Breeze	N	N
	2	2020-05-04	19:23	14	1 - Light Air	N	N
21STGR67	1	2021-04-15	18:05	14	3 - Gentle Breeze	Y	N
	2	2021-05-03	18:38	9	0 - Calm	N	N
21STGR68	1	2021-04-15	18:30	13	3 - Gentle Breeze	Y	N
	2	2021-05-03	19:00	9	0 - Calm	Y	N
21STGR69	1	2021-04-15	18:50			N	N
	2	2021-05-03	19:27	9	1 - Light Air	Y	N
21STGR70	1	2021-04-15	19:05	14	3 - Gentle Breeze	N	N
	2	2021-05-03	19:55	9	0 - Calm	Y	N
	3	2021-05-04	6:00	-5	0 - Calm	Y	N
	4	2021-05-05	6:15	-4	0 - Calm	N	N
21STGR71	1	2021-04-15	19:30	12	3 - Gentle Breeze	N	N
	2	2021-05-03	20:25	5	0 - Calm	N	N
21STGR72	1	2021-04-15	19:50	11	2 - Light Breeze	Y	N
	2	2021-04-16	6:10	-3	1 - Light Air	N	N
	3	2021-05-04	6:50	-3	0 - Calm	Y	N
21STGR73	1	2021-04-15	20:15	11	2 - Light Breeze	N	N
	2	2021-05-04	20:35	9	0 - Calm	N	N
21STGR74	1	2021-04-16	18:05	15	3 - Gentle Breeze	N	N
	2	2021-05-04	20:20	9	2 - Light Breeze	N	N
21STGR75	1	2021-04-16	18:30	15	3 - Gentle Breeze	N	N
	2	2021-05-04	19:55	12	2 - Light Breeze	N	N

Station ID	Survey	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Sharp-Tailed Grouse Detected (Y/N)	Lek Detected (Y/N)
21STGR76E	1	2021-04-16	19:10	14	1 - Light Air	N	N
	2	2021-05-04	19:20	13	2 - Light Breeze	N	N
21STGR76W	1	2021-04-16	18:55	14	0 - Calm	N	N
	2	2021-05-04	19:35	13	2 - Light Breeze	N	N
21STGR77	1	2021-04-17	6:30	2	2 - Light Breeze	N	N
	2	2021-05-03	18:30	19	2 - Light Breeze	N	N
21STGR78	1	2021-04-16	19:50	13	0 - Calm	N	N
	2	2021-05-03	19:00	9	1 - Light Air	N	N
21STGR79	1	2021-04-15	20:10	14	1 - Light Air	Y	N
	2	2021-05-04	20:15	9	2 - Light Breeze	N	N
21STGR80	1	2021-05-04	7:50	-3	0 - Calm	N	N
21STGR81	1	2021-05-04	8:10	-3	0 - Calm	N	N
21STGR82	1	2021-04-16	7:40	-2	0 - Calm	N	N
	2	2021-05-04	8:22	3	2 - Light Breeze	N	N
21STGR83	1	2021-04-16	7:27	-2	0 - Calm	N	N
	2	2021-05-04	7:46	1	2 - Light Breeze	N	N
21STGR84	1	2021-04-16	6:45	-3	0 - Calm	N	N
	2	2021-05-04	7:06	-2	1 - Light Air	N	N
21STGR85	1	2021-05-05	7:20	1	1 - Light Air	N	N
21STGR86	1	2021-05-05	7:40	2	1 - Light Air	N	N
21STGR87	1	2021-04-16	19:45	15	0 - Calm	N	N
	2	2021-05-05	6:45	-1	1 - Light Air	N	N
21STGR88	1	2021-04-16	19:30	15	0 - Calm	N	N
	2	2021-05-05	6:45	-4	0 - Calm	N	N
21STGR89	1	2021-04-17	6:03	2	2 - Light Breeze	N	N
	2	2021-05-03	19:20	8	2 - Light Breeze	N	N
21STGR90	1	2021-04-15	19:50	14	1 - Light Air	Y	N
	2	2021-05-04	18:30	12	2 - Light Breeze	N	N
21STGR91	1	2021-04-15	18:00	14	2 - Light Breeze	N	N
	2	2021-05-03	20:39	6	0 - Calm	N	N
21STGR92	1	2021-05-04	18:35	14	3 - Gentle Breeze	N	N
21STGR93	1	2021-05-04	8:03	1	2 - Light Breeze	Y	N
21STGR94	1	2021-04-16	7:05	-2	0 - Calm	Y	N
	2	2021-05-04	7:22	-1	1 - Light Air	N	N
	3	2021-05-05	7:55	-2	1 - Light Air	Y	N
21STGR95	1	2021-04-16	18:20	15	2 - Light Breeze	N	N
	2	2021-05-05	7:02	1	0 - Calm	N	N
21STGR96	1	2021-04-16	19:05	15	0 - Calm	N	N
	2	2021-05-05	7:05	-4	0 - Calm	N	N
21STGR97	1	2021-05-04	18:48	12	3 - Gentle Breeze	N	N
21STGR98	1	2021-05-03	20:00	8	1 - Light Air	N	N

Station ID	Survey	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Sharp-Tailed Grouse Detected (Y/N)	Lek Detected (Y/N)
21STGR99	1	2021-04-15	18:30	14	2 - Light Breeze	N	N
	2	2021-05-03	20:25	6	0 - Calm	N	N
21STGR100	1	2021-04-15	18:50	14	2 - Light Breeze	N	N
	2	2021-05-04	19:50	11	0 - Calm	N	N
21STGR101	1	2021-04-16	18:45	15	2 - Light Breeze	N	N
	2	2021-05-05	7:25	-4	0 - Calm	N	N
21STGR102	1	2021-04-15	19:25	14	2 - Light Breeze	N	N
	2	2021-05-04	19:16	12	3 - Gentle Breeze	N	N
21STGR103	1	2021-04-15	19:05	14	2 - Light Breeze	N	N
	2	2021-05-04	19:35	12	2 - Light Breeze	N	N
21STGR	1	2021-05-03	19:40	8	1 - Light Air	N	N
20LEK1	1	2020-05-08	6:00	4	1 - Light Air	N	N
20LEK2	1	2020-05-08	6:30	4	1 - Light Air	N	N
21LEK2	1	2021-04-16	7:05	2	2 – Light Breeze		N
20/21LEK3	1	2020-04-29	5:58	3	2 - Light Breeze	Y	Y
	1	2021-04-15	n/a	11	2 – Light Breeze	Y	N
	2	2021-04-16	6:25	-3	0 - Calm	Y	Y
	3	2021-05-04	7:15	-5	0 - Calm	Y	Y

4.2.3.2.3 Amphibian Auditory Surveys

Two amphibian species were detected in the 2020 amphibian auditory surveys; wood frog (*Lithobates sylvaticus)*, and boreal chorus frog (*Pseudacris maculata*). Wood frogs were detected at all survey stations, except for AA4, while boreal chorus frogs were only detected at four survey stations (**Table 4.14**). Northern leopard frogs were not detected at any survey stations. However, adult frogs were observed foraging in both the Northeast Swale and Small Swale incidentally during other surveys in the area. Amphibians were detected at all seven stations surveyed in 2021. Northern leopard frogs were detected at four locations, all during the final survey in June (**Table 4.14**). Wood frogs were detected at six stations in 2021.

Each year, three visits were conducted during ideal weather condition with low winds and air temperatures between 4°C to 21°C. Ambient noise did not typically inhibit aural detection. except on the first survey at AA2 in 2020 causing it to be longer as a result of noisy traffic interfering with detection. The survey was completed when traffic volumes reduced later than evening.

Table 4.14: 2020 and 2021 Amphibian auditory survey results

Station ID	Survey	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Amphibian Calling Index		
						Northern Leopard Frog	Wood Frog	Boreal Chorus Frog
20AA1	1	2020-05-13	23:44	4	1 - Light Air	0	1	0
	2	2020-06-08	22:56	n/a	1 - Light Air	0	0	1
20AA2	1	2020-05-14	00:16	4	1 - Light Air	0	1	0
	2	2020-06-08	23:40	n/a	1 - Light Air	0	0	1
20AA3	1	2020-05-14	00:06	4	1 - Light Air	0	1	0

	2	2020-06-08	23:30	n/a	1 - Light Air	0	0	1
20AA4	1	2020-05-13	23:11	4	1 - Light Air	0	0	0
	2	2020-06-09	00:13	n/a	1 - Light Air	0	0	1
20AA5	1	2020-05-13	21:34	8	1 - Light Air	0	1	0
	2	2020-06-09	00:31	n/a	1 - Light Air	0	0	0
20AA6	1	2020-05-13	21:54	9	1 - Light Air	0	1	0
	2	2020-06-09	01:02	n/a	1 - Light Air	0	0	0
20AA7	1	2020-05-13	22:19	6	1 - Light Air	0	1	0
21AA8	1	2021-05-05	23:05	9	0 - Calm	0	2	0
	2	2021-05-14	22:55	11	2 – Light Breeze	0	0	0
	3	2021-06-04	22:40	21	0 - Calm	1	0	0
21AA9	1	2021-05-05	22:26	9	0 - Calm	0	0	0
	2	2021-05-14	22:32	9	2 – Light Breeze	0	0	0
	3	2021-06-04	22:45	20	1 – Light Air	0	1	0
21AA10	1	2021-05-05	21:51	11	0 - Calm	0	1	0
	2	2021-05-14	22:04	13	3 – Gentle Breeze	0	0	0
	3	2021-06-04	23:35	19	2 – Light Breeze	0	0	0
21AA11	1	2021-05-05	21:25	12	1 – Light Air	0	1	0
	2	2021-05-14	21:25	13	3 – Gentle Breeze	0	0	0
	3	2021-06-04	23:06	19	2 – Light Breeze	1	0	0
21AA12	1	2021-05-05	23:36	5	1 – Light Air	0	0	0
	2	2021-05-14	22:10	14	3 – Gentle Breeze	0	0	0
	3	2021-06-04	22:55	19	2 – Light Breeze	1	0	0
21AA13	1	2021-05-05	22:06	10	0 - Calm	0	0	0
	2	2021-05-14	21:36	14	3 – Gentle Breeze	0	0	0
	3	2021-06-04	23:25	20	2 – Light Breeze	0	1	0
21AA14	1	2021-05-05	22:46	9	0 - Calm	0	1	0
	2	2021-05-14	22:40	11	2 – Light Breeze	0	0	0
	3	2021-06-04	22:20	21	0 - Calm	1	1	0

4.2.3.2.4 Common Nighthawk Short -eared Owl Surveys

Common nighthawk surveys were conducted at nine survey stations in 2020, with two visits at each, except for 20CONI01. This location was determined not to completed during the first survey round, as agricultural work was occurring in the area, preventing site access. Common nighthawks were observed at two of the sites, 20CONI04 and 20CONI05 (**Table 4.15**). Air temperature during visits ranged from 12°C to 27°C, with winds remaining at or below a light breeze. A short-eared owl was observed at 20CONI08 (**Table 4.15**).

Common night hawk and short-eared owl surveys were conducted at eight survey sites in 2021. Short-eared owl surveys required three visits where common nighthawk surveys only required two. Neither target species were observed during the visits (**Table 4.15**). Air temperature during surveys remained between 16°C and 32°C with wind speeds at or below gentle breeze.

Table 4.15: 2020 and 2021 common nighthawk survey results

Station ID	Visit	Survey (CONI/SEOW or both)	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Target Species Detected (CONI/SEOW/N)
20CONI01	1	CONI	2020-06-24	20:33	23	1 - Light Air	N
20CONI02	1	CONI	2020-06-08	21:34	12	0 - Calm	N
	2	CONI	2020-06-24	21:01	22	1 - Light Air	N
20CONI03	1	CONI	2020-06-08	21:11	14	0 - Calm	N
	2	CONI	2020-06-24	21:28	20	1 - Light Air	N
20CONI04	1	CONI	2020-06-08	20:43	13	0 - Calm	N
	2	CONI	2020-06-25	21:17	23	1 - Light Air	Y
20CONI05	1	CONI	2020-06-18	21:37	11	1 - Light Air	N
	2	CONI	2020-06-25	20:37	27	1 - Light Air	Y
20CONI06	1	CONI	2020-06-18	21:54	11	1 - Light Air	N
	2	CONI	2020-07-02	21:30	19	1 - Light Air	N
20CONI07	1	CONI	2020-06-18	20:35	12	2 - Light Breeze	N
	2	CONI	2020-07-02	20:43	21	2 - Light Breeze	N
20CONI08	1	CONI	2020-06-18	21:14	12	2 - Light Breeze	SEOW
	2	CONI	2020-07-02	21:08	18	1 - Light Air	N
20CONI09	1	CONI	2020-06-18	20:53	12	1 - Light Air	N
	2	CONI	2020-06-25	21:55	17	1 - Light Air	N
21CONI10	1	Both	2021-06-16	21:53	16	1 - Light Air	N
	2	SEOW	2021-06-23	21:16	19	1 - Light Air	N
	3	Both	2021-07-01	21:24	32	2 - Light Breeze	N
21CONI11	1	Both	2021-06-14	21:29	25	2 - Light Breeze	N
	2	SEOW	2021-06-23	21:01	19	1 - Light Air	N
	3	Both	2021-07-01	21:49	30	2 - Light Breeze	N
21CONI12	1	Both	2021-06-16	21:29	21	1 - Light Air	N
	2	SEOW	2021-06-23	20:48	19	1 - Light Air	N
	3	Both	2021-06-30	21:31	32	1 - Light Air	N
21CONI13	1	Both	2021-06-16	20:53	21	2 - Light Breeze	N
	2	SEOW	2021-06-24	20:52	24	1 - Light Air	N
	3	Both	2021-06-30	20:49	32	1 - Light Air	N
21CONI14	1	Both	2021-06-14	22:00	24	3 – Gentle Breeze	N
	2	SEOW	2021-06-23	21:31	18	1 - Light Air	N
	3	Both	2021-07-01	21:08	32	2 - Light Breeze	N
21CONI15	1	Both	2021-06-14	21:49	25	2 - Light Breeze	N
	2	SEOW	2021-06-23	21:43	18	1 - Light Air	N
	3	Both	2021-07-01	20:56	32	2 - Light Breeze	N
21CONI16	1	Both	2021-06-14	21:11	25	2 - Light Breeze	N
	2	SEOW	2021-06-23	21:52	18	1 - Light Air	N
	3	Both	2021-07-01	20:45	32	2 - Light Breeze	N
21CONI17	1	Both	2021-06-16	21:11	21	1 - Light Air	N

Station ID	Visit	Survey (CONI/SEOW or both)	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Target Species Detected (CONI/SEOW/N)
	2	SEOW	2021-06-24	21:11	24	1 - Light Air	N
	3	Both	2021-06-30	21:09	32	1 - Light Air	N

Note: CONI = Common nighthawk; SEOW = Short-eared owl

4.2.3.2.5 Yellow Rail Surveys

No yellow rails were observed over the two years of surveys conducted. Seven survey stations were selected for yellow rail surveys in 2020. An additional six survey sites were completed in 2021. Air temperatures during the survey ranged from 7°C to 18°C and winds ranged from calm to light breeze (**Table 4.16**). Other rail species detected during yellow rail surveys included American coot, and sora.

Table 4.16: 2020/2021 yellow rail survey results

Station ID	Survey	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Rail Species Detected		
						Yellow Rail	Sora	American Coot
20YERA02	1	2020-06-25	23:13	18	1 - Light Air	0	0	0
20YERA03	1	2020-06-09	0:40	10	0 - Calm	0	1	0
	2	2020-06-25	23:36	18	0 - Calm	0	1	1
	3	2020-07-03	0:25	11	2 - Light Breeze	0	1	0
	1	2021-07-03	0:23	15	2 – Light Breeze	0	1	0
20YERA04	1	2020-06-09	1:08	10	0 - Calm	0	1	0
	2	2020-06-26	0:25	17	0 - Calm	0	1	0
	3	2020-07-02	23:50	12	2 - Light Breeze	0	1	0
	1	2021-07-02	23:59	15	3 – Gentle Breeze			
20YERA05	1	2020-06-09	1:46	8	0 - Calm	0	1	0
	2	2020-06-26	0:51	16	0 - Calm	0	1	0
	3	2020-07-02	23:30	12	2 - Light Breeze	0	1	1
	1	2021-07-02	23:22	17	3 – Gentle Breeze			
20YERA06	1	2020-06-09	2:18	7	0 - Calm	0	1	0
	2	2020-07-02	23:00	12	2 - Light Breeze	0	1	0
	1	2021-07-02	23:00					
20YERA07	1	2020-06-08	23:52	10	0 - Calm	0	0	0
	2	2020-06-26	2:10	14	1 - Light Air	0	0	0
	3	2020-07-03	1:35	10	2 - Light Breeze	0	1	0
20YERA08	1	2020-06-08	23:10	10	1 - Light Air	0	0	0
	2	2020-06-26	1:15	16	1 - Light Air	0	0	0
	3	2020-07-03	1:05	11	2 - Light Breeze	0	1	0
21YERA10	1	2021-06-16	0:54	21	2 - Light Breeze	0	0	0
	2	2021-06-23	0:00	17	0 - Calm	0	1	0
	3	2021-06-30	0:21	24	2 - Light Breeze	0	0	0
21YERA11	1	2021-06-16	0:27	21	1 - Light Air	0	0	0
	2	2021-06-22	23:00	17	0 - Calm	0	1	0
	3	2021-06-29	23:40	26	0 - Calm	0	1	0

Station ID	Survey	Date	Start Time	Temp (°C)	Wind Speed (Beaufort Scale)	Rail Species Detected		
						Yellow Rail	Sora	American Coot
21YERA12	1	2021-06-15	0:12	21	3 – Gentle Breeze	0	1	0
	2	2021-06-23	23:37	12	1 - Light Air	0	0	0
	3	2021-06-30	1:33	23	0 - Calm	0	0	0
21YERA14	1	2021-06-14	23:45	22	3 – Gentle Breeze	0	0	0
	2	2021-06-24	0:05	12	0 - Calm	0	0	0
	3	2021-06-30	2:01	23	0 - Calm	0	0	0
21YERA15	1	2021-06-14	23:22	22	3 – Gentle Breeze	0	1	0
	2	2021-06-24	0:28	12	0 - Calm	0	1	0
	3	2021-06-30	1:00	24	0 - Calm	0	0	0
21YERA16	1	2021-06-15	23:59	21	1 - Light Air	0	0	0
	2	2021-06-22	23:23	17	0 - Calm	0	0	0

4.2.3.3 Incidental Wildlife Observations

A total of 1,515 incidental wildlife observations were made over the two field seasons combined. Of the 114 wildlife species observed (Appendix D):

- Three species were amphibians (One SAR/SOCC);
- 10 were mammals (One SAR/SOCC);
- 101 were bird species (11 SOCC, 4 SAR)

Species were detected during survey efforts or between survey stations. It should be noted that targeted species observed, and incidental observations are not mutually exclusive as some species targeted in one species detection survey were sometimes detected during a different one.

4.3 Preliminary Vegetation Study

SNC-Lavalin conducted the Phase 2 preliminary vegetation study to identify plant SOCC and sensitive habitat within the proposed freeway concept corridors. The study consisted of the following desktop and field-level investigations:

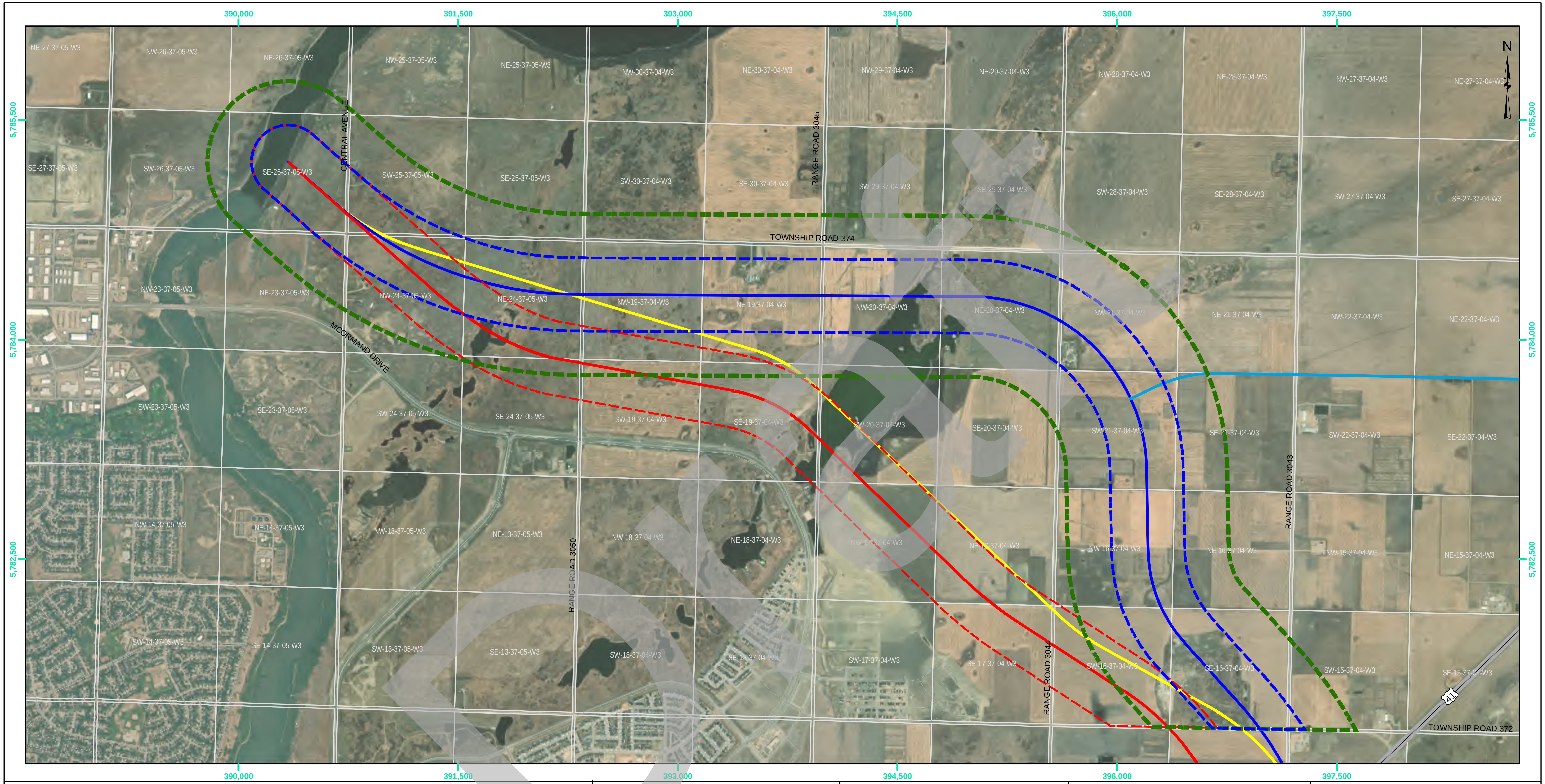
- A desktop screening exercise conducted to identify plant SOCC occurrences and potential plant SOCC habitat within 2021 vegetation study area that may not have been captured by the 2020 SFFPS Environmental and Regulatory Review; and
- Field-level vegetation surveys designed to describe plant habitat within the study areas, collect plant SOCC occurrence data, and identify locations that will require further investigation in future project phases.

The results of the preliminary vegetation study are intended to inform biological studies conducted in support of a future TP and/or EIA for the proposed project. For example, plant SOCC and their associated habitats detected during this study may be used as targets for future vascular plant surveys designed to follow the ENV Vascular Plant Survey Protocol.

4.3.1 Vegetation Study Areas

The preliminary vegetation study was designed to target areas of native-dominant vegetation intersected by the proposed Phase 2 freeway concept corridors, including portions of the Northeast Swale, Small Swale, South Saskatchewan River valley, and surrounding lands. The portion of this study conducted in 2020 followed the original proposed freeway corridor between the northwestern bank of the South Saskatchewan River valley (part of Phase 1) and Township Road 372 (Phase 2), while the 2021 portion followed the proposed corridor associated with Concept 3 between these same endpoints. A small section of the Phase 1 area was included in this study to ensure adequate coverage of the northwestern side of the river valley, which supports riparian green ash (*Fraxinus pensylvanica*) forest and native prairie.

Vegetation study area boundaries were selected based on the 2021 ENV Vascular Plant Survey Protocol, which states that study areas for guild-type surveys (e.g., vascular plants) must include the proposed project footprint as well as the largest applicable setback distance identified in the Saskatchewan ARGs for Sensitive Species (ENV 2021b; ENV 2017). A setback distance of 300 m was selected based on the relevant disturbance category (high) as well as the potential for plant SAR occurrences identified in the 2020 SFFPS Environmental and Regulatory Review. A 300 m buffer distance was applied to the original proposed freeway corridor to create the 862 ha 2020 vegetation study area (**Figure 4.12**). The same buffer distance was applied to the Concept 3 corridor to create the 1,092 ha 2021 vegetation study area.



🟥 ROUTE CONCEPT 1
(BASE CASE/ORIGINAL ALIGNMENT)
🟨 ROUTE CONCEPT 2
🟦 ROUTE CONCEPT 3
🟦 ROUTE CONCEPT 4
▬ HIGHWAY
▭ GENERAL LOCATION CORRIDOR (PHASE 2)
▭ 2021 STUDY AREA
▭ 2021 VEGETATION STUDY AREA

NOTES

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0 165 330 660 990 1,320 Metres

SCALE: 1:26,000

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00	2022 10 06	ISSUED FOR INFORMATION	KH	KVG	KH	JP

REFERENCE DRAWINGS

DWG No.	DESCRIPTION

CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020 AND 2021 VEGETATION STUDY AREAS

DATE	DWG No.	FIG No.	REV
2021 11 30	659183-0000-4EDD-0061	4.12	00

DISCLAIMER

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0061 Vegetation Study Area.mxd

4.3.2 Methods

4.3.2.1 Desktop Plant SOCC Screening

A desktop screening exercise was conducted to identify plant SOCC occurrences and potential plant SOCC habitat within the 2021 vegetation study area, including occurrences that may not have been captured by the 2020 SFFPS Environmental and Regulatory Review. This data was obtained from the following sources:

- The HABISask tool (Government of Saskatchewan 2021) for (i) a list of plant SOCC occurrences that were previously detected within the study area (known as element occurrences), (ii) the locations of federal and/or provincial lands requiring environmental protection, and (iii) predictive distribution models for plant SOCC;
- Available studies in the region with data less than ten years old and with spatial plant SOCC data that could be readily extracted (e.g. presented on maps or with UTM coordinates), including:
  - North Commuter Parkway – Baseline Terrestrial and Aquatic Field Studies, and Heritage Resource Impact Assessment (Stantec 2013a),
  - North Central/North East Natural Area Screening Study, City of Saskatoon (Stantec 2013b), and
  - Previously unreported data from The MVA Habitat Evaluation of the Saskatoon Freeway Project Through the Northeast and Small Swale Complexes (Grilz and Hooey 2020).

Current federal and provincial species rankings were provided by the SARA Public Registry (Government of Canada 2021) and the SKCDC (2021c) (Appendix A).

4.3.2.2 Vegetation Surveys

The 2020 and 2021 field-level vegetation surveys each consisted of two seasonal surveys. Spring surveys took place between 1 June and 5 June 2020 and between 29 May and 1 June 2021. This sampling schedule was chosen to accommodate the optimal detection periods for most spring flowering prairie species, including several SOCC identified during the desktop plant SOCC screening exercise and the 2020 SFFPS Environmental and Regulatory Review. Summer surveys took place between 27 August and 2 September 2020 and between 22 July and 28 July 2021. The 2020 summer survey was conducted later in the growing season to accommodate target species with later detection periods, including members of the aster family (Asteraceae) and the gentian family (Gentianaceae). The 2021 summer sampling schedule was chosen to capture a range of prairie and wetland graminoids and summer flowering forbs.

Surveys focused on areas of native-dominant vegetation within the 2020 and 2021 vegetation study areas, including the Northeast Swale and Small Swale wetland complexes, upland sites surrounding the swales, and the South Saskatchewan River floodplain and banks. These areas were canvassed by a qualified field botanist with experience surveying local flora, including the identification of SOCC and SOCC habitat. Special attention was given to habitats deemed likely to support SOCC based on known habitat requirements and plant community associations, including groundwater seeps, wet meadows, saline wetlands, drying mudflats, eroded banks, and patches of native prairie vegetation. The locations of SOCC element occurrences and predicted SOCC habitat identified by HABISask were also prioritized. Cultivated fields, improved grasslands, residences, development sites, active borrow pits, and aquatic habitats only accessible by watercraft were not included in the vegetation surveys. Some of these areas may be capable of supporting SOCC (e.g., wetlands in cultivated fields, open water and deep marsh zones in the swales' wetland complexes) and should be considered for inclusion in future vascular plant surveys as part of an EIA or TP.

All plant taxa observed during the vegetation surveys were identified to the lowest possible taxonomic designation with the aid of floras, technical keys, and other resources. A voucher specimen was collected if the species could not be identified using these methods. Voucher specimens of possible or probable SOCC were collected at the SKCDC's request.

Occurrence data was collected for all positive SOCC detections made during the vegetation surveys. The surveyor used a GPS-enabled Apple iPad equipped with a digital data collection application (Survey123 for ArcGIS – Esri Software) to take georeferenced photographs and record the time of discovery, occurrence location, abundance and distribution information, habitat characteristics, phenology, and other relevant details. Upon detection of a SOCC, the surveyor searched nearby and/or connected areas of suitable habitat to ensure that the full spatial extent of each occurrence was documented. Spatial data was collected using a digital mapping application (Collector for ArcGIS – Esri Software) in accordance with the SKCDC Guidelines for Collecting Spatial Data during Vascular Plant Surveys (2016). For the purpose of this study, an SOCC occurrence is defined as a plant or patch of plants recorded as a single spatial feature (e.g., waypoint or polygon) as per the SKCDC guidelines:

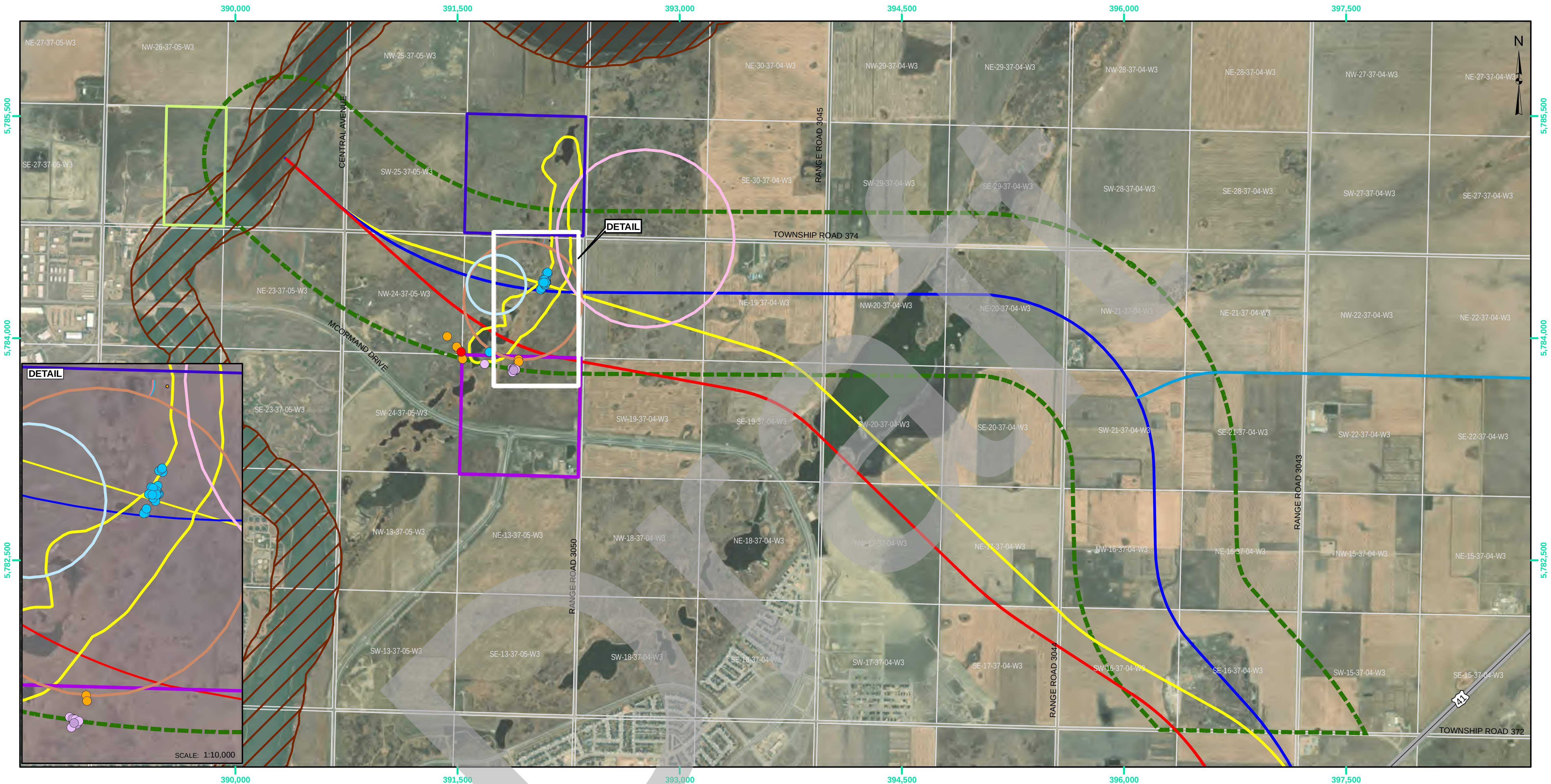
- Single plants and small patches of plants with a radius not exceeding five metres were recorded as waypoints;
- Large patches with a radius greater than five metres were recorded as polygons using the application's track function;
- Large patches separated by a distance of 30 m or more were recorded as separate polygons;
- Single plants or small patches located more than 20 m from large patches were recorded as separate waypoints to avoid misrepresenting coverage within a polygon;
- Patches of plants that occupy a linear feature (e.g., shoreline, roadway) less than five meters wide were recorded as lines using the application's track function; and
- Patches separated by areas of unsuitable habitat were recorded as separate waypoints, polygons, and/or lines.

After establishing the patch boundaries, the surveyor recorded the number or approximate number of individual plants present within the patch if practical. The area occupied by each continuous patch was used as an alternative measure of abundance in cases where individual plants were difficult to count due to growth form (e.g., some graminoids) and/or environmental conditions (e.g., drought). Percent cover within the patch area was estimated if practical. SOCC occurrence data collected during the 2020 and 2021 vegetation surveys was included in the data submission loadforms for species detection permits 20SD034 and 21SD014.

4.3.3 Results

4.3.3.1 Desktop Plant SOCC Screening

A search of HABISask produced records of nine plant SOCC within the 2021 vegetation study area (**Figure 4.13**; **Table 4.17**) (Government of Saskatchewan 2021). Each SOCC is represented by a single element occurrence. No plant SAR element occurrences or lands requiring additional environmental protections or conservation easements were identified within the 2021 vegetation study area. HABISask's predictive distribution model did not identify potentially suitable plant SOCC habitat within the study area. Explanations of federal and provincial species rankings are provided in Appendix A.



LEGEND

- 🟥 ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- 🟨 ROUTE CONCEPT 2
- 🟦 ROUTE CONCEPT 3
- 🟦 ROUTE CONCEPT 4
- ═ HIGHWAY
- ▭ 2021 VEGETATION STUDY AREA
- ▭ CRAWE'S SEDGE
- 🟪 CROWFOOT VIOLET
- ▭ FEW-FLOWERED ASTER
- ▭ LESSER DUCKWEED
- 🟥 LESSER FRINGED GENTIAN (*Gentianopsis virgata ssp. virgata*)
- ▭ LESSER FRINGED GENTIAN[7] (*Gentianopsis virgata*)
- 🟦 MARSH FELWORTH
- ▭ MENZIES' CATCHFLY
- 🟧 PLAINS ROUGH FESCUE
- ▭ PRAIRIE DUNEWORT
- 🟥 RED ELDERBERRY
- ▨ ROCKY MOUNTAIN SEDGE
- ▭ SANDHILLS CINQUEFOIL

NOTES

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5. MEEWASIN VALLEY AUTHORITY SPECIES AT RISK OBTAINED FROM GRILZ AND HOOEY, 2020.
6. RARE SPECIES INFORMATION OBTAINED FROM HABISASK COLLECTED BY THE SASKATCHEWAN CONSERVATION DATA CENTRE. INFORMATION IS SENSITIVE AND INTENDED FOR CONSERVATION PURPOSES ONLY. ONLY SPECIES WITHIN STUDY AREA ARE SHOWN.
7. SUBSPECIES NOT LISTED IN HABISASK DATA.

0 165 330 660 990 1,320 Metres

SCALE: 1:26,000

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REVISIONS

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REV	**DATE**	**DESCRIPTION**	**DES**	**DRN**	**CHK**	**APP**

REFERENCE DRAWINGS

DWG No.	**DESCRIPTION**

CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
DESKTOP VEGETATION SOCC SCREENING RESULTS

DATE 2021 11 30 **DWG No.** 659183-0000-4EDD-0059 **FIG No. 4.13** **REV** 00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0060 2021 Desktop Veg Screening.mxd

Table 4.17: Plant SOCC with documented occurrences in the 2021 vegetation study area

Common Name	Scientific Name	Family	SKCDC Ranking	ARG for Species	Source
Alisma gramineum	narrow-leaved water plantain	Alismataceae	S3; tracked	occurrence	HABISask
Almutaster pauciflorus	few-flowered aster	Asteraceae	S3; tracked	occurrence	HABISask
Botrychium campestre	prairie dunewort	Ophioglossaceae	S3; tracked	occurrence	HABISask
Carex crawei	Crawe's sedge	Cyperaceae	S3; tracked	occurrence	HABISask
Carex saximontana	Rocky Mountain sedge	Cyperaceae	S3; tracked	occurrence	HABISask
Festuca hallii	plains rough fescue	Poaceae	S3; tracked	occurrence	HABISask, MVA
*Gentianopsis virgata**	lesser fringed gentian	Gentianaceae	S3; tracked	occurrence	HABISask
*Gentianopsis virgata ssp. virgata**	lesser fringed gentian	Gentianaceae	S3; tracked	occurrence	MVA
Lemna minor	lesser duckweed	Lemnaceae	S1; tracked	occurrence	HABISask
Lomatogonium rotatum	marsh felwort	Gentianaceae	S3; tracked	occurrence	MVA
Potentilla lasiodonta	sandhills cinquefoil	Rosaceae	S2; tracked	occurrence	HABISask
Sambucus racemosa ssp. pubens	red elderberry	Caprifoliaceae	S2; tracked	occurrence	MVA
Silene menziesii	Menzies' catchfly	Caryophyllaceae	S3; tracked	occurrence	HABISask
Viola pedatifida	crowfoot violet	Violaceae	S3; tracked	occurrence	HABISask, MVA

**Gentianopsis virgata ssp. virgata* records from the MVA; *Gentianopsis virgata* (subspecies not given) records from HABISask
Source: (ENV 2017; Government of Saskatchewan 2021; Grilz and Hooey 2020; SKCDC 2021c)

A review of previous studies conducted within the region produced records of five plant SOCC and 55 plant SOCC occurrences within the 2021 vegetation area (Grilz and Hooey 2020; Stantec 2013) (**Figure 4.13**; **Table 4.17**). No records of plant SAR occurrences were found during the desktop screening exercise.

4.3.3.2 Vegetation Surveys

A total of 371 vascular plant taxa were identified during the 2020 and 2021 vegetation surveys. Subdivided by growth form, this total includes 244 forbs, 87 graminoids, and 40 woody plants. Fifty-one of the 371 detected taxa were not indigenous to the region, inclusive of cultivated species. Eleven noxious weeds and four nuisance weeds designated in accordance with *The [Saskatchewan] Weed Control Act* were observed, but no prohibited weeds were found. Of the 320 native plant taxa detected, two are considered imperiled within Saskatchewan (*S2*), 11 are considered vulnerable (*S3*), 235 are considered apparently secure (*S4*), and 71 are considered secure (*S5*) (SKCDC 2021c).

A total of 13 plant SOCC and 124 plant SOCC occurrences were detected and documented during the vegetation surveys (**Figure 4.14**; **Table 4.18**) Ninety-one of these occurrences fall within the 2020 vegetation study area and 115 occurrences fall within the 2021 vegetation study area. Detailed descriptions of detected SOCC including identifying features, habitat requirements, and range information, are provided in Appendix E. Photographs of plant SOCC and SOCC habitat can be found in Appendix F. No plant SAR were detected. A full list of all plant taxa encountered during the vegetation surveys can be found in Appendix G. SAR and SOCC plant occurrences are presented in Appendix H.

LEGEND

- ● PLAINS ROUGH FESCUE
- ● MACOUN'S GENTIAN
- ● EARLY CINQUEFOIL
- ● HUDSON'S CINQUEFOIL
- ● LOW WHITLOWWORT
- — ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- — ROUTE CONCEPT 2
- — ROUTE CONCEPT 3
- ▢ PLAINS ROUGH FESCUE
- ▢ 2021 VEGETATION STUDY AREA

NOTES

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SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE 2021 11 30 **DWG No.** 659183-0000-4EDD-0050 **FIG No.** 4.14a **REV** 00

SIZE 11x17

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LEGEND

●	CROWFOOT VIOLET
🟥	ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
🟨	ROUTE CONCEPT 2
🟦	ROUTE CONCEPT 3
▨	PLAINS ROUGH FESCUE
⬚	2021 VEGETATION STUDY AREA

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SCALE: 1:3,500

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SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	**DWG No.**	659183-0000-4EDD-0051	**FIG No.**	**4.14b**	**REV**	00

SIZE 11x17

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LEGEND

● PLAINS ROUGH FESCUE
● HAIRY GERMANDER
● CROWFOOT VIOLET
— ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
— ROUTE CONCEPT 2
— ROUTE CONCEPT 3
▨ PLAINS ROUGH FESCUE
▭ 2021 VEGETATION STUDY AREA

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SCALE: 1:3,500

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

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SIZE 11x17

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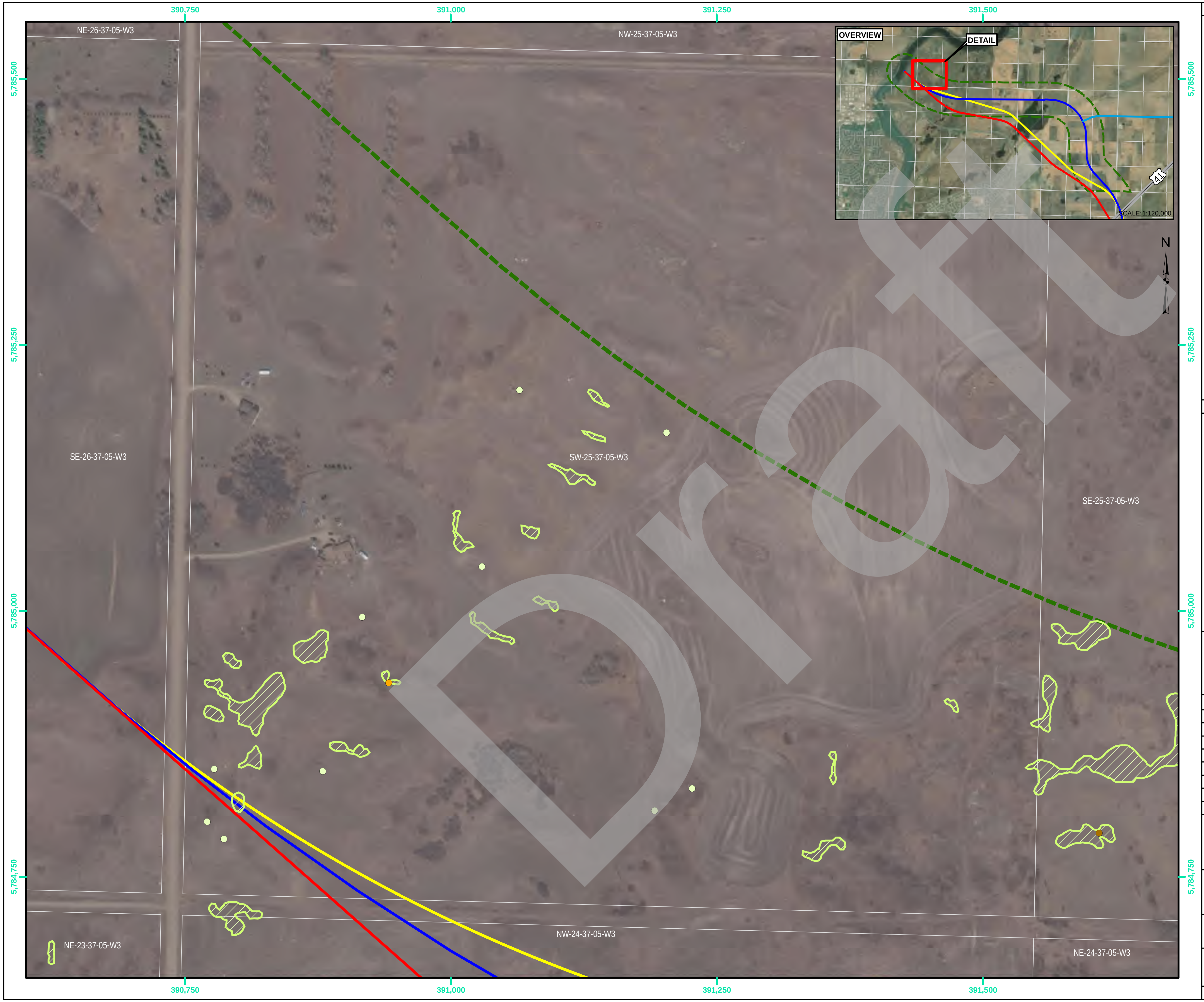

LEGEND

- ● PLAINS ROUGH FESCUE
- ● EARLY CINQUEFOIL
- ● HUDSON'S CINQUEFOIL
- — ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- — ROUTE CONCEPT 2
- — ROUTE CONCEPT 3
- ▨ PLAINS ROUGH FESCUE
- ⬚ 2021 VEGETATION STUDY AREA

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REFERENCE DRAWINGS

DWG No.	DESCRIPTION

REVISIONS

00	2022 10 06	ISSUED FOR INFORMATION	KH	KVG	KH	JP
REV	**DATE**	**DESCRIPTION**	**DES**	**DRN**	**CHK**	**APP**

0 50 100 200 METRES

SCALE: 1:3,500

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SASKATCHEWAN MINISTRY OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	**DWG No.**	659183-0000-4EDD-0052	**FIG No.**	4.14d	**REV**	00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0053 Vegetation 2021.mxd

LEGEND

●	FEW-FLOWERED ASTER
●	PLAINS ROUGH FESCUE
●	HUDSON'S CINQUEFOIL
●	MUCRONATE BLUE-EYED-GRASS
●	UPLAND WHITE GOLDENROD
●	CROWFOOT VIOLET
▨	FEW-FLOWERED ASTER
▨	RED BULRUSH
▨	PLAINS ROUGH FESCUE
▨	MACOUN'S GENTIAN
▨	MARSH FELWORT
⬚	2021 VEGETATION STUDY AREA

NOTES

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DWG No.	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
00	2022 10 06	ISSUED FOR INFORMATION	KH	KVG	KH	JP

0 50 100 200 METRES

SCALE: 1:3,500

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SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	**DWG No.**	659183-0000-4EDD-0054	**FIG No.**	4.14e	**REV**	00

SIZE 11x17

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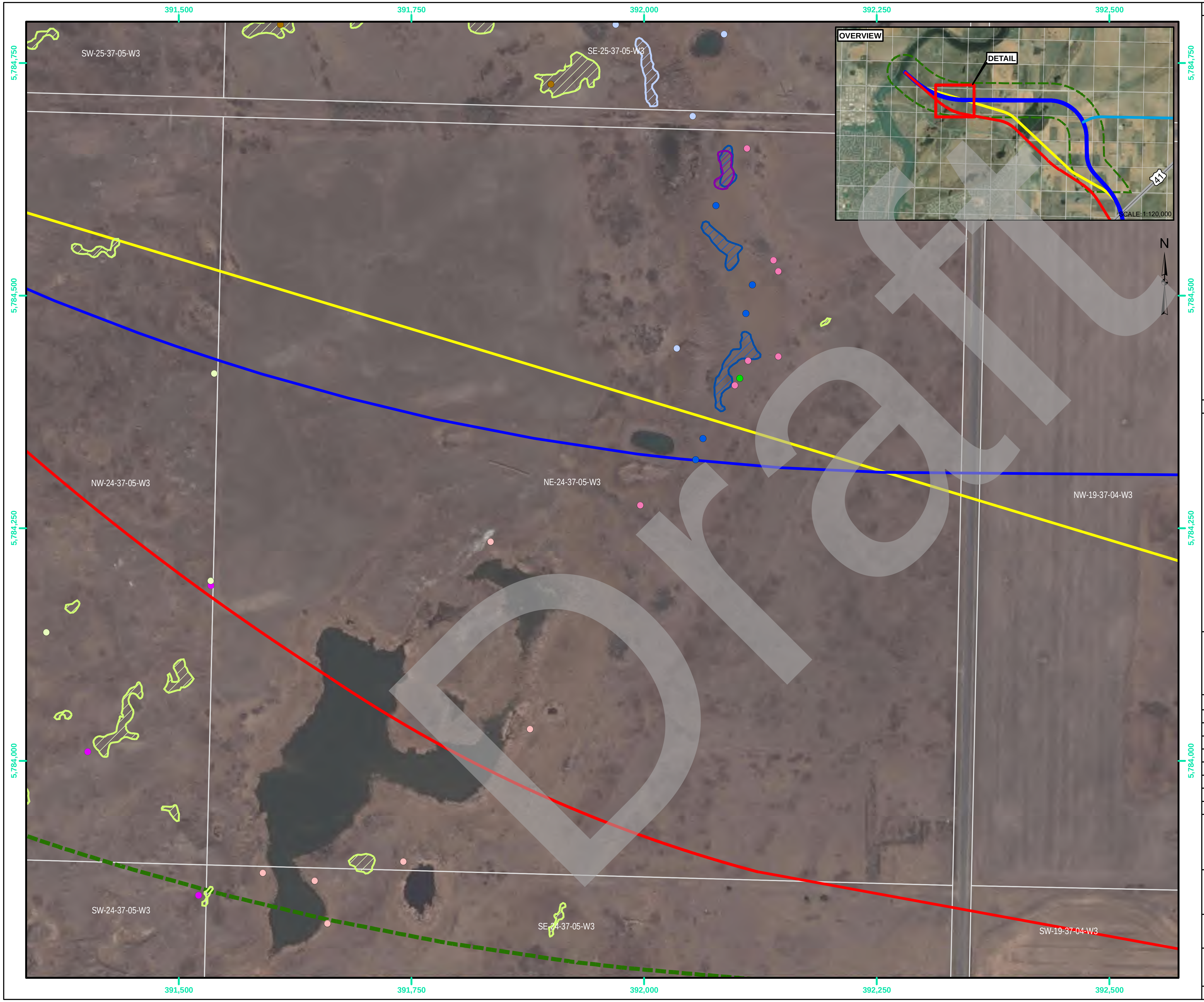

LEGEND

- ● FEW-FLOWERED ASTER
- ● PLAINS ROUGH FESCUE
- ● MARSH FELWORT
- ● HUDSON'S CINQUEFOIL
- ● MUCRONATE BLUE-EYED-GRASS
- ● UPLAND WHITE GOLDENROD
- ● HAIRY GERMANDER
- ● CROWFOOT VIOLET
- ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- ROUTE CONCEPT 2
- ROUTE CONCEPT 3
- ▨ FEW-FLOWERED ASTER
- ▨ PLAINS ROUGH FESCUE
- ▨ MACOUN'S GENTIAN
- ▨ MARSH FELWORT
- ⬚ 2021 VEGETATION STUDY AREA

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00	2022 10 06	ISSUED FOR INFORMATION	KH	KVG	KH	JP

0 50 100 200 METRES

SCALE: 1:4,000

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	DWG No.	659183-0000-4EDD-0055	FIG No.	4.14f	REV	00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0055 Vegetation 2021.mxd

LEGEND

- ● HAIRY GERMANDER
- ● CROWFOOT VIOLET
- ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
- ▨ PLAINS ROUGH FESCUE
- 2021 VEGETATION STUDY AREA

NOTES

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REVISIONS

00	2022 10 06	ISSUED FOR INFORMATION	KH	KVG	KH	JP
REV	**DATE**	**DESCRIPTION**	**DES**	**DRN**	**CHK**	**APP**

0 50 100 200 METRES

SCALE: 1:3,500

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OF HIGHWAYS

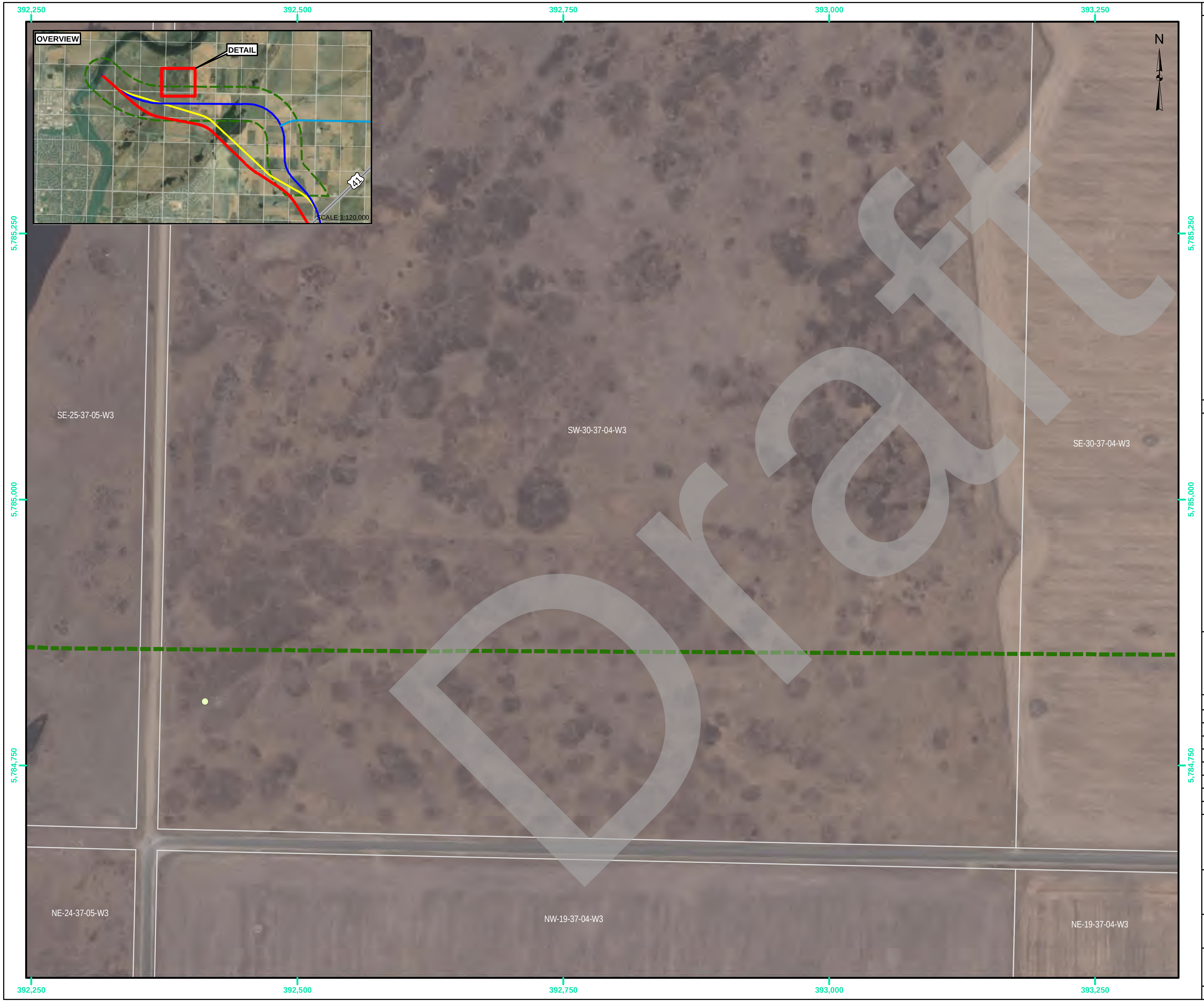
PROJECT LOCATION
SASKATOON FREEWAY

TITLE
2020/2021 PLANT SOCC DETECTION RESULTS

DATE 2021 11 30	**DWG No.** 659183-0000-4EDD-0056	**FIG No.**4.14g	**REV** 00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0056 Vegetation 2021.mxd



SIZE 11x17

LEGEND

- ● PLAINS ROUGH FESCUE
- ▭ 2020 VEGETATION STUDY AREA
- ▭ 2021 VEGETATION STUDY AREA

NOTES

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REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
00	2022 10 06	ISSUED FOR INFORMATION	KH	KVG	KH	JP

0 50 100 200 METRES

SCALE: 1:3,500

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON FREEWAY

TITLE

2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	DWG No.	659183-0000-4EDD-0057	FIG No.	4.14h	REV	00

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0057 Vegetation 2021.mxd

SIZE 11x17

LEGEND

●	NARROW-LEAVED WATER PLANTAIN
🟥	ROUTE CONCEPT 1 (BASE CASE/ORIGINAL ALIGNMENT)
🟨	ROUTE CONCEPT 2
▨	HAIRY GERMANDER
🟩	2021 VEGETATION STUDY AREA

NOTES

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REVISIONS

00	2022 10 06	ISSUED FOR INFORMATION	KH	KVG	KH	JP
REV	**DATE**	**DESCRIPTION**	**DES**	**DRN**	**CHK**	**APP**

0 50 100 200
METRES

SCALE: 1:3,500

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CLIENT SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION** SASKATOON FREEWAY

TITLE

2020/2021 PLANT SOCC DETECTION RESULTS

DATE	2021 11 30	**DWG No.**	659183-0000-4EDD-0058	**FIG No.**	4.14i	**REV**	00

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Biophysical\659183-0000-4EDD-0058 Vegetation 2021.mxd

Table 4.18: Plant SOCC detected during vegetation surveys

Scientific Name	Common Name	Family	SKCDC Ranking	Area(s) Detected			No. of Occurrences (Patches)		Estimated No. of Plants		Total Area of Patches Recorded as Polygons* (m^2)	
				Small Swale and Surrounding Areas	Northeast Swale	South Saskatchewan River Valley	2020 Vegetation Study Area	2021 Vegetation Study Area	2020 Vegetation Study Area	2021 Vegetation Study Area	2020 Vegetation Study Area	2021 Vegetation Study Area
Alisma gramineum	narrow-leaved water plantain	Alismataceae	S3; tracked		✓		5	0	23	-	n/a	-
Almutaster pauciflorus	few-flowered aster	Asteraceae	S3; tracked	✓			1	6	61	> 5,300	n/a	1,123
Blysmopsis rufa	red bulrush	Cyperaceae	S3; tracked	✓			0	1	-	no estimate	-	113
Festuca hallii	plains rough fescue	Poaceae	S3; tracked	✓		✓	57	63	no estimate	no estimate	14,340	35,182
Gentianopsis virgata ssp. macounii	Macoun's gentian	Gentianaceae	S3; tracked	✓		✓	4	5	40	375	n/a	544
Lomatogonium rotatum	marsh felwort	Gentianaceae	S3; tracked	✓			3	8	92	380	1,156	2,466
Paronychia sessiliflora	low whitlowwort	Caryophyllaceae	S3; tracked			✓	1	1	5	5	n/a	n/a
Potentilla concinna var. concinna	early cinquefoil	Rosaceae	S2; tracked	✓			1	1	4	4	n/a	n/a
Potentilla hudsonii	Hudson's cinquefoil	Rosaceae	S2; tracked	✓		✓	2	3	15	16	n/a	n/a
Sisyrinchium mucronatum	mucronate blue-eyed grass	Iridaceae	S3; tracked	✓			1	3	1	4	n/a	n/a
Solidago ptarmicoides	upland white goldenrod	Asteraceae	S3; tracked	✓			4	12	20	80	n/a	n/a
Teucrium canadense var. occidentale	hairy germander	Lamiaceae	S3; tracked	✓	✓		7	6	387	162	86	n/a
Viola pedatifida	crowfoot violet	Violaceae	S3; tracked	✓			5	6	45	69	n/a	n/a

*Patches of plant SOCC with a radius under or equal to 5 m were recorded as waypoints as per the SKCDC Guidelines for Collecting Spatial Data during Vascular Plant Surveys (2016)
Source: (SKCDC 2021c)

4.3.3.2.1 Small Swale and Surrounding Areas

Seven plant SOCC were detected in the portion of the Small Swale wetland complex intersected by the 2020 and 2021 vegetation study areas: few-flowered aster (*Almutaster pauciflorus*; *S3*), red bulrush (*Blysmopsis rufa*; *S3*), Macoun's gentian (*Gentianopsis virgata ssp. macounii*; *S3*), marsh felwort (*Lomatogonium rotatum*; *S3*), mucronate blue-eyed grass (*Sisyrinchium mucronatum*; *S3*), upland white goldenrod (*Solidago ptarmicoides*; *S3*), and hairy germander (*Teucrium canadense var. occidentale*; *S3*) (**Figure 4.14**; **Table 4.18**).

Marl ponds formed by calcareous groundwater seepage were observed within the Small Swale channel in the northern half of NE-24-37-05-W3 and along the southern edge of SE-25-37-05-W3. These seeps provide habitat for a unique assemblage of wetland species, including several previously documented SOCC (Grilz and Hooey 2020; Government of Saskatchewan 2021; Stantec 2013b). Plant communities were dominated by species typical of the fen (alkaline bog) wetland zone as described by Stewart and Kantrud (1971) such as northern reed grass (*Calamagrostis stricta*), water sedge (*Carex aquatilis var. aquatilis*), woolly sedge (*C. pellita*), golden sedge (*C. aurea*), tufted hair-grass (*Deschampsia cespitosa ssp. cespitosa*), hoary willow (*Salix candida*), spotted water-hemlock (*Cicuta maculata var. maculata*), seaside arrow-grass (*Triglochin maritima*), tall cottongrass (*Eriophorum angustifolium ssp. angustifolium*), northern grass-of-Parnassus (*Parnassia palustris var. tenuis*), and Kalm's lobelia (*Lobelia kalmii*). Submerged mats of muskgrass (*Chara sp*., a genera of green algae) frequently occupied pools of standing water. Patches of Macoun's gentian and marsh felwort were detected in NE-24-37-05-W3 during the 2020 vegetation survey, and a single patch of red bulrush was detected in SE-25-37-05-W3 during the 2021 survey. These three species have also been previously observed in marl wetlands within the Small Swale and Peturrson's Ravine, an area of ecological significance that connects the Northeast Swale to the South Saskatchewan River (Harms 2001; Grilz and Hooey 2020; Government of Saskatchewan 2021; Lineman 1993; Stantec 2013b). Macoun's gentian and marsh felwort were not detected in SE-25-37-05-W3 due to survey timing; however, the presence of marl wetland habitat suggests that they are likely to occur within this quarter section.

Mucronate blue-eyed grass and upland white goldenrod were detected in low prairie/wet meadow transition habitat on the margins of marl wetlands in NE-24-37-05-W3 and SE-25-37-05-W3 during the 2021 survey. These sites supported an assemblage of native and exotic plant species, including Baltic rush (*Juncus balticus*), woolly sedge, tufted hair-grass, Kentucky bluegrass (*Poa pratensis*), wolf willow (*Elaeagnus commutata*), silver buffalo-berry (*Shepherdia argentea*), perennial sow-thistle (*Sonchus arvensis ssp. uliginosus*), Canada goldenrod (*Solidago canadensis*), tufted white aster (*Symphyotrichum ericoides var. pansum*), smooth blue aster (*S. laeve var. geyeri*), and heart-leaved Alexanders (*Zizia aptera*). Upland white goldenrod was previously observed in the Northeast Swale (Grilz and Hooey 2020). Records of mucronate blue-eyed grass occurrences within the swales were not found during the desktop plant SOCC screening or the 2020 SFFPS Environmental and Regulatory Review.

Few-flowered aster was found in saline wet meadows within the Small Swale channel during the 2020 and 2021 surveys. It was often associated with Baltic rush, foxtail barley (*Hordeum jubatum ssp. jubatum*), three-square bulrush (*Schoenoplectus pungens*), prairie bulrush (*Bolboschoenus maritimus ssp. paludosus*), seaside arrow-grass, northern reed grass, sea milkwort (*Lysimachia maritima*), seaside buttercup (*Ranunculus cymbalaria*), and creeping saltbush (*Atriplex prostrata*). It was relatively abundant in SE-25-37-05-W3 along the northern edge of the 2021 vegetation study area. One occurrence in NE-24-37-05-W3 overlapped with an occurrence record from 1965 (Element Occurrence ID No. 9052; Government of Saskatchewan 2021).

Hairy germander was detected in peripheral wet meadow zones surrounding areas of open water in the southern half of NE-24-37-05-W3 and along the northern edge of SE-24-37-05-W3 during the 2020 survey. These areas did not contain marl ponds and plant community composition was not heavily influenced by calcareous groundwater seepage or salinity. Baltic rush, creeping spike-rush (*Eleocharis palustris*), northern reed grass, perennial sow-thistle, woolly sedge, western water-horehound (*Lycopus asper*), and common cattail (*Typha latifolia*) frequently occupied sites where hairy germander was identified. Records of hairy germander occurrences within the swales were not found during the desktop plant SOCC screening exercise or the 2020 SFFPS Environmental and Regulatory Review.

Four plant SOCC were detected on upland sites intersected by the 2020 and 2021 vegetation study areas: plains rough fescue (*Festuca hallii*; *S3*), early cinquefoil (*Potentilla concinna var. concinna*; *S2*), Hudson's cinquefoil (*P. hudsonii*; *S2*), and Crowfoot violet (*Viola pedatifida*; *S3*) (**Figure 4.14**; **Table 4.18**).

Extensive patches of plains rough fescue were found on stony hilltops, knolls, and upper slopes in SE-25-37-05-W3 during the 2021 survey. This climax species assumes a codominant role on these sites along with needle-and-thread grass (*Hesperostipa comata ssp. comata*), northern wheatgrass (*Elymus lanceolatus ssp. lanceolatus*), blue grama (*Bouteloua gracilis*), thread-leaved sedge (*Carex filifolia*), sun sedge (*C. inops ssp. heliophila*), and occasionally sand-grass (*Calamovilfa longifolia var. longifolia*). Common mixed grass prairie forbs like prairie crocus (*Anemone patens var. multifida*), hairy golden aster (*Heterotheca villosa*), pasture sage (*Artemisia frigida*), and broomweed (*Gutierrezia sarothrae*) were also abundant. While this area of native prairie is actively grazed, the relative abundance of plains rough fescue observed in 2021 suggests that grazing pressure has decreased over the past two decades (Stantec 2003). The spatial extents of plains rough fescue patches mapped by SNC-Lavalin in 2021 are estimates. The 2021 vegetation survey was conducted during a period extreme drought (AAFC 2021) and as a result, many prairie grasses (including plains rough fescue) were not in flower at the time of survey. Patch boundaries were largely based on standing litter from the 2020 growing season and are therefore subject to a wider margin of error.

Numerous small patches of native mixed grass prairie vegetation occupied similar landscape positions in NE-23-37-05-W3, NW-24-37-05-W3, SW-25-37-05-W3, and SW-30-37-05-W3. Plains rough fescue was detected on many of these hilltops and knolls during the 2020 and 2021 surveys, although patch sizes were limited due to the encroachment of crested wheatgrass (*Agropyron cristatum*), Kentucky bluegrass, smooth brome grass (*Bromus inermis*), and various weeds, including several species designated as noxious by *The [Saskatchewan] Weed Control Act*. The presence of cobbles and boulders has likely prevented these upland sites from being converted to hayland or cropland. A few small patches of plains rough fescue were also observed on the upper banks of the Small Swale in NE-24-37-05-W3, SE-24-37-05-W3, and SW-24-37-05-W3 during the 2020 survey, which is consistent with the MVA's findings (Grilz and Hooey 2020). These slopes have been largely colonized by crested wheatgrass and smooth brome.

Crowfoot violet, early cinquefoil, and Hudson's cinquefoil were also found in the patches of native prairie described above. Multiple occurrences of crowfoot violet were detected in NE-23-37-05-W3, NW-24-37-05-W3, SW-24-37-05-W3, and SE-25-37-05-W3 during the 2021 and 2020 surveys; two occurrences of Hudson's cinquefoil were detected in SE-25-37-05-W3 in 2021 and 2020; and a single occurrence of early cinquefoil was detected in SW-25-37-05-W3 in 2020. All three species were found on hilltops, knolls, and upper slopes dominated by native graminoids, including plains rough fescue. Crowfoot violet was previously observed in the Northeast and Small Swales, while early cinquefoil was previously observed at the southern edge of the Northeast Swale (Grilz and Hooey 2020; Government of Saskatchewan 2021; Stantec 2013b). Records of Hudson's cinquefoil occurrences within the swales were not found during the desktop plant SOCC screening exercise or the 2020 SFFPS Environmental and Regulatory Review. However, it should be noted that Hudson's cinquefoil was first described as a distinct species in 2018 (Ertter 2018) and may have been previously identified as another member of the *Potentilla rubricaulis* species complex.

4.3.3.2.2 Northeast Swale

Two plant SOCC were detected in the portion of the Northeast Swale wetland complex intersected by the 2020 vegetation study area: narrow-leaved water plantain (*Alisma gramineum*; *S3*) and hairy germander (**Figure 4.14**; **Table 4.18**).

Narrow-leaved water plantain were detected in a peripheral shallow marsh zone surrounding an area of open water on the eastern edge of SE-19-37-04-W3, adjacent to Range Road 3045. Surface water within this zone had receded by the time of the 2020 summer survey, revealing a sparsely vegetated mudflat colonized by forbs typical of the natural drawdown emergent wetland phase, including marsh ragwort (*Tephroseris palustris*), red goosefoot (*Chenopodium rubrum var. rubrum*), saline goosefoot (*Chenopodium glaucum var. salinum*), golden dock (*Rumex fueginus*), and rayless aster (*Symphyotrichum ciliatum*) (Stewart and Kantrud 1971). No other narrow-leaved water plantain occurrences were detected within the 2020 and 2021 vegetation study areas despite the abundance of suitable habitat along the wetland complex margins. However, this species was previously observed elsewhere within the Northeast Swale (Government of Saskatchewan 2021; Stantec 2013b).

A single patch of hairy germander was detected in a wet meadow within the Northeast Swale wetland complex during the 2020 survey. This occurrence is situated in SE-19-37-04-W3, approximately 90 m west of Range Road 3045. Plant community composition favoured normal emergent wetland species such as sprangletop (*Scolochloa festucacea*), Baltic rush, western water horehound, and creeping spike-rush. Two noxious weeds were also abundant at this site: Canada thistle (*Cirsium arvense*) and perennial sow-thistle. Records of hairy germander occurrences within the swales were not found during the desktop plant SOCC screening exercise or the 2020 SFFPS Environmental and Regulatory Review.

Plant SOCC were not detected in the portion of the Northeast Swale wetland complex and surrounding upland areas intersected by the 2021 vegetation study area, despite the presence of potentially suitable habitat. Surface water levels within the complex's central deep marsh zone were lower than normal due to the extreme drought conditions experienced by the region in the summer of 2021 (AAFC 2021). This drawdown exposed large areas of undisturbed bottom soils that would normally remain inundated during the growing season. The outer margins of these mudflats were colonized by natural drawdown emergent vegetation, with red goosefoot and golden dock forming dense mats that may obscure the presence of other plants, including SOCC. SNC-Lavalin also noted the presence of small patches of native prairie vegetation occupying upland sites in NE-20-37-04-W3. These patches were heavily grazed at the time of survey which made plant identification challenging.

4.3.3.2.3 South Saskatchewan River Valley

Four plant SOCC were detected in the portion of the South Saskatchewan River valley intersected by the 2020 and 2021 vegetation study areas: plains rough fescue, Macoun's gentian, low whitlowwort (*Paronychia sessiliflora*; *S3*), and Hudson's cinquefoil (**Figure 4.14**; **Table 4.18**).

Plains rough fescue and Hudson's cinquefoil were detected on western riverbank in NE-26-37-05-W3 during the 2020 vegetation survey. Both species were found growing together on the same slope crest, which supports a patch of native mixed grass prairie vegetation including needle-and-thread grass, northern wheatgrass, blue grama, June grass (*Koeleria macrantha*), thread-leaved sedge, pasture sage, tufted fleabane (*Erigeron caespitosus*), and dotted blazing-star (*Liatris punctata var. punctata*). Nodding thistle (*Carduus nutans*), a noxious weed, and smooth brome grass were also abundant at this site. Similar patches of native prairie vegetation were observed on slope crests and upper slopes along the western bank where tame forage grass cover was absent or sparse. Plains rough fescue was previously observed on the banks of the South Saskatchewan River valley, including at a location within the 2020 and 2021 vegetation study areas (Lineman 2000). Records of Hudson's cinquefoil occurrences within the river valley were not found during the desktop plant SOCC screening exercise or the 2020 SFFPS Environmental and Regulatory Review.

Low whitlowwort was detected on western riverbank in SW-26-37-05-W3 during the 2021 vegetation survey. This species was found growing at the apex of a sparsely vegetated, strongly sloping eroded bank alongside smooth blue beardtongue (*Penstemon nitidus var. nitidus*), narrow-leaved stenotus (*Stenotus armerioides var. armerioides*), and yellow umbrellaplant (*Eriogonum flavum var. flavum*). Records of low whitlowwort occurrences within the river valley were not found during the desktop plant SOCC screening exercise or the 2020 SFFPS Environmental and Regulatory Review.

Macoun's gentian was detected at two locations on the eastern riverbank in SE-26-37-05-W3 during the 2020 vegetation survey. Plant community composition and the presence of marl ponds at these upper floodplain sites are indicative of calcareous groundwater seepage. Many herbaceous plants observed within the Small Swale's marl wetland habitat were also present at these sites, including northern reed grass, water sedge, woolly sedge, spotted water-hemlock, seaside arrow-grass, northern grass-of-Parnassus, flat-top goldenrod (*Euthamia graminifolia var. graminifolia*), and marsh skullcap (*Scutellaria galericulata*). Small-fruited bulrush (*Scirpus microcarpus*), inland sedge (*Carex interior*), northern beaked sedge (*C. utriculata*), and fowl manna grass (*Glyceria striata var. striata*) were also abundant. Short and medium shrubs such as red-osier dogwood (*Cornus sericea ssp. sericea*), hoary willow, false mountain willow (*Salix pseudomonticola*), and swamp birch (*Betula pumila*) appeared frequently in sedge meadows at these sites, while taller woody plants like western river alder (*Alnus incana ssp. tenuifolia*), yellow willow (*Salix famelica*), pussy willow (*S. discolor*), and balsam poplar (*Populus balsamifera ssp. balsamifera*) provided some cover where the seeps approached the lower floodplain. Groundwater seeps within the South Saskatchewan River valley have been previously documented in other locations. Macoun's gentian was observed at two such sites: Peturrson's Ravine and a location west of the Regional Psychiatric Centre grounds (Harms 2001; Lineman 1993 and 2000).

5 Recommendations

5.1 Routing Considerations

A large number of options were initially presented as potential routes in the area as a result of extensive stakeholder consultations and opportunities for environmental expert input. Options included are illustrated in **Figure 1-2** and **Figure 1-3.**

Concept 1 (centered within the original General Location Study 500 m corridor) has the shortest road distance of all concept options considered. The proximity of this concept to McOrmond Drive will create small areas of fragmented wetland and native prairie habitat between the two roadways in the Northeast Swale while allowing a large area of land north of the corridor to remain intact. Noise and visual disturbance to wildlife and wildlife habitat may be reduced (in terms of total area affected by sensory disturbance) by selecting this concept, which is close to an existing source of noise pollution. Concept 1 would require the longer crossing structure (bridge, embankment, etc.) to traverse the open water portion Northeast Swale wetland complex. For the Small Swale, the route will cross over an open water portion of the wetlands in that swale, but also impact some of the potential vegetation and wildlife habitat located on the slopes and upland portions of the Small Swale.

Concept 2 is located between Freeway concept 1 and Freeway Concepts 3 and 4. The proximity of this Concept to McOrmond Drive will create moderately sized areas of fragmented wetland and native prairie habitat between the two roadway. Noise and visual disturbance to wildlife and wildlife habitat may be intermediate compared to other concepts (in terms of total area affected by sensory disturbance). The concept is located just over 400 m from a sharp-tailed grouse lek adjacent to the Small Swale, which is the recommended setback distance for this permanent sensitive wildlife feature (ENV 2017). The concept will also cross a sizeable portion of the Northeast Swale, including the largest open water section of all concepts. This Concept 2 avoids the open water portions of the Small Swale, but still may impact some portions of the vegetation and wildlife habitat located within the slopes and upland portions of the Small Swale. The concept also crosses marl wetland habitat within the Small Swale, which supports several plant SOCC.

Concept and 3 and Concept 4 are discussed together, as they generally overlap for the main route of the Freeway. Freeway Concept 4 (a derivative of Concept 3) minimizes the amount of the open-water in Northeast Swale wetland complex that would be covered by the proposed freeway. However, the location of the concept will result in wetland and native prairie habitat fragmentation in the Swales. The concept is located just over 400 m from a sharp-tailed grouse lek, which is the recommended setback distance for this permanent sensitive wildlife feature (ENV 2017). The concept also crosses marl wetland habitat within the Small Swale, which supports several plant SOCC. This concept avoids the open water portions of the Small Swale, but still may impact some portions of the vegetation and wildlife habitat located within the slopes and upland portions of the small swale. Noise and visual disturbance to wildlife and wildlife habitat may be increased (in terms of total area affected by sensory disturbance) by selecting this concept, as this area is closer to areas of previously undisturbed locations. This concept requires the shortest crossing structure over the Northeast Swale wetland complex, reducing costs and leaving a larger section of open-water swale available for wildlife which utilize the area. There are fewer challenges with wildlife crossing placement here as the topography is suitable for overpass construction compared to other concepts. Although Concept 4 will disturb more area to make way for the Highway 41 realignment, this realignment passes over primarily cultivated land.

All Concepts will impact the Northeast Swale and Small Swale wetland complexes, uncultivated grasslands that support native prairie vegetation, cultivated land, as well as native prairie and riparian forest on the banks of the South Saskatchewan River. These areas provide breeding habitat, migration corridors, and stopover sites for migratory birds including common nighthawk, horned grebe, short-eared owl, and many other SOCC. They also function as breeding and foraging habitat for amphibians, including northern leopard frogs which have been identified in both swale complexes. Mammals such as deer, fox, as well as a number of small mammals utilize these habitats for foraging, rearing, and bedding locations. SOCC and SAR have been observed in all potential concepts, and so mitigation strategies will be required for construction and operation of the freeway. In addition to the loss of wildlife habitat within the project footprint, both concept options will impact wildlife through direct mortality (increased vehicle collisions and/or as a result of construction), reduced habitat connectivity, habitat fragmentation, and behavioral changes or habitat avoidance brought on by increased light and noise exposure. Snow tracking results showed considerable wildlife activity in the area, especially around the swale complexes. However, tracks were also observed inside the cultivated and upland areas as well, indicating wildlife movement between the swales as well as adjacent areas. Species that are area sensitive, road avoidant, or at a high risk of mortality from roadkill are especially likely to be impacted by the proposed project. This includes SAR such as American badger, Baird's sparrow (*Centronyx bairdii*), bobolink (*Dolichonyx oryzivorus*), and short-eared owl (COSEWIC 2010, 2012a, 2012b, and 2021).

All Concepts will impact plant species diversity and community composition through ground disturbance, habitat fragmentation, edge effects, and landscape alteration. Roadside rights-of-way facilitate the spread of invasive and non-native plant species by acting as transmission corridors (Hansen and Clevenger 2005). This includes species designated as noxious by *The [Saskatchewan] Weed Control Act* as well as tame forage grasses. The presence of the roadway may also necessitate changes to local land management practices, such as prescribed burning regimes. A reduction in grassland burn frequency could result in the encroachment of woody vegetation as well as invasive and non-native plant species at the expense of native prairie vegetation, including plant SOCC (Bruynooghe and Macdonald 2008). Both proposed concepts may result in the direct loss of plant SOCC and their habitat depending on roadway placement within the corridors.

5.1.1 Multiple Account Evaluation

Multiple Account Evaluation (MAE) processes were used to assess shortlisted interchange functional plan concepts, river crossing options, and mainline concepts. A modified Delphi method was used to assess concepts.

A process of identifying improvement alternatives and then evaluating them is fundamental to many levels of road infrastructure development and operation: planning, design, construction, maintenance, and operations. Road infrastructure planning has evolved to consider a broad spectrum of elements (Elements) which can be categorized into accounts (Accounts). Common Accounts and respective Elements typically used by road authorities are presented in **Figure 5-1**.

Financial Account

- Capital Construction Cost
- Maintenance Cost
- Operating Cost
- (Optional Revenue a negative cost)

Social Account

- Alignment to Road Network Plans
- Alignment to Social Interests

Road User Account (Customer Account)

- Travel Time
- Vehicle Operating Costs
- Safety Costs

Economic Account

- Direct Employment During Construction
- Indirect Employment Resulting from Construction
- Local Economy

Environmental and Heritage Account

- Green House Gas Emissions
- Biophysical
- Natural Resource
- Heritage

Figure 5-1: Multiple Account Evaluation Accounts and Elements (Evaluation Criteria)

These accounts and elements can be standardized to address a specific road authority’s mandate and/or modified to suit specific project attributes. Accounts and their respective Elements (evaluation criteria) were developed and tailored to suit the Saskatoon Freeway Functional Planning Study (SFFPS) – Phase 2: Roadways and the Phase 2 mainline alignment.

In its simplest form MAE can be completed using a modified Delphi method where a group of subject matter experts considers a range of criteria, respective weightings, ratings, and resulting evaluation points. Each participant provides their assessment of weightings and ratings anonymously. The weightings and rating points are typically averaged and the alternative which exhibits the greatest number of points can be established as the preferred alternative. This structured communication process leads to a collective decision which inherently removes some of the bias potential of individual participants. This method was used for Phase 2 of the SFFPS to assess alternative alignment concepts through the northern portion of the Phase 2 mainline, focussing on the route through the Swales and access to Highway 41. The Delphi method was further modified where account weighting was completed by the Environmental and Heritage TWG experts prior to the actual MAE process. These experts also weighted the elements within the Environmental Account at the same time. This method was used to ensure adequate consideration was given to environmental factors associated with the Small and Northeast Swales.

Further detail of the MAE for northern mainline alignment for Phase 2 of the Saskatoon Freeway Functional Planning Study are included in the SFFPS Phase 2 Functional Design Draft Report.

Alignment functional plan concepts were evaluated using the following order of activities:

1. Three northern alignment (through the Swales) concepts were initially developed through multiple public consultation sessions as described in **Section 1.3**. Two concepts for re-aligning Highway 41 were also developed; however, only one of these concepts was carried forward to the MAE because it

was better suited to local land uses and was better aligned to the travel patterns confirmed in TDM analysis (multiple TDM runs). Ultimately Freeway Concept 4 illustrated in **Figure 1-3** was developed based on Freeway Concept 3 which incorporated the realignment of Highway 41.

2. An Excel workbook was developed and used specifically for the Northern Alignment MAE. The workbook included worksheets for completing the weighting and rating processes, data input worksheets to capture input from each participant, and a summary work sheet;
3. The applicable elements were determined for the four alignment concepts.
4. The weighting for each element was determined by each MAE participant by allotting values to each account and subsequently to each element, with a greater value suggesting greater importance. For example, an element could be weighted 0 if it was not applicable, or 7 if it was important. The sum of the elements weightings within each account equaled the predetermined account weighting. For example, if the Financial Account weighting was predetermined to be 13, the 4 elements within this account could be weighted 7, 0, 4, and 2 (or any other variation of non-negative numbers that add up to 13);
5. The weightings were averaged for each element. As an example, Participant 1, Participant 2, and Participant 3 might weight the importance of Travel Time differently considering the array of elements being considered. Average weightings were calculated as a means of capturing the overall group of participants weighting minimizing potential bias for a specific concept. Note the weighting of the elements was completed in advance of participant ratings. This was also done to minimize the potential for bias when completing the weighting process;
6. Participants rated each of the elements on a scale of 0 to 4 (0 = Unacceptable, 1 = Marginally Acceptable, 2 = Acceptable, 3 = Excellent, 4 = Exemplary);
7. The final MAE results were reviewed by the Ministry of Highway (Ministry)'s Senior Project Manager. The executive team members and subject matter experts met with the Ministry Senior Project Manager to further discuss the top two rated concepts (described in this report as Options 1 and 2);
8. The Environmental and Heritage TWG provided comments and/or challenges to the initial results which ultimately led to a refinement of a north route added outside of the initial 500 m general location corridor; and
9. The preferred interchange functional plan concept was selected.

Based on stakeholder input and the results of the Multiple Account Evaluation process, MAE Concept 3 (Freeway Concept 4 - blue route - **Figure 1-3**) was determined to be the preferred route. Despite being the costliest route, this alignment was selected based on opportunities to minimize impacts of the Saskatoon Freeway on the area in the vicinity of the Small Swale and Northeast Swale.

MAE results for the freeway alignments through the swales are included in **Appendix I**.

5.2 Wildlife Crossings

Wildlife crossings passing under the freeway are incorporated in the vicinity of the Northeast Swale and Small Swale to provide wildlife with a path to safely cross the road, connect habitats, and mitigate wildlife-vehicle collisions (WVC). These should be placed in locations where wildlife are mostly likely to utilize these crossing, within the Northeast and small swales, and along the South Saskatchewan River's banks. There are various types wildlife crossing structures, each with their own advantages and disadvantages. According to the *Wildlife Crossing Structure Handbook Design and Evaluation in North America* (Clevenger and Huijser 2011), wildlife crossing structures can be divided into 11 different designs:

- Overpass, which can be subdivided into four different designs:
    - Landscape bridge – large structures designed exclusively for wildlife use. The large size allows a large diversity of wildlife to use;
    - Wildlife overpass – a structure designed exclusively for wildlife use, similar to landscape bridges but is generally smaller;
    - Multi-use overpass – structure that is designed for wildlife and human use. This structure is generally the smallest type of overpass and is best implemented in human disturbed areas, where it will benefit generalist type species; and
    - Canopy overpass – structures that are designed exclusively for semi-arboreal and arboreal species that commonly use canopy cover for travel;
- Underpass, which can be subdivided into seven different designs:
    - Viaduct/flyover – largest type of underpass with a wide span and vertical clearance, which allows for use by a wide range of wildlife. However, this type of structure is usually not built exclusively for wildlife use;
    - Large mammal underpass – smaller than viaducts but is considered the largest underpass type structure that is designed exclusively for wildlife use. Although this type of structure is designed for use by large mammals, smaller mammals will use the structure as well;
    - Multi-use underpass – this structure is similar to large mammal underpasses (albeit smaller) but is designed for mixed use between wildlife and humans. Large mammals may also use the underpass, if the passageway is sufficiently large enough for them to pass through. If riparian habitat or cover is retained within the underpass, small- and medium-sized may also use this type of structure;
    - Small- to medium-sized mammal underpass – one of the smallest types of underpass, this structure is designed for small- and medium-sized mammals and often restricts large mammals from using it. Use of this type of structure is dependent on how the structure has been modified to fit the species' specific crossing needs (i.e. vegetation);
    - Modified culvert – these structures are designed for riparian habitats or irrigation canals, which are used by small-sized wildlife and sometimes medium-sized wildlife, if the passageway is sufficiently large enough for them to pass through; and
    - Amphibian and reptile tunnels – these structures are designed amphibian and reptile use due to the warm and damp environment inside the tunnel. Other small- and medium-sized mammals may also use these structures.

Some wildlife crossings utilize structures or methods to guide and coax wildlife to use the crossings. Fences are commonly used to prevent wildlife from walking off the crossing and onto the road or railway. Occasionally, bait may be used during the first post-construction years to coax wildlife towards the wildlife crossings (Bissonette and Cramer 2008). Culverts and underpasses may implement wildlife shelves to allow small and medium wildlife to cross when passages are wet (Foresman 2001; 2003) or smaller tunnels to allow reptiles and amphibians to cross (Dodds et al. 2004). Shrubs, logs, and woody debris may be placed around the passageway of crossings to lead wildlife towards the crossing and away from the road or railway (Roof and Wooding 1996).

5.2.1 Structure Dimensions

The size and dimensions of wildlife crossing structures vary depending on various factors including environmental and cost limitations. Ungulates tend to use underpasses that are short in length, relatively wide, and high in vertical clearance (Cramer 2012; Clevenger and Barrueto 2014). This is because it allows wildlife to spend less time in the underpass, allows more wildlife to pass through simultaneously (especially those that travel in groups/packs), and allow larger individuals to use the passage. In terms of importance for improving wildlife crossing effectiveness, shortening the length of the underpass is considered the most important, followed by widening the underpass, and finally raising the height of the underpass (Cramer 2012). Studies have reported varying recommendations for effective structural dimensions, as each species tend to have varying preferences for underpass dimensions (Donaldson 2007; Cramer 2012). **Table 5.1** presents a summary of recommended wildlife crossing structure dimensions for effective use.

Table 5.1: Recommended dimensions for wildlife crossing

Crossing Type	Usage	Target Species Group	Minimum Dimensions	Recommended Dimensions
Landscape bridge	Wildlife Only	All wildlife species Amphibians (if adapted)	W: 230 ft (70 m)	W: >330 ft (>100 m)
Wildlife overpass	Wildlife Only	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Small mammals Reptiles and amphibians (if adapted)	W: 130–165 ft (40–50 m)	W: 165–230 ft (50–70 m)
Multi-use overpass	Mixed use: Wildlife & Human activities	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Small mammals Reptiles and amphibians (if adapted)	W: 32 ft (10 m)	W: 50–130 ft (15–40 m)
Canopy crossing	Wildlife Only	Semi-arboreal mammals	none	none
Viaduct or flyover	Multi-purpose	All wildlife species	none	none

Crossing Type	Usage	Target Species Group	Minimum Dimensions	Recommended Dimensions
Large mammal underpass	Wildlife only	Large mammals High-mobility, medium-sized mammals Low mobility, medium-sized mammals Semi-arboreal & semiaquatic mammals (adapted) Small mammals Amphibians (adapted) Reptiles	W: 23 ft (7 m) H: 13 ft (4 m)	W: >32 ft (>10 m) H: >13 ft (>4 m)
Multi-use underpass	Mixed use: Wildlife & Human activities	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Semi-arboreal & semiaquatic mammals (if adapted) Small mammals Amphibians (if adapted) Reptiles	W: 16.5 ft (5 m) H: 8.2 ft (2.5 m)	W: >23 ft (>7 m) H: >11.5 ft (>3.5 m)
Underpass with waterflow	Wildlife and Drainage	Large mammals High-mobility medium-sized mammals Low mobility medium-sized mammals Semi-arboreal mammals (if adapted) Semi-aquatic mammals Small mammals & amphibians Semi-arboreal mammals & reptiles (if adapted)	W: 6.5 ft path (2 m) H: 10 ft (3 m)	W: >10 ft (>3 m) H: >13 ft (>4 m)

Crossing Type	Usage	Target Species Group	Minimum Dimensions	Recommended Dimensions
Small to medium-sized mammal underpass	Wildlife and seasonal drainage	High-mobility medium-sized mammals (if adapted) Low mobility medium-sized mammals Semi-aquatic mammals (if adapted) Small mammals Amphibians (if adapted) Reptiles	W: 1-4 ft (0.3–1.2 m) H: 1-4 ft (0.3–1.2 m) OR 1 – 4 ft diameter (0.3–1.2 m) Size selection is based on the target species needs or connectivity objective at the site.	W: 1-4 ft (0.3–1.2 m) H: 1-4 ft (0.3–1.2 m) OR 1 – 4 ft diameter (0.3–1.2 m)
Modified Culvert	Wildlife and drainage	High-mobility medium-sized mammals (if adapted) Low mobility medium-sized mammals Semi-aquatic mammals Small mammals Reptiles (if adapted) Amphibians	W: 1.5 ft (0.5 m) Clearance: >3 ft (>1 m)	W: >3 ft (1 m) Clearance: >4 ft (>1.5 m)
Amphibian and reptile tunnel	Wildlife Only	Amphibians Low mobility medium-sized mammals (if adapted) Semi-aquatic (if adapted) Small mammals & reptiles (if adapted)	Dimensions vary depending on target species or taxa or local conditions. Tunnels range from 1–3 ft (0.35–1 m) in diameter	Dimensions vary depending on target species or taxa or local conditions. Tunnels range from 1–3 ft (0.35–1 m) in diameter

(Clevenger and Huijser 2011)

5.2.2 Effectiveness

Various factors will determine the location and type of wildlife crossing structure (overpass, box culvert, etc.) to use. The effectiveness of crossing structures is also heavily dependent on the wildlife within the area. Large ungulates (moose, deer, elk), for instance, are more likely to use overpasses due to the openness of the structure, as opposed to underpass structures (e.g. box culverts) which have a limiting vertical clearance that restricts and deters larger species from using the structure (Clevenger and Waltho 2003; Clevenger et al. 2009; Clevenger and Barrueto 2014). However, some of these species can and do use underpasses if the opening is sufficiently large enough for them to pass through. Previous research suggests a strong tendency for moose to almost exclusively use overpasses, however this preference may be more influenced by the presence of favourable habitat than openness of the passage (Clevenger and Barrueto 2014).

Small and medium-sized mammals, such as skunks and raccoons, are more likely to use enclosed culverts (Servheen et al. 2003). The two attributes that influence small and medium-sized mammal use of underpass-type structures are structural dimensions (length, width, and height) and landscape, specifically vegetation cover (**Table 5.1**) (McDonald and St. Clair 2004; Clevenger and Barrueto 2014). Small mammals are less likely to use overpasses possibly because they are more vulnerable to terrestrial and aerial predators (McDonald and St. Clair 2004).

Amphibians and reptiles tend to make up a relatively greater percentage of road kills presumably due to their ecology and life history. Mortality rates tend to peak for amphibian species that move from terrestrial or aquatic hibernacula to aquatic breeding habitats by crossing roads and other barriers during their spring migration period (COSEWIC 2012; Bennett 2017). Each year, a large number of snakes are killed on roads after emerging from their hibernaculum (Government of Saskatchewan 2020f). They tend to be slow-moving and may not be easily observed by a vehicle traveling on the road (and thus likely to be contacted by a vehicle) compared to larger mammals.

While amphibian and reptiles can utilize most wildlife crossing types (**Table 5.1**), crossings that are used exclusively have been developed and used in other provinces, including Alberta and Ontario (Ontario Ministry of Natural Resources and Forestry 2016). These amphibian/reptile-specific crossings are underpasses built under or sometimes into the road, and may feature modifications that allow these species to pass, such as amphibian walls or drift fences. Amphibians and turtles require warm and damp passages due to their high skin permeability and vulnerability to water loss (Ontario Ministry of Natural Resources and Forestry 2016). Drainage culverts that are designed to drain or equalize water may be used by amphibians and reptiles when they are wet or dry.

Vegetation is also important as many wildlife species rely on it for cover (Cramer 2012). Vegetation also simulates the natural habitat that has been fragmented due to roads or other structures, which may lead wildlife towards the crossing.

The project has incorporated two distinct large mammal wildlife crossings, one in the Northeast Swale and one in the Small Swale. Additional underpass crossings should also be implemented into the final bridge design to allow for continued movement along the South Saskatchewan River. Although the exact requirements for these crossing are not yet determined, the topography is suitable for either underpass or overpass crossings. Multiple small mammal crossings (dry culverts) will likely be installed throughout the roadway. Culverts meant to maintain hydrology will also be suitable for aquatic species in Swales and wetland areas. Underpass crossings have been incorporated into the current design. As part of the design, eastbound and westbound lanes will be separate underpasses as this shortens the length of each underpass and allows natural light to pass between the structures, which should improve wildlife crossing usage.

Additional wildlife mitigation measures, such as fencing has also been incorporated into the design to ensure large wildlife interactions with the roadway and traffic are minimized. The fences should direct wildlife either away from the roadway, or towards crossing structures.

5.3 Future Biological Studies

Future biological studies performed within the Phase 2 area may wish to consider the following recommendations based on the results of the 2020 SFFPS Environmental and Regulatory Review and the Phase 2 Biological Assessment. The areas studied in this report represent areas with likely the greatest environmental significance in the area, but other smaller areas that were not assessed as part of Phase II still may have regulatory and environmental significance. This includes studies conducted in support of a TP and/or EIA/EIS for the proposed project.

Future wildlife studies conducted in support of a TP and/or EIA should include grassland bird and prairie raptor surveys. Grassland bird surveys conducted in accordance with the ENV Grassland Birds Survey Protocol (2020e) are used assess occupancy of grassland bird species, including multiple SOCC identified during desktop screenings performed by SNC-Lavalin. Prairie raptor surveys conduced as per the Alberta Environment and Parks Sensitive Species Inventory Guidelines (2013) are used to detect diurnal raptors (including SOCC) and their nest sites. Depending on when the TP/EA is completed, repeat surveys of those completed in this assessment should be done to ensure data is up-to-date.

Future vegetation studies conducted in support of a TP and/or EIA should include vascular plant surveys conducted in accordance with the ENV Vascular Plant Survey Protocol (2021b) to ensure adequate coverage of the project area. Based on the preliminary vegetation study findings, multiple site visits will be required to capture the detection periods of plant SOCC likely to occur in the Phase 2 area. Three terrestrial surveys are recommended for grasslands that support native prairie vegetation while two surveys should be sufficient for wetlands with emergent vegetation. An aquatic vascular plant survey may be required if the proposed project crosses areas of open water.

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Appendix A

Provincial and Federal Status Rankings

Table A.I Provincial species rank definitions

Rank	Status	Definition
S1	critically imperiled	at very high risk of extirpation in Saskatchewan due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors
S2	imperiled	at high risk of extirpation in Saskatchewan due to restricted range, few populations or occurrences, steep declines, severe threats, or other factors
S3	vulnerable	at moderate risk of extirpation in Saskatchewan due to a restricted range, relatively few populations or occurrences, recent and widespread declines, threats, or other factors
S4	apparently secure	at a fairly low risk of extirpation in Saskatchewan due to an extensive range and/or many populations or occurrences, but with possible cause for some concern as a result of recent declines, threats, or other factors
S5	secure	at very low or no risk of extirpation in Saskatchewan due to an extensive range, abundant populations or occurrences, with little to no concern from declines or threats

Ranks provided by the SKCDC are intended to indicate a species' risk of extirpation. They do not necessarily reflect its management priority. In addition, some species may be rare in the province yet not at risk of extirpation" (SKCDC 2020)

Table A.II Codes and modifiers used to further describe provincial species rankings

Code	Definition
SA	accidental or casual in Saskatchewan, including infrequently reported species that are far outside their range
SB	for a migratory species, applies to the breeding population in Saskatchewan
SH	historical occurrence but without recent verification (e.g., within 20 years)
SM	for a migratory species, applies to the transient (migrant) population
SN	for a migratory species, applies to the non-breeding population in Saskatchewan
SNA	conservation status is not applicable to the species (includes introduced species)
SNR	rank is not yet assigned, or species has not yet been assessed (not ranked)
SU	status uncertain in Saskatchewan because of limited or conflicting information (unraked)
SX	believed to be extinct or extirpated from Saskatchewan

Species rank modification codes provided by the SKCDC (2020)

Table A.III Federal species rank definitions

Rank	Definition
Extinct (X)	a species that no longer exists
Extirpated (XT)	a species no longer existing in the wild in Canada, but occurring elsewhere
Endangered (E)	a species facing imminent extirpation or extinction
Threatened (T)	a species likely to become endangered if limiting factors are not reversed
Special Concern (SC)	a species that is particularly sensitive to human activities or natural events but is not an endangered or threatened species
Data Deficient (DD)	a species for which there is inadequate information to make a direct, or indirect, assessment of its risk of extinction
Not at Risk (NAR)	a species that has been evaluated and found to be not at risk

Species rank modification codes provided by COSEWIC (SKCDC 2020)

Appendix B

Ministry of Environment Research Applications and Permits

- Species Detection Research Permit Applications
- Species Detection Research Permit no. 20SD008
- Species Detection Research Permit no. 20SD034
- Species Detection Research Permit no. 21SD003
- Species Detection Research Permit no. 21SD014

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Ministry of Environment

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Species Detection Application Form

March 2019 | CSB | CSB9003

This 'Species Detection Application Form (SDAF)' contains references to other Sections within the document and hyperlinks to other documents, including the **Conservation Standards Terms and Conditions: Species Detection (CSTC-SD)**. Refer to the references and hyperlinks to ensure a complete and accurate application submission.

Section 1 - Contact Information

Proponent (Company/Agency/RM etc.) that is authorizing the work

Name	**Last Name**	**Company, Organization or Municipality**
Geoff	Meinert	Saskatchewan Ministry of Highways and Infrastructure
Street or PO Box Number		**Apartment/Unit Number**
3603 Millar Avenue		18
City	**Province or State**	**Postal Code or Zip Code**
Saskatoon	Saskatchewan	S7P 0B2
Phone Number	**Mobile Number**	**Email Address**
306-933-5966		Geoffrey.Meinert@gov.sk.ca

Primary Technical Contact (Consultant/Contractor) The individual overseeing the surveys must apply.

Name	**Last Name**	**Company**
Hayden	Yip	SNC-Lavalin Inc.
Street or PO Box Number		**Apartment/Unit Number**
216 1st Avenue South		
City	**Province or State**	**Postal Code or Zip Code**
Sakatoon	Saskatchewan	S7K 1K3
Phone Number	**Mobile Number**	**Email Address**
(306) 250-5329		hayden.yip@snclavalin.com

Secondary Technical Contact (Consultant/Contractor) Required **only** if a second company is subcontracted to conduct the surveys.

Name	**Last Name**	**Company**
Street or PO Box Number		**Apartment/Unit Number**
City	**Province or State**	**Postal Code or Zip Code**
Phone Number	**Mobile Number**	**Email Address**

Section 2 - Personnel

See the **Species Detection Personnel Documents**.

Section 3 - Description of Proponent's Proposed Project

In this section, do not include information regarding the location of the proposed project (belongs in Section 4) or to species detection or wildlife surveys (belongs in Section 6).

Title of Proposed Project – **Do not include the Company name or the word 'proposed' in the title. The title should be specific and unique to the project. See Section 7 for examples and CSTC-SD - B.2.b.**

Saskatoon Freeway Functional Planning Study

Description of Proposed Project

In 100 to 200 words, and in clear, simple language, describe the proposed project at completion. Describe the type of project (e.g. wind energy project, drilling program, pipeline construction, highway twinning, etc.) and details pertaining to it (e.g. number of turbines, well pads, access roads, etc.). **Please do not include information on location - see Section 4.**

Once constructed, the freeway is expected to be a four-lane, 55-kilometre stretch of divided highway that will circle the majority of the City of Saskatoon, with roadway connections at eight provincial highways as well as some municipal roads. It will potentially consist of 16 interchanges, five railway overpasses, two flyovers and one major river crossing. This portion of the project is the functional planning study, aimed to establish preliminary route options and identify environmental hazards and concerns which may influence the project design. Construction of the project is not scheduled, and is not anticipated for at least ten years. The provided construction schedule is an estimate, and is very likely to change over the development of the planning study.

Description of Project Area

Quantify the size (ha) of the proposed project footprint. Estimate the relative percentage of land cover types (e.g. native prairie, tame pasture, cultivated, wetland, bush, forest, etc.) within the footprint. See CSTC-SD - **C.2.**

The project consists of a 500 m corridor which extends around the city of Saskatoon from Highway 7 to Highway 11 (north around the city). The proposed Saskatoon Freeway will be constructed somewhere within this corridor.

Snow track surveys are planned for Phase I and Phase II of the project at this time to assist with project planning. This area extends between Highway 16 and Highway 11 (northeast around the city).

Construction Schedule of Proposed Project

Start: Month September Year 2030 **End:** Month Year

Section 4 - Location of Proposed Project

Lay Description of Proposed Project Location

Use proximity to the nearest community (e.g., Linear – 10 km west of Humboldt, via Colonsay to 14 km south of Govan; Point/Polygon – 3.2 km south and 10 km west of Edam).

The planned route begins at Highway 11 south of Saskatoon and connects with Highway 7 west of the city. The project extends west, north, and east of the city to form a nearly complete loop. Shapefiles are attached with the approximate project corridor. Project location presented below is the approximate centre of Phase I of the project where snow tracking surveys are planned.

Technical Description of Proposed Project Location

Provide one of the following: UTM (preferred); Geographic Coordinates; or legal land description.

UTM Coordinates (approximate center of project)

UTM Zone 13 U Easting 386190 Northing 5787927

Geographic Coordinates (approximate center of project)

Latitude N Longitude W

Legal Land Description

¼ Section or LSD Section Township Range Meridian

Section 5 - Administrative Boundaries, Regulatory Processes and Land Designations

Administrative Boundaries

Use HABISask →Layers Panel (Tab) →Operational Layer → Administrative Layer and check all boxes that apply under each of the administrative boundaries. A project may extend over two or more areas.

Wildlife Ecologist Areas

☐ La Ronge
☐ Meadow Lake
☐ Prince Albert
☒ Yorkton
☐ Swift Current

Ecological Protection Specialists (EPS) Districts

☐ Meadow Lake
☐ Prince Albert
☒ Saskatoon
☐ Regina
☐ Swift Current

Compliance and Field Services Regions

☐ La Ronge
☐ Beauval
☐ Meadow Lake
☐ Prince Albert
☒ Saskatoon
☐ Yorkton
☐ Swift Current

Provincial Parks and Recreation Sites (RS*)

See CSTC-SD -A.2. A Parks, Culture and Sport (PCS) RP is also required!

☐ Athabasca Sand Dunes
☐ Blackstrap
☐ Bronson Forest RS*
☐ Buffalo Pound
☐ Candle Lake
☐ Clarence-Steepbank Lakes
☐ Clearwater River
☐ Crooked Lake
☐ Cypress Hills
☐ Danielson
☐ Douglas
☐ Duck Mountain
☐ Echo Valley
☐ Good Spirit Lake
☐ Great Blue Heron
☐ Greenwater Lake
☐ Katepwa Point
☐ Lac La Ronge
☐ Makwa Lake
☐ Meadow Lake
☐ Moose Mountain
☐ Narrow Hills
☐ Pike Lake
☐ Porcupine Hills
☐ Regina Beach RS*
☐ Rowan's Ravine
☐ Saskatchewan Landing
☐ The Battlefords
☐ Wildcat Hill
☐ Other RSs - list them in your cover e-mail.

Regulatory Processes - See CSTC-SD - D.3.

Check the approval type and subtype for which surveys are being done.

☐ **EPS Approval:**
Include EPS File # (e.g. 16ML123) if assigned.

☐ Oil and Gas Proposal
☐ Linear Proposal
☐ Private Land Checklist
☐ Follow-up Monitoring
☐ *Other - please describe

☐ **Environmental Assessment Approval:**
Include EA File # (e.g. 2017-123) if assigned.

☐ Technical Proposal (TP)
☐ Environmental Impact Statement (EIS)
☐ Supplemental Information
☐ Follow-up Monitoring
☐ *Other - please describe

*Other - please describe

Please describe in the body of the cover email, if required.

List other approvals associated with this project:

Research Permit (RP) #'s (e.g. 16FW123)

Land Manager File # (e.g. 550123)

Aquatic Habitat Protection Permit # 2019-SOWE-107-S1

Other – list type and file #

Land Designations

Check all that apply:

☑ Private ☐ AG Crown ☐ WHPA ☐ Resource Crown ☐ FWDF ☐ Provincial Forest ☐ Federal

☐ Community Pasture (name all)

☐ Co-op Pasture (name all)

☐ Other/additional information:

Section 6 - Species Detection Survey Protocols (SDSPs) for Research Permits and Notifications

Select all of the survey types you plan to conduct. Use the Rare and Endangered Species Report on HABISask to guide survey selection (See CSTC-SD **C.1.a.i.**). See CSTC-SD **B.2.a.** for SDAF application windows and CSTC-SD **D.3.** for data submission deadlines. **Download SDSPs.** Review the **SD Loadform** prior to conducting surveys to ensure a complete and accurate data submission.

Select	ENV SDSPs including using Autonomous Recording Units (ARUs)	
☐	1.0	Amphibian Auditory
☐	1.0A	– Use ARUs
☐	2.0	Amphibian Visual
	2.5	Amphibian Salvage - See CSTC-SD **c.10.**
☐	3.0	Greater Short-horned Lizard
☐	4.0	Snake Hibernacula
☐	5.0	Burrowing Owl
☐	6.0	Short-eared Owl
☐	7.0	Prairie Raptors
☐	8.0	Boreal and Foothills Raptors
☐	9.0	Grassland Birds
☐	9.0A	– Use ARUs
☐	10.0	Forest Birds
☐	10.0A	– Use ARUs
☐	11.0	Sharp-tailed Grouse
☐	12.0	Western Grebe
☐	12.0A	– Use ARUs
☐	13.0	Piping Plover
☐	14.0	Yellow Rail
☐	14.0A	– Use ARUs
☐	15.0	Common Nighthawk
☐	15.0A	– Use ARUs
☐	16.0	Bats - see next column. Contact RP Mailbox for non-acoustic surveys
☐	17.0	Swift Fox
☐	18.0	Ord's Kangaroo Rat
☑	19.0	Snow Track
☐	20.0	Rare Vascular Plant (includes protocol for collection of voucher specimens)

Select	Alternate (Client) SDSPs
	Check or list surveys and for each one, cite all previously issued RPs that authorized this survey type. **Attach a copy of the SDSP Template.**
☐	1. SDSP: Acoustic Bat Approved: RP#
☐	2. SDSP: Diurnal Bird Migration Approved: RP#
☐	3. SDSP: Approved: RP#
☐	4. SDSP: Approved: RP#
☐	5. SDSP: Approved: RP#
☐	6. SDSP: Approved: RP#

Select	Notification - See CSTC-SD - C.9
☐	Nest Search for Migratory Birds (Contact **Environment and Climate Change Canada)**
☐	Trail Camera Monitoring

Section 7 - Required Documentation

Documents must be submitted as separate files (e.g. do not merge into a PDF). Clients are welcome and encouraged to tag a brief file reference to the end of the ENV file labels. See CSTC-SD - Appendices 1 to 4.

☑ Previously submitted **Species Detection Personnel Documents**. Do not include Personnel Documents with this application submission.

☑ Rare and Endangered Species Report for the proposed project footprint plus a 1 km buffer; See **CSTC-SD** **C.1.a.i.** (Use HABISask →HABITools Tab →Rare Species Assessment Buffer). **Label and submit as 'HABISaskRESR';**

☑ A zipped shapefile of the proposed project footprint. **Label and submit as 'Shapefile';**

☑ All Alternate (Client) **SDSP Template(s)** listed in Section 6. See **CSTC-SD** - **C.6.**
Label and submit as 'SDSP_SurveyName' (e.g. SDSP_FallBirdMigration); See CSTC-SD Appendix 2 for details.

☑ List any PCS Recreaton Sites, other than those listed in Section 5, in your cover e-mail; and

Label and submit this Species Detection Application Form (SDAF), using the following naming and case style:

☑ SDAF_Consultant Surname_COMPANYCODE*_Proponent Surname_COMPANY_Project Reference. See examples below:
*For the consulting company, please use a 4 to 7 character standard code using letters and/or numbers; See **CSTC-SD** - Appendix 2

☐ SDAF_Sanderson_ECOTEK1_Porter_OCTANE_Dodsland 14-22-39-24 W3M
☐ SDAF_Richards_D2XS_Rhodes_RM 292 MILTON _Hwy 819 Upgrade
☐ SDAF_Benson_XYZCON_Driver_MHI_Hwy 3 Twinning
☐ SDAF_Daniels_SOUTH_Barnett_BEAUFORT_Kincaid WEP

Label the subject line of your email with the name of the SDAF, above.

With submission of this application, you agree to:

☑ Comply with **Conservation Standards Terms and Conditions: Species Detection**;
☑ Review **SD Loadform** in advance of conducting surveys;
☑ Update **Species Detection Personnel Documents** quarterly, as required; and
☑ **cc the Proponent upon submission.**

Section 8 - Application Submission

☑ I acknowledge that all data, information and documentation submitted are truthful and accurate and no material fact has been omitted.

Signature of Primary Technical Contact on Behalf of Proponent

Date of Application
04-Mar-2020

Please allow a minimum of three weeks for processing. Applications lacking detail or labels will be returned to the applicant, resulting in a delay in assessing and processing the application. For more information regarding Research Permits, please visit the **Wild Species Research Permitting web page** or contact **ENV.researchpermit@gov.sk.ca**. Subscribe to our **Mail-out Lists for updates.**

Mail, fax, or email your completed applications to:
Saskatchewan Ministry of Environment
Fish, Wildlife and Lands Branch
4th Floor, 3211 Albert Street
REGINA SK S4S 5W6
Fax: (306) 787-9544
Email: **ENV.researchpermit@gov.sk.ca**

What if I have questions?
For assistance completing this application or for more information, please contact our Client Service Office:
Email: **centre.inquiry@gov.sk.ca**
Tel (toll free in North America): 1-800-567-4224
Tel (Regina): 306-787-2584

Ministry of Environment

Saskatchewan

Species Detection Application Form

APRIL 2020 | CSB | CSB9003

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Section 1 - Contact Information

Proponent (Company/Agency/RM etc.) that is authorizing the work

Name	**Last Name**	**Company, Organization or Municipality**
Geoff	Meinert	Saskatchewan Ministry of Highways a
Street or PO Box Number		**Apartment/Unit Number**
3603 Millar Avenue		18
City	**Province or State (2 digit)**	**Postal Code or Zip Code**
Saskatoon	SK	S7P 0B2
Phone Number	**Mobile Number**	**Email Address**
306-933-5966		geoffery.meinert@gov.sk.ca

Primary Technical Contact (Consultant/Contractor) The individual overseeing the surveys must apply.

Name	**Last Name**	**Company**
Hayden	Yip	SNC-Lavalin Inc.
Street or PO Box Number		**Apartment/Unit Number**
216 1st Avenue South		
City	**Province or State (2 digit)**	**Postal Code or Zip Code**
Saskatoon	SK	S7K 1K3
Phone Number	**Mobile Number**	**Email Address**
306-250-5329		hayden.yip@snclavalin.com

Secondary Technical Contact (Consultant/Contractor) Required **only** if a second company is subcontracted to conduct the surveys.

Name	**Last Name**	**Company**
Street or PO Box Number		**Apartment/Unit Number**
City	**Province or State (2 digit)**	**Postal Code or Zip Code**
Phone Number	**Mobile Number**	**Email Address**

Section 2 - Personnel

See the **Species Detection Personnel Documents**.

Section 3 - Description of Proponent’s Proposed Project

In this section, do not include information regarding the location of the proposed project (belongs in Section 4) or to species detection or wildlife surveys (belongs in Section 6).

Title of Proposed Project – **Do not include the Company name or the word 'proposed' in the title. The title should be specific and unique to the project. See Section 7 for examples and CSTC-SD - B.4.**

Saskatoon Freeway Functional Planning Study

Description of Proposed Project

In 100 to 200 words, and in clear, simple language, describe the proposed project at completion. Describe the type of project (e.g. wind energy project, drilling program, pipeline construction, highway twinning, etc.) and details pertaining to it (e.g. number of turbines, well pads, access roads, etc.). **Please do not include information on location - see Section 4.**

Once constructed, the freeway is expected to be a four-lane, 55-kilometre stretch of divided highway that will circle the majority of the City of Saskatoon, with roadway connections at eight provincial highways as well as some municipal roads. It will potentially consist of 16 interchanges, five railway overpasses, two flyovers and one major river crossing. This portion of the project is the functional planning study, aimed to establish preliminary route options and identify environmental hazards and concerns which may influence the project design. Construction of the project is not scheduled, and is not anticipated for several (potentially 10+) years. The provided construction schedule is an estimate, and is very likely to change over the development of the planning study. The planning study is being to determine the most likely route of the freeway.

Description of Project Area

Quantify the size (ha) of the proposed project footprint. Estimate the relative percentage of land cover types (e.g. native prairie, tame pasture, cultivated, wetland, bush, forest, etc.) within the footprint. See **CSTC-SD - C.1.b.**

The project consists of a 500 m corridor which extends around the city of Saskatoon from Highway 7 to Highway 11 (north around the city). The proposed Saskatoon Freeway will be constructed somewhere within this corridor. The focus of the study will be primarily within the northeast swale and small swale, but additional high value habitat will also be surveyed within the area as required

Species detection surveys are planned for Phase I and Phase II of the project at this time to assist with project planning. This area extends between Highway 16 and Highway 11 (northeast around the city).

Construction Schedule of Proposed Project

Start: Month (mm, e.g., 10) 9 Year (yyyy) 2030 **End:** Month (mm) Year (yyyy)

Section 4 - Location of Proposed Project

Lay Description of Proposed Project Location

Use proximity to the nearest community (e.g., Linear – 10 km west of Humboldt, via Colonsay to 14 km south of Govan; Point/ Polygon – 3.2 km south and 10 km west of Edam).

The planned route begins at Highway 11 south of Saskatoon and connects with Highway 7 west of the city. The prc

Lands administered by Parks, Culture and Sport (PCS)

☐ Check the box if project intersects lands administered by Parks, Culture and Sport (PCS) (e.g., Provincial Parks, Recreation Sites) and list all that apply, below. See CSTC-SD -A.2. A PCS Research Permit is also required!

Section 5 - Administrative Boundaries, Regulatory Processes and Land Designations

Administrative Boundaries

Use the HABISask Project Screening Report and check all boxes that apply. A project may extend over two or more areas.

Wildlife Ecologist Areas

- ☐ La Ronge
- ☐ Meadow Lake
- ☐ Prince Albert
- ☒ Yorkton
- ☐ Swift Current

Ecological Protection Specialists (EPS) Districts

- ☐ Meadow Lake
- ☐ Prince Albert
- ☒ Saskatoon
- ☐ Regina
- ☐ Swift Current

Compliance and Field Services Regions

- ☐ La Ronge
- ☐ Beauval
- ☐ Meadow Lake
- ☐ Prince Albert
- ☒ Saskatoon
- ☐ Yorkton
- ☐ Swift Current

Regulatory Processes - See CSTC-SD - D.3.

Check the approval type and subtype for which surveys are being done.

☐ **EPS Approval:**
Include EPS File # (e.g. 16ML123) if assigned.

- ☐ Oil and Gas Proposal
- ☐ Linear Proposal
- ☐ Mineral Exploration
- ☐ Private Land Checklist
- ☐ Follow-up Monitoring
- ☐ *Other - please describe

☐ **Environmental Assessment Approval:**
Include EA File # (e.g. 2017-123) if assigned.

- ☐ Technical Proposal (TP)
- ☐ Environmental Impact Statement (EIS)
- ☐ Supplemental Information
- ☐ Follow-up Monitoring
- ☐ *Other - please describe

*Other - please describe

Please describe in the body of the cover email, if required.

List other approvals associated with this project:

Research Permit (RP) #'s (e.g. 16FW123) 20SD008

Land Manager File # (e.g. 550123)

Aquatic Habitat Protection Permit # 2019-SOWE-107-S1

Other – list type and file #

Land Designations

Check all that apply:

☒ Private ☐ AG Crown ☐ WHPA ☐ Resource Crown ☐ FWDF ☐ Provincial Forest ☐ Federal

☐ Community Pasture (name all)

☐ Co-op Pasture (name all)

☐ Other/additional information:

Section 6 - Species Detection Survey Protocols (SDSPs) for Research Permits and Notifications

Select all of the survey types you plan to conduct. Use the **HABISask** Project Screening Report on HABISask to guide survey selection (See **CSTC-SD** **C.1.a.i.**). See **CSTC-SD** **B.2.** for SDAF application windows and **CSTC-SD** **D.3.** for data submission deadlines. **Download SDSPs.** Review the **SD Loadform** prior to conducting surveys to ensure a complete and accurate data submission.

Select	ENV SDSPs including using Autonomous Recording Units (ARUs)	
☒	1.0	Amphibian Auditory
☐	1.0A	– Use ARUs
☐	2.0	Amphibian Visual
☐	2.5	Amphibian Salvage - See **CSTC-SD** **C.4.**
☐	3.0	Greater Short-horned Lizard
☐	4.0	Snake Hibernacula
☐	5.0	Burrowing Owl
☐	6.0	Short-eared Owl
☐	7.0	Prairie Raptors
☐	8.0	Boreal and Foothills Raptors
☐	9.0	Grassland Birds
☐	9.0A	– Use ARUs
☐	10.0	Forest Birds
☐	10.0A	– Use ARUs
☒	11.0	Sharp-tailed Grouse
☐	12.0	Western Grebe
☐	12.0A	– Use ARUs
☐	13.0	Piping Plover
☒	14.0	Yellow Rail
☐	14.0A	– Use ARUs
☒	15.0	Common Nighthawk
☐	15.0A	- Use ARUs
	16.0	Bats - see next column. Contact **SD Mailbox** for non-acoustic surveys
☐	17.0	Swift Fox
☐	18.0	Ord's Kangaroo Rat
☐	19.0	Snow Track
☐	20.0	Rare Vascular Plant (includes protocol for collection of voucher specimens)

Select	Alternate (Client) SDSPs
	Check or list surveys and for each one, cite all previously issued RPs that authorized this survey type. **Attach a copy of the SDSP Template.**
☐	1. SDSP: Acoustic Bat Approved: RP#
☐	2. SDSP: Diurnal Bird Migration Approved: RP#
☐	3. SDSP: Approved: RP#
☐	4. SDSP: Approved: RP#
☐	5. SDSP: Approved: RP#
☐	6. SDSP: Approved: RP#

Select	Notification - See **CSTC-SD** - **C.3.**
☐	Nest Search for Migratory Birds (Contact **Environment and Climate Change Canada)**
☐	Trail Camera Monitoring

Section 7 - Required Documentation

Documents must be submitted as separate files (e.g. do not merge into a PDF). Clients are welcome and encouraged to tag a brief file reference to the end of the ENV file labels. See CSTC-SD - Appendices 1 to 4.

☒ Previously submitted **Species Detection Personnel Documents**. Do not include Personnel Documents with this application submission.

☒ HABISask Project Screening Report for the proposed project footprint plus a 1 km buffer; See **CSTC-SD C.1.a.i.** (Use HABISask →HABITools Tab →Rare Species Assessment Buffer). **Label and submit as 'Project Screening Report';**

☒ A zipped shapefile or KMZ file of the proposed project footprint. **Label and submit as 'Shapefile';**

☐ All Alternate (Client) **SDSP Template(s)** listed in Section 6. See **CSTC-SD - C.1.f.** **Label and submit as 'SDSP_SurveyName' (e.g. SDSP_FallBirdMigration); See CSTC-SD Appendix 2 for details.**

☒ **Label and submit this Species Detection Application Form (SDAF), using the following naming and case style:** SDAF_COMPANYCODE*_Consultant Surname_COMPANY_Project Reference. See examples below:

*For the consulting company, please use a 3 to 7 character standard code using letters and/or numbers; See CSTC-SD - Appendix 2

SDAF_ECOTEK1_Sanderson_OCTANE_Dodsland 14-22-39-24 W3M
SDAF_D2XS_Richards_RM 292 MILTON _Hwy 819 Upgrade
SDAF_XYZCON_Benson_MHI_Hwy 3 Twinning
SDAF_SOUTH_Daniels_BEAUFORT_Kincaid WEP

☒ **Label the subject line of your email with the name of the SDAF, above.**

With submission of this application, you agree to:

☒ Comply with **Conservation Standards Terms and Conditions: Species Detection**;

☒ Review **SD Loadform** in advance of conducting surveys;

☒ Update **Species Detection Personnel Documents**, as required; and

☒ **Cc the Proponent upon submission.**

Section 8 - Application Submission

Save a copy of this form prior to adding the signature - once signed, the form becomes locked to editing.

☒ I acknowledge that all data, information and documentation submitted are truthful and accurate and no material fact has been omitted.

Signature of Primary Technical Contact on Behalf of Proponent	**Date of Application**
	23-April-2020

Please allow a minimum of three weeks for processing. Applications lacking detail or labels will be returned to the applicant, resulting in a delay in assessing and processing the application. For more information regarding Research Permits, please visit the **Wild Species Research Permitting web page** or the **Wild Species Research Permitting content in the Publications Centre** or contact **SD.researchpermit@gov.sk.ca**. Subscribe to our **Mail-out Lists for updates.**

Email your completed applications to:
SD.researchpermit@gov.sk.ca

What if I have questions?
For assistance completing this application or for more information, please contact our Client Service Office:
Email: **centre.inquiry@gov.sk.ca**
Tel (toll free in North America): 1-800-567-4224
Tel (Regina): 306-787-2584

Ministry of Environment

Saskatchewan

Species Detection Application Form

APRIL 2020 | CSB | CSB9003

This 'Species Detection Application Form (SDAF)' contains references to other Sections within the document and hyperlinks to other documents, including the **Conservation Standards Terms and Conditions: Species Detection (CSTC-SD)**. Refer to the references and hyperlinks to ensure a complete and accurate application submission.

Section 1 - Contact Information

Proponent (Company/Agency/RM etc.) that is authorizing the work

Name Geoff
Last Name Meinert
Company, Organization or Municipality Saskatchewan Ministry of Highways a
Street or PO Box Number 3603 Millar Avenue
Apartment/Unit Number 18
City Saskatoon
Province or State (2 digit) SK
Postal Code or Zip Code S7P 0B2
Phone Number 306-933-5966
Mobile Number
Email Address geoffery.meinert@gov.sk.ca

Primary Technical Contact (Consultant/Contractor)

The individual overseeing the surveys must apply.

Name Hayden
Last Name Yip
Company SNC-Lavalin Inc.
Street or PO Box Number 216 1st Avenue South
Apartment/Unit Number
City Saskatoon
Province or State (2 digit) SK
Postal Code or Zip Code S7K 1K3
Phone Number 306-250-5329
Mobile Number
Email Address hayden.yip@snclavalin.com

Secondary Technical Contact (Consultant/Contractor)

Required **only** if a second company is subcontracted to conduct the surveys.

Name
Last Name
Company
Street or PO Box Number
Apartment/Unit Number
City
Province or State (2 digit)
Postal Code or Zip Code
Phone Number
Mobile Number
Email Address

Section 2 - Personnel

See the **Species Detection Personnel Documents**.

Section 3 - Description of Proponent's Proposed Project

In this section, do not include information regarding the location of the proposed project (belongs in Section 4) or to species detection or wildlife surveys (belongs in Section 6).

Title of Proposed Project – **Do not include the Company name or the word 'proposed' in the title. The title should be specific and unique to the project. See Section 7 for examples and CSTC-SD - B.4.**

Saskatoon Freeway Functional Planning Study

Description of Proposed Project

In 100 to 200 words, and in clear, simple language, describe the proposed project at completion. Describe the type of project (e.g. wind energy project, drilling program, pipeline construction, highway twinning, etc.) and details pertaining to it (e.g. number of turbines, well pads, access roads, etc.). **Please do not include information on location - see Section 4.**

Once constructed, the freeway is expected to be a four-lane, 55-kilometre stretch of divided highway that will circle the majority of the City of Saskatoon, with roadway connections at eight provincial highways as well as some municipal roads. It will potentially consist of 16 interchanges, five railway overpasses, two flyovers and one major river crossing. This portion of the project is the functional planning study, aimed to establish preliminary route options and identify environmental hazards and concerns which may influence the project design. Construction of the project is not scheduled, and is not anticipated for several (potentially 10+) years. The provided construction schedule is an estimate, and is very likely to change over the development of the planning study. The planning study is being to determine the most likely route of the freeway.

Description of Project Area

Quantify the size (ha) of the proposed project footprint. Estimate the relative percentage of land cover types (e.g. native prairie, tame pasture, cultivated, wetland, bush, forest, etc.) within the footprint. See **CSTC-SD - C.1.b.**

The project consists of a 500 m corridor which extends around the city of Saskatoon from Highway 7 to Highway 11 (north around the city). The proposed Saskatoon Freeway will be constructed somewhere within this corridor. The focus of the study will be primarily within the northeast swale and small swale, but additional high value habitat will also be surveyed within the area as required

Species detection surveys are planned for Phase I and Phase II of the project at this time to assist with project planning. This area extends between Highway 16 and Highway 11 (northeast around the city).

Construction Schedule of Proposed Project

Start: Month (mm, e.g., 10) 9 Year (yyyy) 2030 **End:** Month (mm) Year (yyyy)

Section 4 - Location of Proposed Project

Lay Description of Proposed Project Location

Use proximity to the nearest community (e.g., Linear – 10 km west of Humboldt, via Colonsay to 14 km south of Govan; Point/ Polygon – 3.2 km south and 10 km west of Edam).

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Lands Administered by Parks, Culture and Sport (PCS)

☐ Check the box if project intersects lands administered by Parks, Culture and Sport (PCS) (e.g., Provincial Parks, Recreation Sites) and list all that apply, below. See CSTC-SD -A.2. A PCS Research Permit is also required!

Section 5 - Administrative Boundaries, Regulatory Processes and Land Designations

Administrative Boundaries

Use the HABISask Project Screening Report and check all boxes that apply. A project may extend over two or more areas.

Wildlife Ecologist Areas

☐ La Ronge
☐ Meadow Lake
☐ Prince Albert
☒ Yorkton
☐ Swift Current

Ecological Protection Specialists (EPS) Districts

☐ Meadow Lake
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☐ Swift Current

Compliance and Field Services Regions

☐ La Ronge
☐ Beauval
☐ Meadow Lake
☐ Prince Albert
☒ Saskatoon
☐ Yorkton
☐ Swift Current

Regulatory Processes - See CSTC-SD - D.3.

Check the approval type and subtype for which surveys are being done.

☐ **EPS Approval:**
Include EPS File # (e.g. 16ML123) if assigned.

☐ Oil and Gas Proposal
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☐ *Other - please describe

☐ **Environmental Assessment Approval:**
Include EA File # (e.g. 2017-123) if assigned.

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☐ Supplemental Information
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☐ *Other - please describe

*Other - please describe

Please describe in the body of the cover email, if required.

List other approvals associated with this project:

Research Permit (RP) #'s (e.g. 16FW123) 20SD008

Land Manager File # (e.g. 550123)

Aquatic Habitat Protection Permit # 2019-SOWE-107-S1

Other – list type and file #

Land Designations

Check all that apply:

☒ Private ☐ AG Crown ☐ WHPA ☐ Resource Crown ☐ FWDF ☐ Provincial Forest ☐ Federal

☐ Community Pasture (name all)

☐ Co-op Pasture (name all)

☐ Other/additional information:

Section 6 - Species Detection Survey Protocols (SDSPs) for Research Permits and Notifications

Select all of the survey types you plan to conduct. Use the **HABISask** Project Screening Report on HABISask to guide survey selection (See **CSTC-SD C.1.a.i.**). See **CSTC-SD B.2.** for SDAF application windows and **CSTC-SD D.3.** for data submission deadlines. **Download SDSPs.** Review the **SD Loadform** prior to conducting surveys to ensure a complete and accurate data submission.

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☐	2.0	Amphibian Visual
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☐	4.0	Snake Hibernacula
☐	5.0	Burrowing Owl
☐	6.0	Short-eared Owl
☐	7.0	Prairie Raptors
☐	8.0	Boreal and Foothills Raptors
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☐	15.0A	- Use ARUs
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☐	17.0	Swift Fox
☐	18.0	Ord's Kangaroo Rat
☒	19.0	Snow Track
☐	20.0	Rare Vascular Plant (includes protocol for collection of voucher specimens)

Select	Alternate (Client) SDSPs
	Check or list surveys and for each one, cite all previously issued RPs that authorized this survey type. **Attach a copy of the SDSP Template.**
☐	1. SDSP: Acoustic Bat Approved: RP#
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☐	3. SDSP: Approved: RP#
☐	4. SDSP: Approved: RP#
☐	5. SDSP: Approved: RP#
☐	6. SDSP: Approved: RP#

Select	Notification - See **CSTC-SD - C.3.**
☐	Nest Search for Migratory Birds (Contact **Environment and Climate Change Canada)**
☐	Trail Camera Monitoring

Section 7 - Required Documentation

Documents must be submitted as separate files (e.g. do not merge into a PDF). Clients are welcome and encouraged to tag a brief file reference to the end of the ENV file labels. See CSTC-SD - Appendices 1 to 4.

☒ Previously submitted **Species Detection Personnel Documents**. Do not include Personnel Documents with this application submission.

☒ HABISask Project Screening Report for the proposed project footprint plus a 1 km buffer; See **CSTC-SD C.1.a.i.** (Use HABISask →HABITools Tab →Rare Species Assessment Buffer). **Label and submit as 'Project Screening Report';**

☒ A zipped shapefile or KMZ file of the proposed project footprint. **Label and submit as 'Shapefile';**

☒ All Alternate (Client) **SDSP Template(s)** listed in Section 6. See **CSTC-SD - C.1.f.**
Label and submit as 'SDSP_SurveyName' (e.g. SDSP_FallBirdMigration); See CSTC-SD Appendix 2 for details.

☒ **Label and submit this Species Detection Application Form (SDAF), using the following naming and case style:**
SDAF_COMPANYCODE*_Consultant Surname_COMPANY_Project Reference. See examples below:

*For the consulting company, please use a 3 to 7 character standard code using letters and/or numbers; See CSTC-SD - Appendix 2

SDAF_ECOTEK1_Sanderson_OCTANE_Dodsland 14-22-39-24 W3M
SDAF_D2XS_Richards_RM 292 MILTON _Hwy 819 Upgrade
SDAF_XYZCON_Benson_MHI_Hwy 3 Twinning
SDAF_SOUTH_Daniels_BEAUFORT_Kincaid WEP

☒ **Label the subject line of your email with the name of the SDAF, above.**

With submission of this application, you agree to:

☒ Comply with **Conservation Standards Terms and Conditions: Species Detection**;

☒ Review **SD Loadform** in advance of conducting surveys;

☒ Update **Species Detection Personnel Documents**, as required; and

☒ **Cc the Proponent upon submission.**

Section 8 - Application Submission

Save a copy of this form prior to adding the signature - once signed, the form becomes locked to editing.

☒ I acknowledge that all data, information and documentation submitted are truthful and accurate and no material fact has been omitted.

Signature of Primary Technical Contact on Behalf of Proponent	**Date of Application**
	23-April-2020

Please allow a minimum of three weeks for processing. Applications lacking detail or labels will be returned to the applicant, resulting in a delay in assessing and processing the application. For more information regarding Research Permits, please visit the **Wild Species Research Permitting web page** or the **Wild Species Research Permitting content in the Publications Centre** or contact **SD.researchpermit@gov.sk.ca**. Subscribe to our **Mail-out Lists for updates.**

Email your completed applications to:
SD.researchpermit@gov.sk.ca

What if I have questions?
For assistance completing this application or for more information, please contact our Client Service Office:
Email: **centre.inquiry@gov.sk.ca**
Tel (toll free in North America): 1-800-567-4224
Tel (Regina): 306-787-2584

Ministry of Environment

Saskatchewan

Species Detection Application Form

MARCH 2021 | CSB | CSB9003

This 'Species Detection Application Form (SDAF)' contains references to other Sections within the document and hyperlinks to other documents, including the **Conservation Standards Terms and Conditions: Species Detection (CSTC-SD)**. Refer to the references and hyperlinks to ensure a complete and accurate application submission.

Section 1 - Contact Information

Proponent (Company/Agency/RM etc.)

The proponent has ultimate authority for the project.

Name	**Last Name**	**Company, Organization or Municipality**
Geoff	Meinert	Saskatchewan Ministry of Highways a
Street or PO Box Number		**Apartment/Unit Number**
3603 Millar Avenue		18
City	**Province or State (2 digit)**	**Postal Code or Zip Code**
Saskatoon	SK	S7P 0B2
Phone Number (###-###-####)	**Mobile Number (###-###-####)**	**Email Address**
306-933-5966		geoffery.meinert@gov.sk.ca

Primary Technical Contact (Consultant/Contractor)

The individual overseeing the surveys must apply.

Name	**Last Name**	**Company**
Hayden	Yip	SNC-Lavalin Inc.
Street or PO Box Number		**Apartment/Unit Number**
216 1st Avenue South		
City	**Province or State (2 digit)**	**Postal Code or Zip Code**
Saskatoon	SK	S7K 1K3
Phone Number (###-###-####)	**Mobile Number (###-###-####)**	**Email Address**
306-250-5329		hayden.yip@snclavalin.com

Secondary Technical Contact (Consultant/Contractor)

See CSTC-SD B.6. COMPLETE ONLY IF a second company is subcontracted to conduct the surveys.

Name	**Last Name**	**Company**
Street or PO Box Number		**Apartment/Unit Number**
City	**Province or State (2 digit)**	**Postal Code or Zip Code**
Phone Number (###-###-####)	**Mobile Number (###-###-####)**	**Email Address**

Section 2 - Personnel

See the **Species Detection Personnel Documents**.

Section 3 - Description of Proponent's Proposed Project

In this section, do not include information regarding the location of the proposed project (belongs in Section 4) or to species detection or wildlife surveys (belongs in Section 6).

Title of Proposed Project – **Do not include the Company name or the words 'proposed' or 'project' in the title. The title should be specific and unique to the project and indicate the project type (e.g. SAGD, Wind Facility). See Section 7 for examples and CSTC-SD - B.3. and 4.**

Saskatoon Freeway Functional Planning Study

Description of Proposed Project

In 100 to 200 words, and in clear, simple language, describe the proposed project at completion. Describe the type of project (e.g. wind energy project, drilling program, pipeline construction, highway twinning, etc.) and details pertaining to it (e.g. number of turbines, well pads, access roads, etc.). **Please do not include information on location - see Section 4., unless it is needed to clarify information in this field).**

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Construction Schedule of Proposed Project

Start: Month (mm, e.g., 10) 9 Year (yyyy) 2030 **End:** Month (mm) Year (yyyy)

Section 4 - Location of Proposed Project

Lay Description of Proposed Project Location

Use proximity to the nearest community (e.g.,10 km west of Humboldt, via Colonsay to 14 km south of Govan; 3.2 km south and 10 km west of Edam; directly south of Bradwell and extending for 7.2 km to the east). See CSTC-SD **B.5.c.** & **Appendix 7**.

Lands Administered by Parks, Culture and Sport (PCS)

☐ Check the box if project intersects lands administered by Parks, Culture and Sport (PCS) (e.g., Provincial Parks, Recreation Sites) and list all that apply, below. See CSTC-SD -A.2. A PCS Research Permit is also required!

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Administrative Boundaries

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Compliance and Field Services Regions

☐ La Ronge
☐ Beauval
☐ Meadow Lake
☐ Prince Albert
☒ Saskatoon
☐ Yorkton
☐ Swift Current

Ecological Management Specialists (EMS) Districts

South

☐ 1
☐ 2
☐ 3
☐ 4
☐ 5
☒ 6
☐ 7
☐ 8

North

☐ 9
☐ 10
☐ 11
☐ 12
☐ 13
☐ 14
☐ 15

Regulatory Processes - See CSTC-SD - D.3.

Check the approval type and subtype for which surveys are being done.

Ecological Management Specialist (EMS) Approval:
Include EMS File # (e.g. 2108###) if assigned.

☐ Oil and Gas Proposal
☐ Linear Proposal
☐ Mineral Exploration
☐ Private Land Checklist
☐ Follow-up Monitoring
☐ Site Reclamation
☐ *Other - please describe

Environmental Assessment (EA) Approval:
Include EA File # (e.g. 2021-###) if assigned.

☐ Technical Proposal (TP)
☐ Environmental Impact Statement (EIS)
☐ Supplemental Information
☐ Follow-up Monitoring
☐ *Other - please describe

*Other - please describe

Please describe in the body of the cover email, if required.

List other approvals associated with this project:

Research Permit (RP) #'s (e.g. 20SD###) 20SD008

Land Manager File # (e.g. 2003###)

Aquatic Habitat Protection Permit # 2019-SOWE-107-S1

Other – list type and file #

Land Designations

Check all that apply:

☒ Private ☐ AG Crown ☐ WHPA ☐ Resource Crown ☐ FWDF ☐ Provincial Forest ☐ Federal

☐ Community Pasture (name all)

☐ Co-op Pasture (name all)

☐ Other/additional information:

Section 6 - Species Detection Survey Protocols (SDSPs) for Research Permits and Notifications

Select all of the survey types you plan to conduct. Use the **HABISask** Project Screening Report on HABISask to guide survey selection (See **CSTC-SD** **C.1.a.i.**). See **CSTC-SD** **B.2.** for SDAF application windows and **CSTC-SD** **D.3.** for data submission deadlines. **Download SDSPs.** Review the **SD Loadform** prior to conducting surveys to ensure a complete and accurate data submission.

Select	ENV SDSPs including using Autonomous Recording Units (ARUs)	
☒	1.0	Amphibian Auditory
☐	1.0A	– Use ARUs
☐	2.0	Amphibian Visual
☐	2.5	Amphibian Salvage - See **CSTC-SD** **C.5.**
☐	3.0	Greater Short-horned Lizard
☐	4.0	Snake Hibernacula
☐	5.0	Burrowing Owl
☒	6.0	Short-eared Owl
☐	7.0	Prairie Raptors
☐	8.0	Boreal and Foothills Raptors
☐	9.0	Grassland Birds
☐	9.0A	– Use ARUs
☐	10.0	Forest Birds
☐	10.0A	– Use ARUs
☒	11.0	Sharp-tailed Grouse
☐	12.0	Western Grebe
☐	12.0A	– Use ARUs
☐	13.0	Piping Plover
☒	14.0	Yellow Rail
☐	14.0A	– Use ARUs
☒	15.0	Common Nighthawk
☐	15.0A	- Use ARUs
	16.0	Bats - see next column. Contact **SD Mailbox** for non-acoustic surveys
☐	17.0	Swift Fox
☐	18.0	Ord's Kangaroo Rat
☐	19.0	Snow Track
☐	20.0	Vascular Plant (includes protocol for collection of voucher specimens)

Select	Alternate (Client) SDSPs
	Check or list alternate (client) SDSPs. See CSTC-SD C.1.f. and Appendix 4. If the SDSP(s) apply to this application and cannot be replicated elsewhere, include a copy of the SDSP template when submitting this SDAF package.
☐	1. SDSP: Acoustic Bat
☐	2. SDSP: Diurnal Bird Migration
☐	3. SDSP: Post Construction Monitoring - Wind Energy Projects
☐	4. SDSP:
☐	5. SDSP:
☐	6. SDSP:

Select	Notification - See **CSTC-SD** - **C.4.**
☐	Nest Search for Migratory Birds (See **Environment and Climate Change Canada)**
☐	Trail Camera Monitoring

Section 7 - Required Documentation

Documents must be submitted as separate files (e.g. do not merge into a PDF). Clients are welcome and encouraged to tag a brief file reference to the end of the ENV file labels. See CSTC-SD - Appendices 1 to 5.

☑ Previously submitted **Species Detection Personnel Forms**. Do not include Personnel Forms with this application submission.

☑ Previously submitted alternate (Client) **SDSP Template(s)** listed in Section 6. See **CSTC-SD** - **C.1.f**. See **CSTC-SD** - **Appendix 3** for labels. **These can be deferred until the 2021 Form is posted!**

☑ Alternate (Client) SDSP Template(s) listed in Section 6 for any surveys designed specifically for this project that cannot be replicated in other areas or for other projects.

☑ HABISask Project Screening Report for the proposed project footprint plus a 1 km buffer; See **CSTC-SD** **C.1.a.i.** (Use HABISask →HABITools Tab →Rare Species Assessment Buffer). **Label and submit as 'HABISask Project Screening Report';**

☑ A zipped shapefile or KMZ file of the proposed project footprint. **Label and submit as 'Shapefile';**

☑ **Label and submit this Species Detection Application Form (SDAF), using the following naming and case style:** SDAF_COMPANYCODE*_Consultant Surname_COMPANY_Project Reference. See examples below:
*For the consulting complany, please use a 3 to 7 character code using letters and/or numbers; See **CSTC-SD** - **Appendix 2.**

SDAF_ECOTEK1_Sanderson_OCTANE_13&14-22-39-24-W3_Pads+Roads
SDAF_TARGET_Richards_RM271ELDON_RoadUpgrade_Waseca
SDAF_XYZCON_Benson_MOH_Hwy2Upgrade_Simpson-Imperial
SDAF_SOUTH_Daniels_BEAUFORT_ WindFacility_Kincaid

☑ **Label the subject line of your email with the name of the SDAF, above.**

With submission of this application, you agree to:

☑ Comply with **Conservation Standards Terms and Conditions: Species Detection**;

☑ Review **SD Loadform** in advance of conducting surveys;

☑ Update **Species Detection Personnel Forms**, as required; and

☑ **Cc the Proponent and other Primary/Secondary Technical Contacts if surveys are subcontracted upon submission.**

Section 8 - Application Submission

Save a copy of this form prior to adding the signature - once signed, the form becomes locked to editing.

☑ I acknowledge that all data, information and documentation submitted are truthful and accurate and no material fact has been omitted.

Signature of Primary Technical Contact on Behalf of Proponent

Date of Application
23-April-2020

Please allow a minimum of three weeks for processing. Applications lacking detail or labels will be returned to the applicant, resulting in a delay in assessing and processing the application. For more information regarding Research Permits, please visit the **Wild Species Research Permitting web page** or the **Wild Species Research Permitting content in the Publications Centre** or contact **SD.researchpermit@gov.sk.ca**. Subscribe to our **Mail-out Lists for updates.**

Email your completed applications to:
SD.researchpermit@gov.sk.ca

What if I have questions?
For assistance completing this application or for more information, please contact our Client Service Office:
Email: **centre.inquiry@gov.sk.ca**
Tel (toll free in North America): 1-800-567-4224
Tel (Regina): 306-787-2584

Government of Saskatchewan

Research Permit
Species Detection

Fish, Wildlife and Lands Branch

20SD008

Type: **SPECIES DETECTION**

Dates: Issue Date = 04-Mar-20; Expiry Date = 30-Apr-20

Permittee: Geoff Meinert of Saskatchewan Ministry of Highways and Infrastructure (Proponent)
#18-3603 Millar Avenue
SASKATOON SK S7P0B2

Regarding: Saskatoon Freeway Functional Planning Study located consists of a 500 m corridor which extends around the city of Saskatoon from Highway 7 to Highway 11 (north around the city). Refer to the Species Detection Application Form (SDAF), attached, for additional information.

To: Authorize the Primary Technical Contact, Hayden Yip of SNC - Lavalin and personnel to conduct species detection surveys, according to Section 6 of the SDAF:

1 ENV Species Detection (SD) Surveys; and
0 non-ministry Surveys*.

In addition to the ***Conservation Standards Terms and Conditions: Species Detection (SD) Surveys***, the following conditions apply:

LEGAL:

Pursuant to Section 21 of *The Wildlife Act, 1998*, failure to comply with permit conditions may result in immediate revocation of the permit; subsequent rejection of further permit applications, and/or possible prosecution under *The Wildlife Act, 1998*.

This Research Permit, the SDAF and the Species Detection Survey Protocol(s) must be carried at all times by personnel conducting the surveys. Electronic versions are acceptable.

INFORMATION SUBMISSIONS:

Review Species Detection Survey Protocols (SDSP) and the Species Detection Loadform (SDLf) prior to beginning surveys.

For any questions regarding permit conditions, please contact ENV.researchpermit@gov.sk.ca.

Related Permits:

2019-SOWE-107-S1

Government of Saskatchewan

Research Permit
Species Detection

Fish, Wildlife and Lands Branch

20SD008

The permit must be signed by the permittee and a copy of the signed permit must be returned to ENV.researchpermit@gov.sk.ca. Please refrain from changing the **Permit number** on the signed copy.

Permittee Signature (Proponent)

March 4, 2020

Date

Executive Director, Fish, Wildlife and Lands Branch, Ministry of Environment (or representative)

Wednesday, March 4, 2020

Date

Government of Saskatchewan

Research Permit Species Detection

Fish, Wildlife and Lands Branch

20SD034

Dates: Issue Date = 10-May-20; Active Date = 23-Apr-20; Expiry Date = 10-Nov-20

Permittee: Geoff Meinert of Saskatchewan Ministry of Highways and Infrastructure (Proponent)
3603 Millar Avenue
SASKATOON SK S7P 0B2

Regarding: Saskatoon Freeway Functional Planning Study located in and around the city of Saskatoon, extending from Highway 7 to Highway 11 (north around the city). Refer to the Species Detection Application Form (SDAF), attached, for additional information.

To: Authorize the Primary Technical Contact, Hayden Yip of SNC-Lavalin Inc. and personnel to conduct species detection surveys, according to Section 6 of the SDAF:

4 ENV Species Detection (SD) Surveys; and
0 non-ministry Surveys*.

In addition to the ***Conservation Standards Terms and Conditions: Species Detection (SD) Surveys***, the following conditions apply:

LEGAL:

Pursuant to Section 21 of *The Wildlife Act, 1998*, failure to comply with permit conditions may result in immediate revocation of the permit; subsequent rejection of further permit applications, and/or possible prosecution under *The Wildlife Act, 1998*.

This SD Research Permit, the SDAF and the SD Survey Protocol(s) must be carried at all times by personnel conducting the surveys. Electronic versions are acceptable.

INFORMATION SUBMISSIONS:

Review SD Survey Protocols (SDSP) and the SD Loadform (SDLf) prior to beginning surveys.

Related Permits:

20SD008

The permit must be signed by the permittee and a copy of the signed permit must be returned to SD.researchpermit@gov.sk.ca. Please refrain from changing the file name (permit number/name) of the signed copy.

For any questions regarding permit conditions, please contact SD.researchpermit@gov.sk.ca.

Permittee Signature (Proponent)

Date

Sunday, May 10, 2020

Executive Director, Fish, Wildlife and Lands Branch, Ministry of Environment (or representative)

Date

Government of Saskatchewan

Research Permit Species Detection

Fish, Wildlife and Lands Branch

21SD003

Dates: Issue Date = 10-Mar-21; Active Date = 11-Feb-21; Expiry Date = 30-Apr-21

Permittee: Geoff Meinert of Ministry of Highways (Proponent)
3603 Millar Avenue
SASKATOON SK S7P 0B2

Regarding: Saskatoon Freeway Functional Planning Study located at Highway 11 south of Saskatoon and connecting with Highway 7 west of the city. Refer to the Species Detection Application Form (SDAF), attached, for additional information.

To: Authorize the Primary Technical Contact, Hayden Yip of SNC-Lavalin Inc. and personnel to conduct species detection surveys, according to Section 6 of the SDAF:

1 ENV Species Detection (SD) Surveys; and
0 non-ministry Surveys*.

In addition to the ***Conservation Standards Terms and Conditions: Species Detection (SD) Surveys***, the following conditions apply:

LEGAL:

Pursuant to Section 21 of *The Wildlife Act, 1998*, failure to comply with permit conditions may result in immediate revocation of the permit; subsequent rejection of further permit applications, and/or possible prosecution under *The Wildlife Act, 1998*.

This SD Research Permit, the SDAF and the SD Survey Protocol(s) must be carried at all times by personnel conducting the surveys. Electronic versions are acceptable.

INFORMATION SUBMISSIONS:

Review SD Survey Protocols (SDSP) and the SD Loadform (SDLf) prior to beginning surveys.

Related Permits:

20SD008; 20SD034

The permit must be signed by the permittee and a copy of the signed permit must be returned to SD.researchpermit@gov.sk.ca. Please see instructions in the cover email.

For any questions regarding permit conditions, please contact SD.researchpermit@gov.sk.ca.

	April 5, 2021
Permittee Signature (Proponent)	**Date**
	Wednesday, March 10, 2021
Executive Director, Fish, Wildlife and Lands Branch, Ministry of Environment (or representative)	**Date**

Government of Saskatchewan

Research Permit Species Detection

Fish, Wildlife and Lands Branch

21SD014

Dates: Issue Date = 27-Apr-21; Active Date = 08-Apr-21; Expiry Date = 10-Nov-21

Permittee: Geoffery Meinert of Ministry of Highways (Proponent)
3603 Millar Avenue
SASKATOON SK S7P 0B2

Regarding: Saskatoon Freeway Functional Planning Study located at Highway 11 south of Saskatoon and connecting with Highway 7 west of the city. The project extends west, north, and east of the city to form a nearly complete loop. Refer to the Species Detection Application Form (SDAF), attached, for additional information.

To: Authorize the Primary Technical Contact, Hayden Yip of SNC-Lavalin Inc. and personnel to conduct species detection surveys, according to Section 6 of the SDAF:

5 ENV Species Detection (SD) Surveys; and
0 non-ministry Surveys*.

In addition to the ***Conservation Standards Terms and Conditions: Species Detection (SD) Surveys***, the following conditions apply:

LEGAL:

Pursuant to Section 21 of *The Wildlife Act, 1998*, failure to comply with permit conditions may result in immediate revocation of the permit; subsequent rejection of further permit applications, and/or possible prosecution under *The Wildlife Act, 1998*.

This SD Research Permit, the SDAF and the SD Survey Protocol(s) must be carried at all times by personnel conducting the surveys. Electronic versions are acceptable.

INFORMATION SUBMISSIONS:

Review SD Survey Protocols (SDSP) and the SD Loadform (SDLf) prior to beginning surveys.

Related Permits:

20SD008, 20SD034, 21SD003

The permit must be signed by the permittee and a copy of the signed permit must be returned to SD.researchpermit@gov.sk.ca. Please see instructions in the cover email.

For any questions regarding permit conditions, please contact SD.researchpermit@gov.sk.ca.

Permittee Signature (Proponent)

April 28, 2020
Date

Executive Director, Fish, Wildlife and Lands Branch, Ministry of Environment (or representative)

Tuesday, April 27, 2021
Date

Appendix C

HABISask Query Results

Table C.I Wildlife SOCC element occurrences within the 2021 desktop study area

Element Occurrence ID	Occurrence Class	Common Name	Scientific Name	Taxonomic Group	SKCDC Ranking	COSEWIC Status	SARA Status	Last Observation
9999128365	vertebrate	American badger	*Taxidea taxus taxus*	mammal	S3; tracked	Special Concern	Schedule 1, Special Concern	2019-09-24
9999128372	vertebrate	American badger	*Taxidea taxus taxus*	mammal	S3; tracked	Special Concern	Schedule 1, Special Concern	2020-04-15
999987264	vertebrate	Baird's sparrow	*Centronyx bairdii*	bird	S4B; tracked	Special Concern	Schedule 1, Special Concern	2013-06-28
9999128394	vertebrate	bank swallow	*Riparia riparia*	bird	S4B, S5M; tracked	Threatened	Schedule 1, Threatened	2020-05-23
9999128395	vertebrate	bank swallow	*Riparia riparia*	bird	S4B, S5M; tracked	Threatened	Schedule 1, Threatened	2020-05-18
9999114725	vertebrate	barn swallow	*Hirundo rustica*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	2019-06-10
9999114726	vertebrate	barn swallow	*Hirundo rustica*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	2019-06-10
9999119392	vertebrate	barn swallow	*Hirundo rustica*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	2016-07-09
9999136993	vertebrate	barn swallow	*Hirundo rustica*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	2021-05-30
9999128411	vertebrate	black-necked stilt	*Himantopus mexicanus*	bird	SNA; tracked	No Status	No Status	2020-05-23
9999136995	vertebrate	bobolink	*Dolichonyx oryzivorus*	bird	S4B, S4M; tracked	Threatened	Schedule 1, Threatened	2021-06-19
9999128484	invertebrate	goldenrod gall fly	*Eurosta solidaginis*	insect	S3; tracked	No Status	No Status	2019-08-24
9999117813	vertebrate	horned grebe	*Podiceps auritus*	bird	S5B, S5M; tracked	Special Concern	Schedule 1, Special Concern	2012-04-14
9999119393	vertebrate	horned grebe	*Podiceps auritus*	bird	S5B, S5M; tracked	Special Concern	Schedule 1, Special Concern	2016-07-09
17500	vertebrate	lake sturgeon	*Acipenser fulvescens*	fish	S2; tracked	Endangered	No Status	2005
999936400	vertebrate	loggerhead shrike	*Lanius ludovicianus excubitorides*	bird	S2B, S2M; tracked	Threatened	Schedule 1, Threatened	2009-07-03
999939443	vertebrate	loggerhead shrike	*Lanius ludovicianus excubitorides*	bird	S2B, S2M; tracked	Threatened	Schedule 1, Threatened	Unknown
999971535	vertebrate	loggerhead shrike	*Lanius ludovicianus excubitorides*	bird	S2B, S2M; tracked	Threatened	Schedule 1, Threatened	2017-05-28
9999100956	vertebrate	loggerhead shrike	*Lanius ludovicianus excubitorides*	bird	S2B, S2M; tracked	Threatened	Schedule 1, Threatened	2017-00-00
9999100957	vertebrate	loggerhead shrike	*Lanius ludovicianus excubitorides*	bird	S2B, S2M; tracked	Threatened	Schedule 1, Threatened	2017-00-00
9999128521	vertebrate	loggerhead shrike	*Lanius ludovicianus excubitorides*	bird	S2B, S2M; tracked	Threatened	Schedule 1, Threatened	2020-05-29
3528	animal assemblage	migratory bird concentration site	n/a	n/a	S3	n/a	n/a	n/a
17798	vertebrate	northern leopard frog	*Lithobates pipiens*	amphibian	S3; tracked	Special Concern	Schedule 1, Special Concern	2020-08-22
9999128573	vertebrate	northern shrike	*Lanius borealis*	bird	S1B, S4N, S4M; tracked	No Status	No Status	2020-04-09
9999102764	vertebrate	osprey	*Pandion haliaetus*	bird	S2B, S2M; tracked	No Status	No Status	2019-08-24
9999128584	vertebrate	peregrine falcon	*Falco peregrinus anatum*	bird	S1B, SNRM; tracked	Not at Risk	Schedule 1, Special Concern	2019-09-12
9999102674	vertebrate	rusty blackbird	*Euphagus carolinus*	bird	S3B, SUN, S3M; tracked	Special Concern	Schedule 1, Special Concern	2018-10-03
9999128634	vertebrate	rusty blackbird	*Euphagus carolinus*	bird	S3B, SUN, S3M; tracked	Special Concern	Schedule 1, Special Concern	2019-10-04
9999128635	vertebrate	rusty blackbird	*Euphagus carolinus*	bird	S3B, SUN, S3M; tracked	Special Concern	Schedule 1, Special Concern	2019-10-04
9999128636	vertebrate	rusty blackbird	*Euphagus carolinus*	bird	S3B, SUN, S3M; tracked	Special Concern	Schedule 1, Special Concern	2019-09-20
9999100952	sensitive wildlife feature (lek)	sharp-tailed grouse	*Tympanuchus phasianellus*	bird	S5; tracked	No Status	No Status	Unknown
9999102837	sensitive wildlife feature (lek)	sharp-tailed grouse	*Tympanuchus phasianellus*	bird	S5; tracked	No Status	No Status	2019-04-07
9999127653	sensitive wildlife feature (lek)	sharp-tailed grouse	*Tympanuchus phasianellus*	bird	S5; tracked	No Status	No Status	2018-03-16
999959241	vertebrate	short-eared owl	*Asio flammeus*	bird	S3B, S2N, S3M; tracked	Threatened	Schedule 1, Special Concern	2010-11-02
9999118314	vertebrate	short-eared owl	*Asio flammeus*	bird	S3B, S2N, S3M; tracked	Threatened	Schedule 1, Special Concern	2012-01-08
9999118315	vertebrate	short-eared owl	*Asio flammeus*	bird	S3B, S2N, S3M; tracked	Threatened	Schedule 1, Special Concern	2014-04-29
999987271	vertebrate	turkey vulture	*Cathartes aura*	bird	S3B, S3M; tracked	No Status	No Status	2013-07-16
9999107470	vertebrate	turkey vulture	*Cathartes aura*	bird	S3B, S3M; tracked	No Status	No Status	2019-05-03
9999104830	vertebrate	whooping crane	*Grus americana*	bird	SXB, S1M; tracked	Endangered	Schedule 1, Endangered	2005-10-09
9999100951	vertebrate	yellow rail	*Coturnicops noveboracensis*	bird	S3B, S3M; tracked	Special Concern	Schedule 1, Special Concern	2016-05-03
9999134900	invertebrate	yellow-banded bumble bee	*Bombus terricola*	insect	S4; tracked	Special Concern	Schedule 1, Special Concern	2021-08-21

Source: (Government of Saskatchewan 2021; SKCDC 2021a and 2021b)

Table C.II Plant SOCC element occurrences within the 2021 vegetation study area

Element Occurrence ID	Occurrence Class	Scientific Name	Common Name	Family	SKCDC Ranking	COSEWIC Status	SARA Status	Last Observation
9052	vascular plant	*Almutaster pauciflorus*	few-flowered aster	Asteraceae	S3; tracked	not ranked	not ranked	1965-08-19
999954865	vascular plant	*Botrychium campestre*	prairie dunewort	Ophioglossaceae	S2; tracked	not ranked	not ranked	1994-06-11
10940	vascular plant	*Carex crawei*	Crawe's sedge	Cyperaceae	S3; tracked	not ranked	not ranked	1993
17173	vascular plant	*Carex saximontana*	Rocky Mountain sedge	Cyperaceae	S3; tracked	not ranked	not ranked	1937-06-16
999984240	vascular plant	*Gentianopsis virgata*	lesser fringed gentian	Gentianaceae	S3; tracked	not ranked	not ranked	2018-09-25
9999134129	vascular plant	*Lemna minor*	lesser duckweed	Lemnaceae	S1; tracked	not ranked	not ranked	2019-04-27
999984241	vascular plant	*Potentilla lasiodonta*	sandhills cinquefoil	Rosaceae	S2; tracked	not ranked	not ranked	1993-08-09
1212	vascular plant	*Silene menziesii*	Menzies' catchfly	Caryophyllaceae	S3; tracked	not ranked	not ranked	1992
9999134127	vascular plant	*Viola pedatifida*	crowfoot violet	Violaceae	S3; tracked	not ranked	not ranked	2019-04-27

Source: (Government of Saskatchewan 2021; SKCDC 2021c)

Appendix D

Wildlife and Wildlife Habitat Study Results

Table D.I Field-observed wildlife species

Species/Taxa	Scientific Name	Class	SKCDC Ranking	COSEWIC Status	SARA Schedule 1 Status	SOCC	ARG Feature	Survey Observed	Incidental	Targeted
American avocet	*Recurvirostra americana*	bird	S4B,S4M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk	✓	
American badger	*Taxidea taxus taxus*	mammal	S3; tracked	Special Concern	Schedule 1, Special Concern	✓		sharp-tailed grouse lek, snow track	✓	
American coot	*Fulica americana*	bird	S5B,S5M	Not at Risk	No status			sharp-tailed lek, yellow rail, common nighthawk	✓	
American crow	*Corvus brachyrhynchos*	bird	S5B,S4N, S5M	No status	No status			sharp-tailed lek, common nighthawk	✓	
American goldfinch	*Spinus tristis*	bird	S5B	No status	No status			common nighthawk, plant	✓	
American kestrel	*Falco sparverius*	bird	S5B,S1N, S5M	No status	No status			sharp-tailed grouse lek, common nighthawk	✓	
American robin	*Turdus migratorius*	bird	S5B,SUN, S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
American white pelican	*Pelecanus erythrorhynchos*	bird	S5B,S5M	Not at Risk	No status	✓	nesting colony	common nighthawk, plant	✓	
American wigeon	*Mareca americana*	bird	S5B,S2N, S5M	No status	No status			plant	✓	
Baltimore oriole	*Icterus galbula*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
barn swallow	*Hirundo rustica*	bird	S5B,S5M; tracked	Threatened	Schedule 1, Threatened	✓		plant	✓	
black tern	*Chlidonias niger*	bird	S5B,S5M	Not at Risk	No status			common nighthawk	✓	
black-billed magpie	*Pica hudsonia*	bird	S5	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
black-capped chickadee	*Poecile atricapillus*	bird	S5	No status	No status			sharp-tailed grouse lek, plant	✓	
black-crowned night heron	*Nycticorax nycticorax*	bird	S4B	No Status	No Status	✓	nesting colony	sharp-tailed grouse lek	✓	
blue-winged teal	*Spatula discors*	bird	S5B,S5M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk, yellow rail, plant	✓	
boreal chorus frog	*Pseudacris maculata*	amphibian	S5	Not at Risk	No status			amphibian, common nighthawk, yellow rail	✓	✓

Species/Taxa	Scientific Name	Class	SKCDC Ranking	COSEWIC Status	SARA Schedule 1 Status	SOCC	ARG Feature	Survey Observed	Incidental	Targeted
Brewer's blackbird	*Euphagus cyanocephalus*	bird	S4B,SUN, S4M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
brown thrasher	*Toxostoma rufum*	bird	S5B,S5M	No status	No status			plant	✓	
brown-headed cowbird	*Molothrus ater*	bird	S5B,SUN, S5M	No status	No status			common nighthawk	✓	
bufflehead	*Bucephala albeola*	bird	S5B,S1N, S3M	No status	No status			sharp-tailed grouse lek, common nighthawk	✓	
cackling goose	*Branta hutchinsii*	bird	S5M	No Status	No Status			sharp-tailed grouse lek	✓	
California gull	*Larus californicus*	bird	S4B,S4M	No Status	No Status			sharp-tailed grouse lek	✓	
Canada goose	*Branta canadensis*	bird	S5B,S2N, S5M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk, snow track, plant	✓	
canvasback	*Aythya valisineria*	bird	S5B,S2N, S5M	No status	No status			sharp-tailed grouse lek, plant	✓	
chipping sparrow	*Spizella passerina*	bird	S5B,S5M	No status	No status			sharp-tailed lek	✓	
clay-coloured sparrow	*Spizella pallida*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, yellow rail, plant	✓	
cliff swallow	*Petrochelidon pyrrhonota*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, plant	✓	
common goldeneye	*Bucephala clangula*	bird	S5B,S3N, S3M	No status	No status			sharp-tailed grouse lek	✓	
common grackle	*Quiscalus quiscula*	bird	S5B	No status	No status			sharp-tailed grouse lek	✓	
common merganser	*Mergus merganser*	bird	S5B,S2N, S4M	No status	No status			plant	✓	
common nighthawk	*Chordeiles minor*	bird	S4B,S4M; tracked	Special Concern	Schedule 1, Threatened	✓	breeding bird	common nighthawk		✓
common raven	*Corvus corax*	bird	S5	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk, plant	✓	
coyote	*Canis latrans*	mammal							✓	
common yellowthroat	*Geothlypis trichas*	bird	S5B,S5M	No status	No status			Common nighthawk, plant	✓	

Species/Taxa	Scientific Name	Class	SKCDC Ranking	COSEWIC Status	SARA Schedule 1 Status	SOCC	ARG Feature	Survey Observed	Incidental	Targeted
dickcissel	*Spiza americana*	bird	SNA	No Status	No Status			sharp-tailed grouse lek	✓	
double-crested cormorant	*Phalacrocorax auritus*	bird	S5B,S5M	Not at Risk	No status	✓	nesting colony	sharp-tailed grouse lek, common nighthawk, plant	✓	
downy woodpecker	*Dryobates pubescens*	bird	S5	No status	No status			plant	✓	
eared grebe	*Podiceps nigricollis*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, plant	✓	
eastern kingbird	*Tyrannus tyrannus*	bird	S5B,S5M	No status	No status			common nighthawk, plant	✓	
European starling	*Sturnus vulgaris*	bird	S4B,S4M	No status	No status			sharp-tailed grouse lek	✓	
Franklin's gull	*Leucophaeus pipixcan*	bird	S4B,S4M	No status	No status			sharp-tailed grouse lek	✓	
gadwall	*Mareca strepera*	bird	S5B,S2N, S5M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk, yellow rail	✓	
grasshopper sparrow	*Ammodramus savannarum*	bird	S4B	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
gray catbird	*Dumetella carolinensis*	bird	S5B,S5M	No status	No status			plant	✓	
gray partridge	*Perdix perdix*	bird	SNA	No status	No status			sharp-tailed grouse lek, common nighthawk, snow track	✓	
great blue heron	*Ardea herodias*	bird	S5B,S5M	No Status	No Status	✓		sharp-tailed grouse lek	✓	
great horned owl	*Bubo virginianus*	bird	S4	No status	No status			sharp-tailed grouse lek, common nighthawk, yellow rail	✓	
greater white-fronted goose	*Anser albifrons*	bird	S5M	No status	No status			sharp-tailed grouse lek	✓	
greater yellowlegs	*Tringa melanoleuca*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk	✓	
green-winged teal	*Anas crecca*	bird	S5B,S2N, S5M	No status	No status			sharp-tailed grouse lek, common nighthawk	✓	
herring gull	*Larus argentatus*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek	✓	

Species/Taxa	Scientific Name	Class	SKCDC Ranking	COSEWIC Status	SARA Schedule 1 Status	SOCC	ARG Feature	Survey Observed	Incidental	Targeted
horned grebe	*Podiceps auritus*	bird	S5B,S5M; tracked	Special Concern	Schedule 1, Special Concern	✓	nesting colony	sharp-tailed grouse lek, common nighthawk	✓	
horned lark	*Eremophila alpestris*	bird	S4B,S3N, SUM	No status	No status			sharp-tailed grouse lek	✓	
house sparrow	*Passer domesticus*	bird	SNA	No status	No status			sharp-tailed grouse lek	✓	
house wren	*Troglodytes aedon*	bird	S5B,S5M	No status	No status			common nighthawk, plant	✓	
killdeer	*Charadrius vociferus*	bird	S5B,S5M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk, yellow rail	✓	
least flycatcher	*Empidonax minimus*	bird	S5B,S5M	No status	No status			plant	✓	
Leconte's sparrow	*Ammospiza leconteii*	bird	S5B,S5M	No status	No status			yellow rail	✓	
lesser scaup	*Aythya affinis*	bird	S5B,S3N, S5M	No status	No status			sharp-tailed grouse lek	✓	
lesser yellowlegs	*Tringa flavipes*	bird	S4B,S4M	No status	No status			common nighthawk	✓	
mallard	*Anas platyrhynchos*	bird	S5B,S5M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk, yellow rail, plant	✓	
marbled godwit	*Limosa fedoa*	bird	S4B,S4M	No status	No status			sharp-tailed grouse lek	✓	
marsh wren	*Cistothorus palustris*	bird	S4B,S4M	No status	No status			sharp-tailed grouse lek, common nighthawk, yellow rail	✓	
merlin	*Falco columbarius*	bird	S5B,S5N, S5M	Not at Risk	No status			sharp-tailed grouse lek	✓	
moose	*Alces alces*	mammal	S5	No status	No status			snow track	✓	
mourning dove	*Zenaida macroura*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
mule deer	*Odocoileus hemionus*	mammal	S4	No status	No status			sharp-tailed grouse lek, snow track	✓	
muskrat	*Ondatra zibethicus*	mammal	S5	No status	No status			snow track	✓	
Nelson's sparrow	*Ammospiza nelsoni*	bird	S5B,S5M	Not at Risk	No status			amphibian	✓	

Species/Taxa	Scientific Name	Class	SKCDC Ranking	COSEWIC Status	SARA Schedule 1 Status	SOCC	ARG Feature	Survey Observed	Incidental	Targeted
North American beaver	*Castor canadensis*	mammal	S5	No status	No status			amphibian, yellow rail, snow track	✓	
North American porcupine	*Erethizon dorsatum*	mammal	S4	No status	No status			sharp-tailed grouse lek, snow track	✓	
northern flicker	*Colaptes auratus*	bird	S5B,SUN, S5M	No status	No status			sharp-tailed grouse lek, common nighthawk	✓	
northern harrier	*Circus hudsonius*	bird	S4B,S4M	Not at Risk	No status			sharp-tailed grouse lek, common nighthawk	✓	
northern leopard frog	*Lithobates pipiens*	amphibian	S3	Special concern	Schedule 1, Special concern	✓	breeding and overwintering habitat	yellow rail	✓	✓
northern pintail	*Anas acuta*	bird	S5B,S4N, S5M	No status	No status			sharp-tailed grouse lek, common nighthawk	✓	
northern shoveler	*Spatula clypeata*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
pied-billed grebe	*Podilymbus podiceps*	bird	S5B,S5M	No status	No status			common nighthawk	✓	
prairie falcon	*Falco mexicanus*	bird	S3B,S3N, S3M; tracked	Not at Risk	No status	✓	nest site	common nighthawk	✓	
red-eyed vireo	*Vireo olivaceus*	bird	S5B,S5M	No status	No status			plant	✓	
red fox	*Vulpes vulpes*	mammal	S5	No status	No status			snow track	✓	
redhead	*Aythya americana*	bird	S5B,S2N, S5M	No status	No status			sharp-tailed grouse lek, common nighthawk	✓	
red-tailed hawk	*Buteo jamaicensis*	bird	S5B,S1N, S5M	Not at Risk	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
red-winged blackbird	*Agelaius phoeniceus*	bird	S5B,SUN, S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, yellow rail, plant	✓	
ring-billed gull	*Larus delawarensis*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk	✓	
ring-necked duck	*Aythya collaris*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek	✓	
rock pigeon	*Columba livia*	bird	SNA	No status	No status			sharp-tailed grouse lek, plant	✓	

Species/Taxa	Scientific Name	Class	SKCDC Ranking	COSEWIC Status	SARA Schedule 1 Status	SOCC	ARG Feature	Survey Observed	Incidental	Targeted
ruddy duck	*Oxyura jamaicensis*	bird	S5B	No status	No status			sharp-tailed grouse lek, common nighthawk, yellow rail	✓	
sandhill crane	*Antigone canadensis*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek	✓	
savannah sparrow	*Passerculus sandwichensis*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
sedge wren	*Cistothorus platensis*	bird	S5B,S5M	Not at Risk	No status			sharp-tailed grouse lek, yellow rail	✓	
sharp-tailed grouse	*Tympanuchus phasianellus*	bird	S5; tracked	No status	No status	✓	lek	sharp-tailed grouse lek, common nighthawk, snow track, plant	✓	✓
short-eared owl	*Asio flammeus*	bird	S3B,S2N, S3M; tracked	Special Concern	Schedule 1, Special Concern	✓	breeding bird	common nighthawk	✓	✓
snow goose	*Anser caerulescens*	bird	S5M	No status	No status			sharp-tailed grouse lek	✓	
song sparrow	*Melospiza melodia*	bird	S5B,S5M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk, yellow rail, plant	✓	
sora	*Porzana carolina*	bird	S5B,S5M	No status	No status			amphibian, common nighthawk, yellow rail, plant	✓	
Swainson's hawk	*Buteo swainsoni*	bird	S4B,S4M	No status	No status			sharp-tailed grouse lek, yellow rail, plant	✓	
tree swallow	*Tachycineta bicolor*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
Trumpeter swan	*Cygnus buccinator*	bird	S3B,S3M	Not at risk	No Status	✓	breeding bird	sharp-tailed grouse lek	✓	
tundra swan	*Cygnus columbianus*	bird	S5M	No status	No status			sharp-tailed grouse lek	✓	
vesper sparrow	*Pooecetes gramineus*	bird	S5B,S5M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk, plant	✓	
Virginia rail	*Rallus limicola*	bird	S4B,S4M	No status	No status			yellow rail	✓	
warbling vireo	*Vireo gilvus*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
western kingbird	*Tyrannus verticalis*	bird	S5B,S5M	No status	No status			sharp-tailed grouse, plant	✓	

Species/Taxa	Scientific Name	Class	SKCDC Ranking	COSEWIC Status	SARA Schedule 1 Status	SOCC	ARG Feature	Survey Observed	Incidental	Targeted
western meadowlark	*Sturnella neglecta*	bird	S4B,S4M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
white-tailed deer	*Odocoileus virginianus*	mammal	S4	No status	No status			sharp-tailed grouse lek, common nighthawk, snow track	✓	
white-tailed jack rabbit	*Lepus townsendii*	mammal	S4	No status	No status			sharp-tailed grouse lek, common nighthawk, snow track	✓	
willet	*Tringa semipalmata*	bird	S4B,S4M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk	✓	
Wilson's phalarope	*Phalaropus tricolor*	bird	S5B,S5M	No status	No status			yellow rail	✓	
Wilson's snipe	*Gallinago delicata*	bird	S5B,S5M	No status	No status			amphibian, sharp-tailed grouse lek, common nighthawk, yellow rail	✓	
wood frog	*Lithobates sylvaticus*	amphibian	S5	No status	No status			amphibian, sharp-tail grouse lek, yellow rail	✓	✓
yellow warbler	*Setophaga petechia*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek, common nighthawk, plant	✓	
yellow-headed blackbird	*Xanthocephalus xanthocephalus*	bird	S5B,S5M	No status	No status			sharp-tailed grouse, common nighthawk, plant	✓	
yellow-rumped warbler	*Setophaga coronata*	bird	S5B,S5M	No status	No status			sharp-tailed grouse lek	✓	

Appendix E

Descriptions of Detected Species of Conservation Concern

Wildlife

Mammals

American badger (*Taxidea taxus taxus*) is a medium-sized weasel that breeds and over-winters in Saskatchewan. This species is considered vulnerable *(S3)* and is tracked within Saskatchewan (SKCDC 2021a). It is also listed as a Schedule 1, species of *Special Concern* under SARA. Adults of this species are characterized by their flat bodies, small ears, long brown, black and grey fur, triangular faces, long claws, and white facial striping. The American badger is nocturnal and primarily resides underground in setts; setts are comprised of a complex network of underground tunnels and chambers that are indicated above ground as single holes or groups of holes and surrounded by loose soil. Typical habitat for the American badger includes open grassland and shrubland. Agricultural areas and roadsides are also commonly inhabited by this species. Mating for this species occurs in late summer and early fall when adult females experience delayed implantation, with pregnancies occurring December to February. Young are born in late March and early April (COSEWIC 2012b). The nocturnal nature of the American badger makes it less likely to encounter without targeted surveying. Noted population declines for the American badger have been connected to the application of rodenticides, unmonitored and unregulated mortality by landowners, vehicle collisions, habitat fragmentation, and loss of grassland habitat to crop conversion. Distribution of the remaining American badger population in Saskatchewan extends from the central part of the province to the south (COSEWIC 2012b).

Birds

American white pelican (*Pelecanus erythrorhynchos*) is a large seabird that breeds in Saskatchewan. The breeding and migrant populations of this species are considered secure (*S5B, S5M*) within Saskatchewan (SKCDC 2021a). The American white pelican is considered *Not at Risk* by COSEWIC and is not listed under SARA. The Saskatchewan ARGs for Sensitive Species apply to American white pelican nesting colonies from 1 May to 31 July annually (ENV 2017). Breeding males and females are characterized by bright orange bill and legs, white plumes on the head, and a laterally flattened “horn” on the upper mandible. American white pelicans breed on isolated islands in freshwater lakes, which can be located over 50 km away from their foraging grounds (Cornell 2022). Nests are established on flat or moderately sloped, gravel, sand or soil. The nests contain one or two eggs, with the first egg laid within a day of nest completion and the second egg laid two days after the first egg. The incubation period for this species is 30 days, and the nestling period ranges from 63 to 70 days. Populations in Canada are steadily increasing, but population growth is limited by human disturbance and permanent destruction of foraging and breeding habitats (Cornell 2022).

Barn swallow (*Hirundo rustica*) is a small-sized grassland passerine that breeds in Saskatchewan. The breeding and migrant populations of this species are considered apparently secure (*S4B, S4M*) and are tracked within Saskatchewan (SKCDC 2021a). The barn swallow is listed as a Schedule 1, *Threatened* species under SARA. Breeding males and females are characterized by rusty-coloured rumps and throats, white foreheads, and deeply forked tails. Alike most swallow species, the barn swallow often nests in loose colonies. Nests contain three to seven eggs and are cup-shaped, made of mud and grasses, and built on eaves, ledges, and other man-made structures that have supporting ledges and roof cover. Rural buildings and structures are common nest sites. The incubation period for this species is 15 days, and the nestling period ranges from 15 to 27 days (Cornell 2022). Though locally abundant in portions of southern Saskatchewan, this species is experiencing a large, inexplicable population decline across Canada. There have been documented losses of nest sites and foraging habitat in agricultural areas, however, the exact causes of the recent population decline are attributed to loss of nesting and foraging habitats due to modernization of farming techniques, population declines in insects, and weather perturbances such as cold snaps on the breeding grounds (Cornell 2022; COSEWIC 2011b).

Black-crowned night heron (*Nycticorax nycticorax*) is stocky bird found in a variety of fresh, salt, and brackish water wetlands. The black-crowned night heron is considered apparently secure (S4B) and is not tracked within Saskatchewan (SKCDC 2021a). The Saskatchewan ARGs for Sensitive Species apply to nesting colonies from 1 April to 31 July annually (ENV 2017). Nesting colonies for the black-crowned night heron have been known to last as long as 50 years with individuals returning annually. Adults have a distinct grey and black plumage with long, white head plumes and orange-red eyes. They are most active at dusk and at night. Black-crowned night herons will lay clutches of 3 to 5 greenish-blue eggs in stick nests, usually in trees or cattails, where both the male and female will raise the brood. Eggs are incubated for 24-26 days, with young leaving the nest after a month. Threats to the night herons include wetland drainage and habitat loss, accumulation of pollutants from agricultural run-off causing reduced water quality as they are highly susceptible (Cornell 2022).

Common nighthawk (*Chordeiles minor*) is a medium-sized crepuscular-active nightjar that breeds in Saskatchewan. The breeding and migrant populations of this species are considered apparently secure (*S4B, S4M*) and are tracked within Saskatchewan (SKCDC 2021a). The Saskatchewan ARGs for Sensitive Species apply to common nighthawk breeding activity from 1 May to 31 August annually (ENV 2017). The common nighthawk is listed as a Schedule 1, *Threatened* species under SARA. Common nighthawks are characterized by their long, pointed wings, and tails. They have characteristic white wing bars on the top and bottom of their wings which are easily visible during flight. The birds are most active near sunrise and sunset, and can be frequently seen eating insects in open grasslands or near woods (Cornell 2019). Nighthawks lay eggs on the ground in a scraped area of ground, but do not build a nest. The incubation period is 16 days to 20 days and the nestling period is 17 days to 18 days. The population in Canada is showing a significant long-term decline, but the exact causes of this decline are unknown. Habitat loss and large-scale pesticide use resulting in lower food availability are likely causes for population reductions (COSEWIC 2007).

Double -crested cormorant (*Phalacrocorax auratus*) is a large diving bird found in open wetlands in southern Saskatchewan. Both the breeding and migratory populations are considered secure (S5B, S5M) (SKCDC 2021a). The Saskatchewan ARGs for Sensitive Species apply to breeding colonies from 1 April to 31 July annually (ENV 2017). Double-crested cormorants are considered Not at Risk, with populations seeing increases across Canada (Government of Canada 2021). Cormorant adults have matte black bodies and yellow-orange facial skin with distinct aquamarine eyes and long necks. Due to having less preen oil than most other birds, cormorants are often seen with their wings spread to allow their feathers to dry. They are avid fishers, diving to catch their prey, and are rarely far from water. Up to two broods of one to seven pale-blue eggs are laid in grass and stick nests each year. Eggs are incubated 25-28 days and young leave the nest after a month. Populations saw a slight decrease due to hunting in the 1800s and early 1900s and suffered from pesticides such as DDT in the past (Cornell 2022).

Great blue heron (*Ardea herodias*) is the largest wading bird in North America. The breeding population of this species is considered secure (*S5B*) and is tracked within Saskatchewan (SKCDC 2021a). The Saskatchewan ARGs for Sensitive Species apply to great blue heron breeding colonies from 1 April to 31 July annually (ENV 2017). The subspecies (*Ardea herodias herodias*) of great blue heron found in Saskatchewan holds no federal ranking and is not listed under SARA. The great blue heron has long, stilt-like legs, a long neck, and a short tail. Adult birds have white heads with a black stripe on each side extending from their yellow eyes to thin black plumes at the back of their head. Their backs are subtle grey-blue in colour while the breast is white streaked with black feathers. Breeding adults look similar though males are typically larger than females. In Saskatchewan, herons nest in breeding colonies called rookeries.

Most herons lay three to five eggs, with incubation lasting approximately 27 to 29 days (Audubon 2022; Cornell 2022). Both males and females are known to incubate eggs and feed young. The nestling period is approximately 50 to 80 days. Young herons are able to fly from one tree to another by eight weeks of age (Cornell 2022).

Horned Grebe (*Podiceps auritus cornutus*) is a small water bird that breeds in Saskatchewan. Both the breeding and migratory populations of horned grebe are considered secure (S5B S5M) and is a tracked species in Saskatchewan (SKCDC 2021a) and are listed as a Schedule 1, species of *Special Concern* under SARA (COSEWIC 2009d). Horned grebes have black heads and backs with red necks and characteristic yellow-orange horn-like tufts on their heads. In the winter, horned grebes are grey and white with a black cap and white cheek (Cornell 2022). Their preferred breeding grounds are open wetlands with plenty of emergent vegetation for nesting material, protection, and concealment from predators. Horned grebes prefer nesting alone and will defend a large territory surrounding the nest (COSEWIC 2009d). Three to eight eggs are laid in nests and are incubated for 23 to 24 days, with young becoming independent at 19 to 21 days later (COSEWIC 2009d, Cornell 2022).

Prairie falcon (*Falco mexicanus*) is primarily found in the open grasslands of southern Saskatchewan. This falcon is considered vulnerable (S3B S3N S3M) and is tracked in Saskatchewan (SKCDC 2021a). The Saskatchewan ARGs for Sensitive Species applies to their nest sites from 15 March to15 July (ENV 2017). Prairie falcons range from light greys to light browns with a characteristic dark patch at the axis or “armpit” of their wings. Male falcons are smaller than the females (Audubon 2022, Cornell 2022). Breeding pairs will spend up to a month looking for a nesting location such as a cliff ledge, tree, powerline structure, or caves. A single brood of two to six brown-spotted cream eggs are laid each year. Incubation lasts 29 to 39 days and nesting will last from 29 to 47 days. Males are known to create their own nests separate from the breeding nest to spend nights away from the breeding nest once the eggs are lain. Degradation and loss of breeding habitat due to human disturbances, agricultural conversion, and pollutants have caused declines in populations (Cornell 2022).

Short-eared owl (*Asio flammeus*) is a medium-sized owl that favours open landscapes (COSEWIC 2021). They are considered vulnerable (S3B, S3N, S3M) and are tracked in Saskatchewan (SKCDC 2021a). A recent update has seen the short-eared owl become listed as *Threatened* by COSEWIC and the species is now under review for its current designation as *special concern* under Schedule 1 of SARA (COSEWIC 2022). The Saskatchewan ARGs for Sensitive Species applies to the breeding bird from 15 March to 1 August (ENV2017). The short-eared owl has a round head with short, often invisible, tufts reminiscent of ears with distinctive, black-rimmed yellow eyes (COSEWIC 2021, Cornell 2022). Short-eared owls prefer open terrains for their habitats such as tundra, marshes, grasslands, and old pastures. Males will court females using a complex series of aerial acrobatics including wing clapping and singing (Audubon 2022, Cornell 2022). The female will build the nest by scraping a depression in the ground and lining it with grasses and feathers and will lay one to two broods of 1-11 white eggs. The female will incubate the eggs for 24 to 37days while the male will defend the nest and bring back food (Audubon 2022, Cornell 2022). Females are particularly sensitive to human activities and disturbances during incubation and have been known to desert their nests if disturbed (COESWIC 2021, Cornell 2022). Nestlings can wander from the nest by foot after 12 to 18 days and are capable of flight by 27 to 36 days (Audubon 2022, Cornell 2022). Breeding short-eared owls are active at all hours of the day but are most active at dawn and dusk. They primarily hunt small mammals, especially voles and shrews, using their hearing (Cornell 2022). The Canadian population is estimated at 31,000 mature individuals, approximately 10% of what was previously estimated. Population trends tend to follow that of small mammals but reduced availability of breeding grounds due to urban development, crop conversion, invasive plants, shrubification of grasslands, and intensive livestock grazing has seen a >30% decline of short-eared owls over the last 30 years. Studies are currently underway and are expected completion in October 2022 (COSEWIC 2022)

Sharp-tailed grouse (*Tympanuchus phasianellus*) is a medium-sized grassland gamebird that breeds and overwinters in Saskatchewan. This species is considered secure *(S5)* and is tracked within Saskatchewan (SKCDC 2021a). The Saskatchewan ARGs for Sensitive Species apply to sharp-tailed grouse leks from .15 March to 15 May annually (ENV 2017). The sharp-tailed grouse is characterized by its overall spotted brown and white colour and pointed white tail. Breeding males and females are similar in size and plumage; however, breeding males also exhibit distinct yellow feathers above the eyebrow and purple-coloured air sacs on the neck. Sharp-tailed grouse are known for engaging in a complex breeding ritual which involves adult males congregating and displaying at communal dancing sites, called leks. These sites are active and most sensitive before sunrise through late morning. The sharp-tailed grouse nests in various grassland habitats where nests are built on the ground under shrubs or thick stands of grass. Nests contain five to 17 eggs, and the incubation period is approximately 24 days. Young are precocial and generally leave the nest the day they hatch (Audubon 2022; Cornell 2022). Slight population declines for the sharp-tailed grouse are related to threats of habitat loss and degradation due to agricultural activities and multi-industry development (Cornell 2022).

Trumpeter swan (*Cygnus buccinator*) is the biggest native waterfowl and one of the heaviest flying birds in North America (Audubon 2022, Cornell 2022). The trumpeter swan is considered vulnerable (S3B, S3M) and is tracked in Saskatchewan (ENV 2017) but considered Not at Risk by COSEWIC (2009d). Mature adults are white with a black bill. They require somewhat shallow wetlands with large amounts of open water in order to have enough room for take-off. Their diets consist mostly of aquatic vegetation or tubers foraged on land. Nests are built with large vegetative mounds, reaching diameters of up to 11 feet, with bowls on top made of softer vegetation and feathers for the eggs. Incubation for the four to six eggs laid lasts 32 to 37 days (Cornell 2022). Young are capable of swimming at less than a day old and are able to fly at 3-4 months. Trumpeter swans form pairs at 2-4 years old but won't start nesting until 4-7 years old (Audubon 2022). Most swans migrate as a family group with the occasional pair separating and finding their own migration group (Cornell 2022).

Amphibians and Reptiles

Northern leopard frog (*Lithobates pipiens*) is a medium-sized frog that breeds and overwinters in Saskatchewan. This species is considered vulnerable *(S3)* and is tracked within Saskatchewan (SKCDC 2021a). The Saskatchewan ARGs for Sensitive Species apply to northern leopard frog breeding and overwintering habitat year-round (ENV 2017). Northern leopard frog is listed as a Schedule 1, species of *Special Concern* under SARA. Breeding males and females are predominantly green in colour, but can be brown or a combination of both, with white-outlined dark spots, and a white underside. The northern leopard frog requires three distinct habitat types to complete their life cycle; breeding habitat, foraging habitat, and overwintering habitat (AESRD 2003; COSEWIC 2009a). As there is limited dispersal capability for this species, these habitats must have some connectivity and be within close proximity to each other (ECCC 2012). Breeding habitats are characterized as semi-permanent or permanent wetlands with a maximum water depth of two metres, a neutral pH, and an absence of fish. Seasonal wetlands are also used for breeding if they do not desiccate prior to August to allow tadpoles to metamorphose (AESRD 2003; COSEWIC 2009a). After breeding, adults move to summer foraging habitats consisting of open areas dominated by low-growing vegetation up to 30 cm, such as fresh meadows, shallow marshes, and grassland (AESRD 2003; Wind 2002). Bare areas, areas of mowed or overgrazed vegetation, tall vegetation over one metre and heavily treed areas are all avoided as summer foraging habitat. Overwintering sites are typically permanent water bodies that do not freeze to the bottom, with low water temperatures and high dissolved oxygen content (AESRD 2003; COSEWIC 2009a; Wind 2002).

Plants

Narrow-leaved water plantain (*Alisma gramineum*), a member of the water-plantain family (Alismataceae), is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). This perennial aquatic forb has distinct emergent and submergent growth forms. Submersed leaves are 15 cm to 100 cm long, sessile, linear, and ribbon-like in appearance. Emergent leaves are 4 cm to 6 cm long, basal, linear-lanceolate to narrowly elliptic, and erect with long petioles that widen at the base. Emergent flowers are borne in open, compound panicles with recurved branches. Petals are light pink in color and appear in early to mid-July in this region (FNA Editorial Committee 1993+; Harms et al. 2018). Narrow-leaved water plantain inhabits the shallow marsh zones of fresh to brackish wetlands, muddy lakeshores and riverbanks, and exposed mudflats in the Dark Brown and Brown Soil Zones of Saskatchewan. Its primary range extends from Manitoba to British Colombia south to Minnesota, Colorado, and California. Isolated populations have been recorded in southeastern Ontario and southwestern Quebec.

Few-flowered aster (*Almutaster pauciflorus*) is the sole species in a monotypic genus and a member of the aster family (Aceraceae). It is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). The much-branched stems of this perennial herb are hairless near the base, glandular towards the top, and range from 10 cm to 50 cm in height (Kershaw et al. 2001). Leaves are linear-lanceolate to linear, entire-margined, somewhat fleshy, and become much smaller upward on the stem. The inflorescence is an open, spreading cluster of flower heads with white to pale purple ray florets, yellow disc florets, and conspicuously glandular involucral bracts that overlap in two or three loose rows. Few-flowered aster is a halophyte that grows in damp alkaline habitats such as salt marshes, alkali flats, and saline wetlands (FNA Editorial Committee 1993+). Its primary range extends from the Northwest Territories to the western Great Plains and the North American Southwest.

Red bulrush (*Blysmopsis rufa*) is the sole species in a monotypic genus and a member of the sedge family (Cyperaceae). It is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). This perennial graminoid has a loosely cespitose growth habit from extensively creeping rhizomes (Harms et al. 2018; Kershaw et al. 2001). Culms are terete to rounded-trigonous, 5 cm to 45 cm in height, with 1 to 3 crescent-shaped basal leaves with ligulate sheaths. The inflorescence is a compressed, solitary, terminal spike bearing reddish-brown spikelets attached to the rachis in two vertical rows with a single leaf-like bract at the base. Red bulrush inhabits salt marshes, spring-fed fens, and brackish to saline wetland habitats. Its North American range includes Alaska and all Canadian provinces and territories except Alberta and British Columbia (FNA Editorial Committee 1993+).

Plains rough fescue (*Festuca hallii*), a member of the grass family (Poaceae), is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). This perennial bunch grass has stiff, narrow leaves with persistent purple sheaths. Culms are densely tufted and range from 15 cm to 85 cm in height. Panicles are typically contracted, with erect or strongly ascending branches (Harms and Leighton 2014). Plains rough fescue is a climax species of fescue prairie grasslands in west-central Saskatchewan (Acton et al. 1998). Its regular range extends from the Aspen Parkland and Moist Mixed Grassland Ecozones of the Canadian prairie provinces south into Montana, Wyoming, and North Dakota (FNA Editorial Committee 1993+). While often locally abundant, plains rough fescue populations within Saskatchewan have declined upwards of 30% over the last 100 years due to agricultural development, air pollution, and encroachment by invasive species and tame forage grasses (SKCDC 2017).

Macoun's gentian (*Gentianopsis virgata ssp. macounii*), a member of the gentian family (Gentianaceae), is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). Macoun’s gentian is an annual forb with multiple erect, simple to few-branched stems 15 cm to 40 cm in height arising from a taproot (Douglas et al. 1999; Looman and Best 1987). Stem leaves are opposite, clasping, linear, and 3 mm to 5 mm wide.

Flowers are terminal (rarely axillary) on long, thin stalks. The four-lobed tubular corollas are deep purple to blue in colour with a conspicuous fringe along the rounded lobe margins. Saskatchewan is home to two subspecies of *G. virgata*: ssp*. macounii* (Macoun's gentian; *S3*) and ssp. *virgata* (lesser fringed gentian; *S3*). Macoun's gentian can be differentiated from lesser fringed gentian by its smaller flowers, which range from 2 cm to 4 cm in length, the inconspicuous calyx keels, and the shorter corolla fringe which does not extend to the corolla throat (Gillett 1963; Looman and Best 1987). This species inhabits moist to wet prairie fens, calcareous seeps, marshy shores, and moist meadows with limy soils. Its regular range extends from Quebec to British Columbia north to the Northwest Territories and south to the Dakotas, Montana, and Iowa (Brouillet et al. 2021a; NatureServe 2021).

Marsh felwort (*Lomatogonium rotatum*), a member of the gentian family (Gentianaceae), is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). This small annual forb has an erect growth habit from a poorly developed fibrous taproot (Kershaw et al. 2001; Looman and Best 1987). The slender, upright stems are 10 cm to 35 cm tall and may be simple or branched with strongly ascending branches. Basal leaves are spatulate and stem leaves are linear to lanceolate, opposite, clasping, and small (1 cm to 3 cm in length, and up to 3 mm wide). The saucer-shaped flowers are borne singly or in clusters arising from the leaf axils, each consisting of a deeply cleft calyx and a white to blueish corolla with widely spreading lobes. Marsh felwort can be found in wet prairie fens, calcareous seeps, marshy shores, and wet meadows with limy soils. This species is widespread across Canada, occurring in every province and territory except for Nova Scotia and Prince Edward Island. Its American range extends from Idaho and Montana south to New Mexico (Brouillet et al. 2021b; NatureServe 2021).

Low whitlowwort (*Paronychia sessiliflora*), a member of the pink family (Caryophyllaceae), is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). This perennial forb/subshrub has a densely cespitose growth habit, forming dense cushions up to 15 cm in diameter from a branching woody caudex (FNA Editorial Committee 1993+; Looman and Best 1987). The densely overlapping leaves are linear, spine-tilled, and very short (5 mm to 6 mm in length). Very small yellow flowers are borne in congested terminal cymes or occur as solitary flowers somewhat obscured by the scale-like leaves. Low whitlowwort can be found on dry, rocky hillsides, ridges, and eroded banks. Its regular range includes much of the American Great Plains as well as Alberta and Saskatchewan (FNA Editorial Committee 1993+).

Early cinquefoil (*Potentilla concinna var. concinna*), a member of the rose family (Rosaceae), is considered imperiled (*S2*) in Saskatchewan (SKCDC 2021c). These perennial forbs are low growing (typically under 10 cm in height) from a course woody caudex (FNA Editorial Committee 1993+). Leaves are mostly basal, palmate, greenish silky above, and densely white woolly below. Loose inflorescences contain two to six yellow flowers that bloom early in the spring, often before the leaves are fully expanded. The Saskatchewan prairies are home to two varieties of *Potentilla concinna*: var. *concinna* (*S2*) and var. *divisa* (*S4*). Variety *concinna* is the compact phase of the species with strictly palmate, short-toothed leaves. It can be differentiated form variety *divisa* by the distal ½ to ¾ of the central leaflet, which is incised ¼ to ½ of the way to the midvein with teeth that measure 1 mm to 3 mm (rarely to 5 mm) in length. Its regular range includes much of the American Great Plains as well as Alberta and Saskatchewan (FNA Editorial Committee 1993+).

Hudson's cinquefoil (*Potentilla hudsonii*), a member of the rose family (Rosaceae), is considered imperiled (*S2*) in Saskatchewan (SKCDC 2021c). This member of the *Potentilla rubricaulis* species complex was first described as a distinct species in 2018 (Ertter 2018). Plants are perennial from a woody caudex with ascending to erect stems measuring 10 cm to 30 cm in height. Basal leaves are deeply incised and grey green to silvery white with densely hairy upper and lower surfaces. Both ternate and palmate basal leaves usually occur on the same plant. Three to ten bowl-shaped yellow flowers are borne in congested inflorescences with branch angles of 10° to 30°. Hudson's cinquefoil can be found in open grasslands or heavily grazed sites with thin, rocky, or sandy soils. It also occurs on gravelly slopes, banks, and roadsides. The core range of this species is the prairies of Saskatchewan and Alberta, extending into the adjacent Montana to southwestern Yukon (Ertter 2018).

Mucronate blue-eyed grass (*Sisyrinchium mucronatum*), a member of the iris family (Iridaceae), is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). The slender, leafless stems of this perennial forb can grow up to 42 cm in height from short rhizomes with fibrous roots (Harms and Leighton 2011). Basal leaves are grass-like in appearance, measuring between 0.9 mm and 2 mm wide. The inflorescence is a terminal scorpioid cyme of one to 11 bluish violet to purple flowers subtended by two unequal spathes. Mucronate blue-eyed grass can be differentiated from other *Sisyrinchium* species in Saskatchewan by the combined presence of stems that lack obvious wings and measure under 2 mm wide, spreading pedicels that greatly surpass the inner spathe, and notched tepals that exceed 9 mm in length. This species can be found in moist grasslands, moist open woods, roadsides, and sandy to rocky open shores (FNA Editorial Committee 1993+; Harms and Leighton 2011). The range of mucronate blue-eyed grass extends from central Saskatchewan to the southwestern edge of Quebec and includes portions of the northern and mid-Atlantic United States. Saskatchewan represents the western extent of its range.

Upland white goldenrod (*Solidago ptarmicoides*), a member of the aster family (Aceraceae), is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). This perennial forb can be distinguished by its flat-topped terminal cluster of flower heads with pale yellow disc florets and white ray florets (Looman and Best 1987). Upland white goldenrod requires sandy, well drained calcareous soils for growth. It can be found in patches of dry to mesic grasslands, limestone outcroppings, calcareous flats, fen margins, sandy coulees, and roadside rights-of-way (FNA Editorial Committee 1993+). Its range extends from Quebec to Saskatchewan south to South Carolina, Arkansas, and Colorado. Saskatchewan represents the northwestern extent of its range.

Hairy germander (*Teucrium canadense var. occidentale*), a member of the mint family (Lamiaceae), is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). This perennial forb feels silky-hairy to the touch and grows in colonies from rhizomes that occasionally produce tubers (Looman and Best 1987; W.P. Fraser Herbarium 2006). The square, branching stems range from 30 cm to 75 cm in height. Narrowly ovate to lanceolate leaves are arranged in opposite short-stalked pairs along the stem, which terminates in a spike-like raceme of irregular purple flowers that elongates as the plant matures. Hairy germander can be differentiated from other mint species in Saskatchewan by inconspicuous upper corolla lip, which is reduced to two small, pointed lobes. It inhabits wet meadows, wetland margins, lake and stream shore flats, and prairie depressions (W.P. Fraser Herbarium 2006). The Canadian range of this species spans all mainland provinces except for Alberta. It also occurs throughout the western, central, and northeastern United States (NatureServe 2021).

Crowfoot violet (*Viola pedatifida*), a member of the violet family (Violaceae), is considered vulnerable (*S3*) in Saskatchewan (SKCDC 2021c). This low-growing perennial forb is stemless, with leaves and flower stalks arising from thick, fleshy rhizomes (FNA Editorial Committee 1993+; Kershaw et al. 2001). The diagnostic palmate leaves are deeply cleft into three parts, which are each further divided into two to four linear lobes. Solitary, irregular flowers are borne on nodding, leafless stalks. Flowers are bright violet in colour with bearded lower petals and conspicuous spurs. This prairie species can be found in open grasslands, dry gravelly hillsides, exposed banks, and disturbed sites. The regular range of crowfoot violet extends from Ontario to Alberta south to the central United States (FNA Editorial Committee 1993+).

Appendix F

Biological Assessment Photographs

Narrow-leaved water plantain (*Alisma gramineum*)
1 September 2020; SE-19-37-04-W3

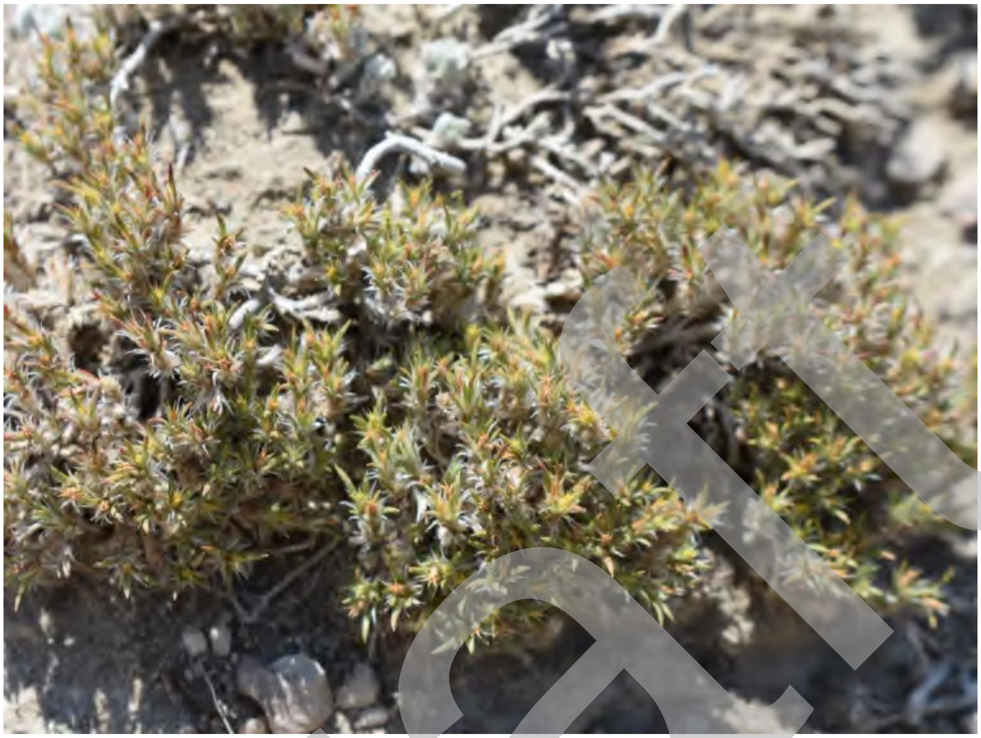
Few-flowered aster (*Almutaster pauciflorus*)
30 August 2020; NE-24-37-04-W3

Red bulrush (*Blysmopsis rufa*)
23 July 2021; SE-25-37-04-W3

Plains rough fescue (*Festuca hallii*)
5 June 2020; NW-24-37-04-W3

Macoun's gentian (*Gentianopsis virgata ssp. macounii*)
29 August 2020; NE-24-37-04-W3

Marsh felwort (*Lomatogonium rotatum*)
30 August 2020; NE-24-37-04-W3



Low whitlowwort (*Paronychia sessiliflora*)
24 July 2021; SW-26-37-05-W3

Early cinquefoil (*Potentilla concinna var. concinna*)
3 June 2020; SW-25-37-05-W3

Hudson's cinquefoil (*Potentilla hudsonii*)
31 May 2021; SE-25-37-05-W3

Mucronate blue-eyed grass (*Sisyrinchium mucronatum*)
25 July 2021; SE-25-37-05-W3

**Upland white goldenrod (*Solidago ptarmicoides*)
22 July 2021; NE-24-37-04-W3**

**Hairy germander (*Teucrium canadense var. occidentale*)
29 August 2020; NE-24-37-04-W3**

Crowfoot violet (*Viola pedatifida*)
5 June 2020; NW-24-37-04-W3

Marl wetland formed by groundwater seepage in the Small Swale (Macoun's gentian and marsh felwort detected)
22 July 2021, NE-24-37-05-W3

Marl pond formed by groundwater seepage in the Small Swale (marsh felwort detected)
28 August 2020; NE-24-37-05-W3

Marl wetland formed by groundwater seepage in the Small Swale (red bulrush detected)
23 July 2021; SE-25-37-04-W3

Low prairie/wet meadow transition zone in the Small Swale (mucronate blue-eyed grass and upland white goldenrod detected)
22 July 2021; NE-24-37-05-W3

Saline wet meadow in the Small Swale (few-flowered aster detected)
23 July 2021; SE-25-37-05-W3

Wet meadow zone in the Small Swale (hairy germander detected)
29 August 2020; SE-24-37-04-W3

Native prairie vegetation on hilltop (plains rough fescue and Hudson’s cinquefoil detected)
31 May 2021; SE-25-37-05-W3

Patch of plains rough fescue on upper slope (crowfoot violet also detected)
8 June 2020; NW-24-37-04-W3

Native prairie vegetation on hilltop (plains rough fescue and early cinquefoil detected)
3 June 2020; SW-25-37-05-W3

Shallow marsh zone natural drawdown emergent phase in the Northeast Swale (narrow-leaved water plantain detected)
1 September 2020; SE-19-37-04-W3

Wet meadow zone in the Northeast Swale (hairy germander detected)
1 September 2020; SE-19-37-04-W3

Shallow marsh zone natural drawdown emergent phase in the Northeast Swale
28 July 2021; NW-20-37-04-W3

Shallow and deep marsh zones drawdown bare soil phase in the Northeast Swale
28 July 2021; SW-20-37-04-W3

Native prairie vegetation on the upper western bank of the South Saskatchewan River (plains rough fescue and Hudson's cinquefoil detected)
4 June 2020; NE-26-37-04-W3

Eroded slope on the upper western bank of the South Saskatchewan River (low whitlowwort detected)
4 June 2020; SE-26-37-04-W3

Green ash riparian forest on the lower western bank of the South Saskatchewan River
30 May 2021; SE-26-37-04-W3

Marl wetland formed by groundwater seepage on the South Saskatchewan River's eastern floodplain (Macoun's gentian detected)
1 September 2020; SE-19-37-04-W3

Marl pond formed by groundwater seepage on the South Saskatchewan River's eastern floodplain
2 June 2020; SE-26-37-04-W3

Appendix G

Vascular Plant Taxa Detected During the Preliminary Vegetation Study

Table G.I Inventory of vascular plant taxa detected during the 2020 and 2021 vegetation surveys

Scientific Name	Common Name	Family	Origin	SKCDC Ranking	SOCC	*The* [SK] *Weed Control Act* Designation	Small Swale and Surrounding Areas	Northeast Swale and Surrounding Areas	South Saskatchewan River Valley
Acer negundo var. interius	Manitoba maple	Aceraceae	native	S5			✓	✓	✓
Acer spicatum	mountain maple	Aceraceae	native	S4					✓
Achillea millefolium	common yarrow	Asteraceae	native	S5			✓	✓	✓
Actaea rubra	red baneberry	Ranunculaceae	native	S4					✓
Agoseris glauca var. glauca	false dandelion	Asteraceae	native	S4			✓		✓
Agrimonia striata	agrimony	Rosaceae	native	S4					✓
Agropyron cristatum	crested wheatgrass	Poaceae	introduced	SNA			✓	✓	✓
Agrostis scabra var. scabra	hair grass	Poaceae	native	S4			✓	✓	
Alisma gramineum	narrow-leaved water plantain	Alismataceae	native	S3	✓			✓	
Alisma triviale	broad-leaved water plantain	Alismataceae	native	S4			✓		✓
Allium textile	prairie onion	Liliaceae	native	S4			✓		✓
Almutaster pauciflorus	few-flowered aster	Asteraceae	native	S3	✓		✓		
Alnus incana ssp. tenuifolia	western river alder	Betulaceae	native	S4					✓
Alopecurus aequalis var. aequalis	water foxtail	Poaceae	native	S4			✓	✓	
Amaranthus retroflexus	red-root pigweed	Amaranthaceae	introduced	SNA				✓	
Ambrosia psilostachya	perennial ragweed	Asteraceae	native	S4					✓
Amelanchier alnifolia var. alnifolia	saskatoon	Rosaceae	native	S5			✓	✓	✓
Androsace septentrionalis	western pygmyflower	Primulaceae	native	S5			✓		
Anemone canadensis	Canada anemone	Ranunculaceae	native	S4			✓	✓	✓
Anemone cylindrica	long-fruited anemone	Ranunculaceae	native	S4			✓	✓	✓
Anemone multifida var. multifida	cut-leaved anemone	Ranunculaceae	native	S4			✓		
Anemone patens var. multifida	prairie crocus	Ranunculaceae	native	S5			✓	✓	✓
Anemone virginiana var. cylindroidea	tall anemone	Ranunculaceae	native	S4					✓
Antennaria neglecta	broad-leaved pussytoes	Asteraceae	native	S4			✓		✓
Antennaria parvifolia	small-leaved everlasting	Asteraceae	native	S4			✓	✓	✓
Anthoxanthum hirtum ssp. arcticum	sweet grass	Poaceae	native	S4			✓		✓
Apocynum androsaemifolium	spreading dogbane	Apocynaceae	native	S4					✓
Apocynum cannabinum var. hypericifolium	Indian hemp	Apocynaceae	native	S4					✓
Arabis pycnocarpa var. pycnocarpa	hairy rockcress	Brassicaceae	native	S4			✓		
Aralia nudicaulis	wild sarsaparilla	Araliaceae	native	S4					✓
Artemisia absinthium	absinthe	Asteraceae	introduced	SNA		Noxious	✓	✓	✓
Artemisia biennis var. biennis	biennial wormwood	Asteraceae	introduced	SNA			✓	✓	
Artemisia campestris ssp. caudata	plains sagewort	Asteraceae	native	S4			✓	✓	✓
Artemisia frigida	pasture sage	Asteraceae	native	S5			✓	✓	✓
Artemisia ludoviciana ssp. ludoviciana	prairie sage	Asteraceae	native	S5			✓	✓	✓
Asparagus officinalis	asparagus	Liliaceae	introduced	SNA			✓		✓
Astragalus agrestis	purple milk-vetch	Fabaceae	native	S4			✓	✓	✓
Astragalus canadensis var. canadensis	Canadian milk-vetch	Fabaceae	native	S4				✓	
Astragalus crassicarpus var. crassicarpus	ground-plum	Fabaceae	native	S4			✓		✓
Astragalus flexuosus var. flexuosus	slender milk-vetch	Fabaceae	native	S4			✓	✓	✓
Astragalus gilviflorus var. gilviflorus	cushion milk-vetch	Fabaceae	native	S5					✓
Astragalus laxmannii var. robustior	Laxmann's milk-vetch	Fabaceae	native	S4			✓		

Scientific Name	Common Name	Family	Origin	SKCDC Ranking	SOCC	*The* [SK] *Weed Control Act* Designation	Small Swale and Surrounding Areas	Northeast Swale and Surrounding Areas	South Saskatchewan River Valley
Astragalus lotiflorus	low milk-vetch	Fabaceae	native	S4			✓		
Astragalus missouriensis var. missouriensis	Missouri milk-vetch	Fabaceae	native	S4					✓
Astragalus pectinatus	narrow-leaved milk-vetch	Fabaceae	native	S4			✓		✓
Atriplex prostrata	creeping saltbush	Chenopodiaceae	introduced	SNA			✓	✓	✓
Avenula hookeri	Hooker's oat grass	Poaceae	native	S5			✓		✓
Axyris amaranthoides	Russian pigweed	Chenopodiaceae	introduced	SNA			✓		
Bassia scoparia	kochia	Chenopodiaceae	introduced	SNA		Noxious	✓	✓	
Beckmannia syzigachne	slough grass	Poaceae	native	S4			✓	✓	
Betula papyrifera	paper birch	Betulaceae	native	S5					✓
Betula pumila	swamp birch	Betulaceae	native	S5					✓
Bidens cernua	nodding beggarticks	Asteraceae	native	S4			✓	✓	
Bidens vulgata	common beggarticks	Asteraceae	native	S5				✓	
Blysmopsis rufa	red bulrush	Cyperaceae	native	S3	✓		✓	▪	▪
Boechera grahamii	Graham's rockcress	Brassicaceae	native	S4			✓		✓
Boechera retrofracta	reflexed rockcress	Brassicaceae	native	S4			✓	✓	✓
Bolboschoenus maritimus ssp. paludosus	prairie bulrush	Cyperaceae	native	S4			✓	✓	
Bouteloua gracilis	blue grama	Poaceae	native	S5			✓	✓	✓
Bromus inermis	smooth brome	Poaceae	introduced	SNA			✓	✓	✓
Calamagrostis canadensis var. canadensis	bluejoint reed grass	Poaceae	native	S4					✓
Calamagrostis montanensis	plains reed grass	Poaceae	native	S5			✓	✓	✓
Calamagrostis stricta	northern reed grass	Poaceae	native	S4			✓	✓	✓
Calamovilfa longifolia var. longifolia	sand-grass	Poaceae	native	S5			✓	✓	
Campanula rotundifolia	harebell	Campanulaceae	native	S5			✓	✓	✓
Capsella bursa-pastoris	shepherd's-purse	Brassicaceae	introduced	SNA				✓	
Caragana arborescens	common caragana	Fabaceae	introduced	SNA			✓		✓
Carduus nutans	nodding thistle	Asteraceae	introduced	SNA		Noxious	✓	✓	✓
Carex aquatilis var. aquatilis	water sedge	Cyperaceae	native	S4			✓	✓	✓
Carex atherodes	awned sedge	Cyperaceae	native	S4			✓	✓	✓
Carex aurea	golden sedge	Cyperaceae	native	S4			✓		
Carex bebbii	Bebb's sedge	Cyperaceae	native	S4					✓
Carex deweyana var. deweyana	Dewey's sedge	Cyperaceae	native	S5					✓
Carex duriuscula	needle-leaved sedge	Cyperaceae	native	S5			✓		
Carex filifolia	thread-leaved sedge	Cyperaceae	native	S5			✓		✓
Carex inops ssp. heliophila	sun sedge	Cyperaceae	native	S5			✓	✓	✓
Carex interior	inland sedge	Cyperaceae	native	S4					✓
Carex obtusata	blunt sedge	Cyperaceae	native	S4			✓		
Carex peckii	Peck's sedge	Cyperaceae	native	S4					✓
Carex pellita	woolly sedge	Cyperaceae	native	S4			✓	✓	✓
Carex praegracilis	graceful sedge	Cyperaceae	native	S4			✓	✓	✓
Carex praticola	northern meadow sedge	Cyperaceae	native	S4			✓	✓	
Carex sartwellii var. sartwellii	Sartwell's sedge	Cyperaceae	native	S4			✓	✓	
Carex scirpoidea ssp. scirpoidea	single-spike sedge	Cyperaceae	native	S4			✓		
Carex siccata	dry-spike sedge	Cyperaceae	native	S4					✓
Carex simulata	copycat sedge	Cyperaceae	native	S4					✓
Carex sprengelii	Sprengel's sedge	Cyperaceae	native	S5					✓

Scientific Name	Common Name	Family	Origin	SKCDC Ranking	SOCC	*The* [SK] *Weed Control Act* Designation	Small Swale and Surrounding Areas	Northeast Swale and Surrounding Areas	South Saskatchewan River Valley
Carex sychnocephala	long-beaked sedge	Cyperaceae	native	S4				✓	
Carex tenera	slender sedge	Cyperaceae	native	S4			✓	✓	
Carex utriculata	northern beaked sedge	Cyperaceae	native	S4					✓
Carex viridula ssp. viridula	green sedge	Cyperaceae	native	S4					✓
Cerastium arvense ssp. strictum	field chickweed	Caryophyllaceae	native	S5			✓	✓	✓
Chamaerhodos erecta	little ground rose	Rosaceae	native	S4			✓		
Chamerion angustifolium ssp. angustifolium	common fireweed	Onagraceae	native	S4					✓
Chenopodium album	lamb's quarter's	Chenopodiaceae	introduced	SNA			✓	✓	
Chenopodium fremontii var. fremontii	Fremont's goosefoot	Chenopodiaceae	native	S4			✓		
Chenopodium glaucum var. salinum	saline goosefoot	Chenopodiaceae	native	S4			✓	✓	
Chenopodium leptophyllum	narrowleaf goosefoot	Chenopodiaceae	native	S4			✓	✓	
Chenopodium rubrum	red goosefoot	Chenopodiaceae	native	S4			✓	✓	
Cicuta maculata var. maculata	spotted water-hemlock	Apiaceae	native	S4			✓		✓
Cirsium arvense	Canada thistle	Asteraceae	introduced	SNA		Noxious	✓	✓	✓
Cirsium flodmanii	Flodman's thistle	Asteraceae	native	S4			✓	✓	✓
Comandra umbellata	bastard toadflax	Santalaceae	native	S5			✓	✓	✓
Conyza canadensis	Canada fleabane	Asteraceae	native	S4			✓	✓	✓
Cornus sericea ssp. sericea	red-osier dogwood	Cornaceae	native	S4			✓		✓
Crataegus chrysocarpa	northern hawthorn	Rosaceae	native	S4			✓		
Crepis runcinata ssp. glauca	smooth hawk's-beard	Asteraceae	native	S4			✓		✓
Crepis tectorum	annual hawksbeard	Asteraceae	introduced	SNA		Noxious	✓	✓	✓
Cystopteris fragilis	fragile bladder fern	Dryopteridaceae	native	S4			✓		
Dalea candida	white prairie clover	Fabaceae	native	S4			✓		✓
Dalea purpurea var. purpurea	purple prairie clover	Fabaceae	native	S4			✓	✓	✓
Deschampsia cespitosa ssp. cespitosa	tufted hair-grass	Poaceae	native	S4			✓		✓
Descurainia sophia	flixweed	Brassicaceae	introduced	SNA			✓	✓	✓
Distichlis spicata	saltgrass	Poaceae	native	S5			✓	✓	✓
Dodecatheon pulchellum ssp. pulchellum	saline shootingstar	Primulaceae	native	S4			✓		
Drymocallis arguta	white cinquefoil	Rosaceae	native	S4			✓		
Echinochloa crus-galli	barnyard grass	Poaceae	introduced	SNA			✓	✓	
Elaeagnus commutata	wolf willow	Elaeagnaceae	native	S4			✓	✓	✓
Eleocharis palustris	common spike-rush	Cyperaceae	native	S4			✓	✓	✓
Eleocharis quinqueflora	few-flowered spike-rush	Cyperaceae	native	S4			✓		✓
Elymus albicans	Montana wheatgrass	Poaceae	native	S5			✓		
Elymus canadensis var. canadensis	Canada wild rye	Poaceae	native	S4					✓
Elymus lanceolatus ssp. lanceolatus	northern wheatgrass	Poaceae	native	S5			✓	✓	✓
Elymus repens	quack grass	Poaceae	introduced	SNA		Nuisance	✓	✓	
Elymus trachycaulus ssp. subsecundus	awned wheatgrass	Poaceae	native	S5			✓	✓	✓
Elymus trachycaulus ssp. trachycaulus	slender wheatgrass	Poaceae	native	S5			✓	✓	✓
Epilobium palustre	marsh willowherb	Onagraceae	native	S4			✓	✓	✓
Equisetum arvense	common horsetail	Equisetaceae	native	S5			✓	✓	✓
Equisetum hyemale var. affine	common scouring-rush	Equisetaceae	native	S4			✓		✓
Equisetum laevigatum	smooth scouring-rush	Equisetaceae	native	S4			✓	✓	✓
Equisetum palustre	marsh horsetail	Equisetaceae	native	S4					✓
Erigeron caespitosus	tufted fleabane	Asteraceae	native	S4			✓	✓	✓
Erigeron glabellus	smooth fleabane	Asteraceae	native	S5			✓		✓
Erigeron lonchophyllus	low-meadow fleabane	Asteraceae	native	S4			✓		

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Eriogonum flavum var. flavum	yellow umbrellaplant	Polygonaceae	native	S4					✓
Eriophorum angustifolium ssp. angustifolium	tall cottongrass	Cyperaceae	native	S4			✓		
Erysimum cheiranthoides	wormseed mustard	Brassicaceae	introduced	SNA			✓		
Erysimum inconspicuum var. inconspicuum	shy wallflower	Brassicaceae	native	S4			✓	✓	✓
Euphorbia virgata	leafy spurge	Euphorbiaceae	introduced	SNA		Noxious	✓		
Euthamia graminifolia var. graminifolia	flat-top goldentop	Asteraceae	native	S4			✓		✓
Fallopia convolvulus	wild buckwheat	Polygonaceae	introduced	SNA				✓	
Festuca hallii	plains rough fescue	Poaceae	native	S3	✓		✓		✓
Festuca saximontana	Rocky Mountain fescue	Poaceae	native	S5			✓		
Fragaria virginiana ssp. glauca	smooth wild strawberry	Rosaceae	native	S5			✓		✓
Fraxinus pennsylvanica	green ash	Oleaceae	native	S4					✓
Gaillardia aristata	great-flowered gaillardia	Asteraceae	native	S4			✓	✓	✓
Galium boreale	northern bedstraw	Rubiaceae	native	S5			✓	✓	✓
Galium triflorum	sweet-scented bedstraw	Rubiaceae	native	S4			✓		✓
Gaura coccinea	scarlet gaura	Onagraceae	native	S4			✓		✓
Gentiana affinis	oblong-leaved gentian	Gentianaceae	native	S4			✓		
Gentianella amarella ssp. acuta	northern gentian	Gentianaceae	native	S4			✓		
Gentianopsis virgata ssp. macounii	Macoun's gentian	Gentianaceae	native	S3	✓		✓		✓
Geum macrophyllum var. perincisum	large-leaved avens	Rosaceae	native	S4				✓	
Geum triflorum	three-flowered avens	Rosaceae	native	S5			✓	✓	✓
Glyceria striata var. striata	fowl manna grass	Poaceae	native	S4			✓		✓
Glycyrrhiza lepidota	wild licorice	Fabaceae	native	S4			✓	✓	✓
Grindelia squarrosa	gumweed	Asteraceae	native	S5			✓	✓	
Gutierrezia sarothrae	broomweed	Asteraceae	native	S4			✓	✓	✓
Hackelia deflexa var. americana	northern stickseed	Boraginaceae	native	S4			✓		
Helianthus nuttallii	common tall sunflower	Asteraceae	native	S4			✓	✓	✓
Helianthus pauciflorus ssp. subrhomboideus	beautiful sunflower	Asteraceae	native	S4			✓		✓
Heliotropium curassavicum var. obovatum	spatulate-leaved heliotrope	Boraginaceae	native	S4				✓	
Heracleum maximum	cow parsnip	Apiaceae	native	S4					✓
Hesperostipa comata ssp. comata	needle-and-thread grass	Poaceae	native	S5			✓	✓	✓
Hesperostipa curtiseta	porcupine grass	Poaceae	native	S5			✓		✓
Heterotheca villosa	hairy golden aster	Asteraceae	native	S5			✓	✓	✓
Heuchera richardsonii	alumroot	Saxifragaceae	native	S4			✓	✓	✓
Hippuris vulgaris	common mare's-tail	Hippuridaceae	native	S4			✓	✓	✓
Hordeum jubatum ssp. jubatum	foxtail barley	Poaceae	native	S5		Nuisance	✓	✓	
Hymenoxys richardsonii var. richardsonii	Colorado rubber-plant	Asteraceae	native	S4			✓		✓
Juncus alpinoarticulatus	northern green rush	Juncaceae	native	S4			✓	✓	✓
Juncus balticus	Baltic rush	Juncaceae	native	S4			✓	✓	✓
Juncus bufonius	toad rush	Juncaceae	native	S4				✓	
Juncus compressus	flattened rush	Juncaceae	introduced	SNA			✓		
Juncus dudleyi	Dudley's rush	Juncaceae	native	S4				✓	
Juncus longistylis var. longistylis	long-style rush	Juncaceae	native	S4			✓		
Juncus nodosus var. nodosus	knotted rush	Juncaceae	native	S4			✓		
Juncus torreyi	Torrey's rush	Juncaceae	native	S4			✓		
Juniperus communis var. depressa	common juniper	Cupressaceae	native	S4			✓		✓
Juniperus horizontalis	creeping juniper	Cupressaceae	native	S5			✓		✓
Koeleria macrantha	June grass	Poaceae	native	S5			✓		✓

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Kraschenninikovia lanata	winter-fat	Chenopodiaceae	native	S4					✓
Lactuca serriola	prickly lettuce	Asteraceae	introduced	SNA			✓	✓	✓
Lappula occidentalis var. occidentalis	flat-spine sheepbur	Boraginaceae	native	S4			✓		✓
Lathyrus ochroleucus	cream-coloured vetchling	Fabaceae	native	S5					✓
Lathyrus venosus	purple vetchling	Fabaceae	native	S4					✓
Lemna trisulca	ivy-leaved duckweed	Lemnaceae	native	S4				✓	
Lemna turionifera	common duckweed	Lemnaceae	native	S4				✓	✓
Lepidium densiflorum	common pepper-grass	Brassicaceae	native	S4			✓		
Liatris ligulistylis	meadow blazing-star	Asteraceae	native	S4			✓		
Liatris punctata var. punctata	dotted blazing-star	Asteraceae	native	S5			✓	✓	✓
Lilium philadelphicum var. andinum	western red lily	Liliaceae	native	S4			✓		
Linum lewisii var. lewisii	Lewis' wild blue flax	Linaceae	native	S4			✓	✓	✓
Linum rigidum var. rigidum	stiff-stemmed flax	Linaceae	native	S5			✓		
Lithospermum incisum	narrow-leaved puccoon	Boraginaceae	native	S4			✓		✓
Lobelia kalmii	Kalm's lobelia	Campanulaceae	native	S4			✓		
Lomatium macrocarpum	long-fruited parsley	Apiaceae	native	S5			✓		✓
Lomatogonium rotatum	marsh felwort	Gentianaceae	native	S3	✓		✓		
Lonicera dioica	twining honeysuckle	Caprifoliaceae	native	S4					✓
Lycopus asper	western water-horehound	Lamiaceae	native	S4			✓	✓	✓
Lygodesmia juncea	skeletonweed	Asteraceae	native	S5			✓	✓	✓
Lysimachia ciliata	fringed loosestrife	Primulaceae	native	S4			✓		
Lysimachia maritima	sea milkwort	Primulaceae	native	S4			✓	✓	
Maianthemum canadense	two-leaved Solomon's-seal	Liliaceae	native	S4					✓
Maianthemum stellatum	star-flowered false Solomon's seal	Liliaceae	native	S4			✓		✓
Malva pusilla	round-leaved mallow	Malvaceae	introduced	SNA		Noxious		✓	
Medicago lupulina	black medic	Fabaceae	introduced	SNA			✓	✓	
Medicago sativa	alfalfa	Fabaceae	introduced	SNA			✓	✓	✓
Melilotus albus	white sweet-clover	Fabaceae	introduced	SNA			✓	✓	
Melilotus officinalis	yellow sweet-clover	Fabaceae	introduced	SNA			✓	✓	✓
Mentha canadensis	wild mint	Lamiaceae	native	S4			✓	✓	✓
Mirabilis albida	pale umbrellawort	Nyctaginaceae	native	S4			✓		
Moehringia lateriflora	blunt-leaved sandwort	Caprifoliaceae	native	S4					✓
Muhlenbergia asperifolia	scratch grass	Poaceae	native	S4			✓		
Muhlenbergia cuspidata	prairie muhly	Poaceae	native	S4			✓		✓
Muhlenbergia richardsonis	mat muhly	Poaceae	native	S4			✓	✓	
Mulgedium pulchellum	common blue lettuce	Asteraceae	native	S4		Nuisance	✓	✓	
Myriophyllum sibiricum	Siberian water-milfoil	Haloragaceae	native	S5			✓	✓	
Nassella viridula	green needlegrass	Poaceae	native	S5			✓		✓
Oenothera biennis	yellow evening primrose	Onagraceae	native	S4			✓		
Oenothera nuttallii	white evening primrose	Onagraceae	native	S5			✓		
Oenothera serrulata	shrubby evening primrose	Onagraceae	native	S4					✓
Orthocarpus luteus	owl's-clover	Scrophulariaceae	native	S4			✓		
Oxytropis campestris var. spicata	early yellow locoweed	Fabaceae	native	S4			✓	✓	✓
Packera cana	silvery groundsel	Asteraceae	native	S4			✓	✓	✓
Packera paupercula	balsam groundsel	Asteraceae	native	S4			✓		
Parnassia palustris var. tenuis	northern grass-of-Parnassus	Saxifragacea	native	S4			✓		✓
Paronychia sessiliflora	low whitlowwort	Caryophyllaceae	native	S3	✓				✓

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Pascopyrum smithii	western wheatgrass	Poaceae	native	S5			✓	✓	✓
Pediomelum argophyllum	silver psoralea	Fabaceae	native	S5			✓	✓	✓
Pediomelum esculentum	Indian breadroot	Fabaceae	native	S4			✓	✓	✓
Penstemon gracilis var. gracilis	lilac beardtongue	Scrophulariaceae	native	S4			✓		✓
Penstemon nitidus var. nitidus	smooth blue beardtongue	Scrophulariaceae	native	S4					✓
Persicaria amphibia var. emersa	water smartweed	Polygonaceae	native	S4			✓	✓	✓
Persicaria lapathifolia	dock-leaved smartweed	Polygonaceae	native	S4			✓	✓	✓
Persicaria maculosa	lady's-thumb	Polygonaceae	introduced	SNA				✓	
Petasites frigidus var. sagittatus	arrow-leaved colt's-foot	Asteraceae	native	S4					✓
Phalaris arundinacea	reed canary grass	Poaceae	native	S4			✓	✓	✓
Phlox hoodii ssp. hoodii	moss phlox	Polemoniaceae	native	S5			✓	✓	✓
Phragmites australis ssp. americanus	common reed-grass	Poaceae	native	S4				✓	
Physaria arenosa ssp. arenosa	great plains bladder-pod	Brassicaceae	native	S4			✓		✓
Plantago eriopoda	saline plantain	Plantaginaceae	native	S4			✓		
Plantago major	common plantain	Plantaginaceae	introduced	SNA			✓	✓	
Platanthera aquilonis	northern green orchid	Orchidaceae	native	S4			✓		✓
Poa compressa	Canada bluegrass	Poaceae	introduced	SNA			✓		
Poa cusickii ssp. pallida	Cusick's bluegrass	Poaceae	native	S4			✓		
Poa palustris	fowl bluegrass	Poaceae	native	S4			✓	✓	✓
Poa pratensis	Kentucky bluegrass	Poaceae	introduced	SNA			✓	✓	✓
Polygonum aviculare	knotweed	Polygonaceae	introduced	SNA				✓	
Populus balsamifera ssp. balsamifera	balsam poplar	Salicaceae	native	S5			✓	✓	✓
Populus deltoides ssp. monilifera	eastern cottonwood	Salicaceae	native	S4			✓		✓
Populus tremuloides	trembling aspen	Salicaceae	native	S5			✓	✓	✓
Potamogeton richardsonii	Richardson's pondweed	Potamogetonaceae	native	S4				✓	
Potentilla anserina ssp. anserina	silverweed	Rosaceae	native	S4			✓	✓	✓
Potentilla bipinnatifida	bipinnate cinquefoil	Rosaceae	native	S4			✓		✓
Potentilla concinna var. concinna	early cinquefoil	Rosaceae	native	S2	✓		✓		
Potentilla concinna var. divisa	divided-leaved cinquefoil	Rosaceae	native	S4			✓	✓	
Potentilla gracilis var. fastigiata	graceful cinquefoil	Rosaceae	native	S4			✓	✓	
Potentilla gracilis var. flabelliformis	fan-leaved cinquefoil	Rosaceae	native	S4			✓		
Potentilla hippiana	woolly cinquefoil	Rosaceae	native	S5			✓	✓	
Potentilla hudsonii	Hudson's cinquefoil	Rosaceae	native	S2	✓		✓		✓
Potentilla norvegica	rough cinquefoil	Rosaceae	native	S4			✓	✓	
Potentilla pensylvanica	prairie cinquefoil	Rosaceae	native	S4			✓	✓	✓
Potentilla plattensis	low cinquefoil	Rosaceae	native	S4			✓		
Prunus virginiana var. virginiana	chokecherry	Rosaceae	native	S5			✓	✓	✓
Psathyrostachys juncea	Russian wild rye	Poaceae	introduced	SNA					✓
Puccinellia nuttalliana	Nuttall's salt-meadow grass	Poaceae	native	S4			✓	✓	✓
Pyrola asarifolia ssp. asarifolia	pink wintergreen	Pyrolaceae	native	S4					✓
Pyrrocoma lanceolata var. lanceolata	lance-leaf goldenweed	Asteraceae	native	S4			✓		
Ranunculus aquatilis var. diffusus	white water crowfoot	Ranunculaceae	native	S4			✓		
Ranunculus cymbalaria	seaside buttercup	Ranunculaceae	native	S4			✓	✓	
Ranunculus gmelinii	yellow water crowfoot	Ranunculaceae	native	S4			✓	✓	
Ranunculus sceleratus var. multifidus	cursed crowfoot	Ranunculaceae	native	S4			✓	✓	
Rhamnus cathartica	European buckthorn	Rhamnaceae	introduced	SNA		Noxious	✓	✓	✓
Rheum rhabarbarum	rhubarb	Polygonaceae	introduced	SNA			✓		

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Ribes americanum	wild black currant	Grossulariaceae	native	S4			✓	✓	
Ribes oxyacanthoides var. oxyacanthoides	bristly gooseberry	Grossulariaceae	native	S4			✓	✓	✓
Ribes triste	swamp red currant	Grossulariaceae	native	S4					✓
Rosa acicularis ssp. sayi	prickly rose	Rosaceae	native	S5					✓
Rosa arkansana	low prairie rose	Rosaceae	native	S5			✓	✓	✓
Rosa woodsii var. woodsii	Wood's rose	Rosaceae	native	S5			✓	✓	✓
Rubus idaeus ssp. strigosus	American red raspberry	Rosaceae	native	S5			✓	✓	✓
Rubus pubescens	dewberry	Rosaceae	native	S4					✓
Rumex acetosa	sour dock	Polygonaceae	introduced	SNA			✓	✓	
Rumex fueginus	golden dock	Polygonaceae	native	S5			✓	✓	
Rumex pseudonatronatus	field dock	Polygonaceae	introduced	SNA			✓	✓	
Rumex stenophyllus	narrow-leaved field dock	Polygonaceae	introduced	SNA				✓	
Rumex triangulivalvis	willow dock	Polygonaceae	native	S5				✓	
Sagittaria cuneata	arum-leaved arrowhead	Alismataceae	native	S4					✓
Salicornia rubra	red samphire	Chenopodiaceae	native	S4			✓	✓	
Salix alba	white willow	Salicaceae	introduced	SNA			✓		
Salix bebbiana	Bebb's willow	Salicaceae	native	S4			✓	✓	✓
Salix candida	hoary willow	Salicaceae	native	S4			✓		✓
Salix discolor	pussy willow	Salicaceae	native	S4					✓
Salix famelica	yellow willow	Salicaceae	native	S4			✓	✓	✓
Salix interior	sandbar willow	Salicaceae	native	S4			✓	✓	✓
Salix petiolaris	basket willow	Salicaceae	native	S4			✓	✓	✓
Salix pseudomonticola	false mountain willow	Salicaceae	native	S4			✓		✓
Sambucus racemosa ssp. pubens	red elderberry	Caprifoliaceae	naturalized	SNA			✓		
Sanicula marilandica	black snakeroot	Apiaceae	native	S4					✓
Schizachyrium scoparium var. scoparium	little bluestem	Poaceae	native	S4			✓		✓
Schoenoplectus acutus var. acutus	hard-stem bulrush	Cyperaceae	native	S4			✓	✓	
Schoenoplectus pungens	three-square bulrush	Cyperaceae	native	S4			✓	✓	✓
Schoenoplectus tabernaemontani	soft-stem bulrush	Cyperaceae	native	S4			✓	✓	✓
Scirpus microcarpus	small-fruited bulrush	Cyperaceae	native	S4			✓		✓
Scolochloa festucacea	sprangletop	Poaceae	native	S4			✓	✓	
Scutellaria galericulata	marsh skullcap	Lamiaceae	native	S4			✓		✓
Selaginella densa	prairie spike-moss	Selaginellaceae	native	S4			✓		✓
Senecio integerrimus var. integerrimus	lamb-tongue ragwort	Asteraceae	native	S4			✓	✓	
Setaria viridis var. viridis	green foxtail	Poaceae	introduced	SNA				✓	
Shepherdia argentea	silvery buffalo-berry	Elaeagnaceae	native	S4			✓	✓	✓
Shepherdia canadensis	Canada buffalo-berry	Elaeagnaceae	native	S4			✓		
Silene drummondii ssp. drummondii	Drummond's catchfly	Caryophyllaceae	native	S4			✓	✓	✓
Sisymbrium loeselii	tall hedge mustard	Brassicaceae	introduced	SNA			✓	✓	✓
Sisyrinchium montanum var. montanum	common blue-eyed grass	Iridaceae	native	S4			✓		✓
Sisyrinchium mucronatum	mucronate blue-eyed grass	Iridaceae	native	S3	✓		✓		
Sium suave	water parsnip	Apiaceae	native	S4			✓	✓	
Smilax lasioneura	herbaceous greenbrier	Smilacaceae	native	S4					✓
Solidago canadensis	Canada goldenrod	Asteraceae	native	S5			✓	✓	✓
Solidago gigantea	late goldenrod	Asteraceae	native	S4					✓
Solidago missouriensis	low goldenrod	Asteraceae	native	S5			✓	✓	✓
Solidago mollis	velvety goldenrod	Asteraceae	native	S4			✓		

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Solidago nemoralis ssp. decemflora	gray goldenrod	Asteraceae	native	S4			✓		
Solidago ptarmicoides	upland white goldenrod	Asteraceae	native	S3	✓		✓		
Solidago rigida ssp. humilis	stiff goldenrod	Asteraceae	native	S4			✓	✓	✓
Solidago simplex var. simplex	mountain goldenrod	Asteraceae	native	S4			✓	✓	✓
Sonchus arvensis ssp. uliginosus	perennial sow-thistle	Asteraceae	introduced	SNA		Noxious	✓	✓	✓
Spartina gracilis	alkali cord grass	Poaceae	native	S4			✓		✓
Sphaeralcea coccinea ssp. coccinea	scarlet mallow	Malvaceae	native	S5			✓	✓	✓
Spiraea alba var. alba	narrow-leaved meadow-sweet	Rosaceae	native	S4			✓	✓	
Sporobolus cryptandrus	sand dropseed	Poaceae	native	S4			✓		
Stachys pilosa var. pilosa	marsh hedge-nettle	Lamiaceae	native	S4			✓	✓	✓
Stellaria crassifolia	fleshy stitchwort	Caryophyllaceae	native	S4			✓		
Stellaria longipes ssp. longipes	long-stalked stitchwort	Caprifoliaceae	native	S4					✓
Stenotus armerioides var. armerioides	narrow-leaved stenotus	Asteraceae	native	S4			✓		✓
Stuckenia pectinata	sago pondweed	Potamogetonaceae	native	S4				✓	
Suaeda calceoliformis	sea-blite	Chenopodiaceae	native	S4			✓	✓	✓
Symphoricarpos occidentalis	western snowberry	Caprifoliaceae	native	S5			✓	✓	✓
Symphyotrichum boreale	northern aster	Asteraceae	native	S4			✓		✓
Symphyotrichum ciliatum	rayless aster	Asteraceae	native	S4			✓	✓	✓
Symphyotrichum ericoides var. pansum	tufted white prairie aster	Asteraceae	native	S5			✓	✓	✓
Symphyotrichum falcatum	white prairie aster	Asteraceae	native	S4			✓		✓
Symphyotrichum laeve var. geyeri	smooth blue aster	Asteraceae	native	S5			✓	✓	✓
Symphyotrichum lanceolatum var. hesperium	white-panicled American aster	Asteraceae	native	S4			✓	✓	✓
Tanacetum vulgare	tansy	Asteraceae	introduced	SNA		Noxious	✓		✓
Taraxacum officinale ssp. officinale	common dandelion	Asteraceae	introduced	SNA		Nuisance	✓	✓	✓
Tephroseris palustris	marsh ragwort	Asteraceae	native	S4			✓	✓	
Teucrium canadense var. occidentale	hairy germander	Lamiaceae	native	S3	✓		✓	✓	
Thalictrum venulosum	veiny meadow-rue	Ranunculaceae	native	S4			✓	✓	✓
Thermopsis rhombifolia	golden bean	Fabaceae	native	S5			✓	✓	✓
Thinopyrum ponticum	tall wheatgrass	Poaceae	introduced	SNA				✓	
Tragopogon dubius	yellow goat's-beard	Asteraceae	introduced	SNA			✓	✓	✓
Triglochin maritima	seaside arrow-grass	Juncaginaceae	native	S4			✓	✓	✓
Triglochin palustris	slender arrow-grass	Juncaginaceae	native	S4			✓		✓
Tripleurospermum inodorum	scentless chamomile	Asteraceae	introduced	SNA		Noxious	✓		
Typha angustifolia	narrow-leaved cattail	Typhaceae	introduced	SNA			✓	✓	
Typha latifolia	common cattail	Typhaceae	native	S4			✓	✓	✓
Ulmus pumila	Siberian elm	Ulmaceae	introduced	SNA			✓	✓	✓
Urtica dioica ssp. gracilis	stinging nettle	Urticaceae	native	S4			✓	✓	✓
Veronica peregrina ssp. xalapensis	hairy speedwell	Scrophulariaceae	native	S4				✓	
Veronica scutellata	marsh speedwell	Scrophulariaceae	native	S4					✓
Vicia americana	American purple vetch	Fabaceae	native	S5			✓	✓	✓
Viola adunca var. adunca	early blue violet	Violaceae	native	S5			✓		✓
Viola canadensis var. rugulosa	Western Canada violet	Violaceae	native	S4			✓		✓
Viola nephrophylla	northern bog violet	Violaceae	native	S4			✓		✓
Viola nuttallii	Nuttall's yellow violet	Violaceae	native	S4			✓		
Viola pedatifida	crowfoot violet	Violaceae	native	S3	✓		✓		
Xanthisma spinulosum var. spinulosum	spiny ironplant	Asteraceae	native	S4			✓	✓	
Xanthium strumarium	cocklebur	Asteraceae	native	S4					✓

Scientific Name	Common Name	Family	Origin	SKCDC Ranking	SOCC	*The* [SK] *Weed Control Act* Designation	Small Swale and Surrounding Areas	Northeast Swale and Surrounding Areas	South Saskatchewan River Valley
Zigadenus elegans ssp. elegans	smooth camus	Liliaceae	native	S4			✓		
Zizia aptera	heart-leaved Alexanders	Apiaceae	native	S4			✓		✓

Source: (SKCDC 2021c)

Appendix H

Plant Species of Conservation Concern Occurrences Detected During the Preliminary Vegetation Study

Table H.I Inventory of plant SOCC occurrences detected during the 2020 and 2021 vegetation surveys

Internal Occurrence ID	HABISask Element Occurrence ID	Feature Type	Scientific Name	Common Name	Confidence Level	Date	Time	Estimated No. of Plants		Area Occupied by Patch* (m^2)	
								2020 Vegetation Study Area	2021 Vegetation Study Area	2020 Vegetation Study Area	2021 Vegetation Study Area
20AG01	-	Point	*Alisma gramineum*	narrow-leaved water plantain	Confirmed	2020-09-01	11:19	9	-	n/a	-
20AG02	-	Point	*Alisma gramineum*	narrow-leaved water plantain	Confirmed	2020-09-01	11:43	3	-	n/a	-
20AG03	-	Point	*Alisma gramineum*	narrow-leaved water plantain	Confirmed	2020-09-01	11:53	5	-	n/a	-
20AG04	-	Point	*Alisma gramineum*	narrow-leaved water plantain	Confirmed	2020-09-01	11:54	4	-	n/a	-
20AG05	-	Point	*Alisma gramineum*	narrow-leaved water plantain	Confirmed	2020-09-01	11:55	2	-	n/a	-
20AP01	9052	Point	*Almutaster pauciflorus*	few-flowered aster	Confirmed	2020-08-30	17:16	61	61	n/a	n/a
21AP01	-	Point	*Almutaster pauciflorus*	few-flowered aster	Confirmed	2021-07-23	11:54	-	2	-	n/a
21AP02	-	Polygon	*Almutaster pauciflorus*	few-flowered aster	Confirmed	2021-07-23	14:01	-	> 5000	-	805.8
21AP03	-	Point	*Almutaster pauciflorus*	few-flowered aster	Confirmed	2021-07-23	14:34	-	75	-	n/a
21AP04	-	Polygon	*Almutaster pauciflorus*	few-flowered aster	Confirmed	2021-07-23	14:47	-	150	-	317.3
21AP05	-	Point	*Almutaster pauciflorus*	few-flowered aster	Confirmed	2021-07-23	15:46	-	20	-	n/a
21BR01	-	Polygon	*Blysmopsis rufa*	red bulrush	Confirmed	2021-07-23	15:31	-	no estimate	-	113.0
20FH01	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-05	12:28	no estimate	no estimate	150.4	150.4
20FH02	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-05	14:02	no estimate	no estimate	1,054.3	1,054.3
20FH03	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-05	15:49	no estimate	no estimate	409.8	409.8
20FH04	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	12:37	no estimate	no estimate	88.9	88.9
20FH05	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	15:40	no estimate	no estimate	n/a	n/a
20FH06	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	15:47	no estimate	no estimate	95.4	95.4
20FH07	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-05	13:33	no estimate	no estimate	82.2	82.2
20FH09	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-05	15:32	no estimate	no estimate	543.7	543.7
20FH10	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-05	17:22	no estimate	no estimate	n/a	n/a
20FH11	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	16:52	no estimate	no estimate	198.2	198.2
20FH12	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	16:45	no estimate	no estimate	205.3	205.3
20FH13	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	16:47	no estimate	no estimate	461.9	461.9
20FH15	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	17:01	no estimate	no estimate	515.2	515.2
20FH17	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	19:58	no estimate	no estimate	682.4	682.4
20FH18	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	18:11	no estimate	no estimate	n/a	n/a
20FH19	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	18:44	no estimate	no estimate	n/a	n/a
20FH20	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-08-31	18:53	no estimate	no estimate	381.6	381.6
20FH22	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	12:56	no estimate	no estimate	504.0	504.0
20FH24	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	13:14	no estimate	no estimate	765.8	765.8
20FH26	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-05	18:15	no estimate	no estimate	1,031.7	1,031.7
20FH29	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	13:47	no estimate	no estimate	233.1	233.1
20FH30	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	13:50	no estimate	no estimate	184.3	184.3
20FH31	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	13:52	no estimate	no estimate	1,445.2	1,445.2
20FH32	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-03	12:30	no estimate	no estimate	138.6	138.6
20FH33	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-03	12:40	no estimate	no estimate	661.4	661.4
20FH34	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-03	13:54	no estimate	no estimate	84.9	84.9
20FH35	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-03	13:51	no estimate	no estimate	249.0	249.0
20FH36	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	14:17	no estimate	no estimate	134.5	134.5
20FH37	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	14:21	no estimate	no estimate	260.5	260.5
20FH38	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	14:25	no estimate	no estimate	114.0	114.0

Internal Occurrence ID	HABISask Element Occurrence ID	Feature Type	Scientific Name	Common Name	Confidence Level	Date	Time	Estimated No. of Plants		Area Occupied by Patch* (m^2)	
								2020 Vegetation Study Area	2021 Vegetation Study Area	2020 Vegetation Study Area	2021 Vegetation Study Area
20FH40	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	14:36	no estimate	no estimate	n/a	n/a
20FH41	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	14:44	no estimate	no estimate	311.0	311.0
20FH42	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	14:50	no estimate	no estimate	96.4	96.4
20FH43	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	14:57	no estimate	no estimate	72.0	72.0
20FH44	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	16:15	no estimate	no estimate	n/a	n/a
20FH45	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-03	14:08	no estimate	no estimate	243.2	243.2
20FH47	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	17:25	no estimate	no estimate	155.3	155.3
20FH49	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2020-09-02	18:09	-	no estimate	-	37.2
20FH50	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2020-06-04	12:52	no estimate	no estimate	n/a	n/a
21FH01	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	10:24	no estimate	no estimate	163.2	163.2
21FH02	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	10:54	no estimate	no estimate	n/a	n/a
21FH03	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	11:26	no estimate	no estimate	231.5	231.5
21FH04	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	11:36	no estimate	no estimate	77.3	77.3
21FH05	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	11:44	no estimate	no estimate	n/a	n/a
21FH06	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	11:55	no estimate	no estimate	101.5	101.5
21FH07	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	11:59	no estimate	no estimate	n/a	n/a
21FH08	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	12:30	no estimate	no estimate	n/a	n/a
21FH09	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	13:17	no estimate	no estimate	n/a	n/a
21FH10	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	14:50	no estimate	no estimate	n/a	n/a
21FH11	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	15:02	no estimate	no estimate	n/a	n/a
21FH12	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	15:05	no estimate	no estimate	n/a	n/a
21FH13	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	16:56	no estimate	no estimate	380.5	380.5
21FH14	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	17:03	no estimate	no estimate	113.7	113.7
21FH15	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	17:37	no estimate	no estimate	264.7	264.7
21FH16	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-26	11:04	-	no estimate	-	207.2
21FH17	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-26	11:17	-	no estimate	-	n/a
21FH18	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-26	12:18	-	no estimate	-	n/a
21FH19	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-26	13:12	no estimate	no estimate	482.8	16,915.5
21FH20	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-26	14:01	-	no estimate	-	465.0
21FH21	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-26	14:08	-	no estimate	-	784.9
21FH22	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-26	16:04	-	no estimate	-	1,651.2
21FH23	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-26	16:53	-	no estimate	-	1,264.1
21FH24	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-26	17:22	no estimate	no estimate	751.6	751.6
21FH25	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-28	8:54	no estimate	no estimate	117.7	117.7
21FH26	-	Point	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-28	14:31	-	no estimate	-	n/a
21FH27	-	Polygon	*Festuca hallii*	plains rough fescue	Confirmed	2021-07-25	17:55	no estimate	no estimate	101.2	101.2
20GV01	-	Point	*Gentianopsis virgata ssp. macounii*	Macoun's gentian	Probable	2020-08-28	17:42	7	7	n/a	n/a
20GV02	-	Point	*Gentianopsis virgata ssp. macounii*	Macoun's gentian	Probable	2020-08-28	17:44	12	12	n/a	n/a
20GV03	-	Point	*Gentianopsis virgata ssp. macounii*	Macoun's gentian	Probable	2020-08-28	18:34	8	8	n/a	n/a
20GV04	-	Point	*Gentianopsis virgata ssp. macounii*	Macoun's gentian	Probable	2020-08-28	18:38	13	13	n/a	n/a
20GV05	999984240	Polygon	*Gentianopsis virgata ssp. macounii*	Macoun's gentian	Probable	2020-08-29	16:47	-	335	-	544.2
20LR01	-	Point	*Lomatogonium rotatum*	marsh felwort	Confirmed	2020-08-30	14:46	7	7	n/a	n/a
20LR02	-	Polygon	*Lomatogonium rotatum*	marsh felwort	Confirmed	2020-08-30	15:40	84	84	1,155.7	1,155.7

Internal Occurrence ID	HABISask Element Occurrence ID	Feature Type	Scientific Name	Common Name	Confidence Level	Date	Time	Estimated No. of Plants		Area Occupied by Patch* (m^2)	
								2020 Vegetation Study Area	2021 Vegetation Study Area	2020 Vegetation Study Area	2021 Vegetation Study Area
20LR03	-	Point	*Lomatogonium rotatum*	marsh felwort	Confirmed	2020-08-30	15:56	1	1	n/a	n/a
20LR04	-	Point	*Lomatogonium rotatum*	marsh felwort	Confirmed	2020-08-30	16:09	-	18	-	n/a
20LR05	-	Point	*Lomatogonium rotatum*	marsh felwort	Confirmed	2020-08-30	16:14	-	18	-	n/a
20LR06	-	Polygon	*Lomatogonium rotatum*	marsh felwort	Confirmed	2020-08-30	16:22	-	142	-	774.3
20LR07	-	Point	*Lomatogonium rotatum*	marsh felwort	Confirmed	2020-08-30	16:40	-	4	-	n/a
20LR08	-	Polygon	*Lomatogonium rotatum*	marsh felwort	Confirmed	2020-08-30	16:46	-	106	-	536.1
21PS01	-	Point	*Paronychia sessiliflora*	low whitlowwort	Confirmed	2021-07-24	11:30	5	5	n/a	n/a
20PC01	-	Point	*Potentilla concinna var. concinna*	early cinquefoil	Confirmed	2020-06-03	12:57	4	4	n/a	n/a
20PH01	-	Point	*Potentilla hudsonii*	Hudson's cinquefoil	Probable	2020-06-03	12:57	3	3	n/a	n/a
20PH02	-	Point	*Potentilla hudsonii*	Hudson's cinquefoil	Probable	2020-06-03; 2021-07-26	16:17; 16:57	12	12	n/a	n/a
21PH01	-	Point	*Potentilla hudsonii*	Hudson's cinquefoil	Probable	2021-07-25	18:26	-	1	-	n/a
21SM01	-	Point	*Sisyrinchium mucronatum*	mucronate blue-eyed grass	Confirmed	2021-07-22	16:25	1	1	n/a	n/a
21SM02	-	Point	*Sisyrinchium mucronatum*	mucronate blue-eyed grass	Confirmed	2021-07-23	16:32	-	1	-	n/a
21SM03	-	Point	*Sisyrinchium mucronatum*	mucronate blue-eyed grass	Confirmed	2021-07-25	11:40	-	2	-	n/a
21SP01	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-22	11:34	5	5	n/a	n/a
21SP02	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-22	17:00	1	1	n/a	n/a
21SP03	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-22	11:57	11	11	n/a	n/a
21SP04	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-22	12:11	3	3	n/a	n/a
21SP05	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-22	12:48	-	6	-	n/a
21SP06	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-22	13:03	-	20	-	n/a
21SP07	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-22	13:32	-	17	-	n/a
21SP08	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-23	16:10	-	2	-	n/a
21SP09	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-23	16:21	-	4	-	n/a
21SP10	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-23	16:47	-	4	-	n/a
21SP11	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-26	11:23	-	3	-	n/a
21SP12	-	Point	*Solidago ptarmicoides*	upland white goldenrod	Confirmed	2021-07-26	11:32	-	4	-	n/a
20TC01	-	Point	*Teucrium canadense var. occidentale*	hairy germander	Confirmed	2020-08-29	9:30	22	22	n/a	n/a
20TC02	-	Point	*Teucrium canadense var. occidentale*	hairy germander	Confirmed	2020-08-29	10:17	4	4	n/a	n/a
20TC03	-	Point	*Teucrium canadense var. occidentale*	hairy germander	Confirmed	2020-08-29	10:25	13	13	n/a	n/a
20TC04	-	Point	*Teucrium canadense var. occidentale*	hairy germander	Confirmed	2020-08-29	11:36	30	30	n/a	n/a
20TC05	-	Point	*Teucrium canadense var. occidentale*	hairy germander	Confirmed	2020-08-29	13:07	14	14	n/a	n/a
20TC06	-	Point	*Teucrium canadense var. occidentale*	hairy germander	Confirmed	2020-08-29	13:57	79	79	n/a	n/a
20TC07	-	Polygon	*Teucrium canadense var. occidentale*	hairy germander	Confirmed	2020-09-01	16:12	225		86.0	n/a
20VP01	-	Point	*Viola pedatifida*	crowfoot violet	Confirmed	2020-06-02	15:22	11	11	n/a	n/a
20VP02	-	Point	*Viola pedatifida*	crowfoot violet	Confirmed	2020-06-02	16:20	8	8	n/a	n/a
20VP03	-	Point	*Viola pedatifida*	crowfoot violet	Confirmed	2020-06-05	12:13	4	4	n/a	n/a
20VP04	-	Point	*Viola pedatifida*	crowfoot violet	Confirmed	2020-06-05	12:46	16	16	n/a	n/a
20VP05	-	Point	*Viola pedatifida*	crowfoot violet	Confirmed	2020-06-05	16:23	6	6	n/a	n/a
21VP01	-	Point	*Viola pedatifida*	crowfoot violet	Confirmed	2021-05-31	14:30	-	24	-	n/a

*If recorded as a polygon

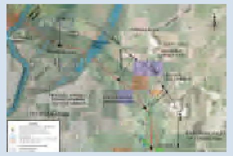
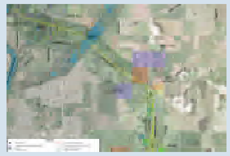
Source: (Government of Saskatchewan 2021)

Appendix I

Multiple Account Evaluation Results

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - Northeast Swale and Small Swale

Multiple Account Evaluation: SUMMARY

		Concept 1 (Base Case - Red Route) 			Concept 2 (Yellow Route) 			Concept 3 (Blue Route) 			Concept 3 Hwy 41 Re-Alignment B 		
Accounts and Elements	Weighting /Importance	Average Rating	Total Evaluation Points		Average Rating	Total Evaluation Points		Average Rating	Total Evaluation Points		Average Rating	Total Evaluation Points	
ROAD USER ACCOUNT	10.0		22.0	13%		22.0	13%		20.7	9%		21.9	10%
Travel Time Cost (Delay Time)	3.3	2.4	8.1		2.4	8.1		1.9	6.2		2.0	6.6	
Vehicle Operating Cost (Congestion, Start/Stop)	1.9	2.1	4.0		2.1	4.0		2.2	4.2		2.2	4.2	
Safety Cost (At-grade intersections, LOS/Congestion)	2.6	2.0	5.2		2.0	5.2		2.2	5.8		2.4	6.3	
Construction Impacts to Road Users (Detours, Delays)	1.3	2.1	2.7		2.1	2.7		2.1	2.7		2.3	3.0	
Maximized Benefits Related to Construction Schedule	0.9	2.2	2.0		2.2	2.0		1.9	1.7		1.9	1.7	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
ENVIRONMENTAL ACCOUNT	46.0		62.3	38%		68.4	40%		105.9	47%		97.3	45%
Green House Gas Costs (Construction/Operation)	0.4	2.1	0.9		2.1	0.9		1.8	0.7		1.7	0.7	
Landscape (Native Habitat/Grass Lands)	3.8	1.1	4.3		1.6	6.0		2.6	9.8		2.2	8.5	
Impact to Ecologically sensitive areas	9.6	0.9	8.5		1.2	11.7		2.2	21.3		2.0	19.2	
Other Wetlands (outside of Swales)	1.8	1.9	3.3		1.9	3.3		2.1	3.7		1.9	3.3	
Other Grasslands (outside of Swales)	1.4	1.6	2.2		1.7	2.4		2.1	3.0		2.1	3.0	
Impact to Breeding Birds and Migratory Birds	3.4	1.4	4.9		1.4	4.9		2.4	8.3		2.2	7.6	
Impact to SOCC	2.8	1.6	4.4		1.6	4.4		2.3	6.6		2.2	6.3	
Impact to SAR	4.0	1.6	6.2		1.6	6.2		2.3	9.3		2.1	8.4	
Impact to Wildlife Movement/Connectivity (to existing crossings)	5.3	1.6	8.3		1.7	8.9		2.3	12.4		2.1	11.2	
Impact Resulting from Habitat Fragmentation	4.1	1.1	4.5		1.1	4.5		2.4	10.0		2.3	9.5	
Illumination Impact	2.0	1.6	3.1		1.6	3.1		2.0	4.0		2.0	4.0	
Noise Impact	2.0	1.3	2.7		1.6	3.1		2.2	4.4		2.2	4.4	
Surface Runoff/Water Quality	4.1	1.7	6.8		1.7	6.8		2.3	9.5		2.1	8.6	
Impact to Heritage Resources	1.3	1.7	2.1		1.7	2.1		2.2	2.8		2.0	2.5	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
SOCIAL ACCOUNT	24.0		37.8	23%		38.8	23%		54.7	24%		54.0	25%
City of Saskatoon Road Network Plans (Alignment)	5.6	1.2	6.8		1.3	7.4		2.4	13.7		2.1	11.8	
RM Corman Park Road Network Plans (Alignment)	4.3	1.9	8.1		1.9	8.1		2.1	9.1		2.2	9.5	
First Nations Road Network Plans (Alignment)	2.2	1.9	4.2		1.9	4.2		2.1	4.6		1.9	4.2	
Public Information Session Feedback/Acceptance	3.3	1.0	3.3		1.1	3.7		2.9	9.5		2.6	8.4	
Land Owner Impacts/Access	3.2	1.7	5.3		1.7	5.3		2.1	6.8		2.3	7.5	
Business Impacts/Access	3.5	1.8	6.2		1.8	6.2		2.0	7.0		2.4	8.5	
Multi Use Paths (Connectivity)	1.9	2.0	3.8		2.0	3.8		2.1	4.0		2.1	4.0	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
ECONOMIC ACCOUNT	7.0		13.2	8%		13.2	8%		15.3	7%		16.8	8%
Employment During Construction	1.9	2.1	4.0		2.1	4.0		2.1	4.0		2.2	4.2	
Development Opportunities (Land Access Availability)	3.6	1.7	6.0		1.7	6.0		2.2	8.0		2.6	9.2	
Local Resource Availability	1.5	2.1	3.2		2.1	3.2		2.2	3.3		2.2	3.3	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
FINANCIAL ACCOUNT	13.0		29.4	18%		28.4	17%		27.1	12%		25.9	12%
Capital Cost (Excludes Utility Costs)	4.8	2.4	11.7		2.2	10.7		2.2	10.7		2.1	10.1	
Operating Cost	3.0	2.2	6.7		2.2	6.7		2.0	6.0		1.9	5.7	
Maintenance Cost	3.0	2.2	6.7		2.2	6.7		2.0	6.0		1.9	5.7	
Utility Cost/Impacts	2.2	2.0	4.4		2.0	4.4		2.0	4.4		2.0	4.4	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
Total Rating Points (elements) =	100		164.7			170.7			223.6			215.8	

SNC · LAVALIN

APPENDIX B

Phase 2 Information Session Survey Results

Prepared for:
The Ministry of Highways

Submitted by:
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Regina, SK S4S 7H9

March 2021

Survey Results

Ministry of Highways: Saskatoon Freeway Functional Planning Study

Phase 2: Virtual Stakeholder Engagement

Table of Contents

Introduction

This report is a summary of results from the Saskatoon Freeway Functional Planning Study Project's Phase 2 Feedback Surveys conducted online via virtual platform in March 2021.

Introduction

The Government of Saskatchewan, through the Ministry of Highways, is engaging in a functional planning study that will determine how the Saskatoon Freeway will look and operate. This freeway is expected to be a four-lane, 55-kilometre stretch of divided highway that begins at Highway 11 south of Saskatoon and connects with Highway 7 west of the city. SNC Lavalin, AECOM and Praxis Consulting were retained by the Ministry to undertake the planning study, which includes 55 km of freeway, 16 interchanges, 5 railway crossings, at least 2 flyovers and 1 major bridge crossing.

Throughout the functional planning study process, a wide range of stakeholders and members of the public will be asked to share their input.

In order to accommodate the moratorium on in-person meetings due to COVID-19, members of the general public and other stakeholders had a chance to learn more about the proposed route for Phase 2 of the Saskatoon Freeway via a virtual platform that was open between February 17 and March 2, 2021.

Participants were encouraged to share their feedback in multiple online surveys available on the virtual platform. All discussions and feedback will help inform the eventual design concepts for Phase 2 of the Saskatoon Freeway Functional Planning Study (SFFPS).

Approximately 160 responses were received through the online surveys. Surveys were included in the virtual rooms that focused on detailed concepts being proposed for:

- Environmental and Heritage Considerations
- Central Avenue Interchange Concepts
- Highway 41 Interchange Concepts with Current Alignment
- Highway 41 Interchange Concepts with Realigned Highway
- Highway 5 Interchange Concepts
- 8th Street Interchange Concepts
- Highway 16 Interchange Concepts
- Floral Road Interchange Concepts
- Grasswood/Floral Road Interchange Concept
- Highway 11 Interchange Concepts
- Bridge Concepts

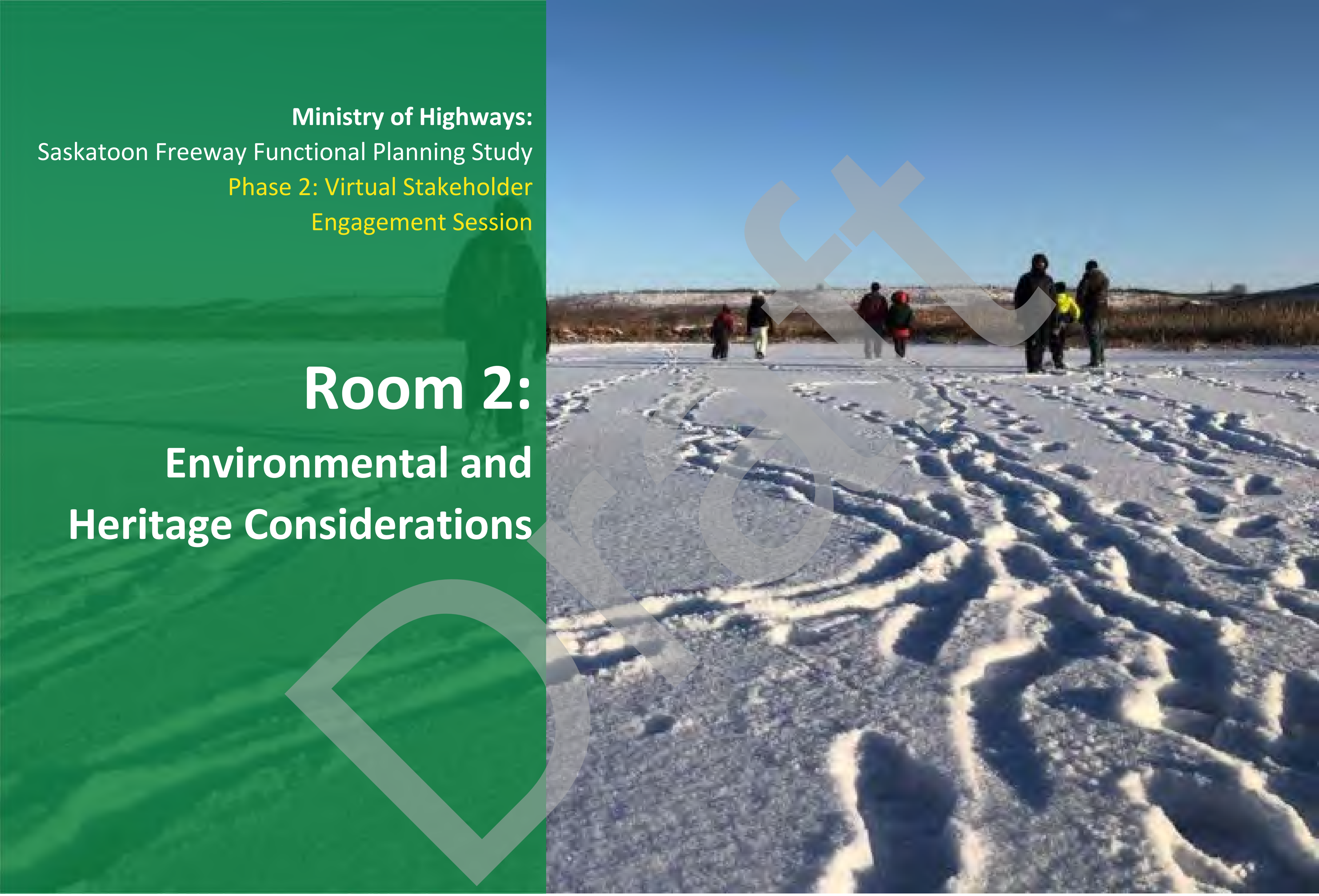
After progressing through all the rooms, participants were also given the opportunity to provide general feedback via an exit survey.

Survey Design

The surveys were designed in consultation with the Saskatchewan Ministry of Highways. Each survey was programmed into an online survey platform and pre-tested to
ensure the questions flowed efficiently and incorporated correct branching and skip patterns.

Analysis

This report presents the analysis of survey data for each room and includes frequency tables and charts. The surveys included several open-end questions, which have been included verbatim; listed alphabetically and unedited.



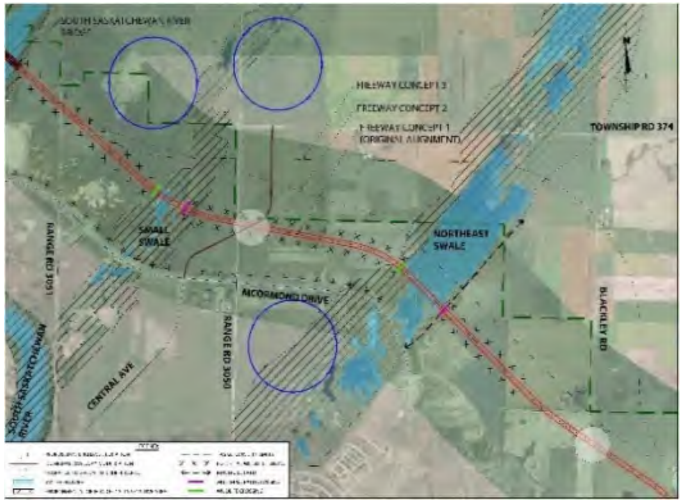
Ministry of Highways:

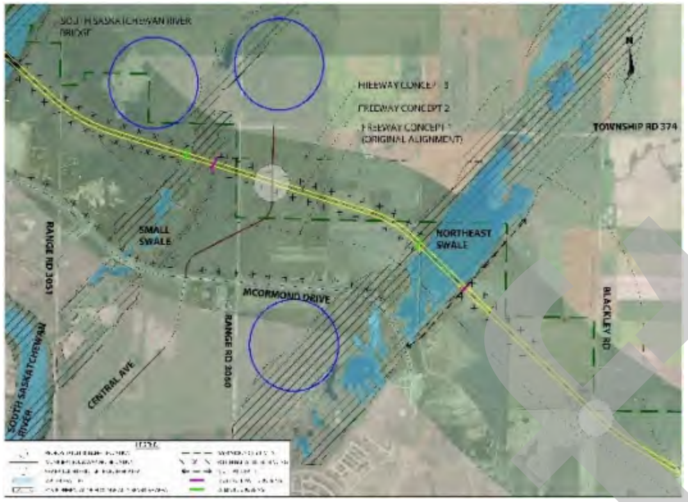
Saskatoon Freeway Functional Planning Study

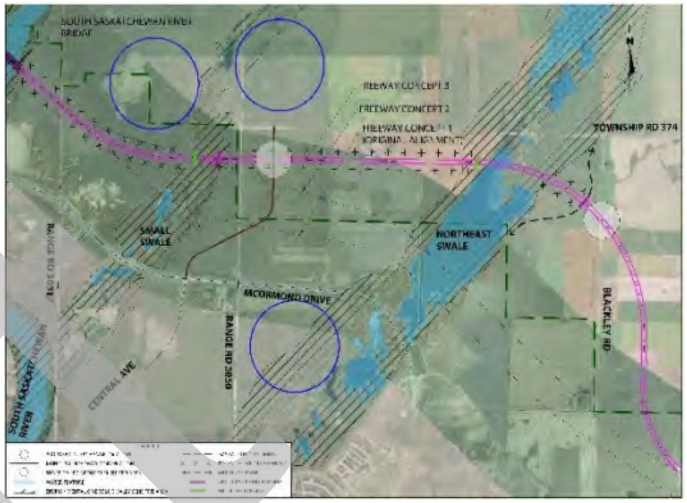
Phase 2: Virtual Stakeholder Engagement Session

Room 2:

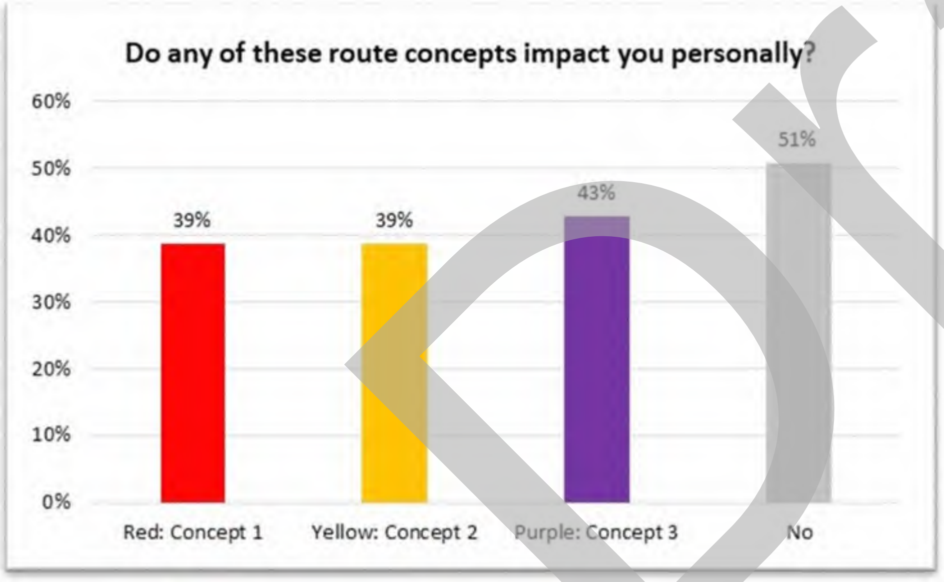
Environmental and Heritage Considerations

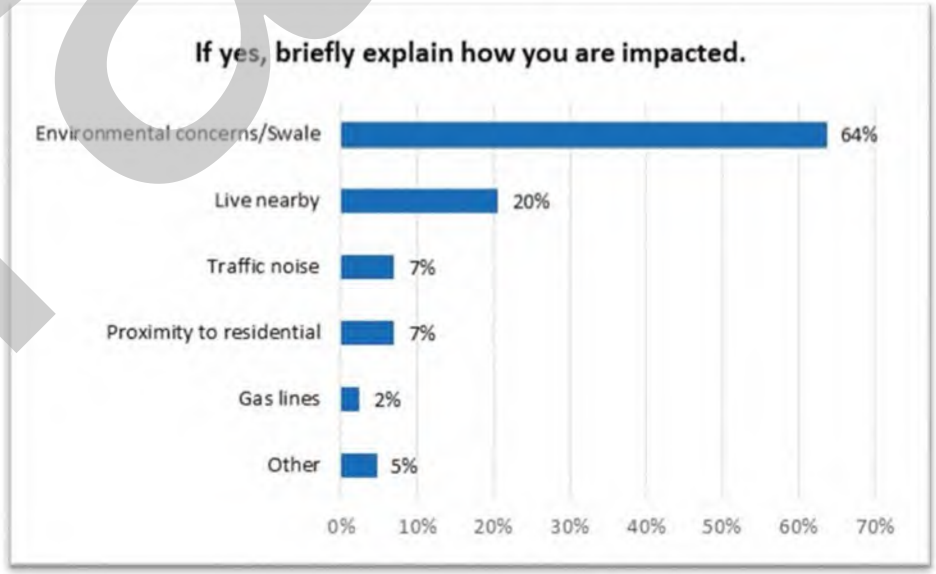


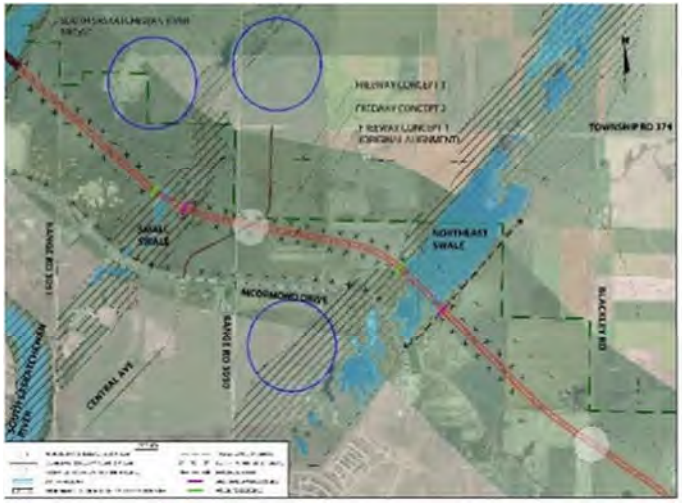


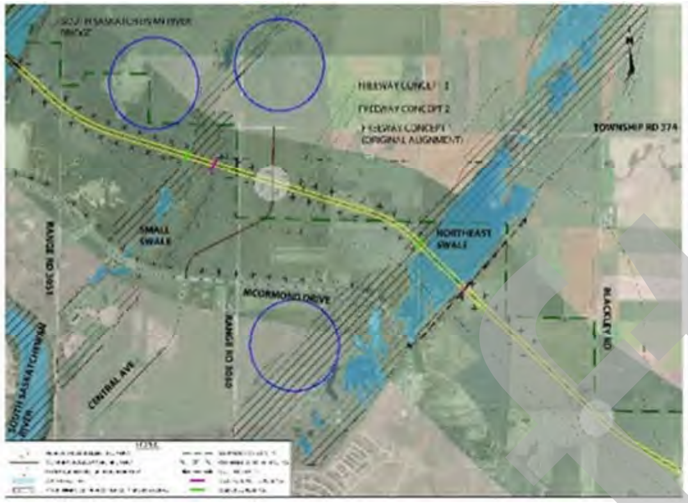


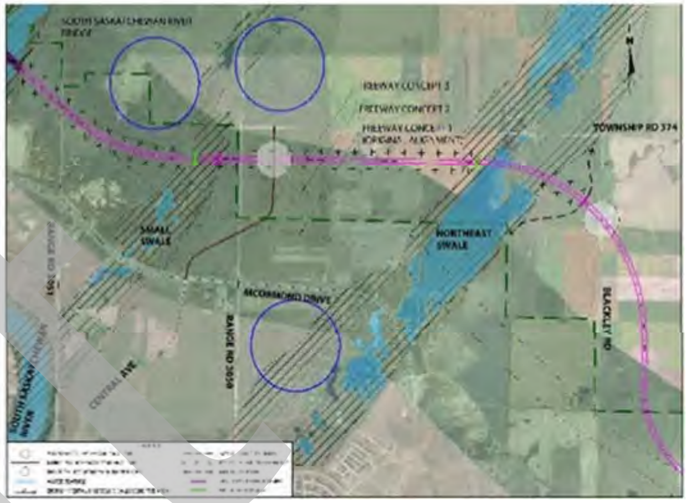
Overall, Concept 3 (purple) is strongly preferred.

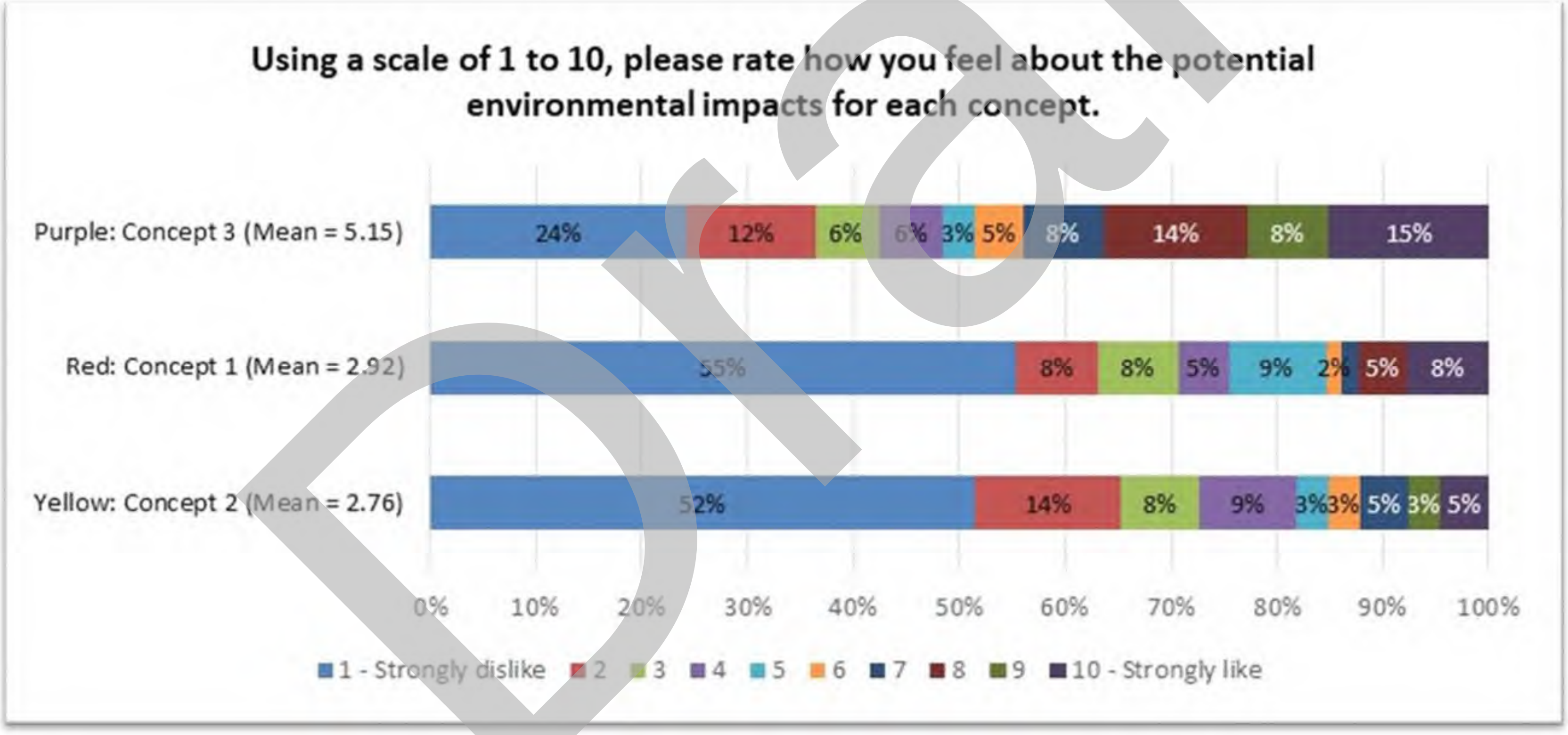

Do any of these route concepts impact you personally?


If yes, briefly explain how you are impacted.

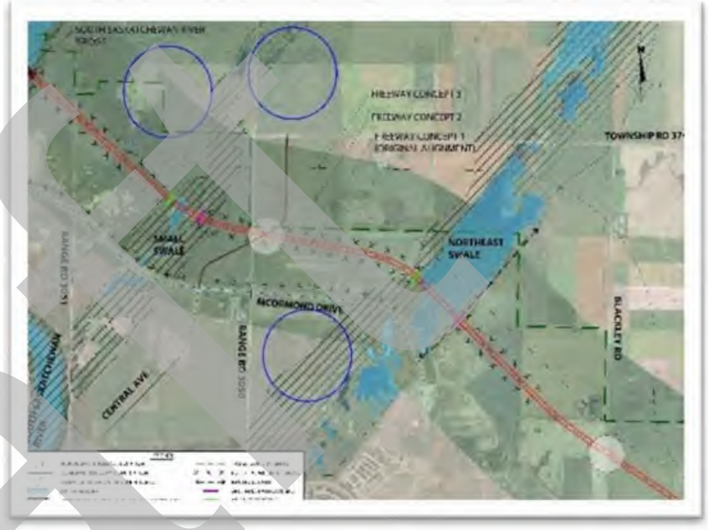






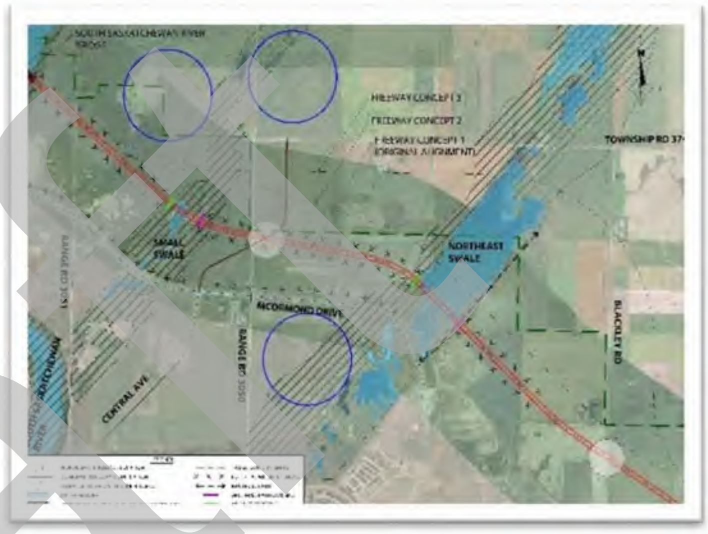

Using a scale of 1 to 10, please rate how you feel about the potential environmental impacts for each concept.

What, if anything, do you like best about Red:



- *avoids area with high density of marsh felwort, bog orchids*
- *Close to McOrmond, keeping impact in a more localized area and other portions of swales remain preserved.*
- *Closest option*
- *Doesn't break up northern portion of swale.*
- *Honestly, I can see no benefits to this placement*
- *I'm raised to live in harmony with Mother Earth so I prefer natural habitat as opposed to any human disturbance and exploitation.*
- *It does have some consideration about the environment*
- *It is a straighter freeway and is on the land already set aside*
- *max distance away from leks*
- *moves further away from Eagle Ridge*
- *Nothing good about this location compared to the new NE bump out*
- *Quickest route?*
- *Shortest distance*
- *shortest route*
- *This is the shortest route with the least amount of roadway having to be built. It has the most straight sections will be safest for drivers and animals. Crossings of sensitive areas are reasonably small and will not have a true outcome much different than any other proposed route.*
- *This would require a bridge over the northeast swale wetlands*

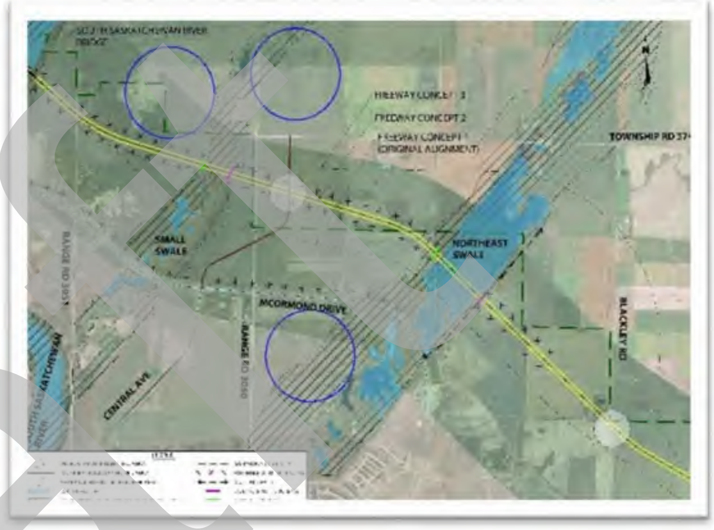
What, if anything, do you not like about Red:



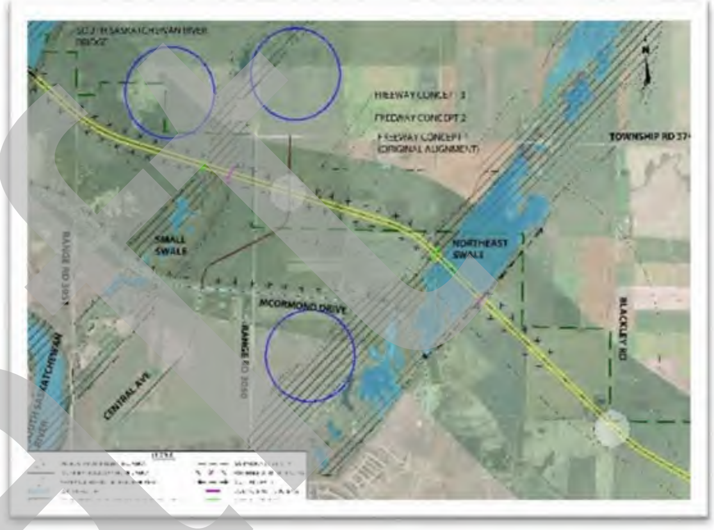
- *As I have said previously, I am VERY concerned about the impact on plant and animal life of any road construction in this area.*
- *As the CONS state it would have devastating environmental impact in the swale.*
- *Because it goes right through a "protected area" and will irreparably damage the area and wildlife*
- *Complexity to avoid environmental impacts*
- *Cut through the Northeast Swale and Small Swale and it's directly adjacent to a developing neighbourhood.*
- *Cuts directly through the Swale, resulting in habitat fragmentation*
- *Cuts right through swales, too close to neighbourhoods*
- *Distance from McOrmond Drive.*
- *Divides the swale*
- *Everything, extremely descructive plan for a sensitive area.*
- *Heavy impact on NE Swale. The environmental impacts will be severe from any of these options, but the red option is by far the worst in terms of impact on the swale.*
- *High impact on swale habitat areas*
- *Highly disruptive to the swales; Places two highways right next to each other.*
- *I do not like it's impact on the enviroment*
- *I goes through the valuable Northeast Swale and the Small Swale, irreplaceable assets to our city. WIldlife will be damaged and those who live nearby will see a decrease in the quality of air and sound.*
- *If a potential road goes through endangered habitat, it should not go there*
- *Impact on small swale. I believe the other concepts would cross in previously altered areas.*
- *Impact to Small and Northeast Swale maybe the greatest with this alignment*
- *Impact to swale*
- *It confuses me as to why a new road almost duplicating McOrmond Drive would be considered.*
- *It crosses a wetland and leaves little space beween it and McOrmand.*

- *It crosses the Small Swale and Northeast Swale over wetland area. The proximity to the grouse leks in the NW corner are also concerning with sound and traffic.*
- *it disturbs the greatest amount of swale*
- *It is a little close to Aspen Ridge.*
- *It is cutting through a main ecological site.*
- *It is going right through the Swale.*
- *It runs through too much water on the NE swale; it is too close to McOrmond Road.*
- *It's just a worse version of Option 2*
- *More swale disturbance, closer to the city, no wildlife overpasses*
- *Most impact on swale*
- *Negative effects on a sensitive ecosystem*
- *No to developers for real estate and industry.*
- *Proximity to existing neighbourhoods*
- *Right through the Swale*
- *Roads through the Swale will destroy this important area.*
- *Severe impacts on both swales and habitats, too close to McOrmond as well.*
- *the greater disturbance of the small swale, how close it is to the other highway, impacting species at risk habitat areas*
- *The red alignment did not take the water bodies in consideration as part of the alignment design.*
- *The road is going through a sensitive native prairie habitat*
- *This further creates a bottleneck for the numerous migrating animal species and has the potential to further fragment the prairie south west of the area, creating a biological remnant of what that area once was. Bottlenecking has been shown throughout biological reserac to have disasterous effects on wildlife movement, and therefore the overall health of an ecosystem. Overall choosing this site will lead to concentraition of all anthropogenic conseuqneces, from light pollution and noise pollution to wildlife crossings and limits to seed dispersal. This to me is the worst option*
- *This will totally destroy the wildlife and wetlands in the Swale.*
- *Too close to city's current infrastructure, too much disruption of wildlife and habitat, only underpasses suggested which are not preferable*
- *too close to current residential development*
- *Too close to McOrmond Drive.*
- *Too close to recently constructed bridge*
- *Too close to residential areas, puts a highway through recreational access points from the city to the swale.*
- *too much disturbance of remaining native grassland*
- *Too much environmental impact*
- *Too much of a cut through the NE Swale, too close to NCP road, too close to City development*
- *Too much possibility of negative environmental effects*
- *Very disruptive*
- *We need passenger rail. Not more motorways.*
- *where it crosses the swales*

What, if anything, do you like best about Yellow:



- *avoids area with high density of marsh felwort, bog orchids*
- *best balance of minimizing impacts to swales but keeping length down*
- *Closest to already planned route, therefore will require the least additional assessment. Most direct route. Least amount of roadway..*
- *farther away from neighbourhoods, lower impact on small swale*
- *further than red from existing neighbourhoods.*
- *Good middle ground*
- *I don't like it. We don't need another bridge just a stone's throw from another one that isn't used to its maximum.*
- *It avoids more of the small swale.*
- *It moves across the swale at a point of open water. While the bridge may be more expensive, it is cheaper than concept three. Disturbances to wildlife will happen. Going over open water is more easily accomodated by birds. Nesting areas are not disturbed*
- *It protects the small swale better than does the Red plan.*
- *Less impact on small swale*
- *Like more space for small swale*
- *lower distance*
- *Minimizing the disturbance to the native prairie*
- *Nothing compared to the other options*
- *Preferred crossing at small swale for less environmental impact. Remains close to McOrmond, keeping impact more localized to one area. Maintains distance from human habit north of the freeway.*
- *Same thing here. Land needs to be less developed.*
- *smaller crossing at small swale*
- *Straight-forward, less curves in roadway.*
- *This concept would require a bridge over the North East Swale Wetlands*

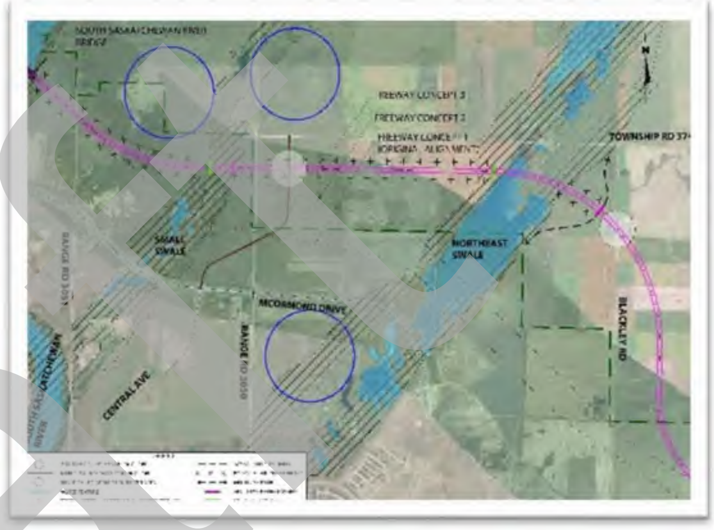


What, if anything, do you not like about Yellow:

- *All cons listed above - this seems to be the most impactful of the three options to both wildlife and recreational uses.*
- *As I have said previously, I am VERY concerned about the impact on plant and animal life of any road construction in this area.*
- *As the CONS state the impact on the swale is too high.*
- *As with Red, straight through both Swales and destructive to invaluable wildlife habitat, and reducing air and sound quality of the surrounding residential areas.*
- *Complexity to avoid environmental impacts*
- *Cuts through both swales and is directly adjacent to a developing neighbourhood.*
- *cuts through NE swale*
- *Cuts through swale, no wildlife overpasses*
- *Cuts through the middle of the water on the NE Swale, too close to the NCP, too close to Saskatoon development*
- *Development and encroachment by humans.*
- *Divides the swale*
- *Do not like it's impact on the environment*
- *Extremely descructive to a sensitive area*
- *greater impact on the northeast swale*
- *Heavy impact on NE Swale. The environmental impacts will be severe from any of these options.*
- *I do not like the longer crossing of the Northeast swale.*
- *If a potential road goes through endangered habitat, it should not go there*
- *Impact to swale*
- *It crosses a wetland in particular; it crosses the NE Swale and Small Swale at all.*
- *It crosses the NE Swale over significnat wetlands. It is even closer to the grouse leks in the NW corner.*
- *It is also going right through the Swale.*
- *It is pushing wildlife into dangerous areas without water.*

- *It is too close to McOrmond; it should go much further north; it crosses too much water on the NE swale.*
- *Just go all the way and pick option 3*
- *Less impact than Concept 1 to Small Swale due to missing the wetlands and growing "in between". But may have impact to NE Swale.*
- *Long water crossing*
- *most effect on swale*
- *negative effects on a sensitive ecosystem*
- *not as close to McOrmond as concept 1. more impact on swale.*
- *Right through the Swale*
- *Roads through the Swale will destroy this important area.*
- *Same answer as the red one. Wildlife impact and right through the "protected area"*
- *Severe impacts on both swales and habitats.*
- *Still creating too much disturbance while adding cost through longer water crossing and difficult wildlife corridors*
- *Still cuts through a lot of the Swale*
- *Still fairly high impact to habitat and wildlife and again only underpasses proposed, crosses large area of open water which will require a long bridge*
- *Still too much environmental impact*
- *Still too much impact on wildlife.*
- *The length of the open water crossing over Northeast Swale is concerning.*
- *The road is going through a sensitive native prairie habitat*
- *There is really no difference in yellow or red so you might as well stay with the red as all levels of Government already approved the red alignment.*
- *This is the best option*
- *This plan strikes me as Ministry of Highways attempt to convince the public that it is a compromise between red and purple?*
- *This still creates a bottleneck for wildlife movement in the area, while also being a very costly option due to the larger overpass and wildlife crossings needed. This also croses one of the most significant water sources in the swale where breeding birds visit regularly. This further fragments the landscape and prevents the system being a corridor in general for all the species that live there. This is a really bad option.*
- *too close to Eagle Ridge*
- *Too close to recently constructed bridge*
- *too close to residential development*
- *too much disturbance of wetland portion*
- *Too much environmental impact*
- *We need a provincial bus service. Not more highways.*
- *While better than Concept 1 (Red), it is still highly disruptive to wildlife*

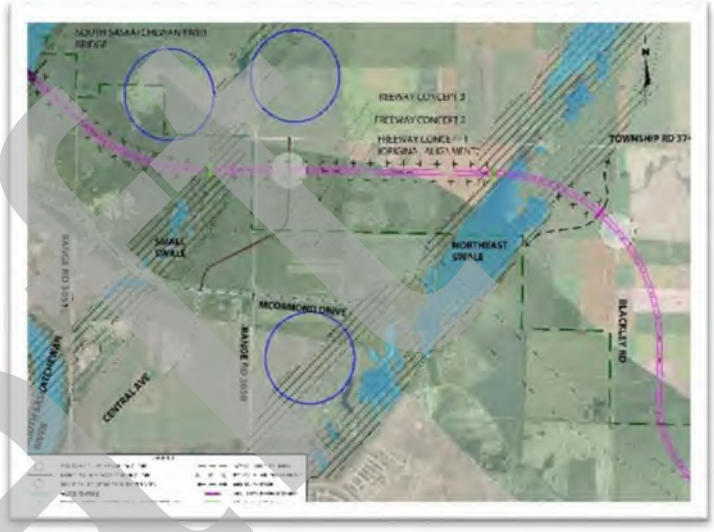
What, if anything, do you like best about Purple:



- *All the Pros that were described are such positives. This results in the most minimized disturbance to one of the most important natural areas in our City, while also allowing for the City's future expansion. The major crossings and roadways are in alreay disturbed areas which is a huge benefit. The impacts to the people that reside in that area are minimal considering the significant amount of ecosystems services and aesthetically pleasing views the residents will receive from this placement. This is also the furthest away from Aspen Ridge, which results in less noise and light pollution.Sacrifices need to be made in any decision and I think this areas has paid the price enough. Please proceed with this option.*
- *appears to be a better option for the swale environment*
- *Appears to do the least disturbance to the swales?*
- *Avoids the swale. Provides more opportunity to create a buffer between residential neighbourhoods and the highway.*
- *Covers more already disturbed area, provides some distance between neighbourhoods in the city and the freeway*
- *Does the best to avoid environmental zones of concern, with likely reduced complexity*
- *Except for local residents seams like less impact*
- *farther away from city residential, smaller interstitial fragment*
- *Farther from residential developments, retains a good swath of the swale unbroken between the freeway and McOrmond*
- *Farthest away from schools, neighbourhoods, swales*
- *Goes through more cultivated land, has wildlife overpasses*
- *I do not like.*
- *It appears to be the best of the three options presented.*
- *It appears to better insofar as it avoids more of the swales.*
- *it avoids the majority of the sensitive areas and goes through previously disturbs areas.*
- *It crosses the NE Swale over less water. However, any native prairie habititat is valuable.*
- *It has the least impact on the environment (I know that further study is pending).*
- *It is further north; it crosses the NE swale at a better spot.*

- *It is going through the least amount of thenSwale.*
- *It is the least destructive of three very bad ideas.*
- *It's natural ability to remain beautiful.*
- *It's a huge improvement over the other options, as it lessens the NE Swale impacts, give room between the NCP and the Freeway and allows for Saskatoon development to expand within the Freeway for years to come.*
- *least amount of disturbance and furthest away from neighbourhoods.*
- *Least bad.*
- *Least environmental impact; 1 extra km is a minimal disruption for drivers*
- *leaves larger piece of NE Swale intact*
- *less disturbance of remaining grassland and wetland - build on already disturbed land whenever possible*
- *Less harmful than the others since it would skirt the central part of the Swale*
- *Less obtrusive, land bridge*
- *Limits the environmental impacts*
- *location of small swale crossing*
- *Minimal environmental impact*
- *Most environmentally sound option, particularly by crossing primarily cultivated lands*
- *nothing.*
- *Nothing.*
- *Of the three Concepts given, Concept 3 (Purple) seems to do the least damage to the Northeast Swale and Small Swale.*
- *Out of the three options, the pros outweigh the cons, so far.*
- *overpasses for wildlife*
- *Reduces swale impact. Provides more distance from city allowing more room.*
- *Smaller impacts on both swales and wetlands.*
- *smallest impact on small swale, least disturbance on overall habitat areas, mostly through cultivated lands*
- *This is the best option to cross the two swales.*
- *This moves the Blackley rd interchange to the east which will reduce impacts on another ecologically sensitive area, Kernen PRairie*
- *This one is slightly better than the previous other two examples but not by much*
- *This one is way better than the other two proposals, it is wise to use previously disturbed areas. Thank you*
- *This seems to leave larger area for wild life*
- *Well considered re: wildlife and the swales*

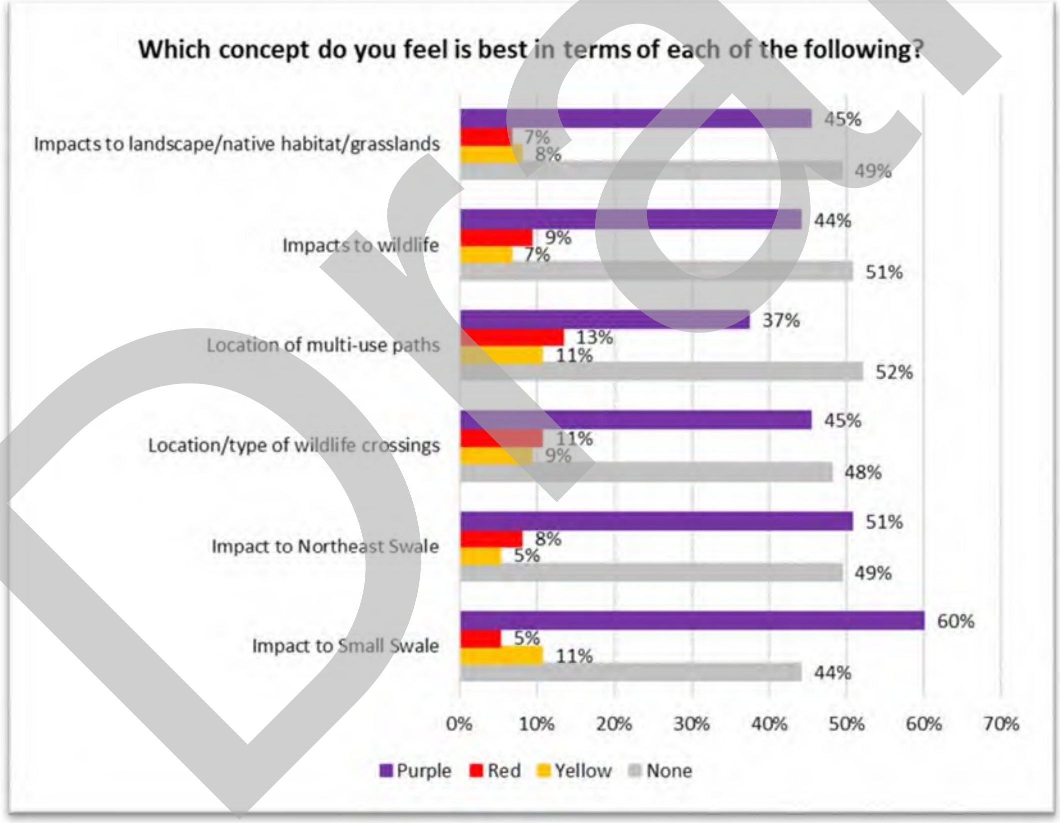
What, if anything, do you not like about Purple:

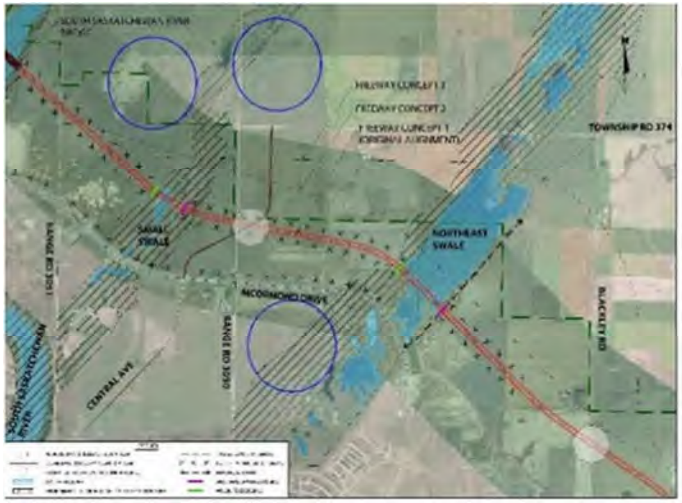


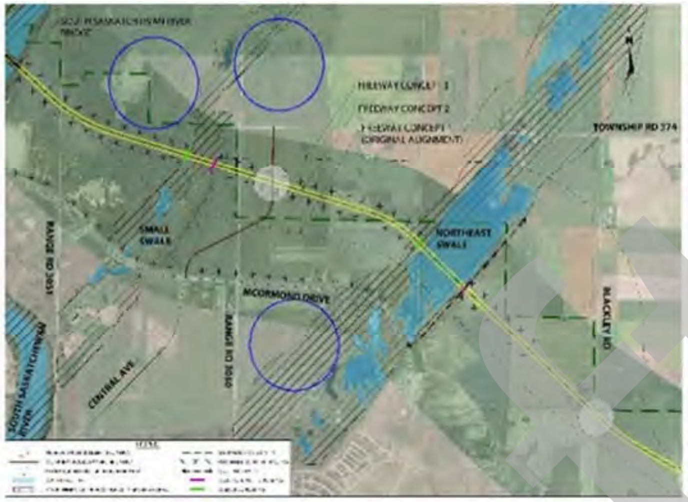
- *Additional cost.*
- *Any good initiatives in that minimize environmental impacts will be "value engineered" out and we will be left with an extremely destructive road through a very sensitive area.*
- *As I have said previously, I am VERY concerned about the impact on plant and animal life of any road construction in this area.*
- *By the time the Freeway is built, there may already be development on both sides of it, at the pace of development I see taking place already. Instead of going around the north end of the city to connect Hwys 7, 16 and 11 why not look at going around the south end of the city? Has that been examined?*
- *Heavy impact on NE Swale. The environmental impacts will be severe from any of these options.*
- *Human altering of any kind.*
- *I did not give it a full 10 as the alignment should follow the Twp 374 and RR 3043. The (pink line) multiuse path should be always shown on the swale edges (north and south) and the (green line) wildlife crossing should be on both sides but within the swales. On the south side of the NE Swale why does the multi-use trail swing out towards the interchange. This is not good design.*
- *I don't like that it will affect more residents. Your study doesn't say who those residents are, i.e., which neighbourhoods. I think the road is still way too close to the City; in fact, if should not be in City limits at all.*
- *If a potential road goes through endangered habitat, it should not go there*
- *I'm not convinced of the need for a greater number of highways around Saskatoon -- the experience of many cities has been that more is not always better -- adding freeways often increases traffic, congestion, and pollution.*
- *impact to residential areas-not clear as to what that might be*
- *Impact to swale*
- *Increased amount of roadway will impact the environment with increased construction and use of materials. Curved roadway is more dangerous for drivers and animals. Very little difference on overall environmental impact compared to other proposed routes.*
- *It blocks animals like deer from getting to water resources.*

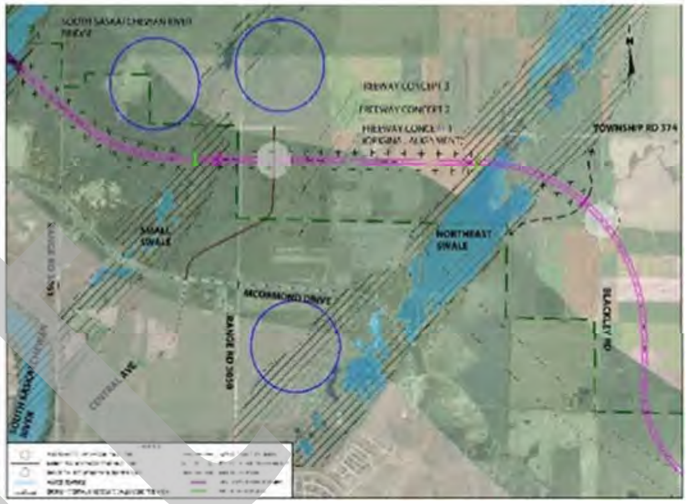
- *it crosses the small swale and the NE swale.*
- *It is still crossing an endangered natural ecosystem. It should not be built at all. The negative environmental impacts are too great.*
- *It is still going through thenSwale.*
- *It should completely avoid the swales, grasslands, and wetlands in Saskatoon and surrounding area.*
- *It's unnecessary, there's already a bridge right there, and I'm not convinced the City is going to grow as much as the planners seem too. I don't like the fact that it will bring more traffic at high speed going through a sensitive area for both wildlife (plants and animals) and local residents - more pollution means lower quality of living.*
- *Least disruptive to the swale*
- *Longer road impacts more land*
- *Maybe the best alternative of the 3 concepts. Concerns with the uncertainty of that area of the NE Swale ecologically and also the impact to 3 farm yards. Also potential impact to the "branch" of the NE Swale*
- *Meaningful environmental studies must be done before this option is pursued*
- *more length = more cost, but you can't have it all. the additional length (cost) is worth the benefits.*
- *needs more study apparently*
- *negative effects on a sensitive ecosystem*
- *Not as terrible as the other 2 options. However I don't think the Freeway should cross the Swales at all. The whole route should be moved a long way north, away from native grasslands and swales, and go north of the whole city. It makes no sense to build 2 roadways and bridges so close together, and still go through a lot of the City.*
- *Not much -- who cares that it's 1.2 km longer*
- *Potential remaining noise impacts and environmental degradation of exterior swale areas*
- *Roads through the Swale will destroy this important area.*
- *roadway is much more curved than original design.*
- *Seems like the best option, but still cuts through a lot of the Swale*
- *Still feels like not a whole lot of space between it and Mcormond Drive.*
- *Still too close to the Swale*
- *That this option was not not on the table earlier.*
- *The close proximity to the grouse leks in the NW corner.*
- *The road is going through native prairie habitat*
- *There will still be ecological impacts to the site, but they are minimzed as best as possible with choosing this option.*
- *This concept has more than three disadvantages. One, it is now running through more nesting and wildlife habitat. Yes this habitat is somewhat disturbed but we know that a huge amount of wildlife reside and hide here. It could easily be rehabilitated. Two, the Freeway drives straight through previously designated Agricultural Research lands. Three, more cost.*
- *this concept places the freeway directly onto homes of 3 families, human habit was not taken into consideration. This concept also have a severe impact on much more agricultural land. I would prefer for the freeway to be*

- *located closer to McOrmond to keep impact localized to a smaller area.*
- *This is the plan that is supposed to make those who care about the future of the planet accept it? The money spent on these mitigation efforts would be best applied to McOrmond Drive, which is already built. Don't even build the "Saskatoon Freeway" - spend far less money and mitigate the damage done by McOrmond Drive.*
- *too close to Eagle Ridge*
- *Too close to recently constructed bridge*
- *Unsure of impacts to residents outside of the city and environmental assessment has not yet been completed*
- *We need a provincial bus service. And passenger rail. Not more highways.*
- *will still destroy/disturb locally uncommon habitat and plant communities*









Do you have any additional comments you would like to add about one of the routes?

- *Again, all have a negative impact in breaking up the corridor of a native prairie ecosystem, disrupts the functioning of the landscape, and puts species at risk in the area at greater peril.*
- *All are too close to north east neighborhoods and redundant due to recently constructed bridge*
- *All of these routes are bad. The Freeway should cross the river much further north, and not go through the two swales at all. I objected to the Central and McOrmond extensions through the swales, and I strongly object to this Freeway route, which was apparently chosen many years ago without any public consultation.*
- *All options will results in further environmental degradations so steps should be taken to minimze this during development as best as possible. However, option 3 by far limits the impacts to wildlife, native prairie plants, and the surrounding residents at the cost of a higher price tag. I certainly would be willing to pay more for the project knowing our environment and sustainble protection of our vital ecosystems is ensured. Environmental considerations are just as important as others and it is time Saskatchewan stands up for this notion.*
- *Balance is required. The Yellow route does this. However, a fourth concept could be drawn. That one would draw something similar the the third concept. Two difference: One, move the turn north onto the west side of Blackley road. Two, bend west again further south of road 374 and cross over open water.*
- *Concept 3 is the least destructive, but they are all destructive and I am very sad that this plan is going ahead.*
- *Consideration for a utility corridor should be considered. As well, individual consultation with utilities should be considered given the potential impact s and associated costs of impacting the infrastructure. For example th eRegina Bypass ending up costing in the range of $50 Million to move all pipelines, power lines, etc. Where if consulted sooner, likely a decent portion of these costs could have been decreased or even not required in some cases. Thanks for the consideration.*

- *DO NOT PROCEED WITH THIS PROJECT IF IT IMPACTS THE SWALE AND OUR ENVIRONMENTALLY SENSITIVE AREAS.*
- *Get it away from the Swale and future Residential development*
- *I am disappointed by the combined willingness of the city and provincial governments to build high impact roads across such an ecologically sensitive area. I would like to see a southern route for the freeway examined.*
- *I appreciate all the work Phase 2 has done to look for a new alignment to cross the swales. I really like the images in this section but I wish there was a video presentation explaining this more.*
- *I saw deer crossing McOrmand Road on on February 25th. The deer ran down Kerr Road. The new freeway would create more roads for deer to cross just like what happened on Sunday. It is dangerous not only for animals but for those people driving.*
- *I sincerely hope this plan will not go ahead, but if it does, it MUST include protection for the plants and animals in the area*
- *I think it would be a great idea (if this was stated/noted, I did not see it) to leave the land between McOrmond and the Freeway from the river to the first interchange as a greenway and convert it back to natural grass lands (as best as possible).*
- *I think more consideration should be taken for residents/farmers north of the city. I did see mention only to residents of Aspen Ridge but not to the residents outside of the city, particularly to the residents and farmers who will be directly impacted by the freeway.*
- *I think this is an expensive, unnecessary project, that would do great harm to human, animal and plant life. Such an investment could be better directed to alternative transportation and promotion of healthy lifestyles. Thank you for the opportunity to comment.*
- *I think this is terrible and the swale should be left alone.*
- *I think we have to realize that any roadway built will have an environmental impact. The most important points in deciding a route should be to build the shortest (and most direct) roadway that can efficiently and safely transport people around the city. This freeway is to be built for the people of Saskatoon, not the artificially propped up swale area. If the new route 3 is to be chosen several more farmers will lose their yards. Additional length of roadway will have to be built and it will inconvenience every driver that will use the roadway for its lifespan. If fuel usage and time is taken into account in considering environmental impact any increase in the length of the roadway will have a huge impact on the environment over time. People need to consider the whole environment in a realistic manner. Listen to so called environmentalists complain about the protected sloughs is ridiculous. This roadway is built for every tax payer in Saskatoon/Saskatchewan and should be built as such.*
- *no thanks*
- *None of the routes are a good idea as they will all lead to the demise of this important natural area.*

- *None of the routes is good. The route should be changed altogether or, better yet, the highway should be moved to the south side of the City where land has already been cultivated.*
- *None of these routes should be going through the swale. You all have zero regard for protecting a so-called "protected area." You have no regard for anything concerned citizens or groups are saying about the swale. You continue to show that you have zero respect for any protections of this area.*
- *Once built, Aspen Ridge neighborhood residents would likely complain of noise pollution devaluing their properties in options 1 and 2*
- *Overall, I do not understand why a highway bypass around Saskatoon needs to be so close to the city, given that a 6 lane bridge is already available a short distance to the south. My understanding is that there are other bridge options including Clarkboro that would provide an effective bypass without impacting high ecologcial value lands in the vicinity of the city.*
- *Please put this expensive endeavour into a high speed railway for passengers and goods between Saskatoon and Regina and onwards to Edmonton. This is safer, more energy efficient and acknowledges that we need to transition from fossil fuel based transportation of goods and people. If we could cut the travel time between Saskatoon and Regina in half, many would choose to use a train for transportation. Please invest in exploring this option.*
- *Please stop development and focus on what's been created and is slowly being left to urban squall and gangster culture.*
- *Thank you for taking the time to further study this situation*
- *The highway should not be in City limits.*
- *The purple route is a great addition to the project.*
- *The purple route should be moved north to Township road 374 to minimize impact on Northeast Swale*
- *They're all terrible. This freeway should be going around west of the city*
- *This freeway is obscene. We would not have bought near an ecologically sensitive area knowing it is going to be destroyed by a freeway. Brutal planning and no consideration for environmental protection, growth of the city and future generations*
- *This is no longer a perimeter highway and will end up passing through a residential neighbourhood. That raises all sorts of negative health effects on both people and animals. This highway is ill concieved given our current climate and biodiversity emergencies. We should be doing a thorugh review of provincial transportation policty and finidng ways to have far viewer vehicles on the roads. We should be doing all we can to protect and restore natural ecosystems as they will do more to mitigate the effects of climate change and lower our carbon footprint than a major highway will, no matter how many "eco-friendly" add-ons are incorporated.*

- *Use the red concept for the majority of the routing, except cross the small swale where the yellow and purple concepts cross. This would limit the impact to both swales, result in the shortest routes, and result in more space between Mcormond and the freeway so that the wildlife have more space to thrive.*
- *wasn't clear impact on multi use paths*
- *We are in a climate emergency. Even electric cars cause pollution. Electric cars are bad for air quality and bad for quality of life, as is all motor traffic congestion. We need to get beyond private cars. Building more very expensive freeways is the wrong move. The money wasted on this project could fund a provincial bus system for many years. We are addicted to a very expensive and damaging car dependency. We cannot build our way out of congestion. We can do better.*
- *We don't need this route*
- *We don't need to add routes to areas we are trying to protect. There are other alternatives*
- *Would need to review the wildlife crossings and fencing in more detail to have a better understanding. Concepts look favourable.*
- *Yes. The province is offering to spend a whole heck of a lot of money on a brand new freeway, that is less than a km from a major route that is already damaging the Swales. Why not save us all money by working with the city to mitigate that damage - put in the wildlife crossings and fencing, improve the interchange on the west side of the river to build out to hwy 11 and 16 through already disturbed industrial area, and provide landscaping along the highway to ameliorate the noise. Way cheaper, way more effective for preserving the environment.*
- *You are going to impact farmyards of people I know. I believe that the city will expropriate their land for future development at some point anyway, so why not do what is best for the environment. I have neighbors who feel it will add to much light and noise to our area, but I believe that the city will build up between us and the freeway and that will dampen those effects. If you are having a dark sky designation over those areas of the freeway that also mitigates their concerns for noise. My concern is that you won't clearly explain to them what the future will look like outside of the freeway and I will have to listen to their complaints for a long time.*

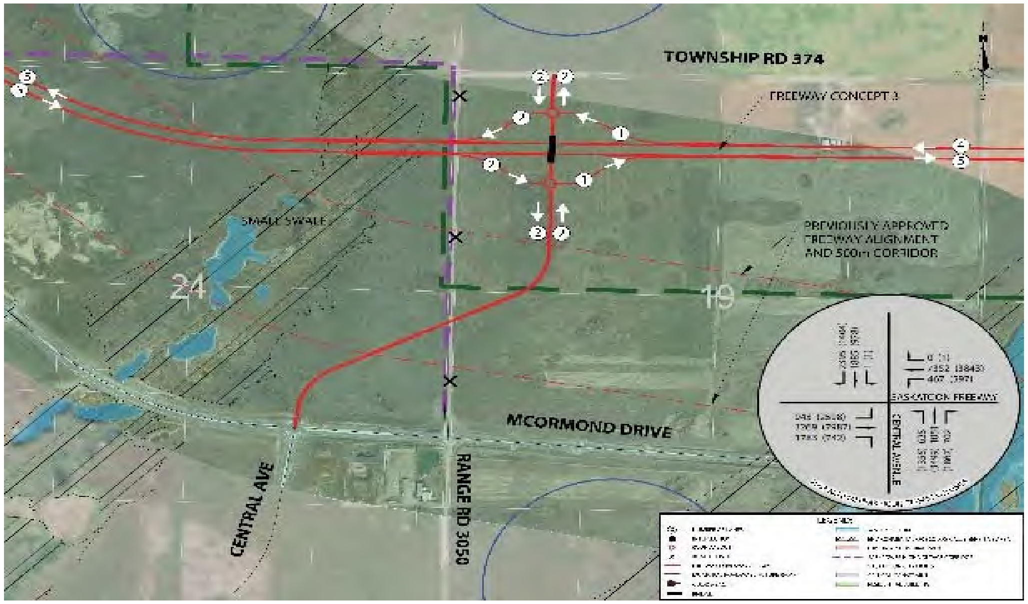
Ministry of Highways:

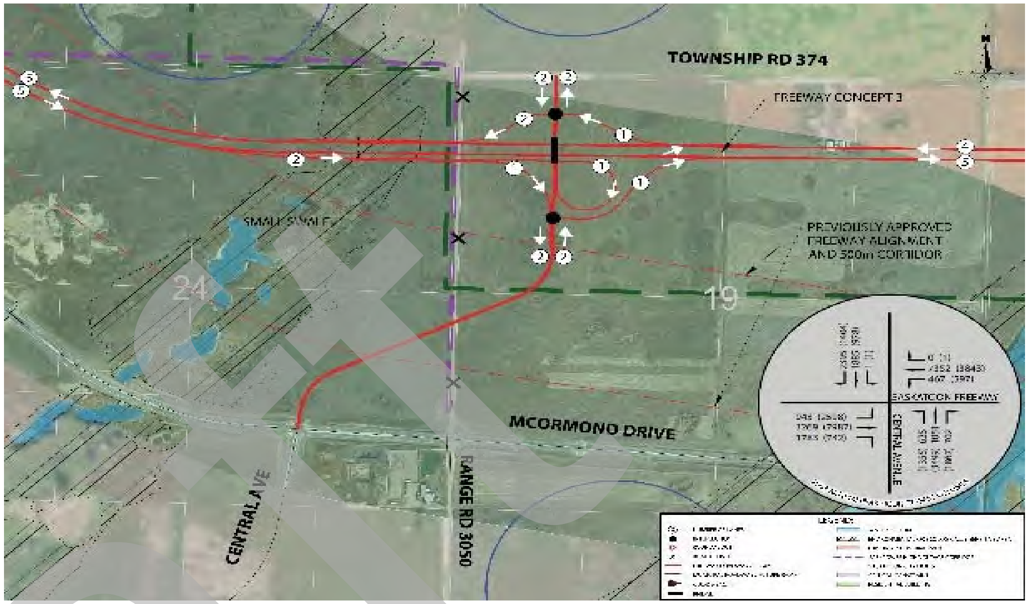
Saskatoon Freeway Functional Planning Study

Phase 2: Virtual Stakeholder Engagement Session

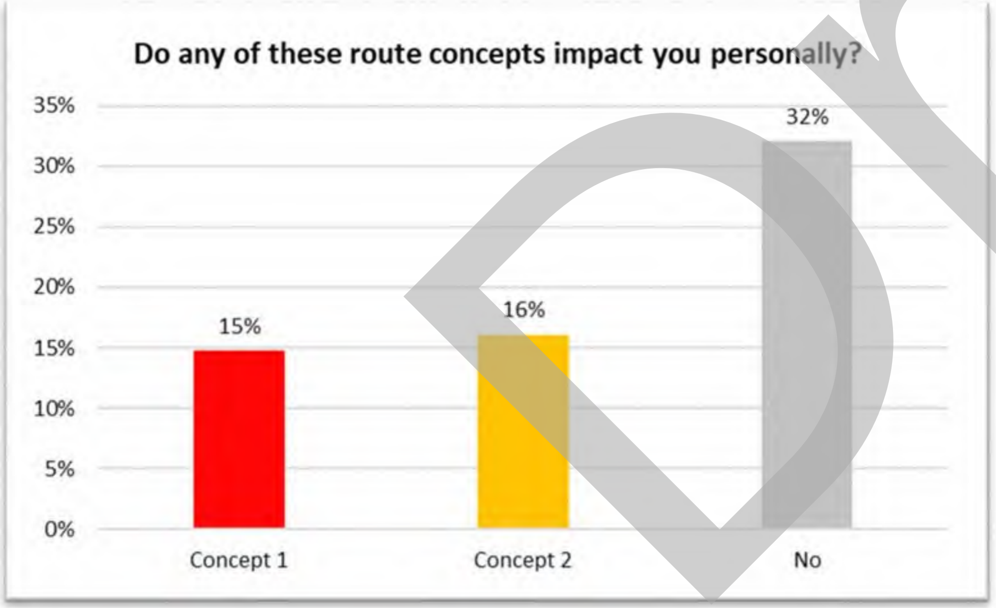
Room 3, Board 5:

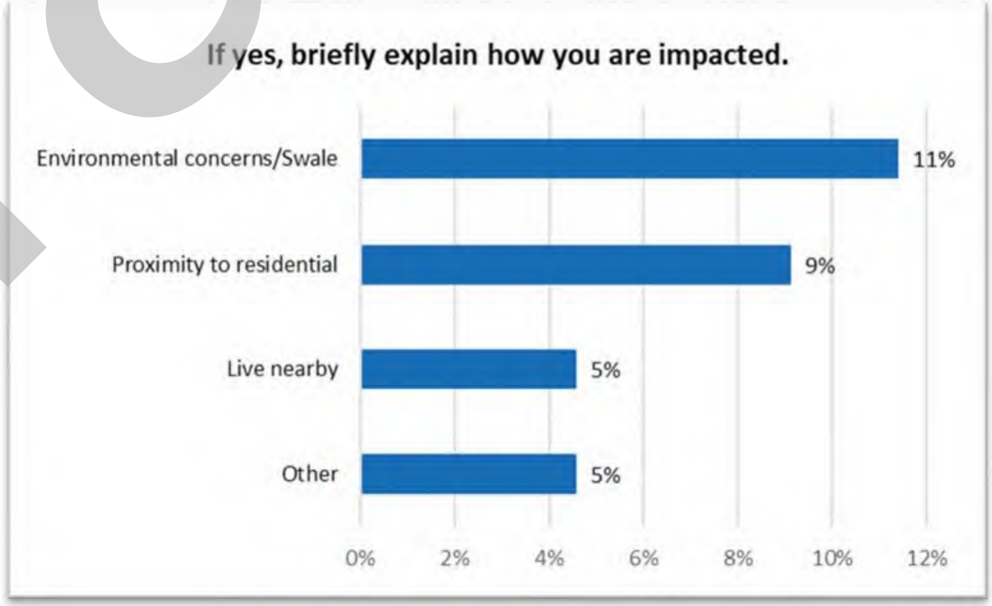
Central Avenue Interchange Concepts

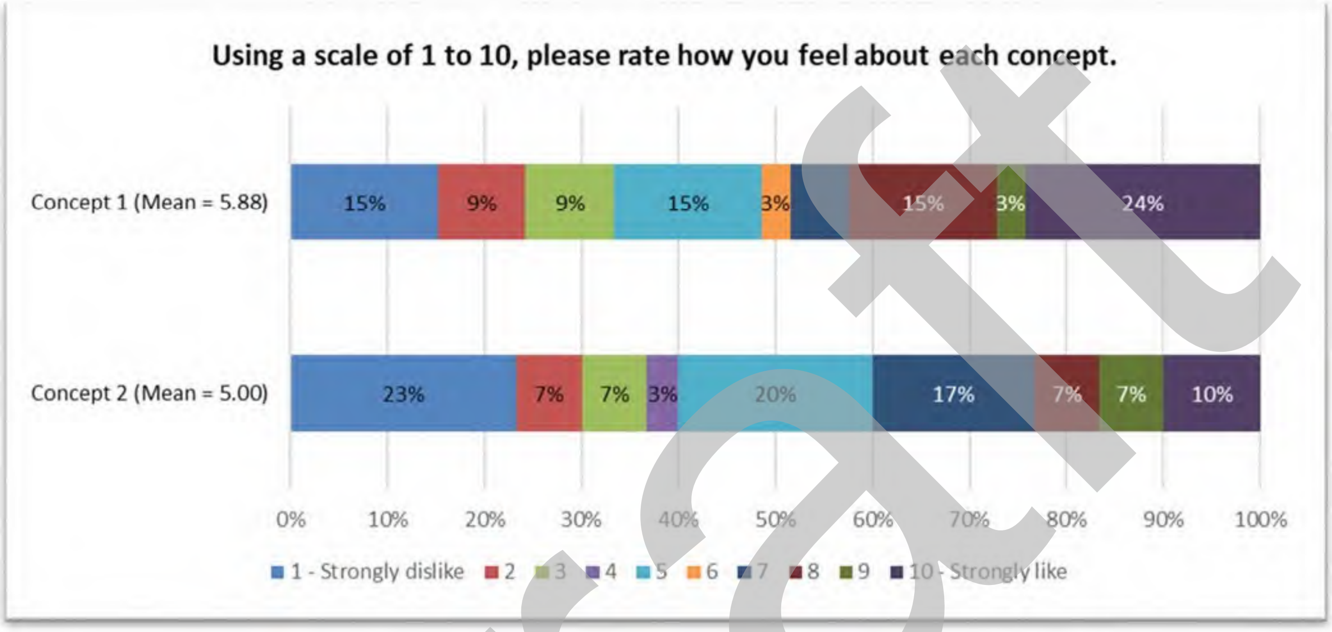




Concept 1 is slightly preferred mostly due to better traffic flow.







What, if anything, do you like best about Concept 1:

- *appears simpler to construct*
- *Efficient use of space. Use of roundabouts to provide easy options for where to go.*
- *It crosses the Small Swale at a better location.*
- *Low impact on Land and a simple design.*
- *no traffic lights use roundabouts*
- *None*
- *Roundabouts keep traffic flowing*
- *Roundabouts will allow traffic to flow well on and off the freeway.*
- *simple and straight forward*
- *Simple Design, shown to work well*

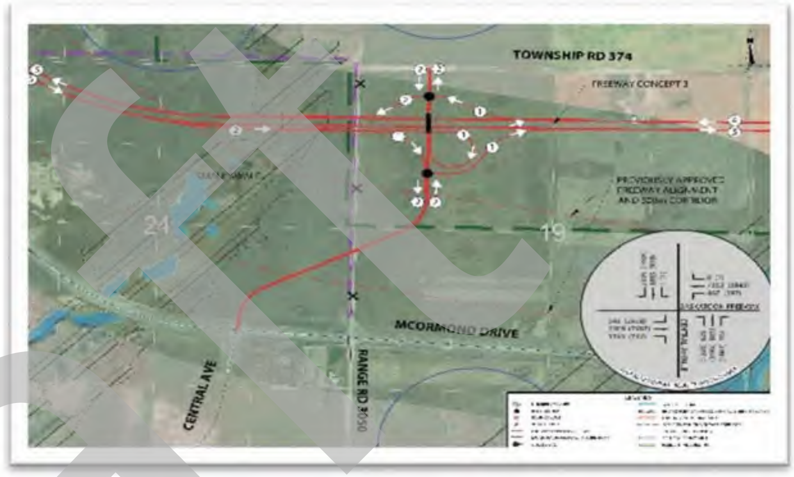
- *Simple, appears less expensive.*
- *simple, predictable*
- *simple. people need to learn to use roundabouts*
- *The least impact on surrounding land*
- *Traffic flows freely. Its nice.*
- *use of roundabouts to create easier options for access and to reduce the overall space used. Its about time we start using these types of interchanges!*

What, if anything, do you not like about Concept 1:

- *"Freeways" cut up the landscape, making it difficult to get around by environmentally friendly modes of transport, like walking and biking.*
- *Amount of Distance roadway re-aligned from Grid. Half-Cover (Like Circle Drive & Warman Road) may be able to fit.*
- *Any road through this Swales will degrade this important area, I do not think the province should be building this.*
- *Close to small swale*
- *Could shift to the west to better line up with Central*
- *Drivers seem to find traffic circles difficult at the best of times, but if traffic volumes warrant this interchange, traffic circles do not seem suitable and at best look like a temporary arrangement.*
- *I would like to see the interchanged move to the west so it doesn't have a curve or less of a curve in Central Ave.*
- *May not provide future proofing/longevity.*
- *nothing*
- *poor traffic flow from freeway to Central Ave SB*
- *risk of drivers exiting too quickly, entering roundabout at high speed*
- *Roundabouts.*
- *The interchange is too close to the grouse leks.*
- *Too close to Swale*
- *Too many intersections with traffic lights.*
- *would have like to seen a looped system with no crossing traffic and stops*

What, if anything, do you like best about Concept 2:

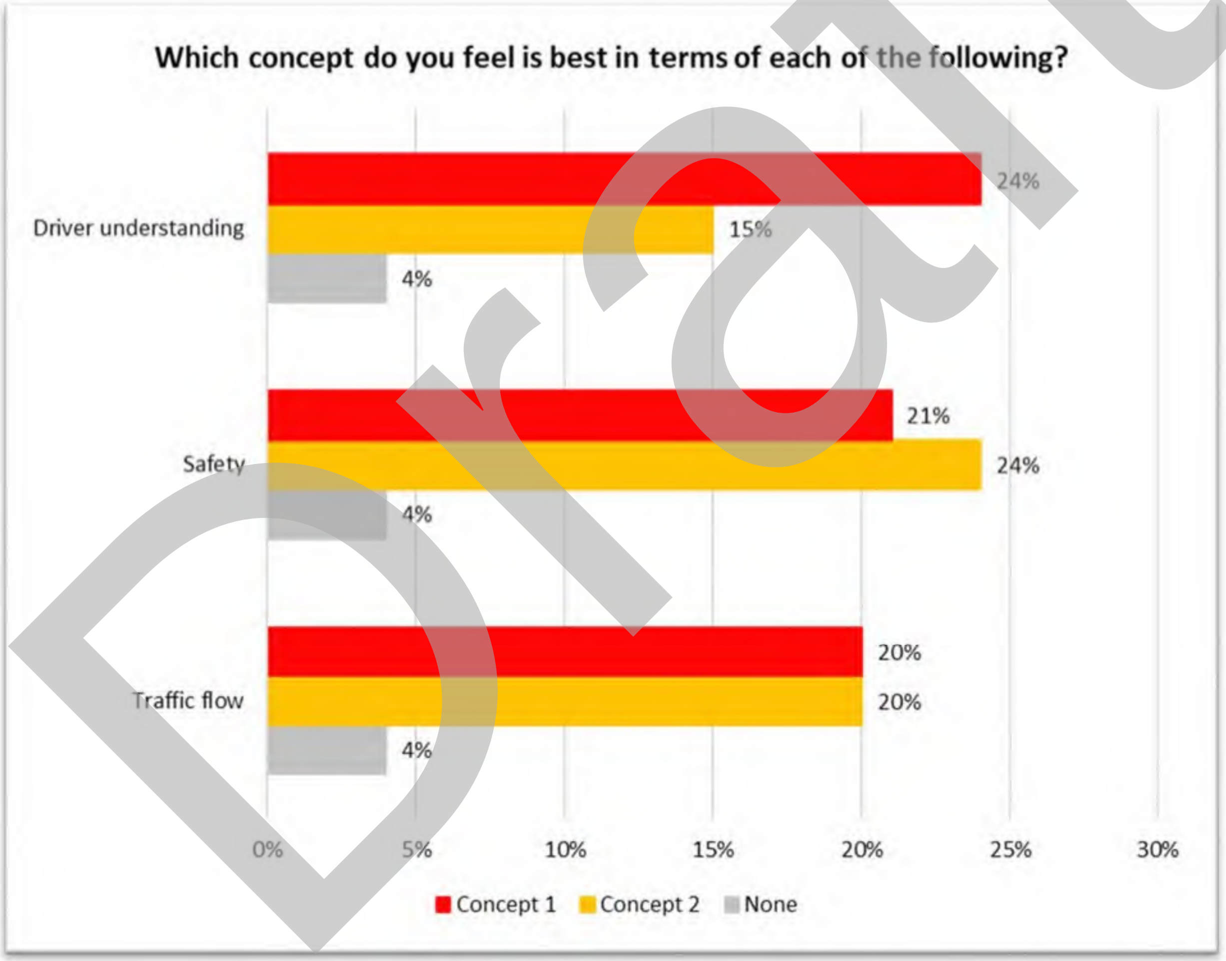
- *Almost Complete Free-Flow for South-East bound traffic on Freeway*
- *better flow from freeway to Central Ave SB*
- *for south side, induces drivers to slow down*
- *It avoids traffic circles.*
- *Keep traffic flowing*
- *Like Concept 2 better because it moves the off/on ramps away from the quarter section with the Small Swale - there is some important secondary habitat for wildlife in the uplands*
- *Lower footprint*
- *More efficient.*
- *More loops for better traffic flow.*
- *None*
- *not much*
- *Will help in the future/future growth/longevity.*

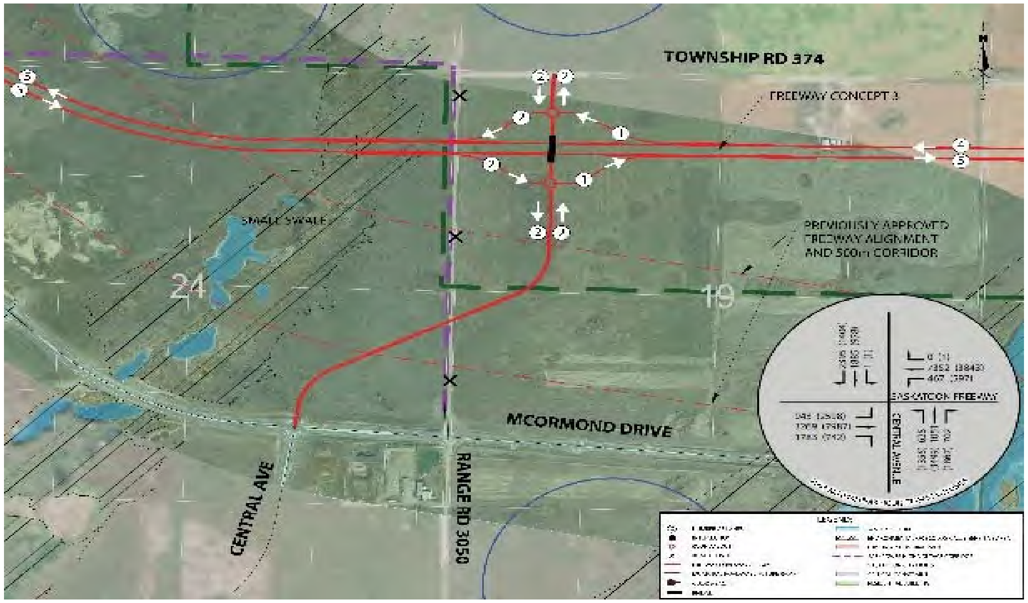


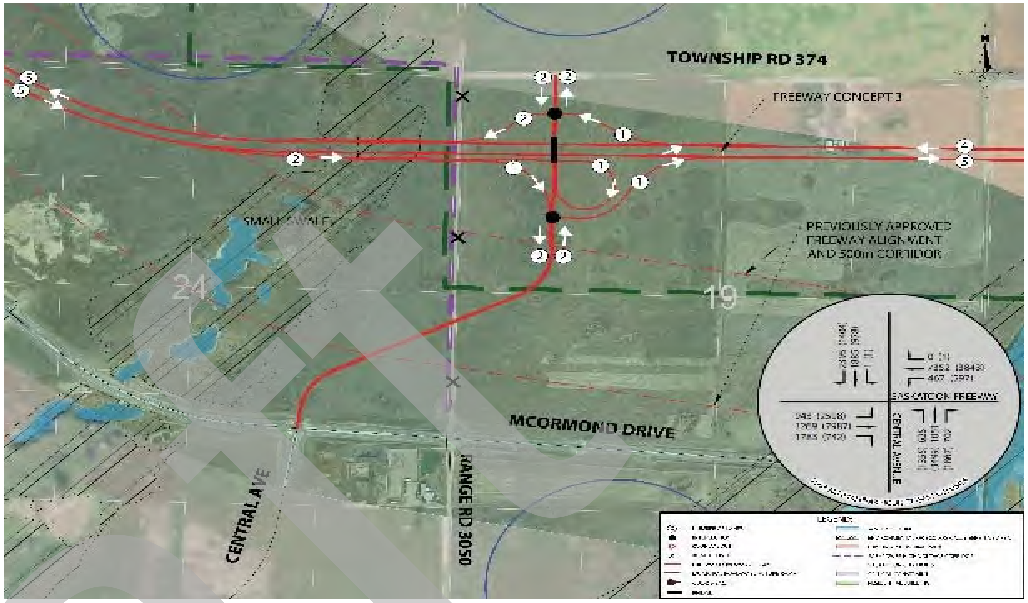
What, if anything, do you not like about Concept 2:

- *complicated, lots of infrastructure*
- *for south side, will be more dangerous in ice/snow conditions*
- *Greater impact on surrounding land*
- *larger area needed for the interchange*
- *May be too expensive when not needed.*
- *no intersections with traffic lights in a interchange*
- *Should have another loop on the north side. Try to minimize interruptions to traffic flow on to and off of the freeway.*
- *should have put a loop where the majority of traffic is going to flow, north heading west*
- *takes up too much land, get rid of the loop. Roads and freeways can have a huge impact on Urban Sprawl.*
- *The interchange is too close to the grouse leks.*
- *The lights and extra traffic lanes will cause traffic to bottleneck a lot more than with the roundabouts.*
- *The loop takes up too much land.*

- *This freeway will prevent me from walking and cycling. My tax dollars should be going into passenger rail and bus service.*
- *Too close to Swale*
- *Traffic lights yuk*
- *traffic circles seem too small diameter relative to curvature of other roads in the area*
- *Traffic lights stop traffic, no flow.*







Do you have any additional comments you would like to add about this route?

- *Concept 1 uses principles that have been successful in other jurisdictions. Time for SK to catch up.*
- *Cost saving on Option 1 as less land is needed and less road surface.*
- *I note it lines up better with freeway concept 3.*
- *It appears you are only asking survey question for interchanges along Concepts 3 and 4. Is Concepts 1 and 2 no longer an option?*
- *N/A*
- *Prefer Concept 2 since it removes the off/on ramps away from the uplands of the Small Swale*
- *Routes should have more loops to enable better traffic flow without traffic lights. Traffic throughput should be highest priority.*
- *This freeway will prevent me from walking and cycling wherever it goes. It is massively expensive. My tax dollars should be going into passenger rail and bus service.*
- *This portion of the freeway should cross the northeast swale where the red concept crosses, but then cross the small swale where the yellow and purple concepts cross. This allows enough room for this Central Ave intersection, while minimizing the impact to both the small swale and the northeast swale.*
- *Too close too Swale*
- *traffic circles are risky, but if they allow better flow without the use of traffic lights - they should be considered*
- *Was Half-Clover Interchange considered for Central Ave?*

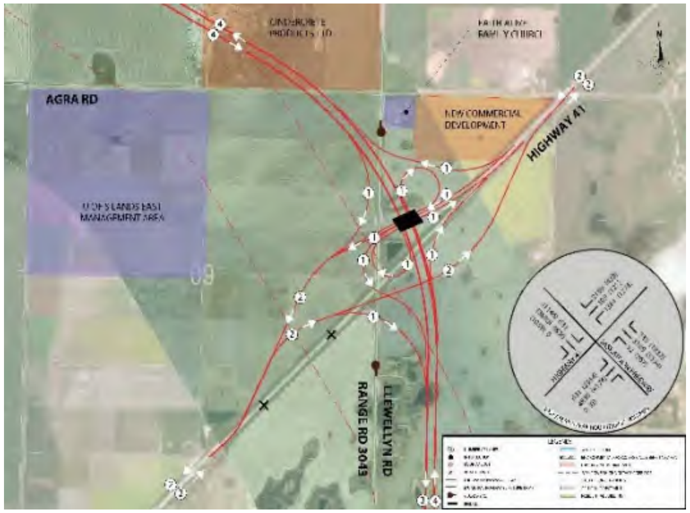
Ministry of Highways:

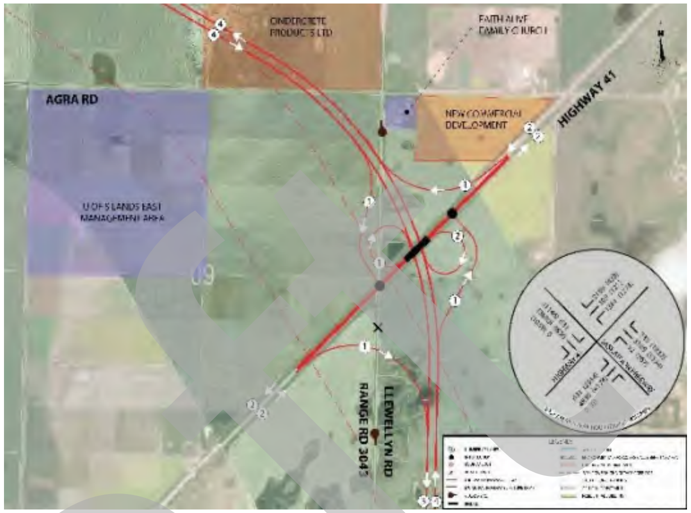
Saskatoon Freeway Functional Planning Study

Phase 2: Virtual Stakeholder Engagement Session

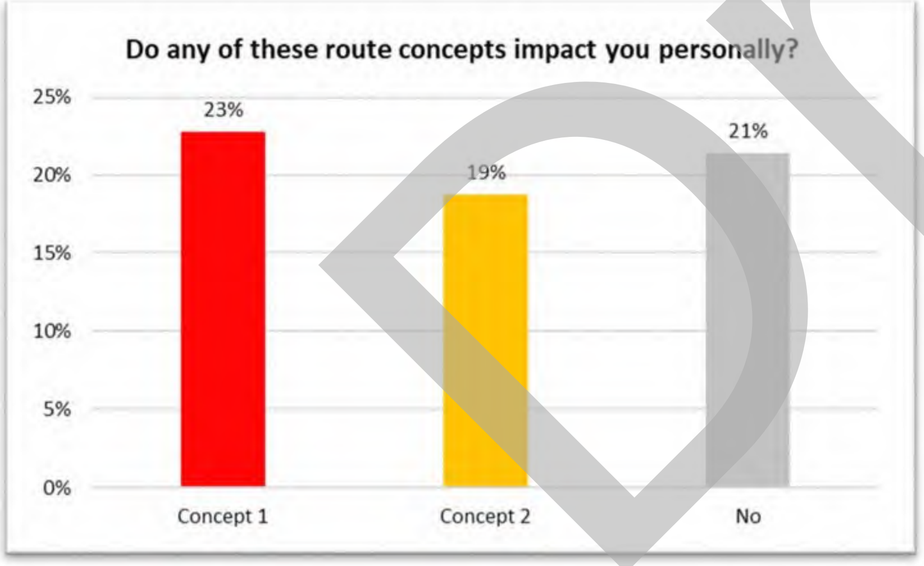
Room 3, Board 6:

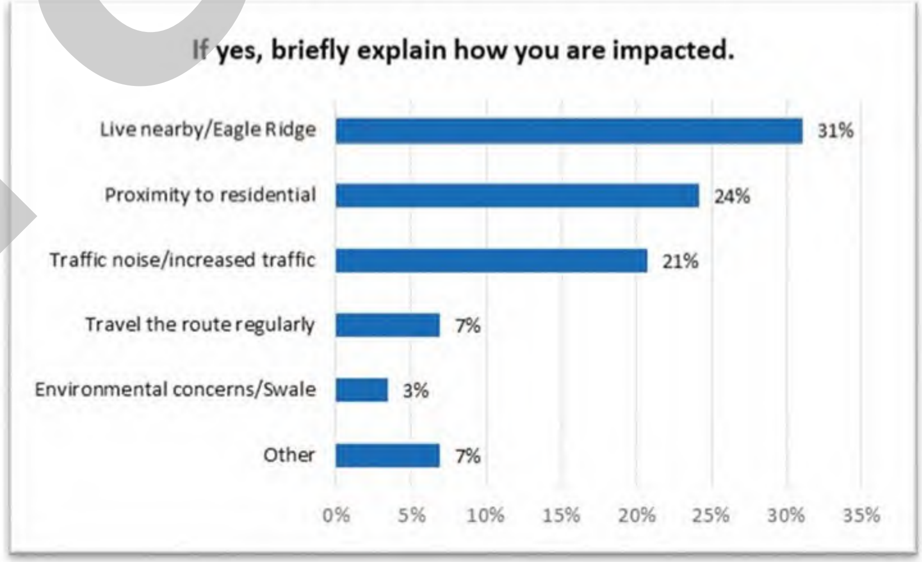
Highway 41 Interchange Concepts with Current Alignment

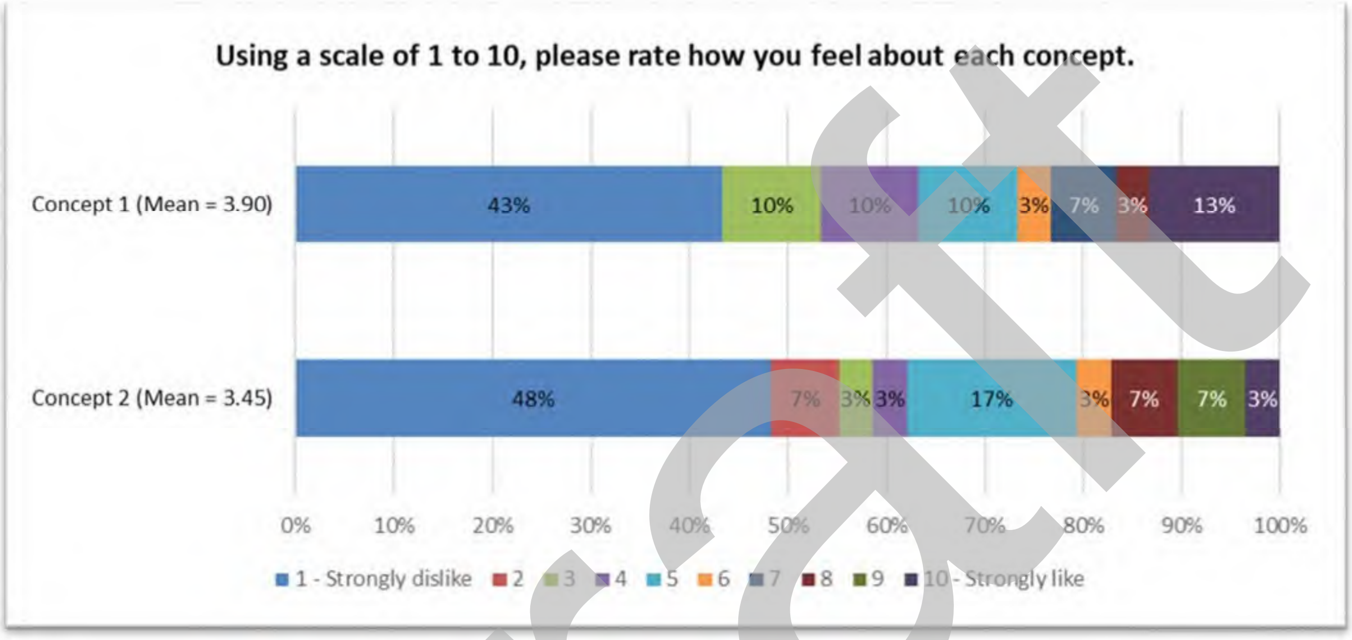




Both concepts are of particular concern to Eagle Ridge residents.
Concept 2 is perceived to be slightly better due to better traffic flow and driver understanding.

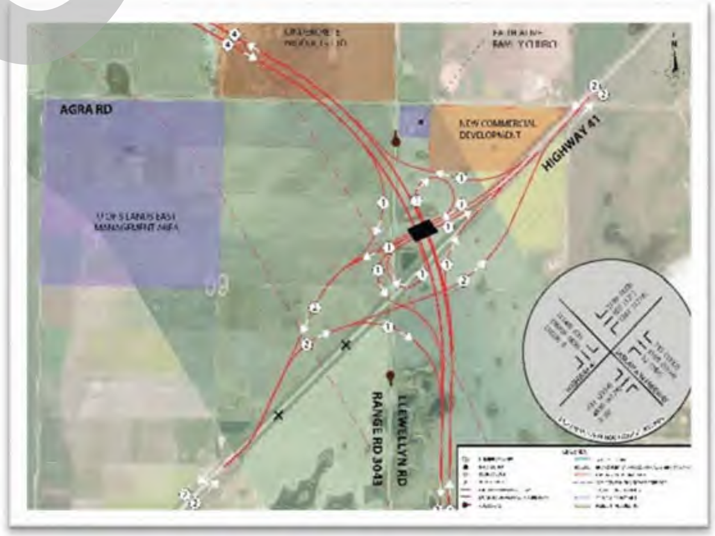




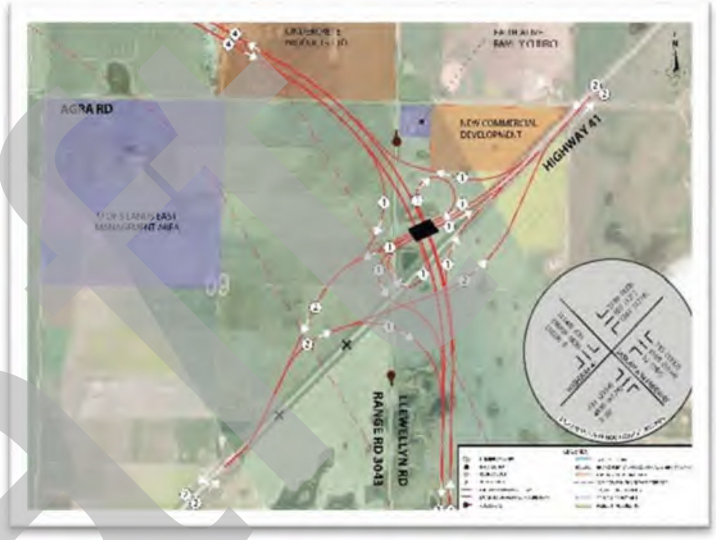


What, if anything, do you like best about Concept 1:

- *access to freeway NB from 41*
- *Almost Complete Free-Flow*
- *Better flow*
- *Continued ease of access to Saskatoon from Hwy 41*
- *It retains an alignment close to the original concept.*
- *More freeflow*
- *Nothing*
- *Safety. Free flow. Build for the future.*
- *There is nothing that I like about this concept.*
- *Traffic flow. No lights on Hwy 41*
- *would look pretty crazy*



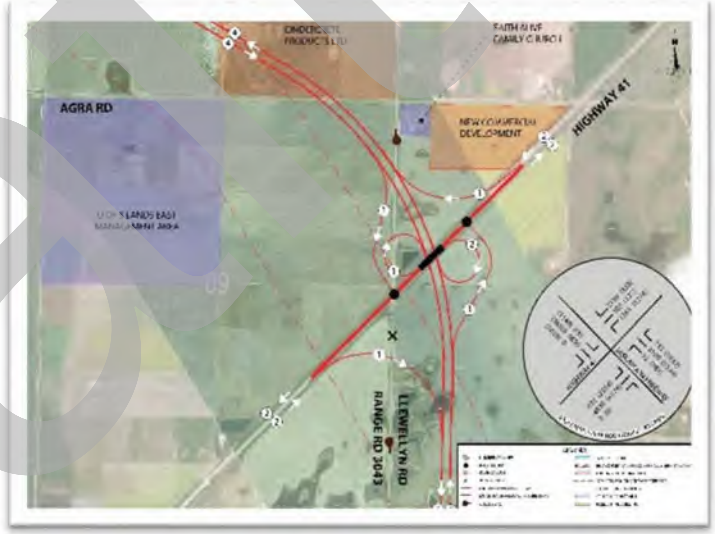
What, if anything, do you not like about Concept 1:



- *Cannot turn west when driving north.*
- *Disruption to acreage life in Eagle Ridge area*
- *Don't understand the NE bound (#2)on hwy 41 intersection where it crosses the freeway*
- *Highway 41 North-East to Freeway North West. Lack of loop exit (south-east quadrent). Looks like that loop could be put in with side-road if Mainline Hwy 41 shifted north, loop in middle, and Freeway to Hwy 41 North Exit shifted south.*
- *I don't like anything about this concept. It is the worst of all the options since it is such a massive interchange. It is outside the original border proposed for the Freeway and will have a significant affect on the existing residents of Eagle Ridge. There is no amount of sound buffering that will be able to mitigate the effects to Eagle Ridge as all properties are sitting up on a ridge. This will also have a significant impact on our views (which we all paid a premium for when we purchased our properties). Inconceivably, it will also require a change to the recently completed and newly re-aligned intersection off of Highway 41 to access our homes.*
- *I dont like that traffic going north-south crosses over the east west*
- *I don't think it is needed.*
- *increased requirement for land on the west side of the interchange for the access roads.*
- *No underpass for Hwy 41 north bound traffic*
- *Overly complicated and costly. There is another interchange at Highway 5. Can this not be a T intersection where the Highway 5 flow is split north or south. The west side of existing Highway 41 becomes a "local" road.*
- *probably take more land than concept 2*
- *proximity to Eagle Ridge, the only area near the freeway*
- *So much road and looping. A Dimond is much simpler and cost less. IMO, it's okay that non main thoroughfare traffic might have to stop to turn.*
- *Strongly opposed because it comes very close to our property*
- *The increased traffic flow in our backyard!*

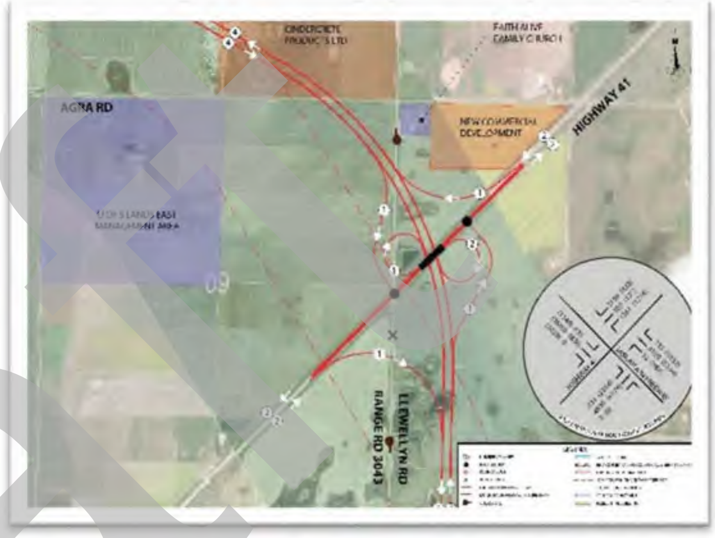
- *too close to Eagle Ridge - noise concern*
- *Too close to several houses and acreages, compared to concepts 3 and 4 for highway 41 interchange.*
- *too complex, would likely be confusing to navigate*
- *What would be the reason for Hwy 41 to continue south west with the intersection at Hwy 5 remaining.*
- *Why are there no bikeways or multi-use trails in these concepts?*

What, if anything, do you like best about Concept 2:

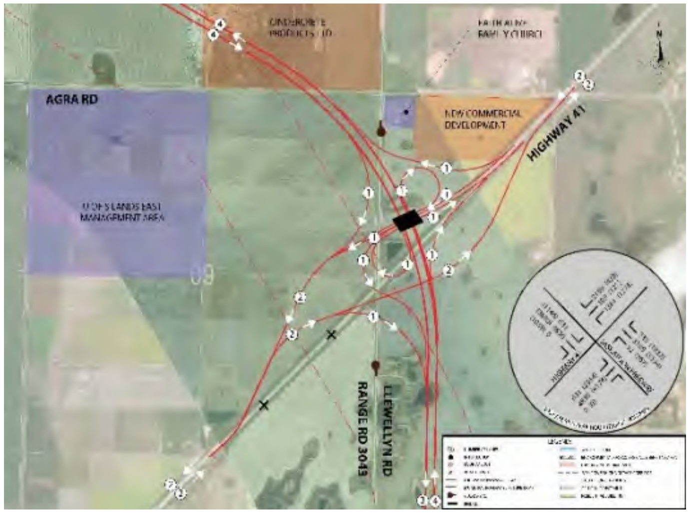


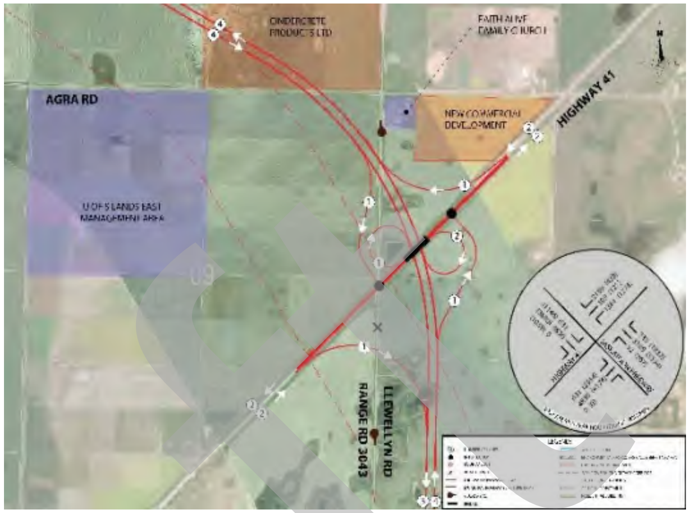
- *Access to Freeway from Hwy 41*
- *access to freeway NB from 41*
- *appears simple to navigate*
- *better use of land. smaller footprint.*
- *Can turn in any direction.*
- *Continued ease of access to Saskatoon from Hwy 41*
- *I like the 41 goes under the Freewasy and has appropriate access onto the freeway at this location*
- *Nothing*
- *Simple design*
- *Simpler than Concept 1.*
- *somewhat free flowing*
- *The only thing I like about concept 2 is that it is slightly better than concept 1 since it is not as major an interchange, but both concepts are the worst options available in my opinion.*
- *The traffic lights will slow down traffic*
- *Traffic does not yield to oncoming traffic*

What, if anything, do you not like about Concept 2:



- *Disruption to acreage life in Eagle Ridge area*
- *I cannot see any safe or quiet or inviting places to walk or bike or spend time in any of these concepts. It's just a huge waste of billions of dollars to encourage people to drive cars more than they already do.*
- *I don't like anything about concept 2 except that it is slightly better than concept 1 since it is not as major an interchange. Similar to concept 1, this concept is outside of the original border proposed for the Freeway and will have a significant affect on the existing residents of Eagle Ridge with respect to views, sound, and value of our properties. It will also require a new access off of Highway 41 despite the fact that this intersection was just newly re-aligned and completed a few months ago.*
- *I don't think it is needed.*
- *Intersections and lights on Hwy 41*
- *Not enough freeflow and ramps*
- *Overly complicated and costly. There is another interchange at Highway 5. Can this not be a T intersection where the Highway 5 flow is split north or south. The west side of existing Highway 41 becomes a "local" road.*
- *proximity to Eagle Ridge*
- *Bad flow*
- *So much road and looping. A Dimond is much simpler and cost less. IMO, it's okay that non main thoroughfare traffic might have to stop to turn.*
- *Strongly opposed because it comes very close to our property*
- *The increased traffic flow in our backyard*
- *too close to Eagle Ridge - noise concern*
- *Too close to several houses and acreages compared to concepts 3 and 4 for highway 41 interchange.*
- *Too simple. Would involve traffic lights on Highway 41. Would require re-build if Hwy 41 were ever upgraded.*
- *traffic lights*
- *Traffic lights is an issue as well as when the city grows and we question why we did this in the first place. Save a couple dollars here, or save pains later.*
- *two lane loop would be unnerving in some conditions, and with some drivers.*
- *What would be the reason for Hwy 41 to continue southwest with the interchange at Hwy 5 remaining.*
- *would have liked to see a full cloverleaf*


CONCRETE PRODUCTS LTD
FAITH ALIVE FAMILY CHURCH
AGRA RD
NEW COMMERCIAL DEVELOPMENT
HIGHWAY 41
U OF S LANDS EAST MANAGEMENT AREA
RANGE RD 3043
LLEWELLYN RD


CONCRETE PRODUCTS LTD
FAITH ALIVE FAMILY CHURCH
AGRA RD
NEW COMMERCIAL DEVELOPMENT
HIGHWAY 41
U OF S LANDS EAST MANAGEMENT AREA
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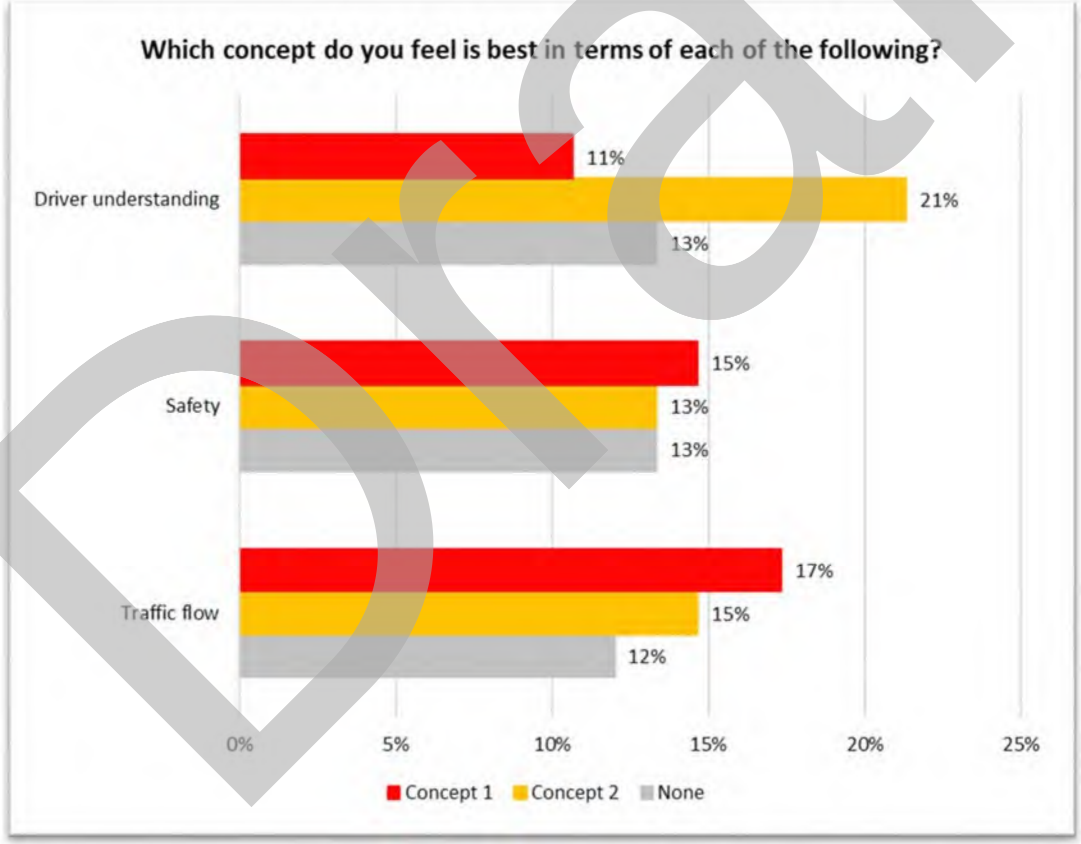

Which concept do you feel is best in terms of each of the following?
Driver understanding
11%
21%
13%
Safety
15%
13%
13%
Traffic flow
17%
15%
12%
0%
5%
10%
15%
20%
25%
🟥 Concept 1
🟨 Concept 2
⬜ None

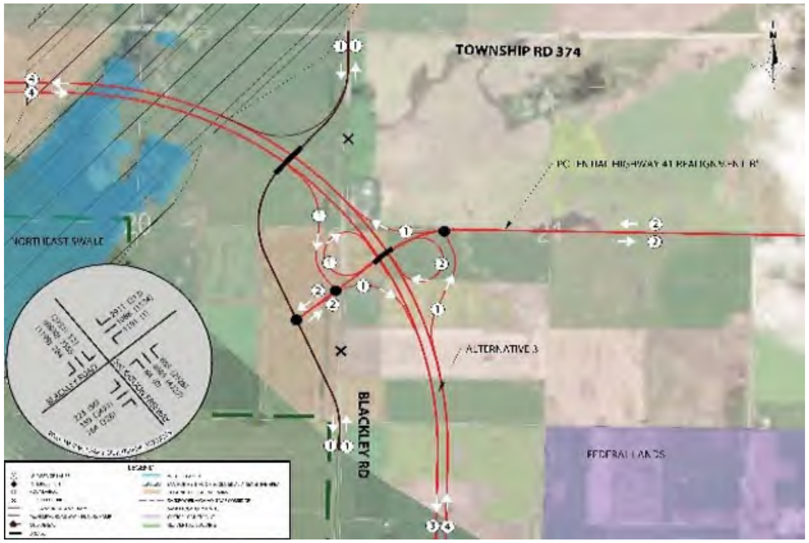
Do you have any additional comments you would like to add about this route?

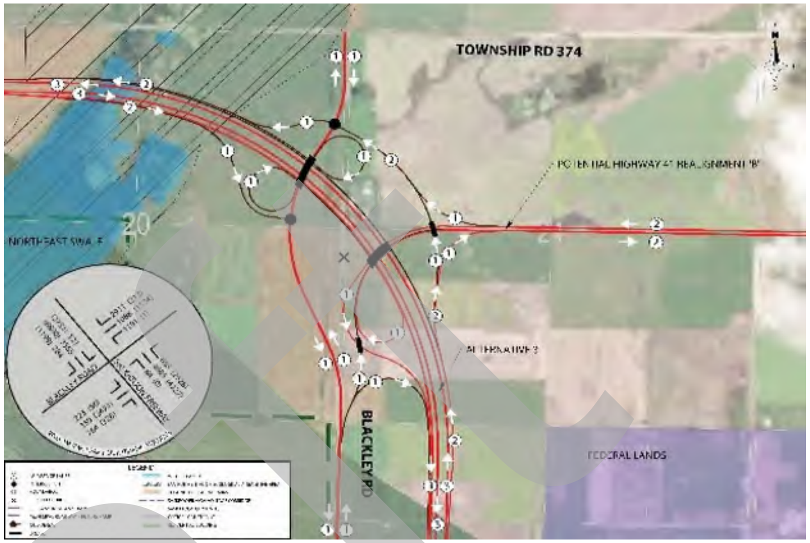
- *Both of these options are in close proximity to the major interchange at Highway 5. It doesn't make any sense to have another major interchange so close to Highway 5 especially when it will have such a significant impact to the residents of Eagle Ridge. The logistics of simply trying to drive to and from Saskatoon on a daily basis is significantly complicated with our existing access/intersection at Highway 41 (newly completed a few months ago) needing to be changed to accommodate either of these interchanges and then having to cross the Freeway through both of these interchanges. It would make much more sense to go with a simple under/overpass and move the major interchange to one of the concepts shown for the re-alignment of Highway 41.*
- *Both options are costly to accommodate a secondary highway. There is another interchange at Highway 5. Can this not be a T intersection where the Highway 41 flow is split north or south. The west side of existing Highway 41 becomes a "local" road.*
- *can't tell, especially on concept 1, where the new access road to Eagle Ridge is, if access is the same...*
- *I'm not understanding how northbound Hwy 41 crosses the Freeway, (Concept 1). If the crossing is unimpeded, Concept 1 is a great design.*
- *Interchange could be located at existing intersection of Hwy 5 & 41*
- *Land requirements are large on both options. Design speed for ramps and loops should be 70kmh, this would make for large cost savings and little impact on the usability of the Freeway.*
- *Need to speak with the City about Hwy 41 as the hwy should be given to the City to develop.*
- *Please don't build this highway. I cannot see any safe or quiet or inviting places to walk or bike or spend time in any of these concepts. It's just a huge waste of billions of dollars to encourage people to drive cars more than they already do.*
- *Please move this interchange elsewhere as shown in alternate concepts*
- *Sask people should learn to drive, don't dumb down designs for morons*
- *Why can't we install a generic cloverleaf? This would result in the least number of overpasses, driver's understand them well, they wouldn't take up as much space as these concepts, and they won't result in traffic lights on the highway. I would much prefer a cloverleaf just like what is installed at highway 11 and 16 at the Southeast corner of Circle Drive.*

Ministry of Highways:
Saskatoon Freeway Functional Planning Study
Phase 2: Virtual Stakeholder Engagement Session

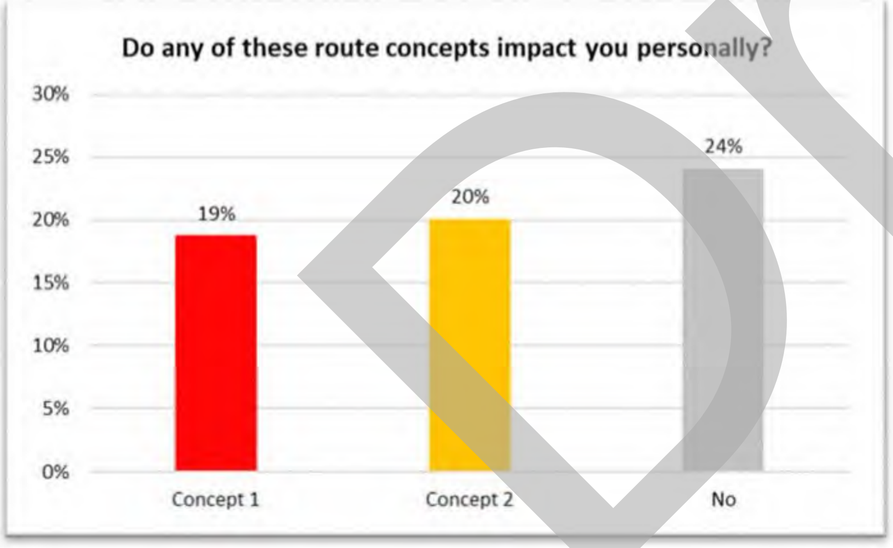
Room 3, Board 7:

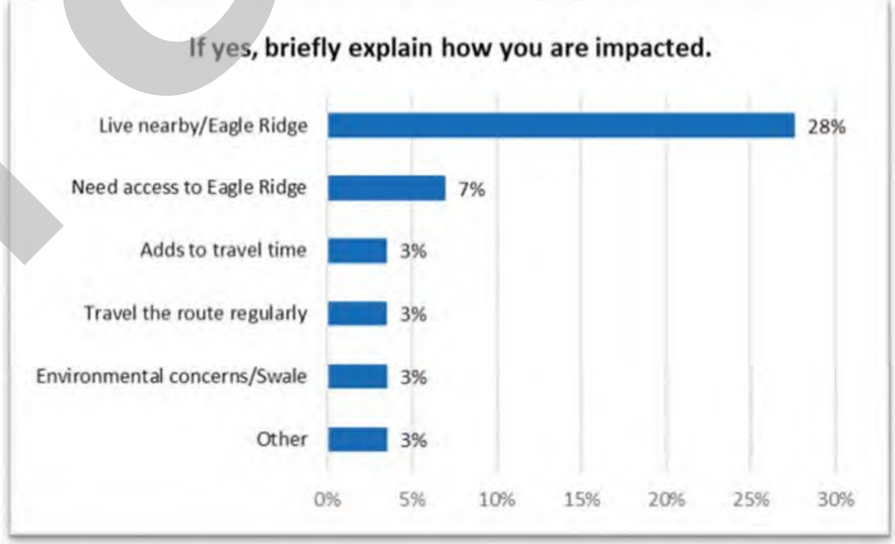
Highway 41 Interchange Concepts with Realigned Highway

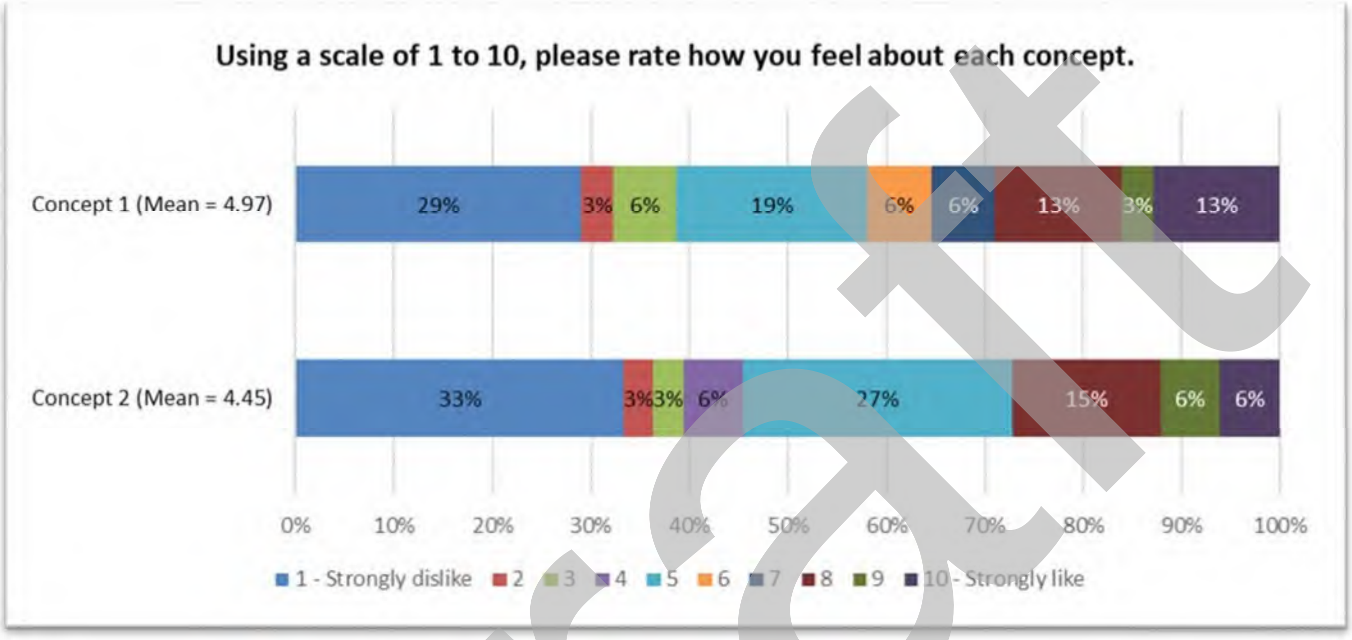




Eagle Ridge residents prefer the realigned highway options to the current alignment.
Concept 1 edges out Concept 2 due to simpler design and driver understanding.

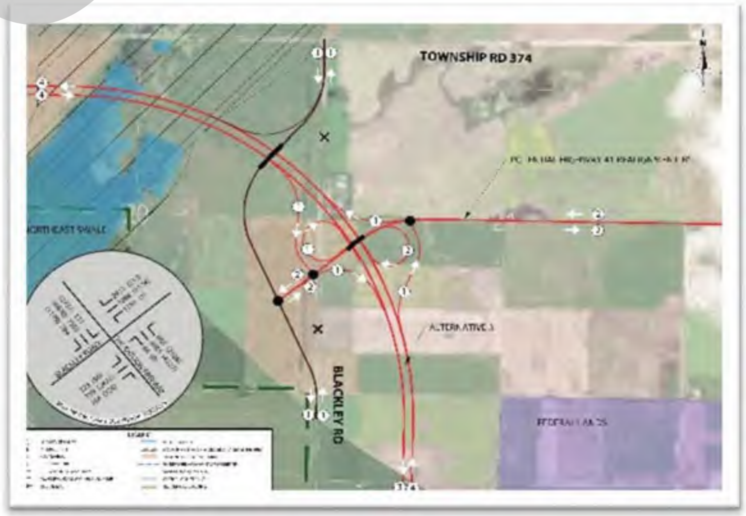

Do any of these route concepts impact you personally?


If yes, briefly explain how you are impacted.

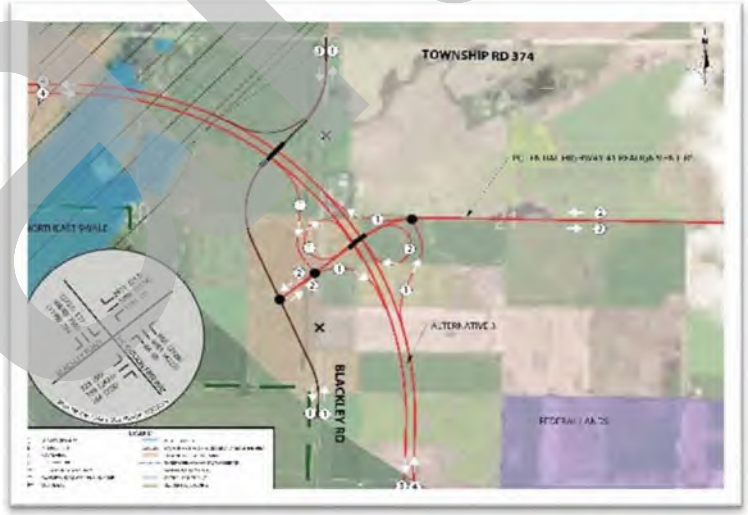


What, if anything, do you like best about Concept 1:

- *Does not appear to limit access to the city for people living east of hwy41*
- *Fewer homes and properties will be negatively affected by this interchange*
- *footprint smaller than 2*
- *I like the alternate route for hwy 41. It connects in better for all traffic*
- *I like the low land impact on this one*
- *I think this is a good realignment of Hwy 41. The interchange takes up less land.*
- *It looks simpler*
- *It's not Concept 2.*



- *Less expensive*
- *Much simpler. Easy to understand. Lower cost.*
- *Nothing*
- *seems simpler, less concrete*
- *simple*
- *Simple Design*
- *Simple, only affects farmland, not acreage communities*
- *smaller interchange*
- *This concept is simple to understand, takes up less land space overall, and provides another interchange that is more reasonably spaced from the Highway 5 interchange versus the other options proposed in the backyards of Eagle Ridge properties. This option is by far the best option available of these 4 proposed options.*



What, if anything, do you not like about Concept 1:

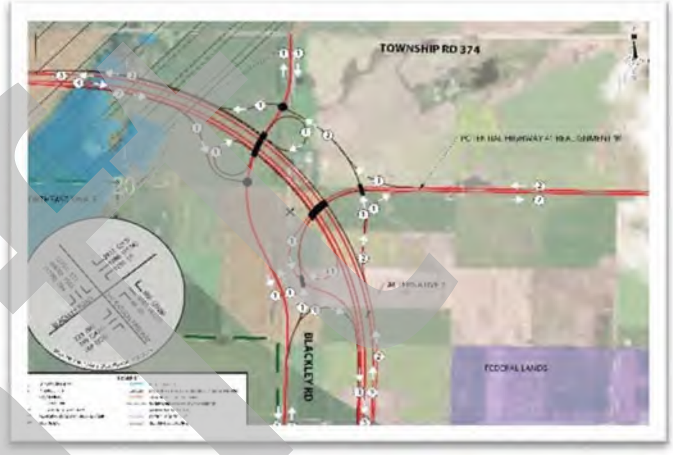
- *avoid traffic lights, seems more complicated that it has to be*
- *Construction won't start for 15 years. When will the land be purchased?*
- *don't understand how you align a highway going north-south to one going east-west*
- *highway 41 runs adjacent to our land, and impacts our sedimentation and evaporation ponds, which will have to be relocated.*
- *If we are going to do this, we better do it right the first time. The second option is by far the better option as it is free flow.*
- *Is this interchange required? Do the Highway 41/5 interchanges not suffice? The further a major interchange can be from the swale the better.*
- *not free flowing*
- *not great use of land. what will happen between Blackley Road and the freeway/interchange?*
- *potential for backlog of traffic at stop lights*
- *Right through Swale*
- *So much road and looping. A Dimond is much simpler and cost less. IMO, it's okay that non main thoroughfare traffic might have to stop to turn.*

- *There is nothing that I don't like about this concept. This is the interchange that I would use the most to access the Freeway heading north out of the city and back. It's simple, easy to access, and not in my backyard.*
- *Too close to Eagle Ridge Estates*
- *Too Simple. Could likely lead to problems in future with demand issues.*
- *Traffic lights*
- *We need to build a healthy future. I cannot see any safe or quiet or inviting places to walk or bike or spend time in any of these concepts. It's just a huge waste of billions of dollars to encourage people to drive cars more than they already do.*

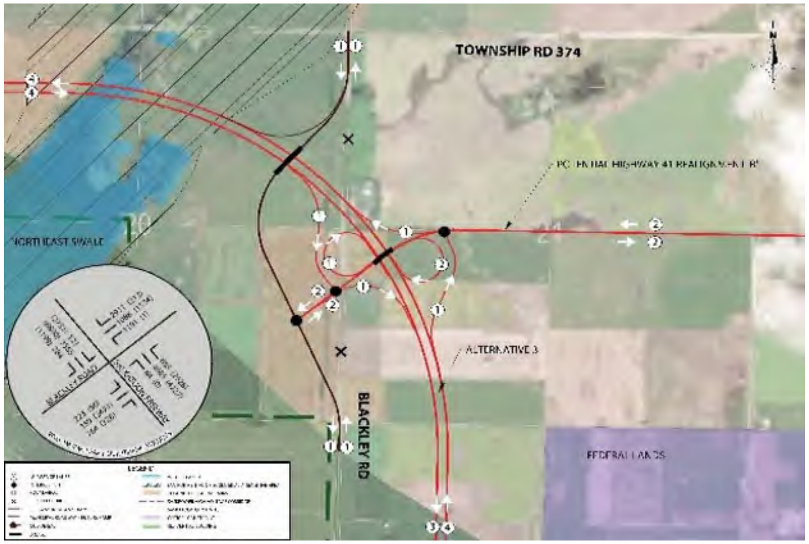
What, if anything, do you like best about Concept 2:

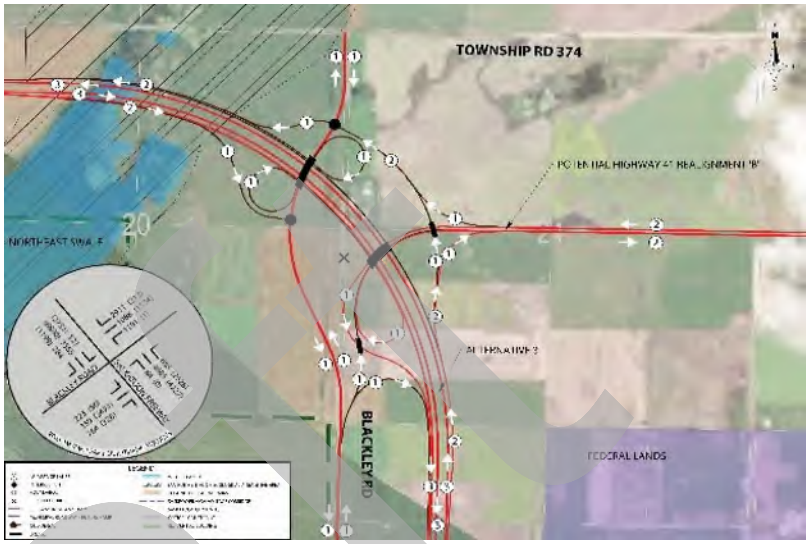
- *Alternate route of 41 is better.*
- *could provide overall better traffic flow and access*
- *Does not appear to limit access to the city for people living east of hwy41*
- *Free flow. Ease of use. Doing it right the first time, opposed to having to redo it sooner.*
- *free flowing*
- *I like the traffic flow of this one*
- *seems better flow to/from Blackley to Freeway*
- *Seperated movement between Hwy 41 & Blackley Rd.*
- *Similar to concept 1, I like that this option moves a major interchange away from the backyard of Eagle Ridge properties.*
- *That there is another option to pick (Concept 1)!*
- *This will not have as much of a negative affect on the existing acreages and properties near by*

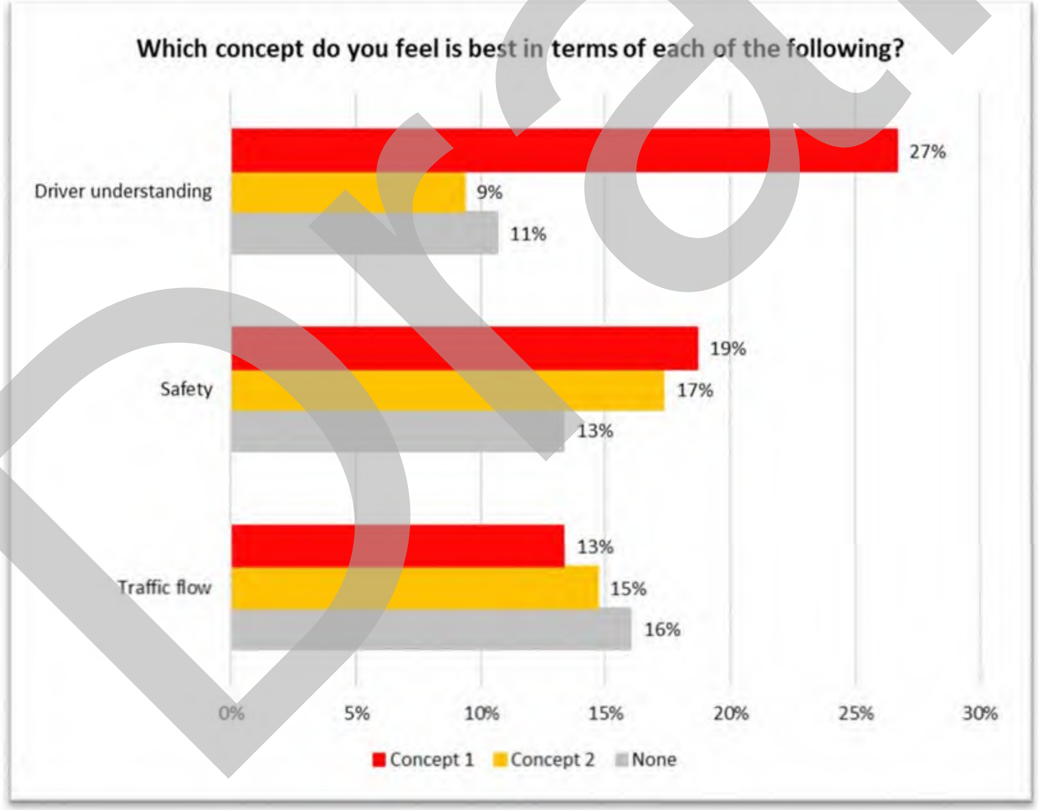
What, if anything, do you not like about Concept 2:



- *1 traffic light going from Hwy 41 West to Freeway West crossing over Blackley Road.*
- *could be confusing/overwhelming*
- *Highway 41 relocation runs adjacent to our land and impacts our sedimentation and evaporation ponds, which would have to be relocated.*
- *I am confused on all the movements of this interchange. It takes up too much land and it kicks the can (cost) down the road for the City to pay for more interchange loops shown in black lines.*
- *I rated this one slightly less than concept 1 because it is more complicated to understand and takes up more land space. That said, it is still the second best option of all 4 proposed options (where Highway 41 is re-aligned or kept the same).*
- *it look svery confusing for drivers.*
- *larger footprint*
- *Looks expensive.*
- *not great use of land. what would happen between blackley road and the freeway/interchange?*
- *Overly complex. Hard to understand. Expensive,*
- *Right through Swale*
- *seems more complicated than necessary with an interchange on a curve*
- *So much road and looping. A Dimond is much simpler and cost less. IMO, it's okay that non main thoroughfare traffic might have to stop to turn.*
- *somewhat complicated*
- *Too close to Eagle Ridge Estates*
- *Too complicated. Significant infrastructure.*
- *Two interchanges yikes*
- *We need to build a healthy future. I cannot see any safe or quiet or inviting places to walk or bike or spend time in any of these concepts. It's just a huge waste of billions of dollars to encourage people to drive cars more than they already do.*


TOWNSHIP RD 374
POTENTIAL HIGHWAY 41 REALIGNMENT 'B'
NORTHEAST SWALE
ALTERNATIVE 3
BLACKLEY RD
FEDERAL LANDS


TOWNSHIP RD 374
POTENTIAL HIGHWAY 41 REALIGNMENT 'B'
NORTHEAST SWALE
ALTERNATIVE 3
BLACKLEY RD
FEDERAL LANDS


Which concept do you feel is best in terms of each of the following?
Driver understanding
27%
9%
11%
Safety
19%
17%
13%
Traffic flow
13%
15%
16%
0%
5%
10%
15%
20%
25%
30%
Concept 1
Concept 2
None

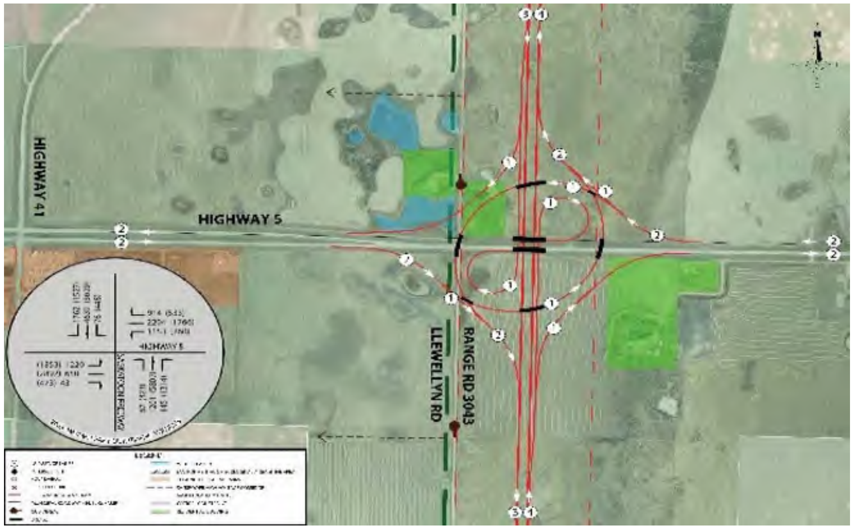
Do you have any additional comments you would like to add about this route?

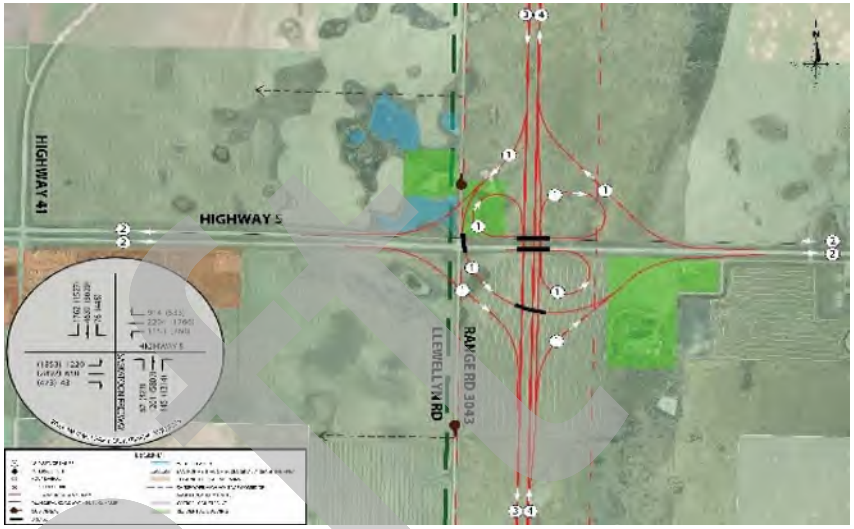
- *an animation would help understand flow*
- *Go around Swale*
- *Land requirements are large on both options. Design speed for ramps and loops should be 70kmh, this would make for large cost savings and little impact on the usability of the Freeway.*
- *Please consider relocating Highway 41 further North to the corridor currently used by Township Rd 374.*
- *Realigning Highway 41 could be a great solution, but doing this should eliminate the need for a significant interchange where the freeway crosses Highway 41.*
- *The Eagle Ridge/Eagle Heights area has an expanding population that cannot have reduced access to the city.*
- *The purple Concepts 3-4 do not match the Blackley interchange options. You will have to bring this interchange design back out for another open house.*
- *This highway 41 realignment is a poor way to connect highway 41 with the freeway.*
- *Very poor for anyone accessing the City core or University from Highway 41. Will add significant amount of time for travel and confusion. Best to keep the current alignment of 41 but allow for an access road off of 41 and Blackey to the Freeway if this is desired.*
- *What I like about both of these options is that it more appropriately spaces out the major interchanges for the Saskatoon Freeway. The idea was not to have a bunch of interchanges close together to access the Freeway and I feel that both of these options accomplish that. Also, both of these options would prevent a major interchange in very close proximity to Eagle Ridge (directly affecting all existing residents and the future residents of the adjacent Eagle Heights community).*
- *Why are there no provisions in any of the concepts for people who get around by walking or biking? Also the maps do not show the amount of land affected by noise and air pollution from these freeways.*

Ministry of Highways:
Saskatoon Freeway Functional Planning Study
Phase 2: Virtual Stakeholder Engagement Session

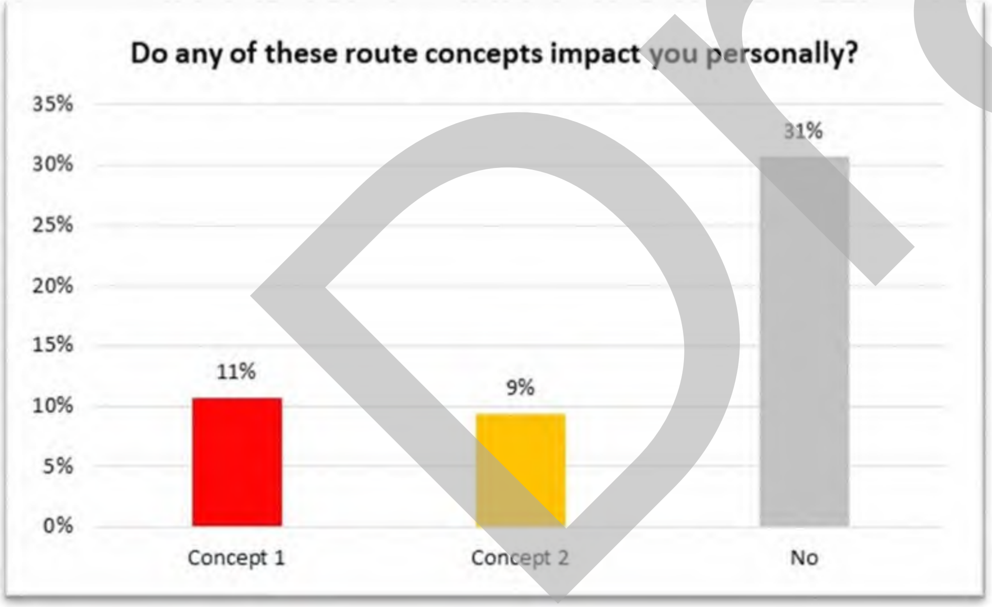
Room 3, Board 8:

Highway 5 Interchange Concepts



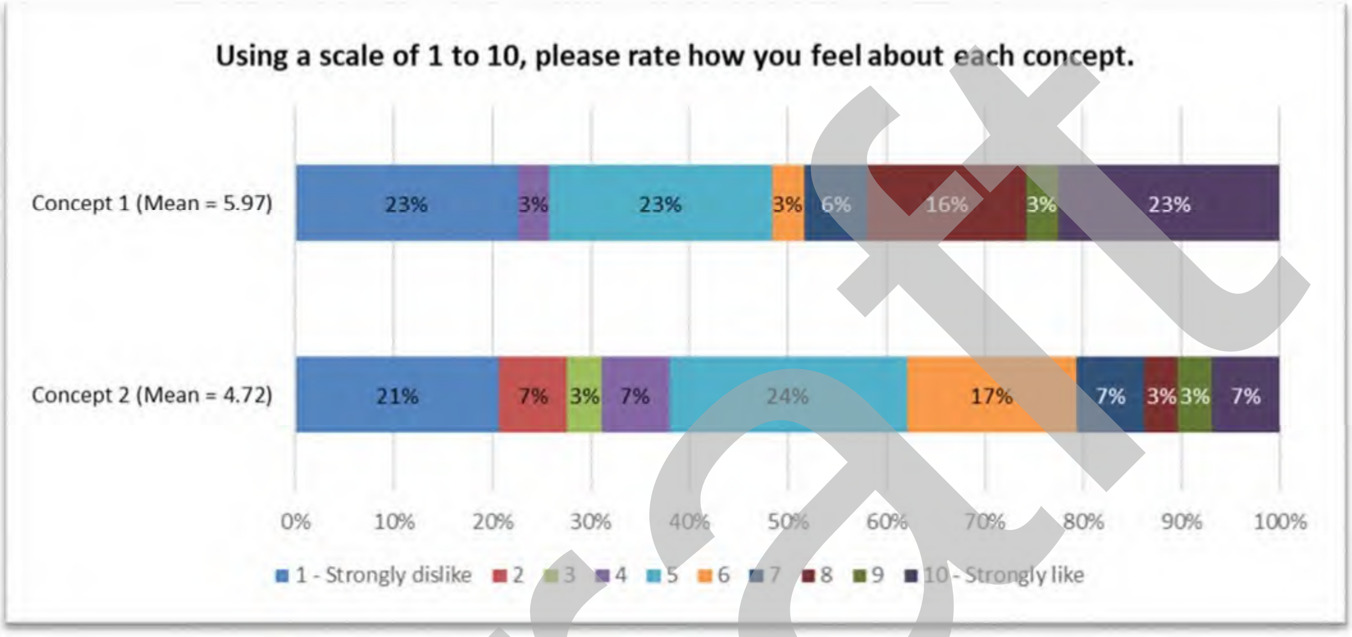


Concept 1 is preferred in terms of traffic flow, higher speed ramps, safety, and driver understanding.



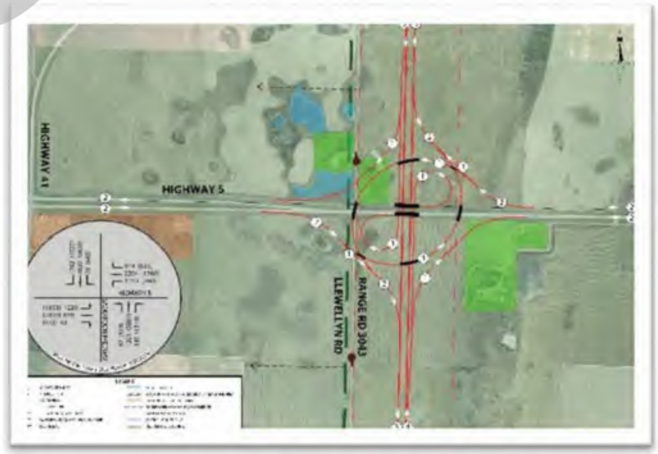
Briefly explain how you are impacted:

- *Access to the City.*
- *live in the area*
- *Regular Driving Route*
- *Resident of Eagle Ridge - may be using this interchange almost daily depending on how I'm able to get onto freeway from Eagle Ridge to commute to Saskatoon North Industrial area. It's unclear to me what happens to 41 if realigned w/ freeway north of Agra Rd.*
- *Traffic safety.*
- *We live in Eagle Ridge Estates, we use Hwy 5 regularly for work and to visit family.*
- *we use highways 5 and 41 everyday*



What, if anything, do you like best about Concept 1:

- *Better flow*
- *free flow*
- *Freer traffic flow, safer merging*
- *good traffic flow*
- *Good traffic flow*
- *higher speed flow.*
- *Higher speed ramps*
- *Higher speed ramps*
- *Higher speed ramps in every direction*
- *Higher speed ramps. Simple and easy to understand traffic flow all directions.*



- *higher speed traffic flow from Hwy 5 to freeway NB/SB*
- *I appears to allow for more free flow movements.*
- *It has clean simple traffic flow*
- *maintaining speed*
- *Neutral*
- *Traffic safety. Traffic flow. Let's avoid the problems of Circle Drive south with the four leaf clover intersection.*
- *Ultimate design, shouldn't need upgrading again*

What, if anything, do you not like about Concept 1:

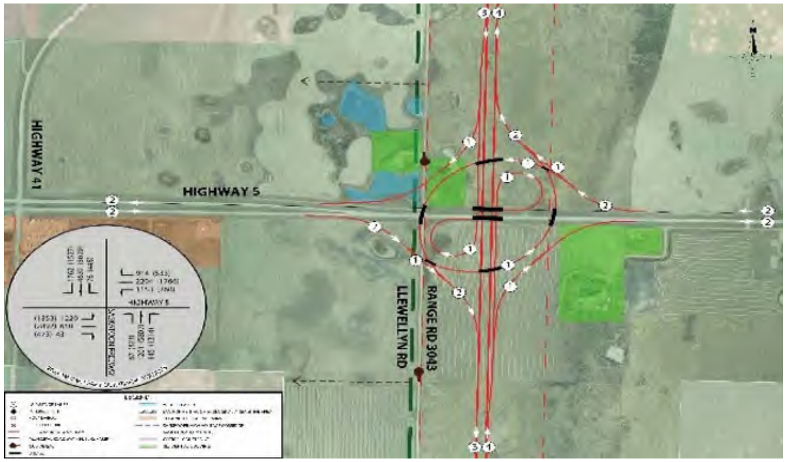
- *(Depending on traffic flow) rotate the interchange 90 degrees. Make the freeway have both the Flyover exits, not Highway 5.*
- *8 brigdes are exoensive to build and maintain*
- *Access to the city from Kilmeny road to hwy 5 would likely be reduced.*
- *close proximity to 41/5 intersection that is brutal and getting worse. 41 realignment north would make 41/5 intersection safer by reducing volume*
- *don't understand the outer loops*
- *It appears 7 bridges are required. Very complex and expensive.*
- *Neutral*
- *Nothing. All looks good to me.*
- *So much road and looping. A Dimond is much simpler and cost less. IMO, it's okay that non main thoroughfare traffic might have to stop to turn.*
- *Too many overpasses*
- *unclear if there is sufficient merge space where hwy5e meets hwy5w going north or south*

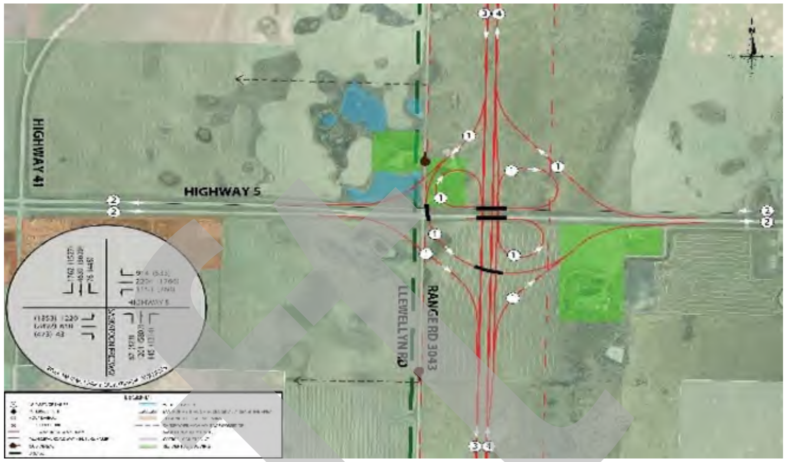
What, if anything, do you like best about Concept 2:

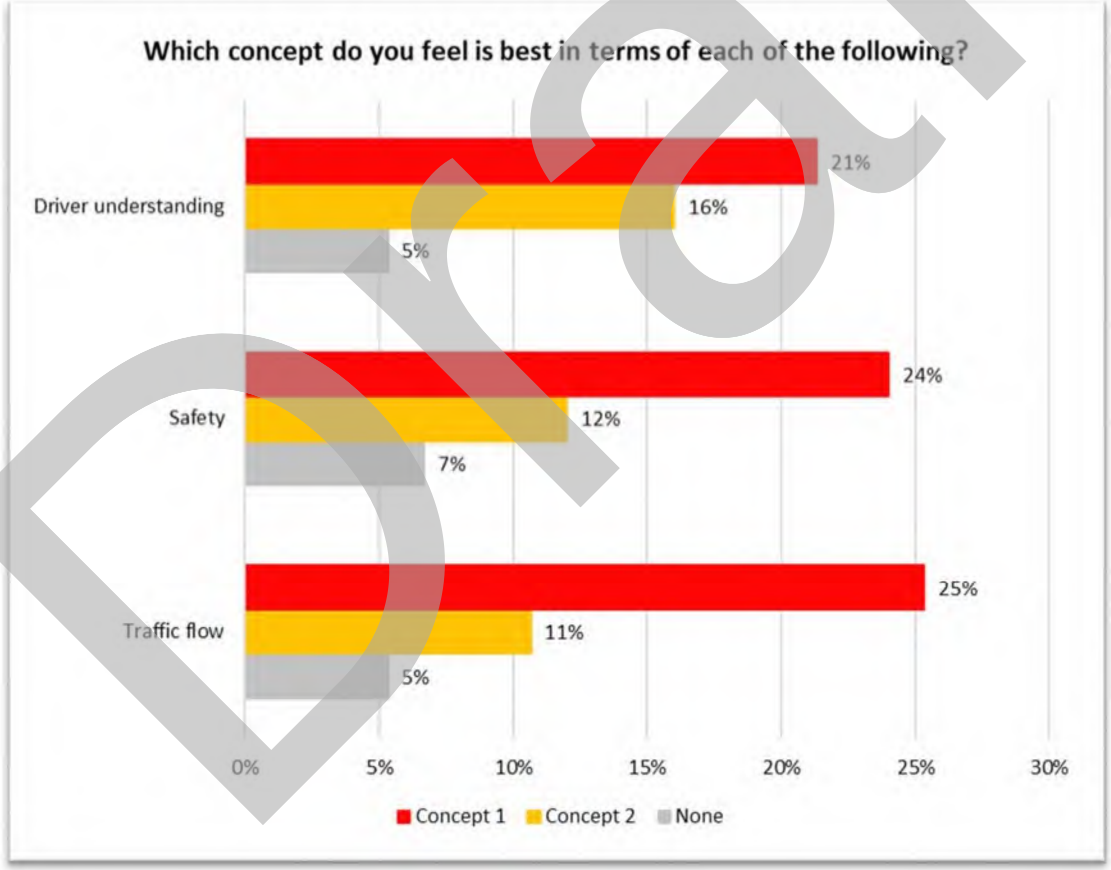
- *easier clover leaf*
- *less bridges than concept 1 which is good*
- *Neutral*
- *Not too different from Concept 1, clean simple traffic flow*
- *Nothing, concept 1 is far better.*
- *Nothing.*
- *similar to Concept 1*
- *Simple design, should be cheaper at first than Concept 1.*
- *Simpler design*
- *Some improvement over Concept 1.*
- *use of collectors to allow for getting up to speed to merge*

What, if anything, do you not like about Concept 2:

- *A three leaf clover is proven to be less safe opposed to Concept 1. Four leaf clover on Circle Dr. south is a proven headache.*
- *Access to the city from Kilmeny road to hwy 5 would likely be reduced.*
- *Cloverleafs are dated. Saskatoon is trying to remove the 11/16 cloverleaf because of safety and traffic flow issues. I'm not sure why would we add another cloverleaf with its tight merge pattern in a new freeway.*
- *Is the arrow on the SE loop showing the wrong way?*
- *It is three quarters of a clover leaf with a total of 4 bridges. Why not go to a full clover leaf with only two bridges. Much easier to understand.*
- *Lower speed flow.*
- *lower speed maintained overall*
- *Lower speed ramps*
- *Neutral*
- *Bad flow*
- *slower ramp from Hwy 5 EB to freeway NB*
- *So much road and looping. A Dimond is much simpler and cost less. IMO, it's okay that non main thoroughfare traffic might have to stop to turn.*
- *takes more land*
- *This concept is more difficult to understand traffic flow and direction and mixes higher speed ramps with slower clover leaf.*
- *why not a full cloverleaf?*
- *Would likely need upgrading in future for the 2nd flyover in Concept 1.*


HIGHWAY 41
HIGHWAY 5
LLEWELLYN RD
RANGE RD 3043


HIGHWAY 41
HIGHWAY 5
LLEWELLYN RD
RANGE RD 3043


Which concept do you feel is best in terms of each of the following?
Driver understanding
21%
16%
5%
Safety
24%
12%
7%
Traffic flow
25%
11%
5%
0%
5%
10%
15%
20%
25%
30%
Concept 1
Concept 2
None

Do you have any additional comments you would like to add about this route?

- *Access to the city for people living in this area must not be reduced or made worse.*
- *Agree with design allowing higher speed for merging onto both highways.*
- *close proximity to 41/5 and safety concern - this will only work if 41 is realigned north. If 41 is not realigned, 41/5 is a disaster waiting to happen*
- *Concept 2 looks more expensive with overpasses and underpasses*
- *Go with concept 1. It's by far the better option.*
- *If you build an interchange at Hwy 5 you do not need to build one at Hwy 41.*
- *It seems like we're trying to re-invent the wheel. Why not stay with a simple clover leaf that is less expensive, does not consume any more land and is safer and more easily understood.*
- *Land requirements are large on both options. Design speed for ramps and loops should be 70kmh, this would make for large cost savings and little impact on the usability of the Freeway.*
- *No*

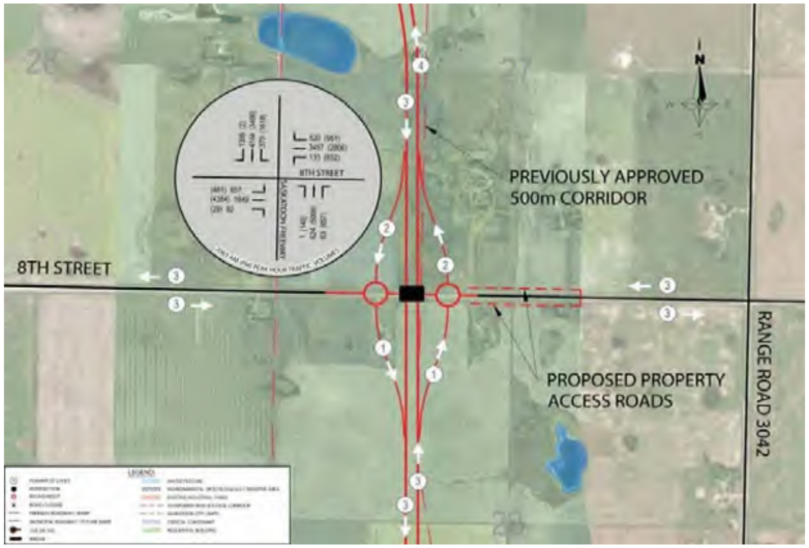
Ministry of Highways:

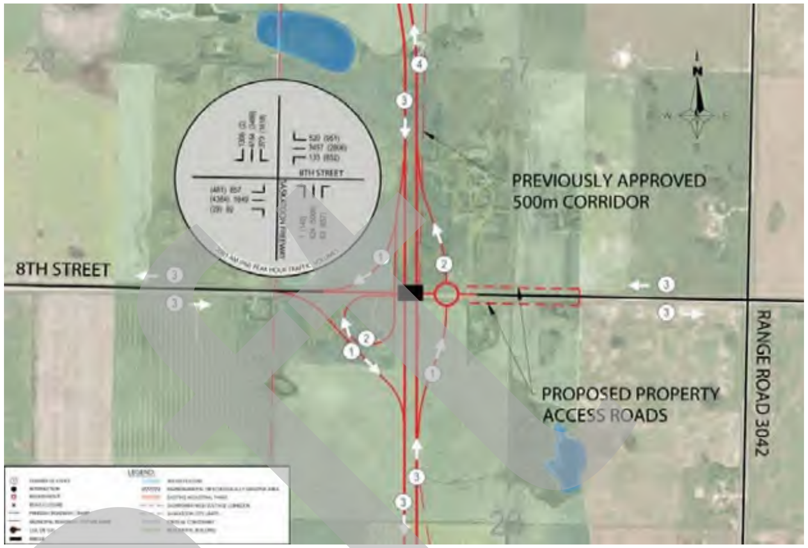
Saskatoon Freeway Functional Planning Study

Phase 2: Virtual Stakeholder Engagement Session

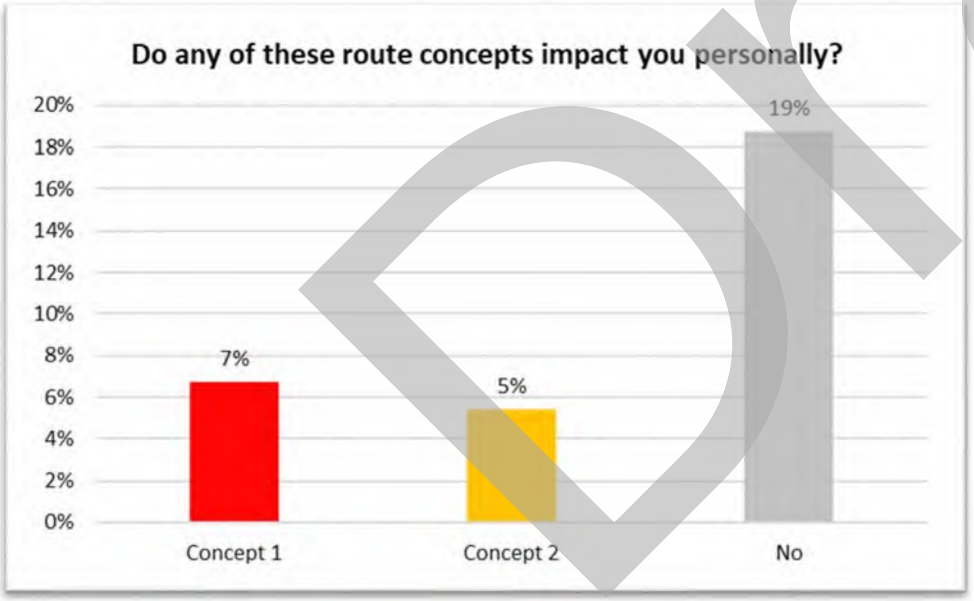
Room 4, Board 2:

8th Street Interchange Concepts



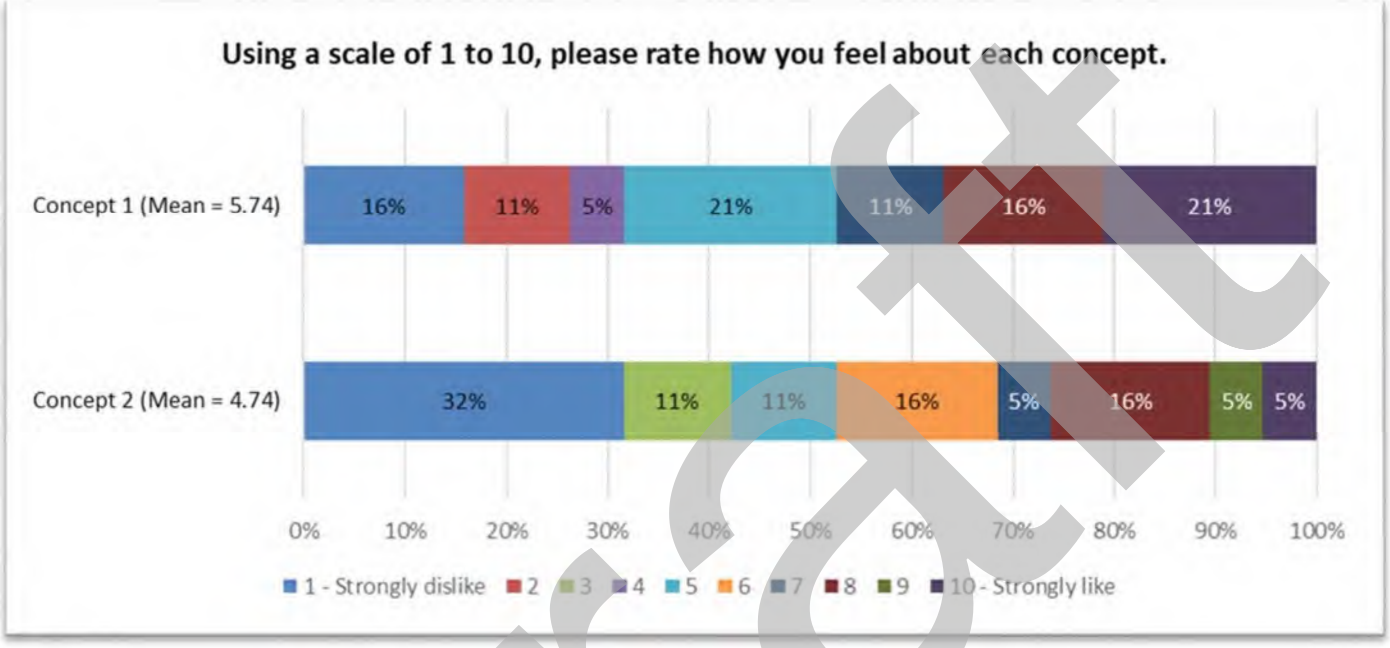


While Concept 1 is preferred overall, Concept 2 has a slight edge in terms of safety and traffic flow.

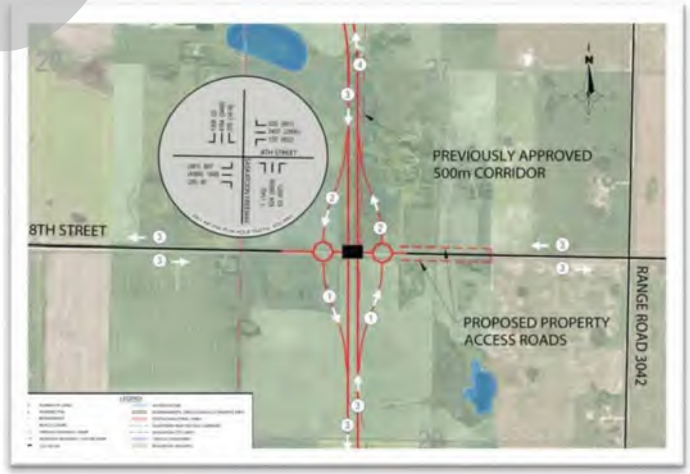


Briefly explain how you are impacted:

- *Highway is going through my NW 15 TWP 36 W 3 RGE 4 Which is not shown on detailed map ?*
- *I like the traffic circle aspect, although Saskatchewan drivers need more training/experience with traffic circles. The circle that used to be at 8th St and circle drive worked great for the people who knew how to use it.*
- *I own the 75 acres south of 8th St. and east of Range Road 3043 where an interchange is planned.*
- *My whole acreage in side the corridor.*
- *Traffic safety.*



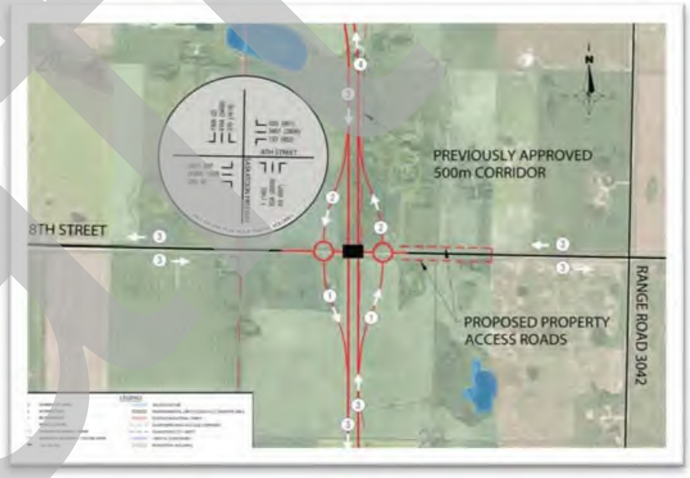
What, if anything, do you like best about Concept 1:



- *Less expensive*
- *Less expensive.*
- *Less impact because less infrastructure*
- *less land*
- *N/A*
- *Should be much further east, this is too close to the City.*
- *Simple Design, Doesn't take much room*
- *sIMPLE, Takes less land. I like the 2 roundabouts on 8th street instead of the loops on concept 2*
- *Standard interchange. Minimizes land take.*
- *the traffic circles as opposed to traffic lights*

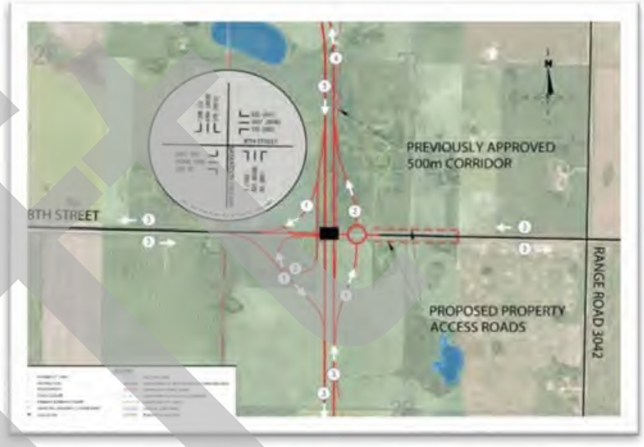
- *The use of traffic circles is excellent and has potential for cost saving.*
- *Use of roundabouts to provide greater access options, while reducing the land area needed for the interchange.*
- *uses less*
- *land*

What, if anything, do you not like about Concept 1:



- *Don't like that there are 2 roundabouts so close together.*
- *eventual stoplights*
- *has two roundabouts vs 1.*
- *Highways is holding me hostage , I can not proceed with any future plans.*
- *I am not in favor of the roundabout concept at all. I believe that Loops should be built right out of the gate!*
- *Likely would need upgrading in the future.*
- *no*
- *Restricts traffic flow by incorporating lights. Reduced safety.*
- *Should be much further east, this is too close to the City.*
- *Traffic circles with higher traffic volumes are likely problematic - people do not know how to use them.*
- *unsure how well roundabout or intersections would work*
- *why don't we use a full on cloverleaf design, or a full on traffic circle design?*

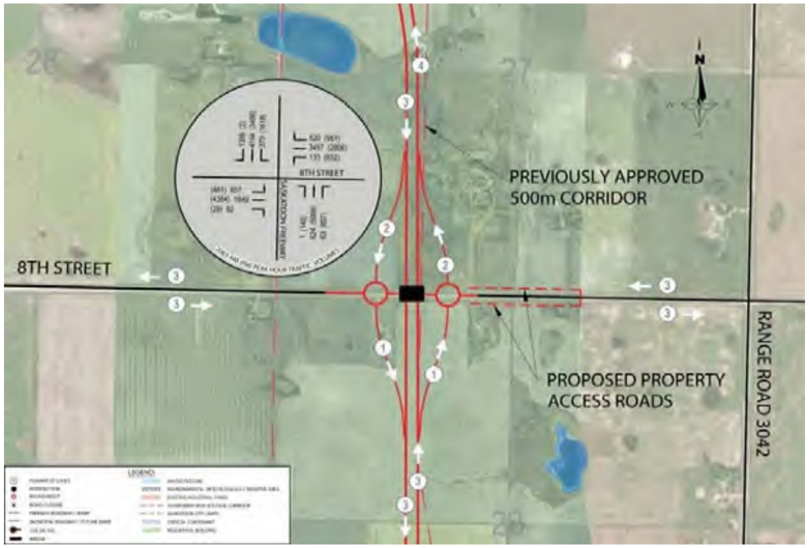
What, if anything, do you like best about Concept 2:

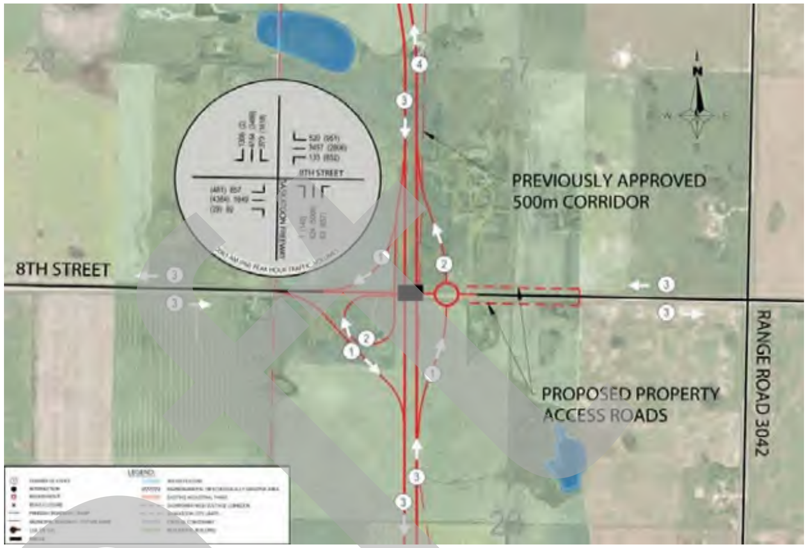


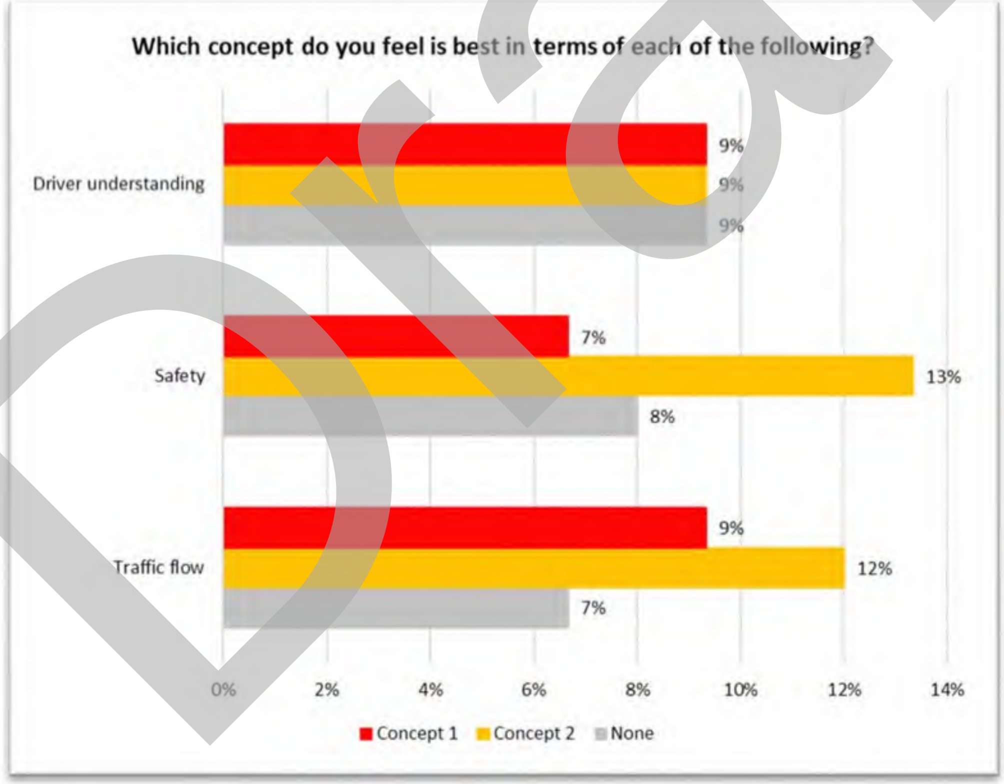
- *at least there is 1 loop of a cloverleaf.*
- *can exit onto westbound 8th with no traffic cirlce / roundabout.*
- *fewer stoplights*
- *Has one traffic circle*
- *If traffic volumes warrant, this is a much better option for traffic flow.*
- *It has at least one loop.*
- *Less roundabouts*
- *Out of the two options, this one is better as it prioritized moving traffic efficiently as well as increases safety.*
- *perhaps better traffic flow for eastbound*
- *Should be much further east, this is too close to the City.*
- *Simple Design, More future proof with loop already in place*
- *The construction of the loop for the south bound traffic*

What, if anything, do you not like about Concept 2:

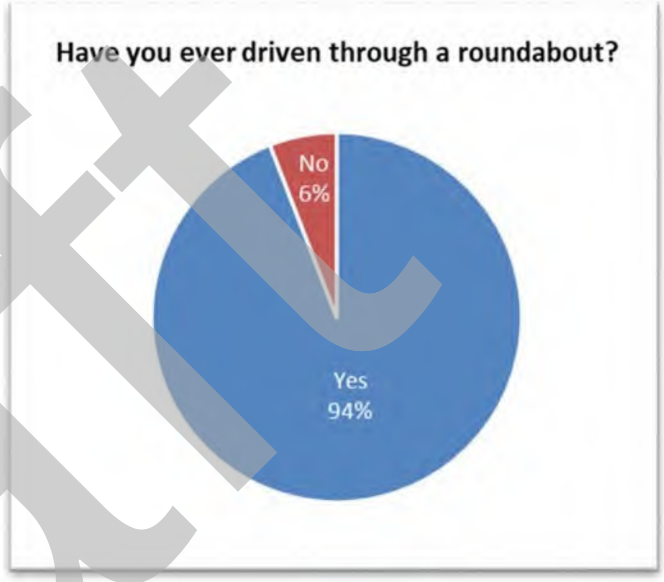
- *I believe a loop should be constructed for both north and south bound lanes of the freeway*
- *It would be nice to do away with the roundabout and have more loops. Look at highway 11 and 16 full clover leaf built in 1972? still getting the job done.*
- *it's not consistent. drivers are distracted already, lets not challenge them by changing concepts in the same intersection.*
- *more expensive*
- *more land use, more concrete*
- *Perhaps this does not go far enough in terms of preparing for future traffic demands.*
- *Same as Concept 1*
- *Should be much further east, this is too close to the City.*
- *Significant land take compared to Concept 1.*
- *takes lots of land for all the loops*
- *The lack of a roundabout on the west side, resulting in more land being required.*
- *Too much road and looping, takes up too much land, roads and freeways can have a huge impact on Urban Sprawl.*
- *Traffic volumns that high for South to East? Though that North to West would be more popular.*
- *uses more land*



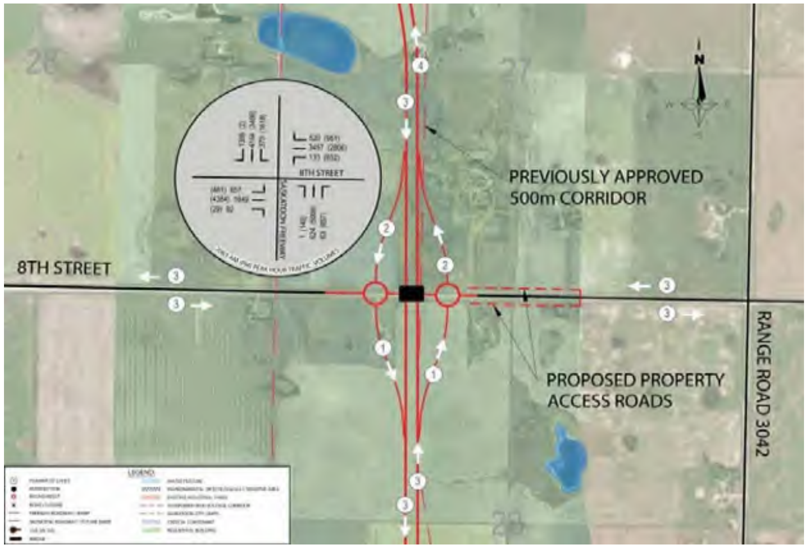


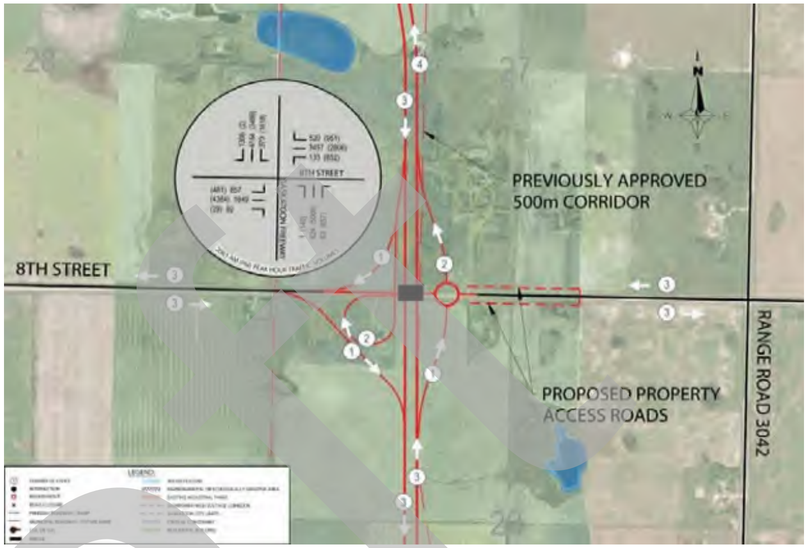

Which concept do you feel is best in terms of each of the following?

What concerns, if any, do you have about roundabouts?



- *I love roundabouts, think they are awesome. I have driven all over the world and wondered why we don't have more of them. We had one on 8th street and it was awesome but the city removed it. Roundabouts work great in the city but out in the country were traffic speeds are higher it seems unnatural. Also I have never seen 2 so close together.*
- *Most Sask drivers are too dumb to use them properly*
- *No concerns. They are great for flow and the way of every other jurisdiction outside SK.*
- *None*
- *None*
- *None myself. The more around, the more people get used to them.*
- *None. The use of roundabouts like what you are showing has proven to be very effective. I've driven them many times while in the UK (and having to drive on the 'wrong' side of the road) and I've never had issues with them and I don't consider myself to be a great driver.*
- *Nothing as they work well is locations all over the world. Some education might be useful for some drivers.*
- *other people not knowing how to use them*
- *People in Saskatchewan don't have enough training or experience with roundabouts.*
- *people not sure who to yield to*
- *people who don't know how to use them*
- *They can be very confusing for many drivers.*
- *Usually high-accident locations, too many drivers do not understand proper right of way in two-lane roundabouts.*
- *With round-abouts - other drivers have difficulty understanding the concept and using them*





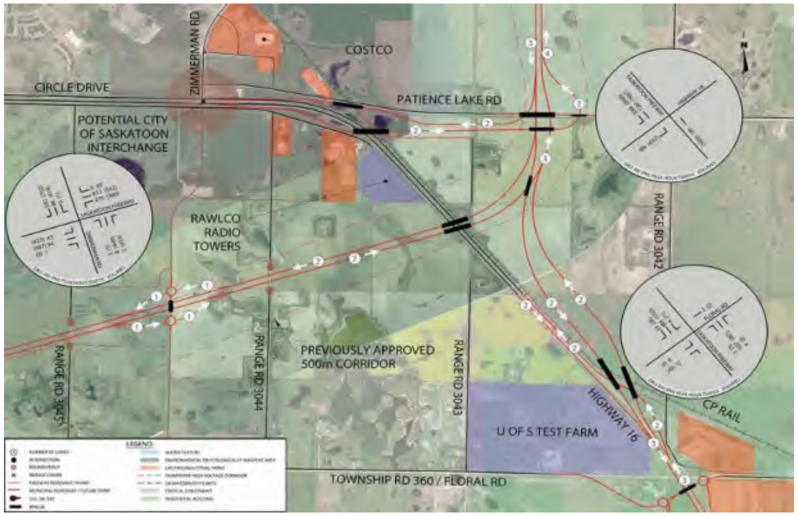
Do you have any additional comments you would like to add about this route?

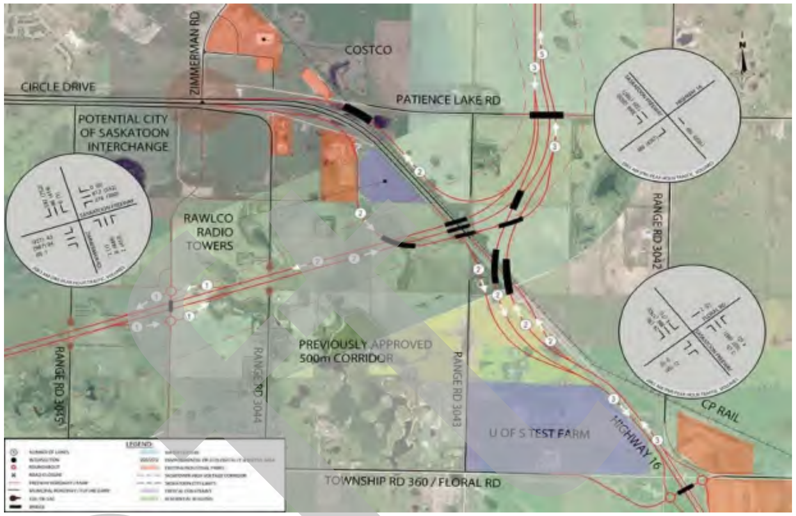
- *I understand there is a budget but it would be nice to have 4 traffic loops.*
- *like McCormond road , this freeway will be seldom used.*
- *None*
- *The use of traffic circles is excellent and has potential for cost saving as less land and road surface is needed.*
- *They are the best way to maintain flow.*

Ministry of Highways:
Saskatoon Freeway Functional Planning Study
Phase 2: Virtual Stakeholder Engagement Session

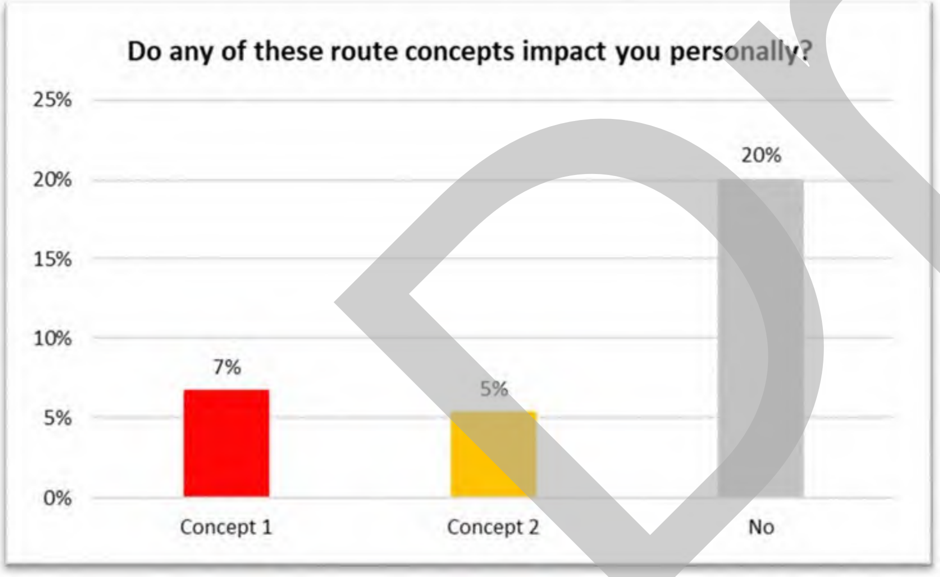
Room 4, Board 3:

Highway 16 Interchange Concepts



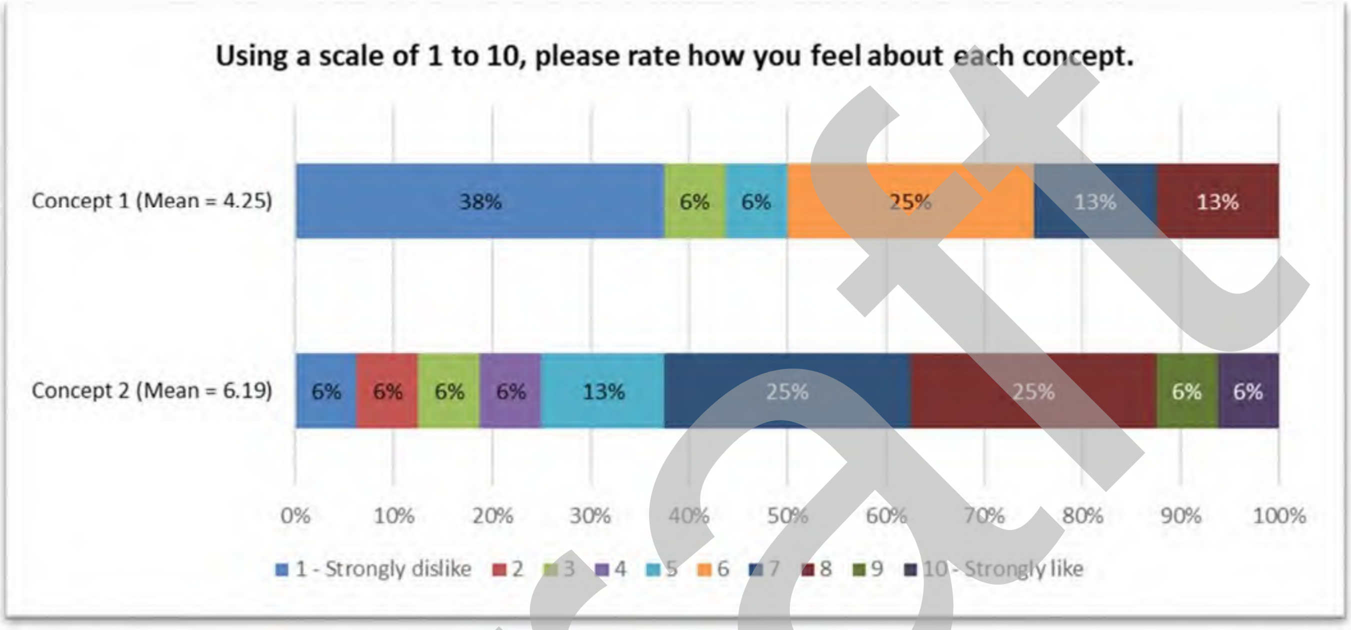


Concept 2 is strongly preferred in terms of traffic flow, safety, and driver understanding.



Briefly explain how you are impacted:

- *Both concepts cut through our property at NW10-36-4W3*
- *Landowner in area*
- *The route runs through my home quarter NW10-36-4W3*



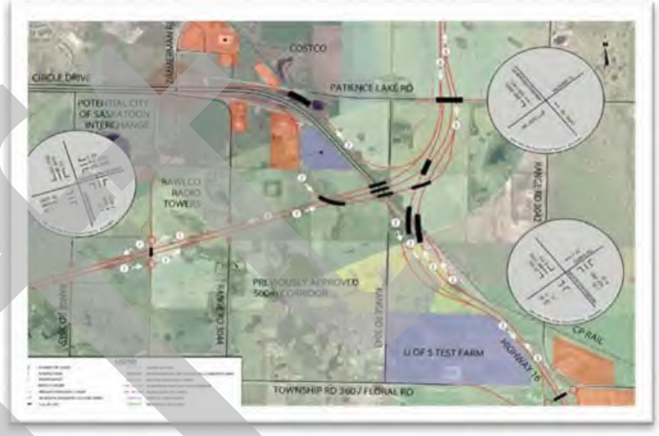
What, if anything, do you like best about Concept 1:

- *I like nothing about concept 1*
- *Large land area allows for future movements if so desired. Spacing between areas allows plenty of decision time.*
- *less concrete, maintains some existing routing*
- *Lower bridges and road embankments, fewer bridges*
- *None*
- *Nothing to like about concept 1*
- *Nothing.*
- *Smaller footprint and less stranded land inside the various lanes of traffic*

What, if anything, do you not like about Concept 1:

- *Eliminates suitable access to approximately 100 acres of prime City of Saskatoon owned land, zoned for future Urban Commercial/Industrial under P4G • Eliminates suitable access to approximately 80 acres of our home residence and agricultural base. This land is also zoned for future Urban Commercial/Industrial under P4G • Has larger losses of agricultural land for our farm • The additional roadway also brings the footprint closer to limited wildlife habitat previously noted in other environmental assessments by the City of Saskatoon for development in the area • Creates a large, disjointed construction footprint and inefficiencies • Restricts traffic flow, including a 90 degree change of direction • Results in our primary residence being isolated and encircled by roadway on all sides Requires a more complicated interchange at Floral Road to the south*
- *excessively complicated. also it creates an odd, isolated patch of land between the highways and the railway tracks.*
- *I believe that the freeway traffic, both north and south should flow over the Patience Lake Rd vs have that road go over the freeway*
- *It negatively impacts what little wetland is left is this area.*
- *It surrounds my residence and main agricultural base with freeway on all sides. Makes my residence uninhabitable. Cuts off all viable access to Patience all road to me and the City's adjacent quarter at NE9-36-4W3. Effectively cuts off 150-180 acres of prime future urban commercial/industrial property from viable development. Takes up a much larger footprint and requires much more land. Restricts traffic flow*
- *May be too spread out, resulting in wasted land that can't be effectively used for other purposes.*
- *seems convoluted with a larger footprint*
- *seems very spread out*
- *This spreads out the footprint over far too large of an area.*
- *Ugly and complicated*

What, if anything, do you like best about Concept 2:

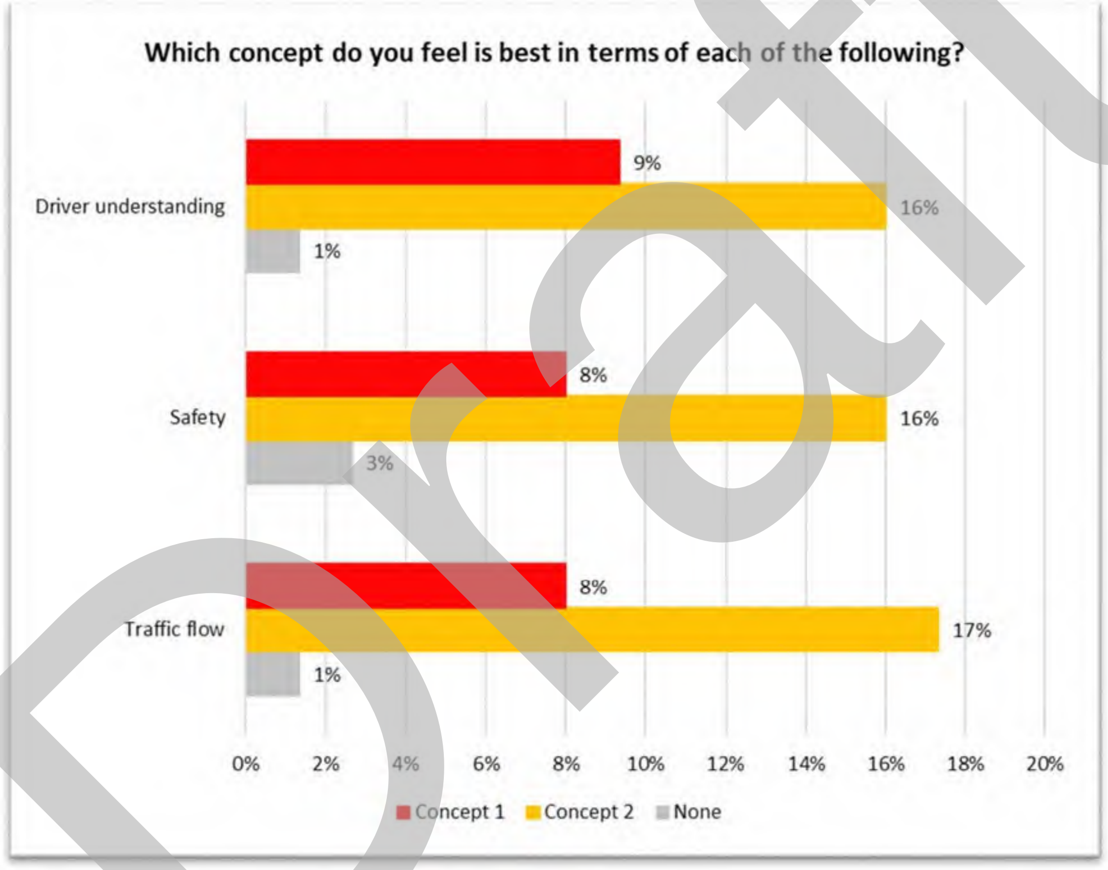


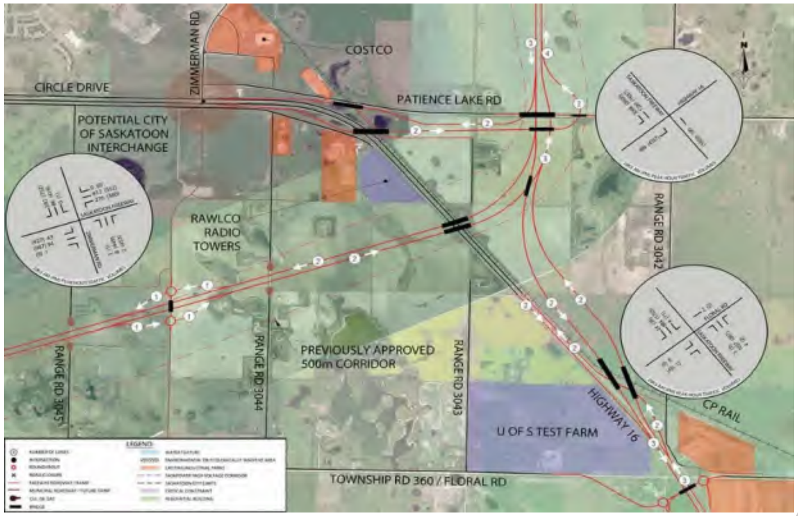
- *Better flow*
- *Better than option 1, it has a smaller footprint on homes in the area.*
- *Compact design, with the majority of movements.*
- *like the smaller footprint with any new concept as it generally correlates with lesser impact to environment*
- *Minimizes the footprint as compared to Concept 1 (does not create an island between the freeway, Highway 16, and Patience Lake Road)*
- *more clear, reasonable access to Circle Dr. Better use of land.*
- *None*
- *Provides unlimited access to approximately 180 acres of land inside the freeway perimeter, located at the most significant crossroads of the Saskatoon Freeway Project • Allows the City of Saskatoon to retain more land • Allows our farm operation to retain more land • Has a much smaller impact on our primary residence in terms of noise and safety • Does not isolate and encircle our primary residence by roadway on all sides • Enables the viability of future planned high density development within the freeway perimeter as per P4G • Keeps the footprint as far away as possible from wildlife habitat noted in the area during previous City of Saskatoon assessments • Has a reduced construction footprint, which results in large scale overpass and roadway construction along one route instead of two.   • Has a streamlined design, providing greater traffic flow • Provides for a simpler, more efficient Interchange Concept at Floral Road*
- *Same as comments regarding Concept 1 of this board*
- *seems to be more compact in design - more in one place*
- *Takes less land from me.   Leaves open access to patience ok road for me. Preserves 150-180 acres of mine and the city of Saskatoon's land for future viable development.   Takes up less of a footprint.   More compact. Traffic has a smoother flow.*

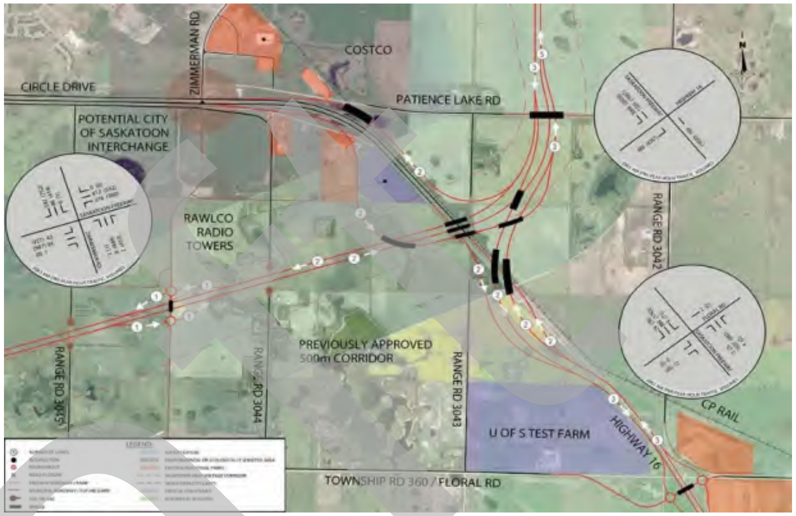
What, if anything, do you not like about Concept 2:

- *appears to need more land, more concrete*
- *Higher bridges and road embankments, looks a lot more complex for similar traffic flow*
- *It negatively impacts what little wetland is left is this area.*
- *It runs over our property.   I believe this route should have been planned further east of me over NE10-36-4W3 which would give more options for an angle of attack at HW16 as well as cross land that would be a willing seller.*

- *It runs through and near my property, I rather it did neither*
- *May not be able to accomodate expansion if needed. Bridges may be expensive.*
- *Same as comments regarding Concept 1 of this board*







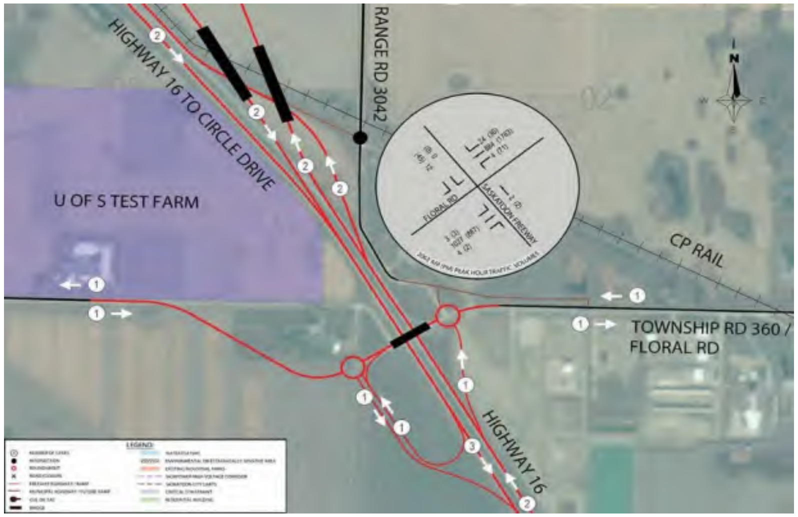
Do you have any additional comments you would like to add about this route?

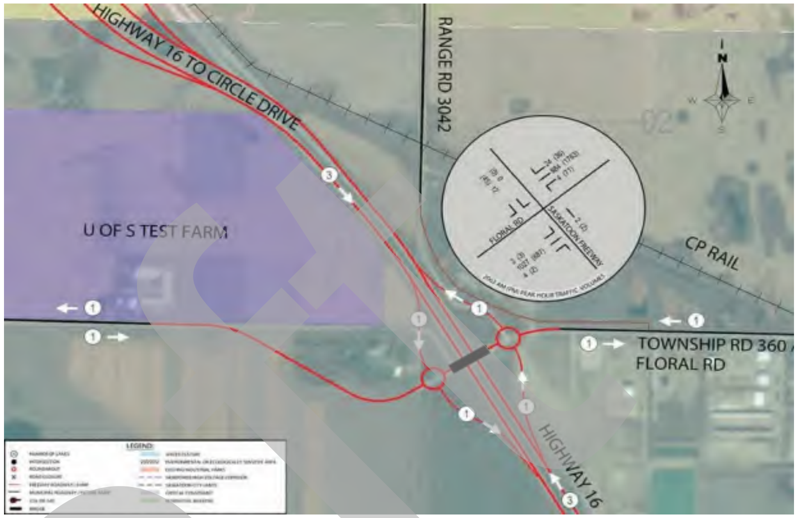
- *Both options should be much further out, routing should be outside of Freeborn Road at a minimum. This will be useless/obsolete by the time it is built. The stupidity of tying into Highway 16 at the same locations where a CP Rail track and a huge Saskpower ROW with massive towers both exist is astounding. Both of these options should be moved east to save taxpayers dollars and an unnecessary overbuild.*
- *Concept 2 provides better traffic flow, better accessibility to NE9-36-4W3 and NW 10-36-4W3, provides possible viability for my family to continue on in our residence. Uses a smaller land footprint.*
- *none*
- *Pick route 2 or create a new route further east and south.*
- *Please consider noise impacts on residential areas with raised roadways and bridges. The city has spent a lot on noise abatement along Circle Drive in the southeast, but it is not effective where the road is raised such that the noise goes above the soundwall, such as around the 11/16 cloverleaf interchange. Highway and particularly truck noise can be heard well away from the highway. I'm not sure if a newer raised roadway design would be quieter, but the higher bridges of option 2 probably would have more noise impact on the SE of the city.*

Ministry of Highways:
Saskatoon Freeway Functional Planning Study
Phase 2: Virtual Stakeholder Engagement Session

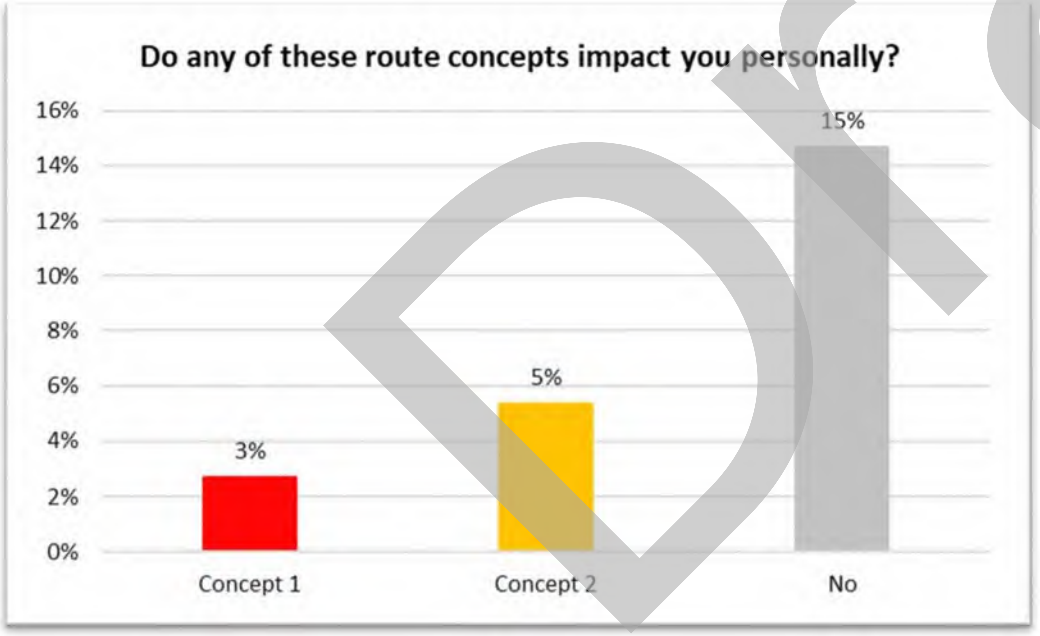
Room 4, Board 4:

Floral Road Interchange Concepts



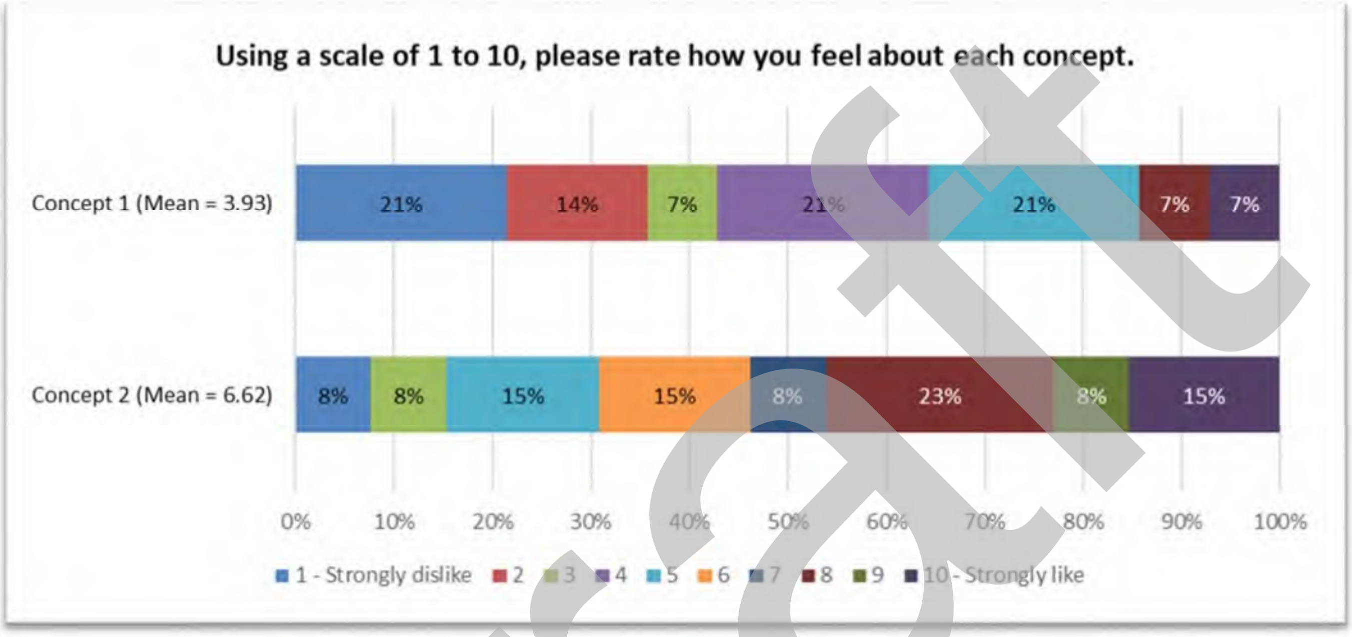


Concept 2 is strongly preferred in terms of traffic flow, safety, and driver understanding.



Briefly explain how you are impacted:

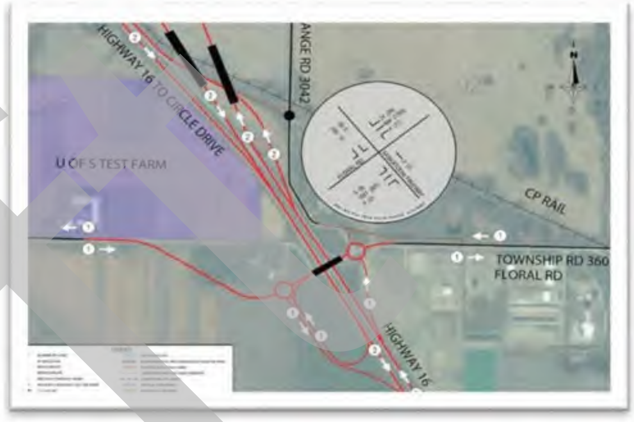
- *I use this intersection daily*
- *landowner in area*
- *Will there be access from 663?*



What, if anything, do you like best about Concept 1:

- *Good design made to fit.*
- *no*
- *None*
- *The nearby highway 16 interchange should be updated to this location, with the whole route shifted east. this would result in large efficiencies and savings of tax payers dollars.*

What, if anything, do you not like about Concept 1:



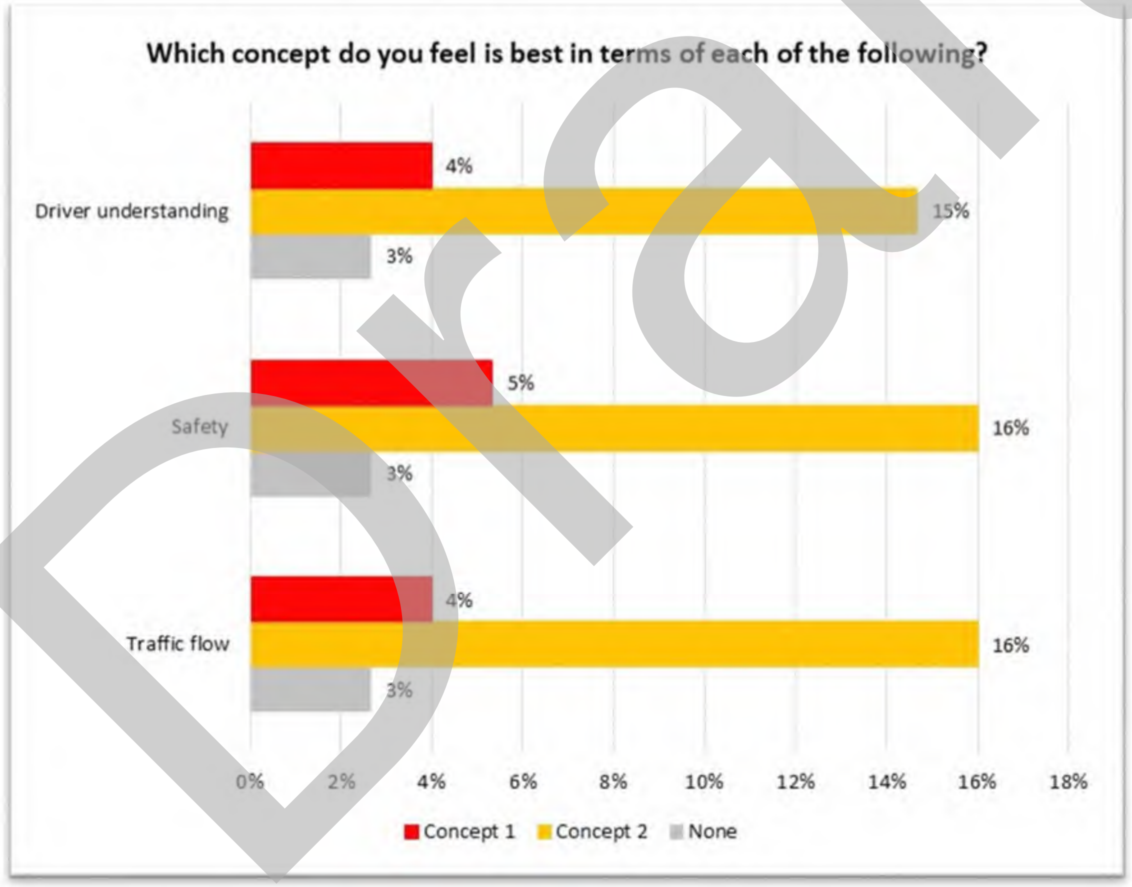
- *Don't like the big loop to get off 16 to floral road*
- *Dont like the big loops*
- *excessive use of land for the west access.*
- *Looks expensive with all the overpasses and too much looping.*
- *Lots of land required.*
- *Northbound traffic from 3042 is not accounted for in the drawing, and there is a fair amount of commuter traffic that comes from here going to Saskatoon each day, and back again. The onramp back to 16 is placed weirdly.*
- *overpasses*
- *The nearby highway 16 interchange should be updated to this location, with the whole route shifted east.*
- *uses a lot of land*

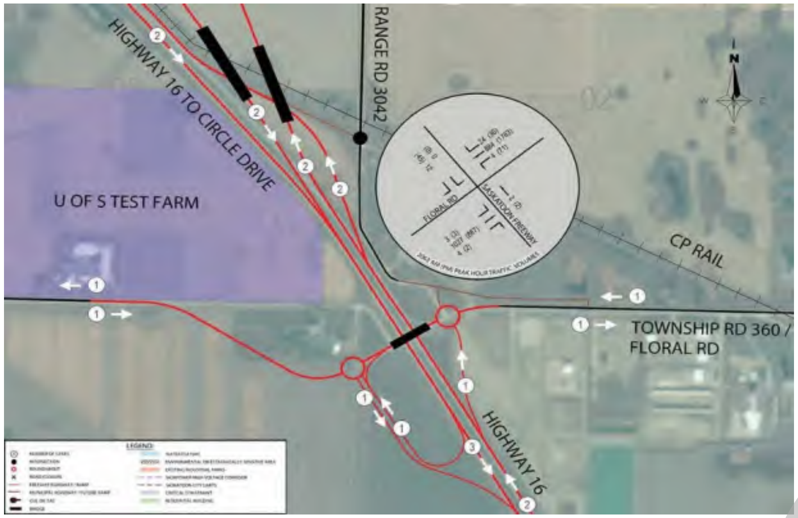
What, if anything, do you like best about Concept 2:

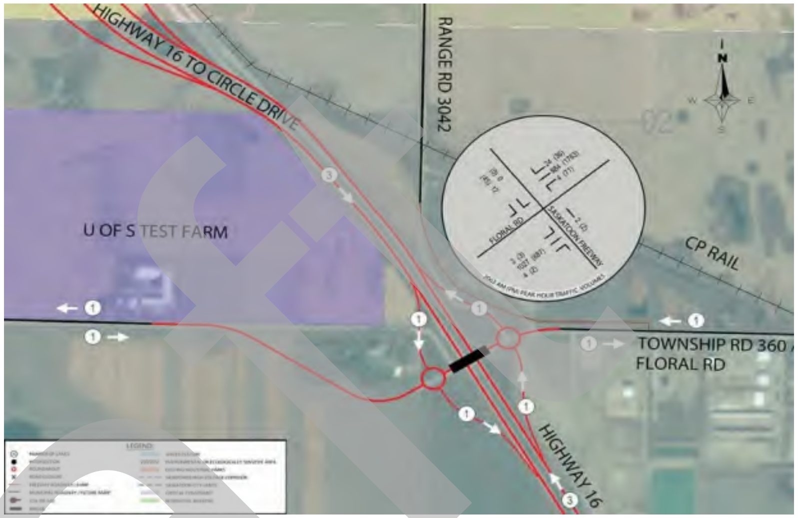
- *better use of land. clear, easy roundabouts provide more access.*
- *Easier access to highway 16*
- *It looks simpler and there are fewer railroad crossings (safety concern).*
- *Keeps it simple. Limited land take compared to Concept 2.*
- *like the 2 roundabouts, good traffic flow*
- *Simple design, made to fit.*
- *simple, predictable*
- *simple. like direct access to and from traffic circles*
- *straight forward*
- *The nearby highway 16 interchange should be updated to this location, with the whole route shifted east.*
- *The use of traffic circles is excellent and provide large cost saving.*

What, if anything, do you not like about Concept 2:

- *Doesn't take into account commuter traffic nortbound/southbound on 3042... Without this access there is no paved road to lead to my house.*
- *goes right thru the field I farm at floral road.*
- *no access for hwy 663*
- *The nearby highway 16 interchange should be updated to this location, with the whole route shifted east.*







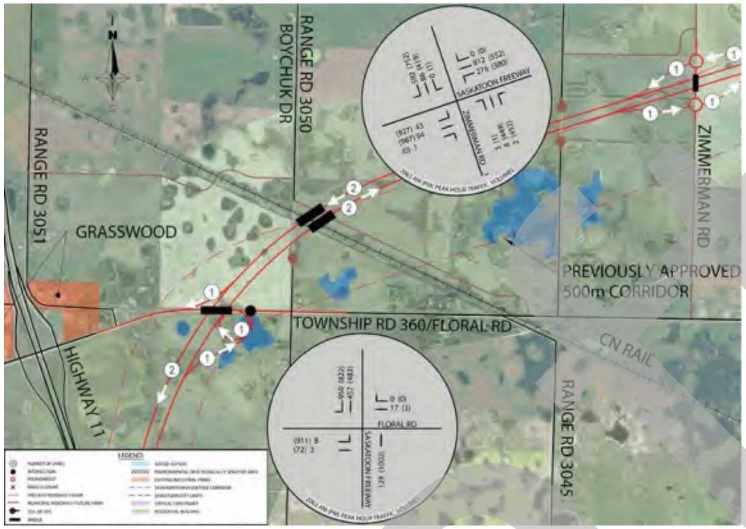
Do you have any additional comments you would like to add about this route?

- *I didn't expect this to affect my existing intersection, but I think that it can make it safer as long as it accounts for the traffic on 3042*
- *The nearby highway 16 interchange should be updated to this location, with the whole route shifted east.*
- *The use of traffic circles is excellent and has potential for cost saving as less land and road surface is needed.*
- *will farm equipment have enough room, if equipment takes 1 lane and shoulder can a car pass on the bridges. need access for hwy 663*

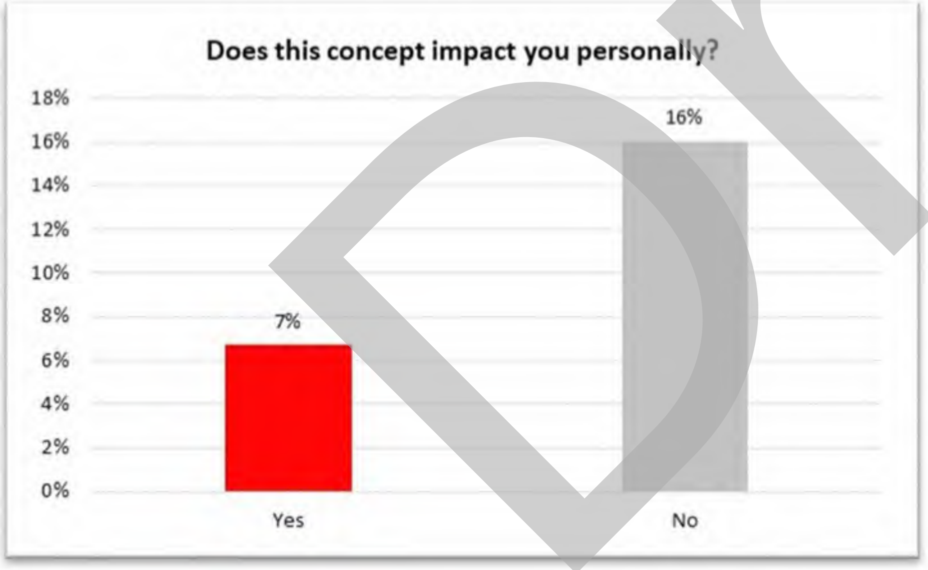
Ministry of Highways:
Saskatoon Freeway Functional Planning Study
Phase 2: Virtual Stakeholder Engagement Session

Room 4, Board 5:

Grasswood/Floral Road Interchange Concept

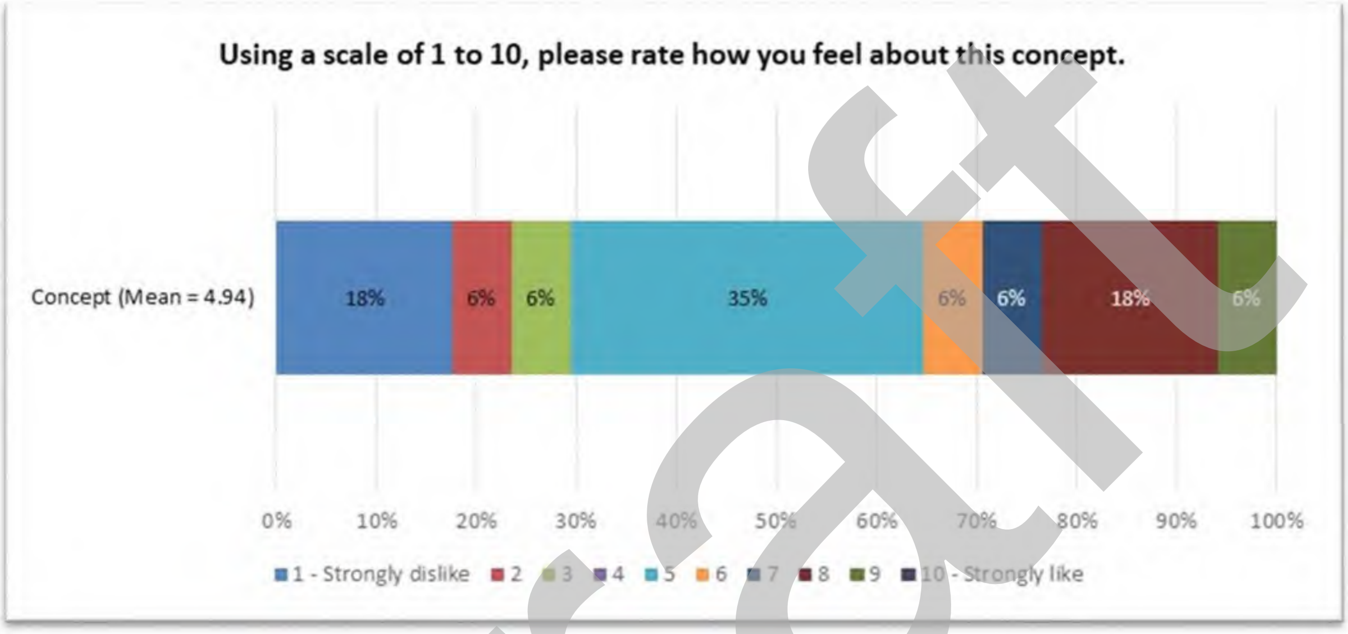


The concept receives mixed reviews from local residents.



Briefly explain how you are impacted:

- *I live off of range road 3051 south of floral road. I am concerned about wildlife, birds, noise and light.*
- *ownership of land for where purposed freeway is going.*
- *We live at Ashwood Estates and it's the nearest country residential development. Many homes still have well water and so water security (protected from contamination) is very important. Traffic noise is also very important to the lifestyle we've invested in.*
- *We live east of this interchange. Ease of access to and from Saskatoon for emergency vehicles is a concern.*
- *We live very close to proposed development area.*



What, if anything, do you like best about this Concept:

- *I have a better idea of where it's going.*
- *I like that the concept is being thoroughly investigated with numerous variables taking into consideration*
- *It doesn't go right through my property.*
- *Looks like it will address ease of our commute to Saskatoon.*
- *None*
- *seems straight forward*
- *Simple design, reasoned well for not all turning movements.*
- *That it is 15 years away :)*

What, if anything, do you not like about this Concept:

- *Increased noise, light, danger to wildlife, potential access impediments, potential for significant property value impact.*
- *It crosses an area with numerous wetlands.*
- *Needs to rethink pushing it farther down Hwy #11 to Baker Road as the access to and from the city will create further congestion due to commercial development in the Grasswood area (i.e Hockey rink, Gas stations, etc.)*
- *That the RM of Corman Park is even remotely involved in the concept as they have previously not shown much leadership or forethought to future development doing piecemeal approvals*
- *This seems unnecessary, access from Hwy 11 seems sufficient (or needs to be upgraded anyway, since this does not resolve the issue of EB Grasswood traffic turning north onto 11).*

Do you have any additional comments you would like to add about this concept?

- *Environmental considerations need to be considered in all areas of the development, not just the sensitive NE portion. Although the land in this area is agricultural there are significant amounts of natural bluff areas and wetlands that support a diverse ecology.*
- *I do hope that the concept takes into account landowners who have moved to a rural life to enjoy just that. I have had ten deer in my yard periodially all winter. I love that about where I live as well as the numerous species of birds my yard hosts all spring, summer, fall and to a lesser extent winter. I am not against future development at all. I just ask that the rural landowners be respected for their lifestyle and the investment of their homes and land.*
- *I'd be willing to volunteer as part of further public input. Feel free to reach out to me.*
- *Looks good. Lets do it!*
- *Remove the connections to Floral Road. You can access Floral from Highway 11.*

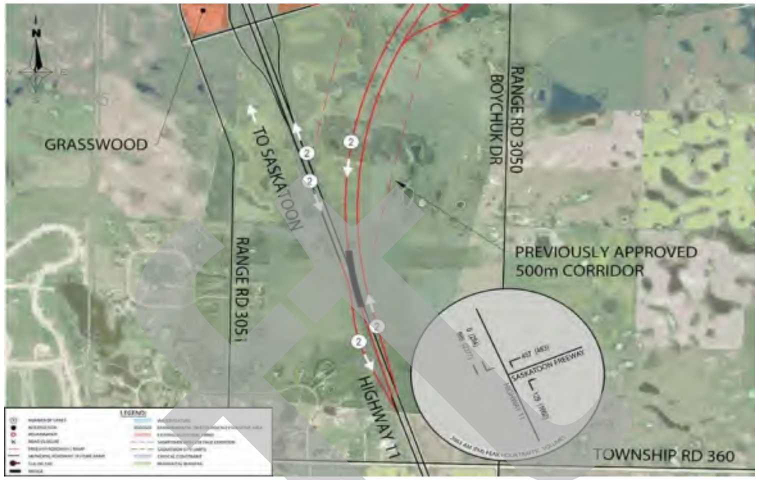
Ministry of Highways:

Saskatoon Freeway Functional Planning Study

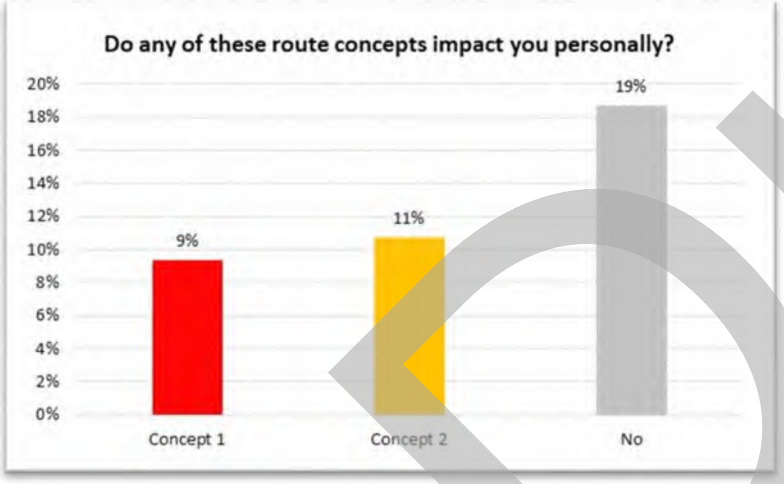
Phase 2: Virtual Stakeholder Engagement Session

Room 4, Board 6:

Highway 11 Interchange Concepts



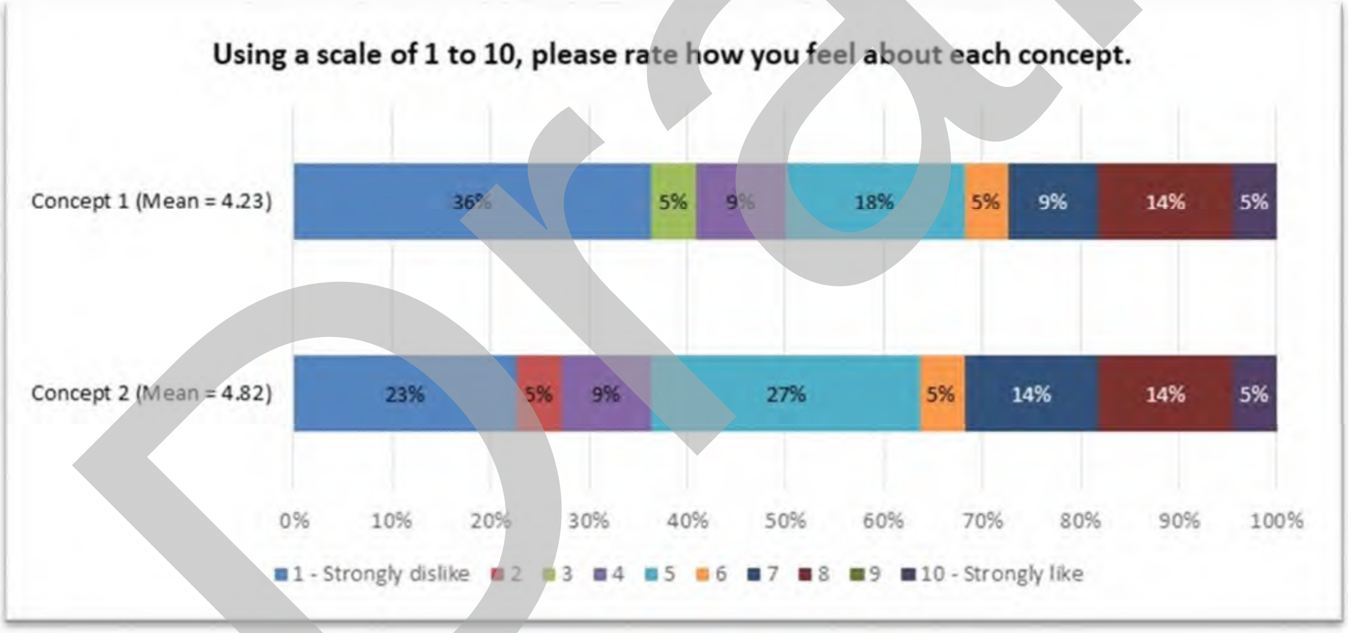
Neither concept is clearly preferred over the other.



Briefly explain how you are impacted:

- *Because of elevated roadway: Traffic noise potentially louder & Light pollution of night sky Recommend attention to noise barriers and lighting detail*
- *Because they are taking my land and it has been frozen for how many years to this date and how many more years will it be frozen would enybody looking after this like it if they couldn't do anything with their house or property I don't think so to me this is all a bunch of BS*
- *Driver/User*
- *I drive thru every day*
- *I live in Ashwood Estates approx 1 mile west of the proposed overpass. There is a lot of commuter traffic going to and from the acreages south near Highway #11 on Baker Road etc. and there is a lot of passenger vehicle traffic going straight up and down highway #11 so it makes more sense to have the traffic going south from the Saskatoon Freeway to Highway #11 have an overpass.*

- *I live in the Grasswood area and will be impacted by construction activities as well as ongoing highway usage. It will be important for our continued enjoyment of our homes, that appropriate consideration be given to minimizing noise through proper sound barriers. In addition I am concerned about wildlife crossing the highway in this area as well. There are moose, deer, foxes and coyotes sighted on a regular basis. As well, have impacts on sandhill crane migratory paths been considered?*
- *I live on South Point Drive and the reason why I live here is to enjoy the country and the quiet with little traffic. The construction and increased traffic worries me for the noise, and the construction will be daunting. Baker road is so busy now for the people who live in the area, to put the exchange at Grasswoods will bring congestion*
- *noise, visually unappealing sitting out on our deck or yard. Inevitable reduction in our land value.*
- *Travel this road every day and not having overpass to enter this city would be better*



What, if anything, do you like best about Concept 1:

- *Assuming most truck traffic is on the new freeway, it provides a better non-elevated route for the trucks.*
- *high speed traffic maintains right of way*
- *None*
- *nothing*
- *Nothing*
- *nothing*
- *Right exit for Saskatoon Traffic, Saskatoon Freeway stays at ground level.*

What, if anything, do you not like about Concept 1:

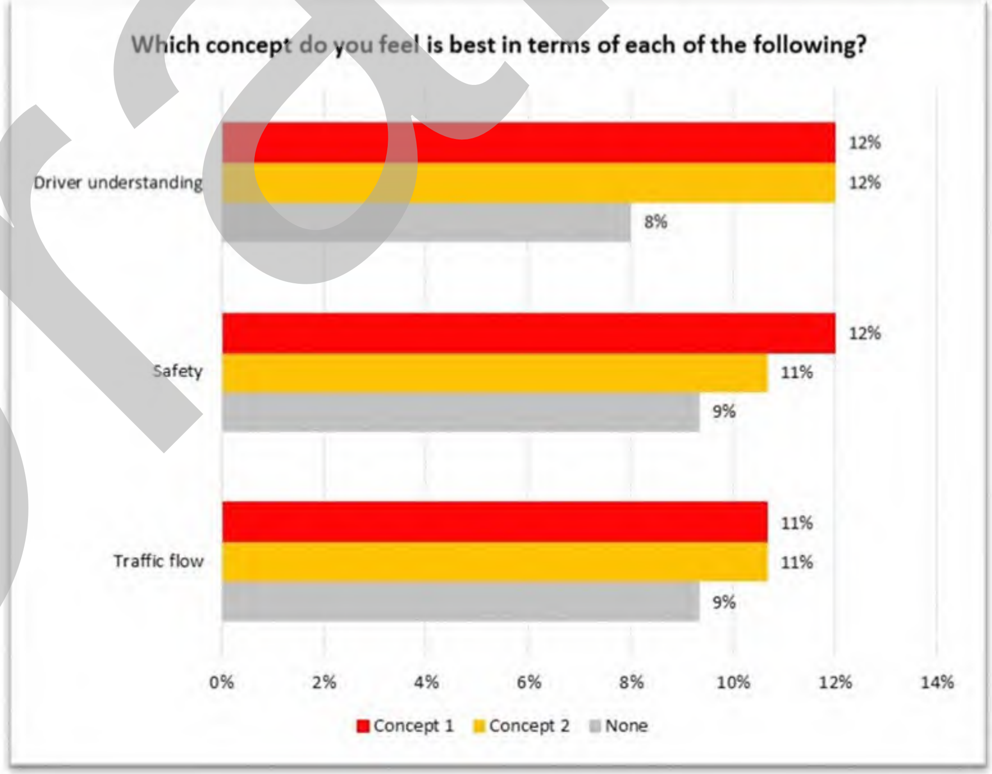
- *Additional construction compared to concept 2*
- *Crosses over an area with multiple wetlands.*
- *Dont like when I have to exit right to go straight thru. Very confusing*
- *It looks to be more expensive for only a small advantage.*
- *location*
- *more traffic will be continuing on highway 11 - they should stay on direct route*
- *nothing*
- *There is alot of commuter traffic to and from Regina and from the area southeast of Saskatoon so the overpass should be on the new freeway to the east.*
- *To close to surrounding acreages and increasing congestion*
- *Travelers coming from the south on Hwy 11 should not have to use a an elevated overpass to stay on Hwy 11, Hwy 11 is the main roadway and those wishing to use the freeway should exit as in concept 2 ,*

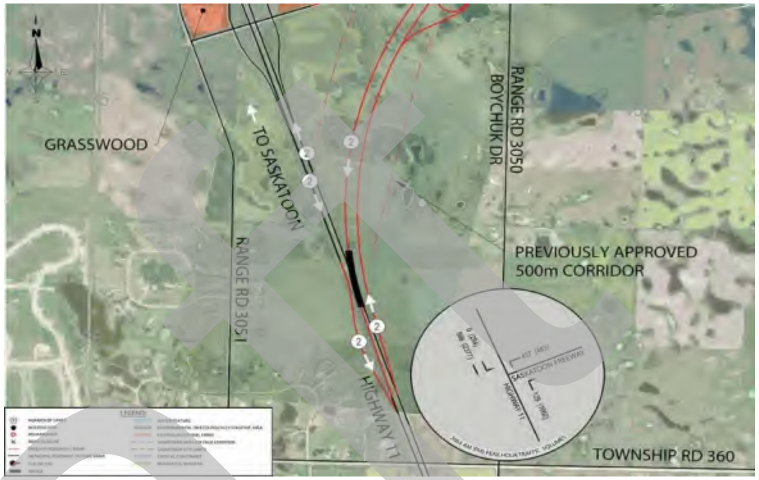
What, if anything, do you like best about Concept 2:

- *Easier to follow*
- *I like to stay in the left lane to go straight thru N on hwy 11*
- *I think it would be less confusing for motorists*
- *keeps traffic on highway 11 and people leave to go on Saskatoon Freeway*
- *Less construction and disruption*
- *Looks simpler*
- *nothing*
- *nothing*
- *people going in to saskatoon don't have to exit*
- *The high volume of commuter traffic to and from the southeast side of Saskatoon on Highway #11 does not have an overpass.*

What, if anything, do you not like about Concept 2:

- *all of it*
- *Crosses over an area with multiple wetlands.*
- *curved bridge*
- *Jct of Hwy 11 & Freeway should be further south*
- *Left exit for Saskatoon-bound traffic, Mainline Freeway traffic having to go over Southbound Hwy 11*
- *location*
- *To close to acreages, increasing congestion especially during construction*
- *Use this road each day and not having to exit and go over overpass not as convenient*





Do you have any additional comments you would like to add about this route?

- *Is the roads and bridges going to be built for farm equipment width? Enough room so farm equipment can drive taking up shoulder and 1 lane and still leave 1 lane for cars to pass at all times.*
- *Move this Farther South So you are not impacting people that live right here. There is lots of open field between Baker road and Victor road*
- *No*
- *No*
- *Not at this time.*
- *The concepts are so similar (it's a matter of which road crosses over the other). This should come down to the lowest cost concept.*
- *Would like to see some clearances established between the Freeway, commercial development, and residential use especially in the P4 areas development that will accompany it, and residential use especially in the P4 areas.*

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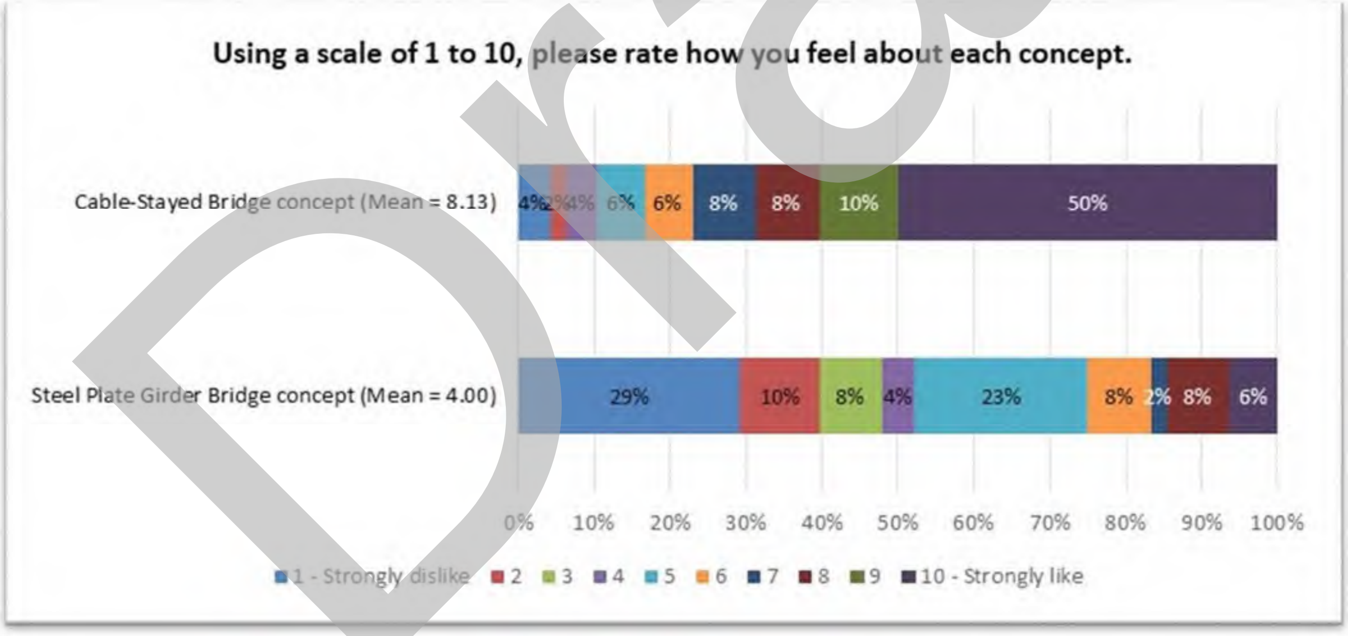
Room 5:

Bridge Concepts

There is a strong preference for the cable-stayed bridge concept.



What, if anything, do you like best about the Cable-Stayed Bridge concept:

- *Aesthetically pleasing*
- *Aesthetics, landmark opportunity*
- *Asthetics*
- *Can be expanded*
- *Clean look*
- *clean looking*
- *Could be an iconic bridge. Staying out of the river is always good.*
- *Easier to expand*
- *I like the fact that it doesn't have has much disturbance in the river*
- *I like the look of the bridge as Saskatoon is the City of Bridges but we don't have a nice looking bridge like this in our skyline.*
- *It sounds like it might be less impact on the environment? It is also attractive and because I will see it from my home, I like that it could be attractive.*
- *It would be easier to add another bridge if needed.*
- *it's looks nice. also it limits impact on the river.*
- *least disruptive to the natural area under the bridge along the river bank*
- *Less impact on river, looks good.*
- *less impact to the environment*
- *less impact to the river bank*
- *Less impact to the river.*
- *Less piers in the middle of the river.*
- *looks better than steel plate girder*
- *looks interesting, could provide perches for birds, less impact to green ash forest & riverbank*
- *Nothing in the river, ascetically better*
- *Pedestrian and cyclist crossing has been inlcuded*
- *Pedestrian and Cyclist infrastructure*
- *piers stay out of the river.*
- *Potential for aesthetic architectural treatment and perhaps less bulky than another form of bridge.*

- *Potentially less impact on the Green Ash Forest and river ecosystem.*
- *Sexy*
- *The cable stayed bridge is aesthetically pleasing compared to a standard steel or concrete girder bridge. It would provide some variety and style to the city and further reinforce the nickname "City of Bridges"!*
- *The Double Bridge completely separating the traffic lanes makes the most sense*
- *The riverbank riparian forest and river itself will have minimal impact. The cable bridge may provide iconic view that fits with Wanuskewin design concept*
- *Towers may be able to be built out of the river water, distictive design.*

What, if anything, do you not like about the Cable-Stayed Bridge concept:

- *Added environmental damage*
- *cables may cause issues in bird flight path*
- *Concerns that the cables may have am impact to bird strike issues.*
- *Cost certainty, is the design more expensive relative to the benifits?*
- *harder to expand*
- *I don't like that eventually there would be two bridges.*
- *I don't think the roadway needs to be split. Keep the driving lanes together.*
- *ice forming on cables and falling into traffic as melt*
- *Icing of the cables can result in falling ice onto the road deck. Also, damage to the cables due to rusting from salt exposure immediately above the bridge deck.*
- *If it costs more for capital and operating then other designs, then that's not good.*
- *I'm surprised there would ever be a need for that many lanes.*
- *Impacts to the river bank*
- *It still has negative impact on several ecosystems (aquatic, riparian, and grassland).*
- *It would cause twice as much damage to the river bed and banks over time.*
- *More difficult to build, realistically will be more challenging and expensive for our construction crews to build*
- *more land used*
- *more piers required in the river, extending construction time and causing additional river issues*

- *Not indication of whether there will be a pedestrian/cyclist crossing UNDER the bridge, which is the only type of crossing I could support*
- *Nothing. It is way better than a standard concrete or steel girder bridge*
- *Only potential impact to the river bed would be my concern*
- *Peirs in water and longer to build*
- *Poor aesthetics*
- *Potential noise.*
- *the bridge is unessesary*
- *The bridge is unnecessary and should not be built*
- *We need to build a healthy future. It's just a huge waste of billions of dollars to encourage people to drive cars more than they already do.*
- *You can't see the water*

What, if anything, do you like best about the Steel Plate Girder Bridge concept:

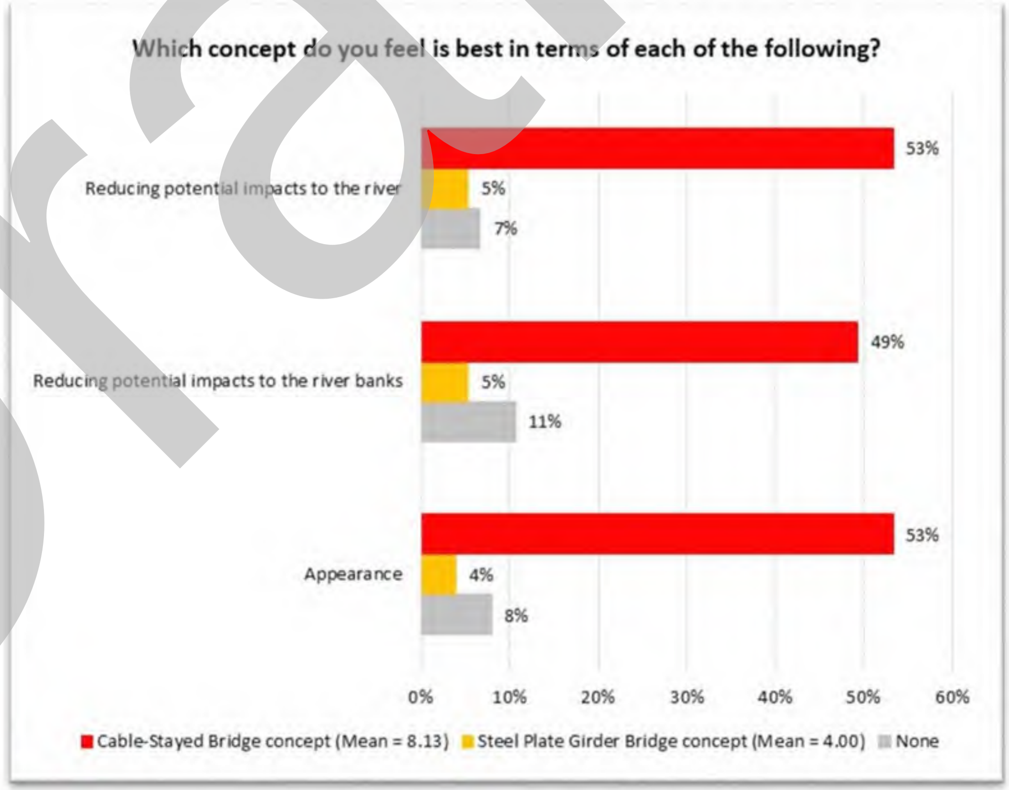
- *Better for hauling large loads that may extend over the edge of the bridge deck*
- *Cheap and easy to build*
- *cleaner look*
- *Cost effective.*
- *does not look good*
- *Easier to add another bridge when needed.*
- *easy to expand*
- *fewer places for debris to fly off bridge onto pedestrians*
- *Great aesthetics*
- *I am not sure if this is necessarily a like, as I don't like the idea of this road or bridge. But the idea of it having less of a footprint on the river bank compared to the cable in theory seems "better".*
- *I think Wanaskawin would like this bridge better since it is not to tall in the skyline.*
- *It's a bridge, this decision should be made off construction and operating costs.*
- *It's a bridge. Proven design*

- *least disruption to riverbank under the bridge*
- *low profile , less visual impact on landscape*
- *None*
- *Nothing*
- *Pedestrian and Cyclist infrastructure*
- *Pedestrian and Cyclist infrastructure has been included*
- *Perhaps less noise than a suspension bridge.*
- *Simple bridge, same cofferdam approach that construction crews are familiar with, cheapest*

What, if anything, do you not like about the Steel Plate Girder Bridge concept:

- *Aesthetically unappealing, drivers might hardly know they are crossing a major prairie river, views might be cut of with solid railings. Also the pillars. The river would disturb the river flow more than a suspension bridge.*
- *Alternate could be built out of the river water, this one has to distrub the river during contruction and after.*
- *Boring. A cable stayed design has the ability to create an iconic piece of infrastructure.*
- *Construction within river*
- *Everything*
- *I don't agree with building a road or bridge near the Swales or the rare green ash forest.*
- *Impact on the environment*
- *impacts to river bank*
- *It appears it will have a greater negative impact on the ecosystems (aquatic, riparian, and grassland).*
- *It is not aesthetically pleasing. Saskatoon already has this style of bridge so it would not be an attraction like the cable stayed bridge would be*
- *It's a bridge, this decision should be made off construction and operating costs.*
- *It's pretty boring. Also, it would impact the river bed and river bank more due to more piers.*
- *Larger environmental impact to the banks, river bed and not as nice looking, we are the city of bridges.*
- *looks the same as all the other new bridges in Saskatoon*
- *looks. impact on river.*
- *more environmental impact*
- *more environmental impact to surrounding areas*

- *No indication here concerning how pedestrians/cyclists could use this crossing. My strong preference is for a suspended walk/cycleway UNDER the bridge*
- *piers in the river*
- *piers in the water.*
- *prefer the cable bridge concept. Less impact to the riverbank and the river itself*
- *Snore*
- *The bridge is unnecessary and should not be built*
- *This bridge is unnecessary*
- *This looks like the Gordie Howie Bridge, it works to move traffic but nothing to be proud of as a City.*
- *Too many piers, too much shadowing over the river and the multi-use trail especially if twinned.*
- *Traffic separation could be problematic.*
- *Utilitarian looking*
- *We need to build a healthy future. I cannot see any quiet places to walk or bike or spend time in any of these concepts. The Gordie Howe bridge is a disaster in terms of noise and liveability in our area. It's just a huge waste of billions of dollars to encourage people to drive cars more than they already do.*



Do you have any additional comments you would like to add about the bridge concepts?

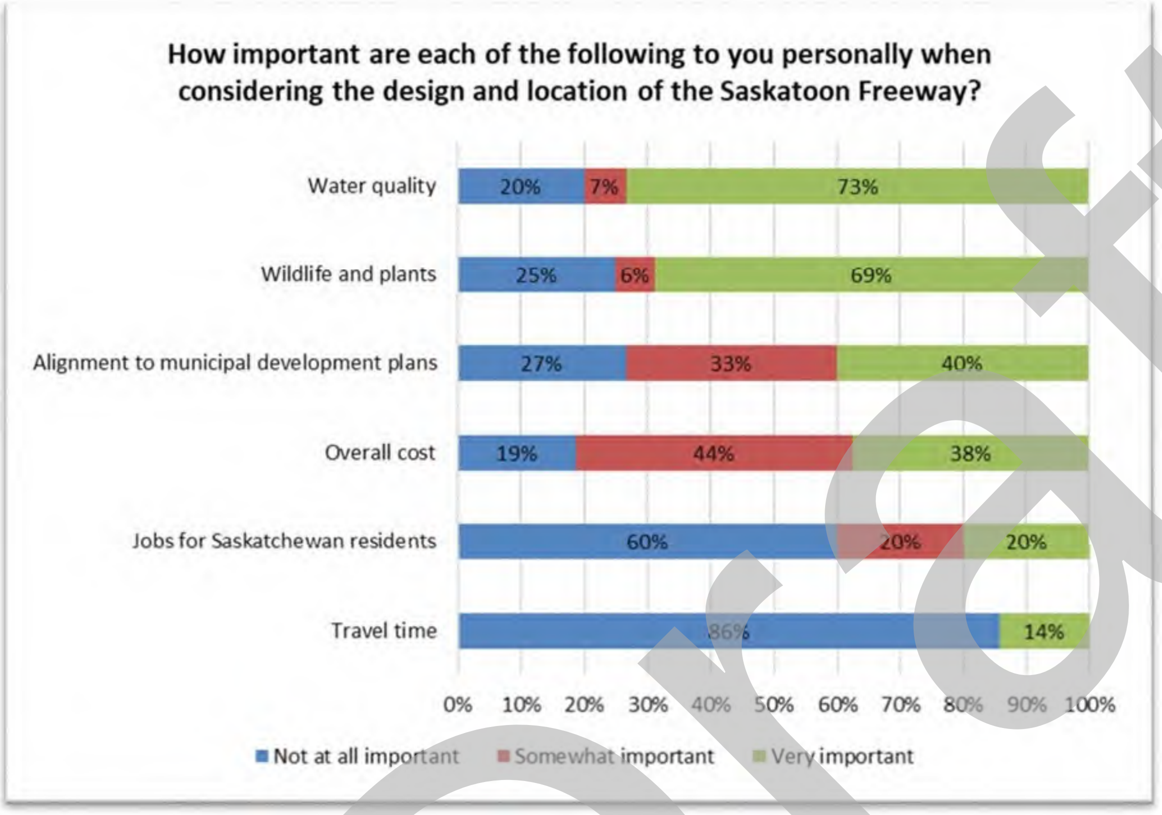
- *Add concrete details to the structure so art work is pleasing to the users.*
- *All these billions could be put to much better use, building a carbon-neutral passenger rail system.*
- *are cable bridges appropriate for our climate?*
- *Both bridges will be invasive to river and riverbank but I think necessary for traffic flow of expanding city. Not sure there would be realizable differences between the two designs.*
- *By route do you mean the freeway itself? I said I was not impacted by any of your choices or plans for the overpasses. That is because I will be able to drive under them to get home. That is why I say the plans don't impact me.*
- *Cable bridge is the best choice for minimizing impact to river bank and river itself. Opportunity for an "iconic" bridge tied to Wanuskewin with the look. Potential concerns with bird strikes on the cables*
- *Have the piers on each side of the river sit on a common pier above the water level. This way the water would just have to divert around one larger pier (60' long by 20' wide) rather than around two smaller piers (10' long by 10' wide) where the water has to flow in and out around them.*
- *It's a bridge, the decision should be made off construction and operating costs.*
- *More research needs to be done on the environamental impacts of another bridge (in addition to the Mistawasis bridge) in such close proximity.*
- *Move the entire highway farther out of the city*
- *No questions here about the "Alternative 3" route related to crossing of the Swales?*
- *Please do not proceed with this project*
- *Routes are fine. Just make posted speed limit 110 and build a unique feature bridge such as the cable stayed bridge*
- *Should incorporate a ped pathway below bridge deck, like Gordon Howe Bridge.*
- *Steel cable bridge rocks!*
- *The bridge is not required and we should not proceed with this project.*
- *The purple route is the best but could be improved with some changes as described in my comments.*
- *This bridge is far too close to the city for a 'perimeter' highway. Think 15 years. Southwestern route should still be considered.*
- *Your comments about ash trees in 15 years we will have the emerald ash bore and new plantings around bridge will enhance area so impact on existing trees is a non issue*

Ministry of Highways:

Saskatoon Freeway Functional Planning Study

Phase 2: Virtual Stakeholder Engagement Session

Exit Survey



Other – please specify:

- *Finding a route that will be what we need in 25 years, and this is not it!*
- *Health and quality of life for Saskatoon residents*
- *Immediate jobs is irrelevant. Sustainability of life forms so all will be able to have healthy lives and thus be able to work is more important tha immediate jobs. a freeway to go around a city should dpo that.GO AROUND not through, not through what little historic, native habitat there is that is accessible to all people of Saskatoon. Build the road to go around..why not where it was to go first, south and west to meet 7 and 16???*
- *Jobs for Saskatchewan residents are important, but for $2,000,000,000 there are much better job creation opportunities than this unnecessary and destructive project.*
- *Loss of prairie habitat and disruption of its' function*
- *Noise, Induced demand for motorways, air quality, greenhouse gases, community, liveability, public transit, passenger rail, walking, cycling, enjoying the natural landscape, etc*
- *The environment, biodiversity*

Do you have any other comments or questions you would like to share or submit?

- *I am strongly opposed to any road crossing through the swales. I do not think that a road through native prairie is appropriate and any development, not matter how many mitigating measures are put into effect will degrade the area.*
- *I don't think this road is a good idea, there are so many negative impacts it will have on the surrounding area - for the animals, the grasslands, wetlands, and local residents. I also think that the money could be better spent housing people that are homeless, providing proper mental health services...the list goes on.*
- *I grew up in Saskatoon, lived in other cities for 20 years, and then returned to Saskatoon several years ago. One thing I noticed is lacking in and around Saskatoon compared with other cities is natural areas. In central Saskatchewan, natural wetlands are greatly reduced, and natural prairie almost all gone. The Northeast Swale is a rare gem, and further fragmentation by a second highway would, in the long term, greatly reduce the diversity of wildlife there. The other thing I want to bring up is the question of whether an additional freeway is a good idea in the first place. I strongly advise consulting with outside experts in city planning. Adding more highways tends to increase motor traffic, and without careful planning, often results in increased congestion -- contrary to the common naiive expectation. Both issues have a big impact on the quality of life and health of city residents, and ultimately the city's ability to attract high value added jobs. More highways isn't always better.*
- *I have said my say in a number of places. I gave up on your repetitive questions and just wrote. Go and read that.*
- *I hope the new Highways Minister will take a good look at this routing and see that it is NOT in the location that is needed. It needs to be moved much further out to be what is needed in 15 years time. As it stands, it will be inadequate for it's purpose by the time it is ready to be built. Stop and think before spending billions of tax payers dollars on a shortsighted and incorrectly planned route.*
- *No speed limits lower than 90 kph*
- *Please build public transit and inter-city bikeways instead of freeways.*
- *The use of traffic circles is excellent and has potential for cost saving as less land and road surface is needed. Too much road and looping, takes up too much land, roads and freeways can have a huge impact on Urban Sprawl. Decisions should be made off construction and operating costs. Dimond interchanges are much simpler and cost less. IMO, it's okay that non main thoroughfare traffic might have to stop to turn. Design speed for ramps and loops should be 70kmh, this would make for large cost savings and little impact on the usability of the Freeway.*
- *This project is not required for the future of Saskatchewan. We could spend the $2,000,000,000 on areas that would have a far greater impact on Saskatchewan residents quality of life, job creation, GHG reduction etc. Please do not proceed with this project.*

- *This survey was extremely difficult to navigate and the questions were ineffective. This Highway project is poorly planned and executed. The incentive for this highway seems completely one-sided in business, which makes no sense as the freeway os supposed to bypass the city, which it does not. It also simply moves pollution concerns and greatly impacts and disrupts what little native prairie we have left in Canada (including numerous species at risk), not to mention the wildness of Saskatoon. This highway is unnecessary with poorly researched impacts.*

Please explain what would help in making you feel more informed:

- *access to the unredacted cost-benefit analysis that got the southwest connection dropped*
- *Better press coverage, news releases, explanation of where pedestrians and cyclists fit into these plans, release information about the response to these surveys, make public studies and maps about the noise and air pollution that would be caused by these plans.*
- *It's not a question of feeling informed. I know I will not like the anwers to my questions and they seem to need to be pushed or forced to get some kind of a truthful response. A lot of the information is simply to check boxes with no guarantees.*
- *More transparency about the decision-making process and the underlying analysis used to justify decisions; Less marketing.*
- *Presentation given at the Saskatoon Nature Society was very informative. More group presentations like that to stakeholders is important. As a resident of RM Aberdeen, felt that I was informed that way eventhough this is vital infrastructure for commuting to work plus economic development in the RM and the Town of Aberdeen*
- *Stake holders are the individual city residents and all the organizations that play and work in it. I would really like to know to what extent was the involvement with the Indigenous organizations. Where can I read what their inputs where? Were they ongoing or just to inform them? Who from them was the representative? or actually meeting with several individuals at decission making levels? what efforts were made to access Indigenous voices of Indigenous citizens of Saskatoon?*

RESEARCH | STRATEGY | RESULTS

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Ministry of Highways

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March 2022

Survey Results

Ministry of Highways: Saskatoon Freeway Functional Planning Study

Phase 2: Second Virtual Stakeholder Engagement Session

Table of Contents

Introduction

This report is a summary of results from feedback surveys collected during the second engagement of the Saskatoon Freeway Functional Planning Study Project's Phase 2. The engagement was conducted online via virtual platform in February 2022.

Introduction

The Government of Saskatchewan, through the Ministry of Highways, is engaging in a functional planning study that will determine how the Saskatoon Freeway will look and operate. This freeway is expected to be a four-lane, 55-kilometre stretch of divided highway that begins at Highway 11 south of Saskatoon and connects with Highway 7 west of the city. SNC Lavalin, AECOM and Praxis Consulting were retained by the Ministry to undertake the planning study, which includes 55 km of freeway, 16 interchanges, 5 railway crossings, at least 2 flyovers and 1 major bridge crossing.

Throughout the functional planning study process, a wide range of stakeholders and members of the public will be asked to share their input.

In order to accommodate the health restrictions in place due to COVID-19, members of the general public and other stakeholders had a chance to learn more about the proposed route for Phase 2 of the Saskatoon Freeway via a virtual platform that was open between February 14 and 27, 2022.

Participants were encouraged to share their feedback in multiple online surveys available on the virtual platform. All discussions and feedback will help inform the eventual design concepts for Phase 2 of the Saskatoon Freeway Functional Planning Study (SFFPS).

Approximately 92 responses were received through the online surveys. Surveys were included in the virtual rooms that focused on layouts being proposed for:

- Environmental and Heritage Considerations
- Central Avenue Interchange
- Blackley/Highway 41 Interchange
- Highway 41 Interchange and Realigned Highway 41
- Highway 5 Interchange
- 8th Street Interchange
- Highway 16 Interchange
- Floral Road East Interchange
- Grasswood/Floral Road Interchange
- Highway 11 Interchange
- Bridge Concepts

After progressing through all the rooms, participants were also given the opportunity to provide general feedback via an exit survey.

Survey Design

The surveys were designed in consultation with the Ministry of Highways. Each survey was programmed into an online survey platform and pre-tested to ensure the questions flowed efficiently and incorporated correct branching and skip patterns.

Analysis

This report presents the analysis of survey data for each room and includes frequency tables and charts. The surveys included several open-end questions, which have been included verbatim; listed alphabetically and unedited.

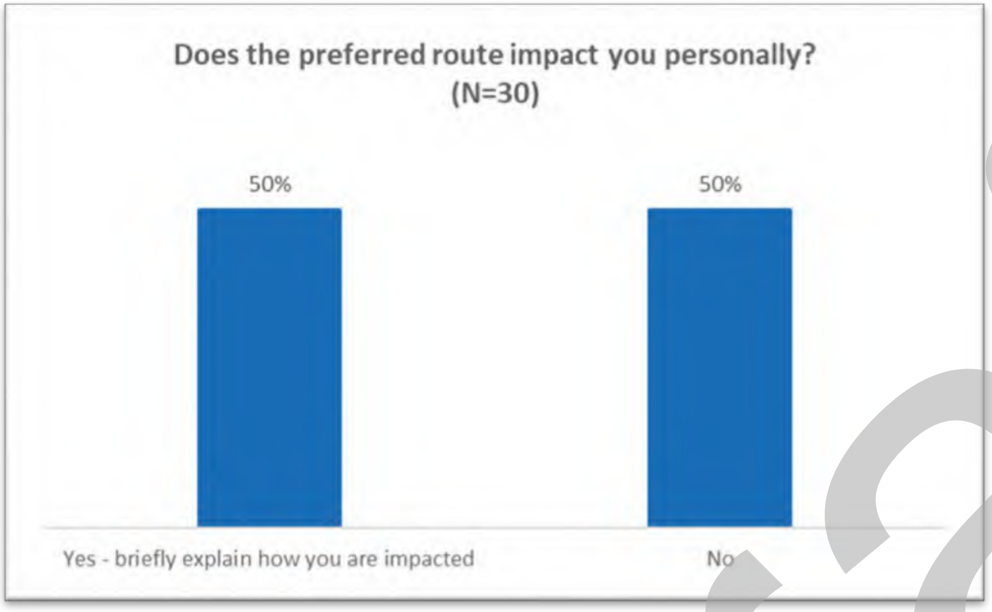
Ministry of Highways:

Saskatoon Freeway Functional Planning Study

Phase 2: Second Virtual Stakeholder Engagement Session

Room 2:

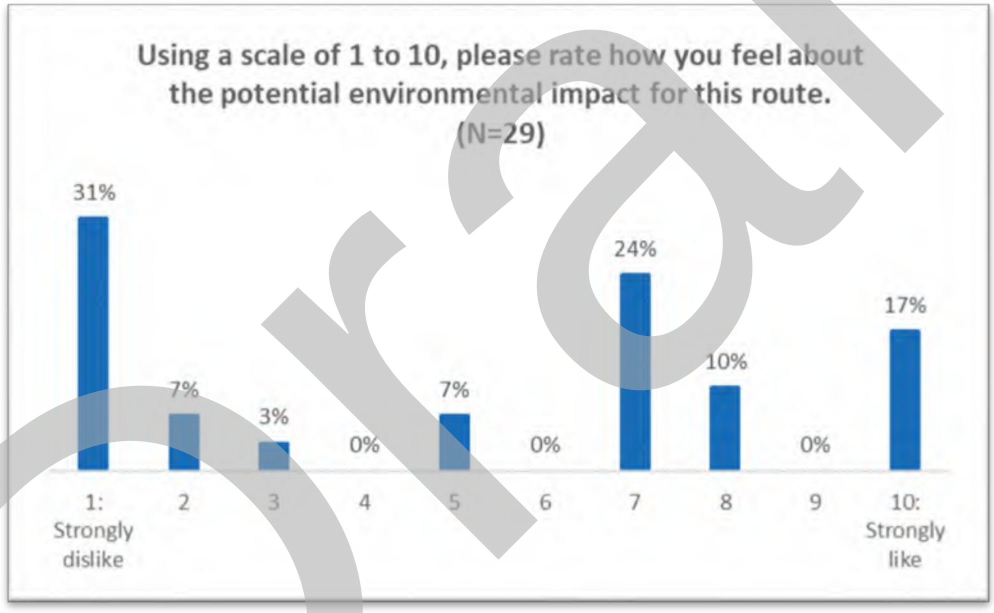
Environmental and Heritage Considerations



Yes – briefly explain how you are impacted:

- *As a Swale biker, hiker and nature appreciator, the least invasive plan is preferred.*
- *I am dismayed that the highway will reduce their habitat and impact endangered species*
- *I like nature...i visit Saskatoon often, I have family in Saskatoon.*
- *I like to walk in the NE Swale, where I appreciate the fragile and special ecosystem. I can't imagine how I will be able to do this when the road is built.*
- *I live and work within the swale wildlife corridor. With potential for Meewasin land to be designated as an National Urban Park, I believe that the proposed route for this freeway will drastically reduce the effectiveness of keeping our green spaces full of biodiversity, which directly contribute to our quality of life as citizens in Saskatoon, and into the economy because a biologically diverse, and rich Urban Park will bring many into the economy by way of tourism. Please reroute this in a way that makes more sense for our growing city and the current residents, including humans and wildlife.*
- *I live in Saskatoon and want wildlife to thrive, and am not convinced that routing major roads through the swale, even if it may have been disturbed, is a good thing. Also, I am very concerned about how this would affect Saskatoon's opportunity to create a National Urban Park, with the economic, environmental and social advantages it would bring.*
- *ill be using this freeway frequently*
- *Less disturbance of wildlife*
- *loss of precious sensitive environment*
- *Other than this plan impacts everyone, I am personally impacted by having this valuable resource for the study of native plants (a number of endangered species), and wildlife (a few endangered species), and how urban areas can learn to protect precious spaces. The Swales need to be protected from sound, light, and chemical pollution. There should not be (another!) highway going through the Swales, and Saskatoon does not need yet another bridge. Prince Albert and St. Louis need bridges before Saskatoon.*

- *The preferred route impacts the Northeast Swale, the Small Swale and a remnant ash forest. These areas have been identified as "conservation targets" that provide a margin of survival for prairie species. The continued degradation of natural areas and decline of species affects me deeply and personally.*
- *We will see and hear all the lights and traffic; the west side of the bridge will be straight out our dining room window.*
- *We'll all be impacted by the loss of the critical ecological functions the swale provides.*
- *Why doesn't the freeway track north until it meets township road 374 and then replace 374 instead of forging a new East-West tract through farms and swales? Why not use the path 374 already provides and just upgrade it into the freeway?*



What, if anything, do you like best about this route:

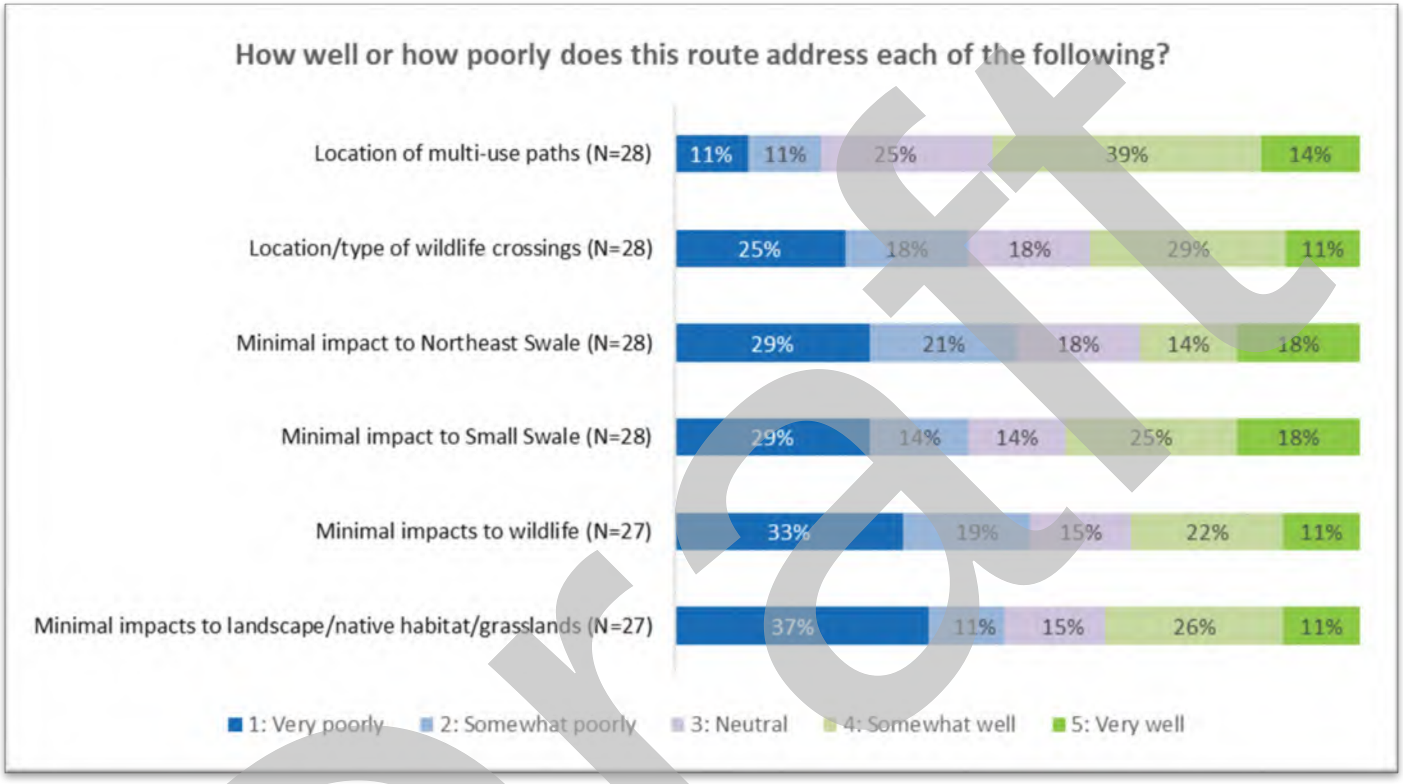
- *Avoids crossing the middle of this swale pond.*
- *Happy that it minimizes the open water crossing in a large breeding bird habitat area*
- *I appreciate the flexibility, thought and effort that have gone into minimizing damage to the Swales.*

- *I like the allowances for retaining natural spaces and the wildlife*
- *I think the concerns about environmental impact are overstated*
- *it avoids the Northeast Swale*
- *It is further from Saskatoon.*
- *It may be the least bad one.*
- *It seems to have the least impact on the swale*
- *its placement within existing cultivated/disturbed areas*
- *Least damaging to swales*
- *least environmental impact and also it will have wildlife crossings- right?*
- *Least impact on the swale of all the options.*
- *nothing*
- *NOTHING*
- *The more land area inside the freeway the better.*
- *The preferred design did take into account the information provided during the consultation*

What, if anything, do you not like best about this route:

- *(1) By the time the highway is built, 15+ years from now, the route may already be obsolete. (2) As the city expands to the northeast, residents will be inevitably be subjected to noise of up to 64 decibels of noise and to airborne pollution, with inevitable consequences to health. Highways do not belong in cities. (3)Despite the care that has been taken to minimize damage and degradation, degradation and damage to high-quality natural areas will occur. Physical barriers, noise, headlights, lit interchanges, etc. are all significant disturbances.We should be restoring and protecting these surviving fragments of life and beauty, not driving through them. I'm going to stop now before I get too sad.*
- *Disturbance to an area where wildlife are relatively abundant and can roam safely. I'm not convinced there's going to be all that much traffic in the future.*
- *going through the swales - sensitive environments and threatened prairie - we should know better by now*
- *I'd like to know the flood frequency and capacity for water flow in/under the culverts and bridges please.*
- *If Saskatchewan needs another bridge across the S SK to connect to west side highways heading north, why not build one at the north end of the Swale, near to Aberdeen? A century of farming there has already destroyed the native prairie.*

- *It continues to impact the Small Swale, including cultural and ecological features. It continues to represent a new scar across a natural landscape (including across previously disturbed or agricultural lands). It continues to create narrow and fragmented habitat, especially as being so close to McOrmond drive. No information is presented to suggest SAR habitat, incl grassland (tame, native etc.) will be adequately protected.*
- *It doesn't follow existing roads.*
- *it has the most turns and not a straight road*
- *It will only be a problem of noise, wildlife death, biodiversity loss, and poorer quality of life for all that live near it.*
- *It would be best to avoid the swail.*
- *Its entrapment of the Swales and sprawl of city activity*
- *Its too close to existing crossings and McOrmond drive. In the long term having the route shifted slightly north to township road 374 keeps traffic farther from residential areas and accommodates Saskatoons growth, requires less in-fill of the naturalized areas, and makes use of infill, crossings, and right of way already at township road 374.*
- *LEAVE NATURE ALONE...AND MEEWASIN. WHAT IS WRONG WITH GREEDY PEOPLE?*
- *n/a*
- *that it still has to cross the small and northeast swales so close to occurrences of species at risk*
- *The route should more widely circle the future Saskatoon growth and not parallel the existing Chief Mistawasis Bridge freeway*
- *We should make rewildimg our priority. Building more highways is wasting resources we need to adapt and recover from.the extreme weather events we're creating. We should replace roads with rails, not build more.*
- *With a National Urban Park proposal currently under consideration, it seems strange that the province is still proposing a route through the North East Swale at all. In my opinion, at the very least, a comprehensive business plan and environmental impact study should be undertaken, and I sincerely hope the road can be re-routed around, NOT THROUGH, the swale.*
- *You're fragmenting the swale, a unique piece of habitat of which little remains. Fragmenting it with a highway is as bad as destroying it, you're removing its ability to function, and wildlife will move away from the decreased habitat. We do not need another road there, just adapt the road you already built through it.*



Do you have any additional environmental and/or heritage comments you would like to add about the preferred route and/or interchange layouts for Phase 2?

- *Already addressed*
- *detailed assessments for species at risk are necessary for the new route*
- *Don't take a final decision until the Urban Park negotiations have concluded, and cooperate with the City and other partners negiotating this.*
- *Green space and wildlife protection is vital to the firture of our city, province and country.*
- *How does it impact the Red River Cart trails used from Round Prairie to Batoche?*

- *I could not find on the maps where the wildlife crossings would be. However, by drawing on the noise level maps, every wildlife crossing would be in a noisy zone. All wildlife crossings are tunnels under the highway, and that means that birds are not considered at all in this plan.*
- *I think it's more important to consider other factors, like construction cost, greenhouse gases, and travel time. Heritage should be of least concern and impact to the swale should be next least.*
- *I truly do appreciate all the care that has gone into this proposal. All the same, I hope this uber-expensive, wasteful and destructive project never gets built and that better ideas and values will one day prevail.*
- *I was looking for the water crossing information but was only asked about my thoughts on suitability. Very hard to comment when one doesn't have the design specifications.*
- *Leave nature alone...take down houses if you must!!*
- *no*
- *Please reconsider this highway. You already built one road through the Swale that sees less traffic then expected, so why not adapt it into a highway using some of the wildlife friendly modifications you're using in this plan? Make the existing road useful, do not fragment this habitat. You will be responsible for the collapse of our ecosystem. I want to leave Saskatchewan because of how poorly it handles environmental decisions.*
- *Restoration of disturbed lands with native/pollinator plants.*
- *Sorry for my extremely negative view.. The Swales are too precious to put a highway through. And who is even asking for this? Do the people want their money spent this way? Let's have a full federal environmental assessment with public hearings well publicized.*
- *The consideration of the cumulative impact of this proposal is critical. When considered alongside UH3 and wider P4G growth plans the impacts to the area are very significant indeed. In addition, a feasibility study is currently underway looking at the potential of a National Urban Park in Saskatoon, with the consideration of the natural features of the whole area of this NE quadrant a critical component to the success of a National Urban Park where it is likely the leading objective will be maintaining ecological integrity. This should be a consideration in any further actions related to this proposal.*
- *This site is important culturally and biologically and deserves protection. Our future generations need forward-thinking and innovative planning in order to consider the importance of our wildlife corridors and green spaces.*
- *We have already lost 80% of native prairie habitat. We can't afford to lose more. Stay out of the swales !*

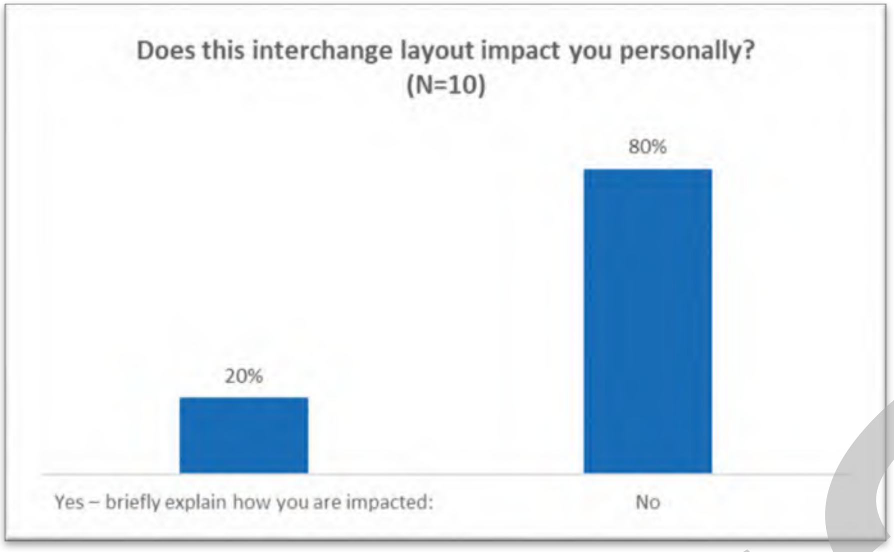
Ministry of Highways:

Saskatoon Freeway Functional Planning Study

Phase 2: Second Virtual Stakeholder Engagement Session

Room 3, Board 5:

Central Avenue Interchange Layout



Yes – briefly explain how you are impacted:

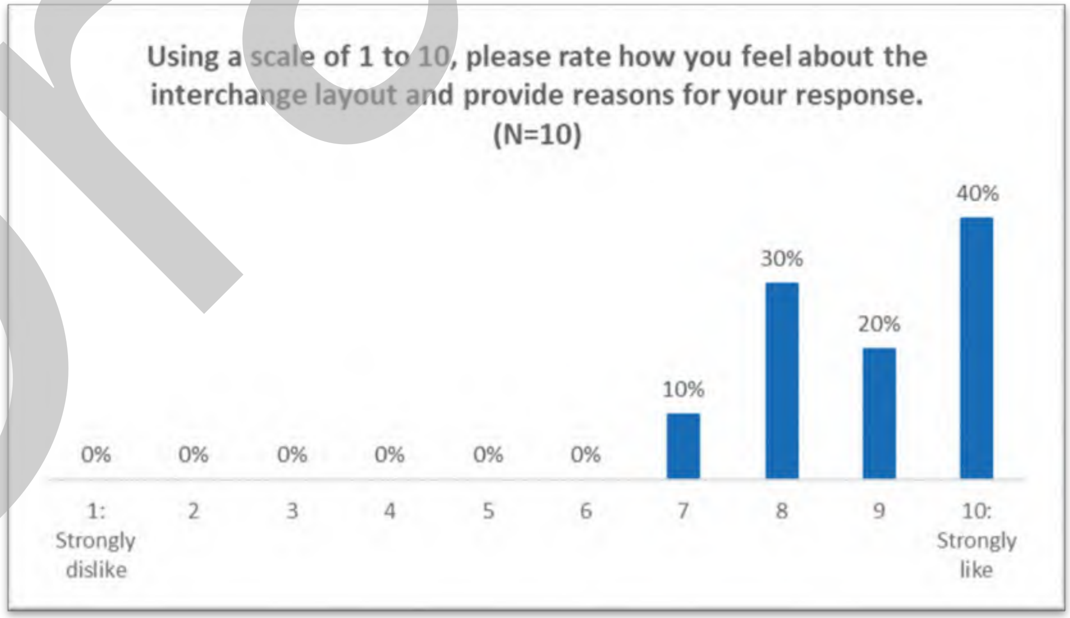
- *Please don't use roundabouts. Use traffic lights like the other interchange. Even if I know how to use a roundabout, there are plenty of people here that don't*
- *Would drive this at times*

What, if anything, do you like best about this interchange:

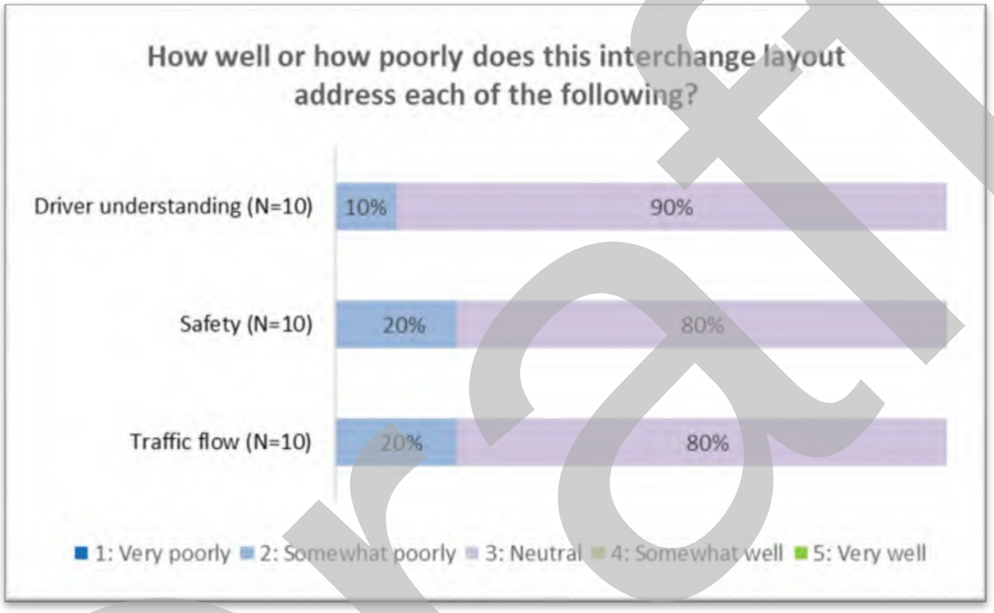
- *I like the lessenened impact on the swale and think its important to protect the swale*
- *It's really ambitious. Feels like I am in a much larger city. And this is only to hook up to highway 41!*
- *roundabouts*

What, if anything, do you not like about this interchange:

- *It doesn't have roundabouts and the video doesn't show ped or cycling on the bridge deck.*



- *the large loop, waste of land, and is there that much traffic going to 41?*
- *The roundabouts. Just use lights. I'd rather wait at a light*



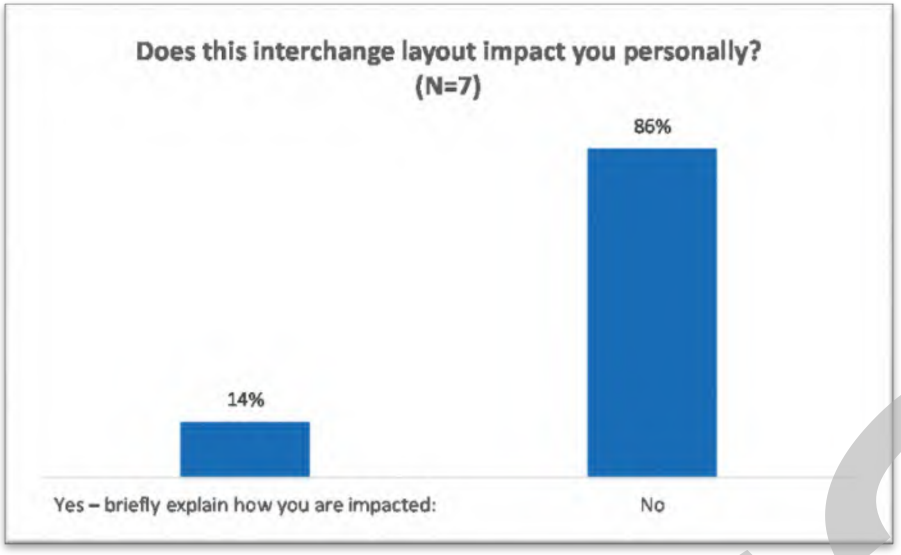
Do you have any additional comments you would like to add about this interchange layout?

- *Definitely want to protect the natural swale as much as possible. Would be good to keep bicycles in mind too- how would bikes get around and across safely.*
- *For the last 3 questions (traffic flow, safety, I can't remember the other one) it only let me pick from very poor, poor, or neutral. Are there supposed to be positive responses? I think it's laid out pretty well. It's a little complicated but there'll be signs and we'll get used to it*
- *happy that the new route is further away from Kernen Prairie*
- *Have you looked at raising the Freeway and moving the interchange to the west?*
- *You will need good signage at all of these ramps.*

Ministry of Highways:
Saskatoon Freeway Functional Planning Study
Phase 2: Second Virtual Stakeholder Engagement Session

Room 3, Board 6:

Blackley/Highway 41 Interchange



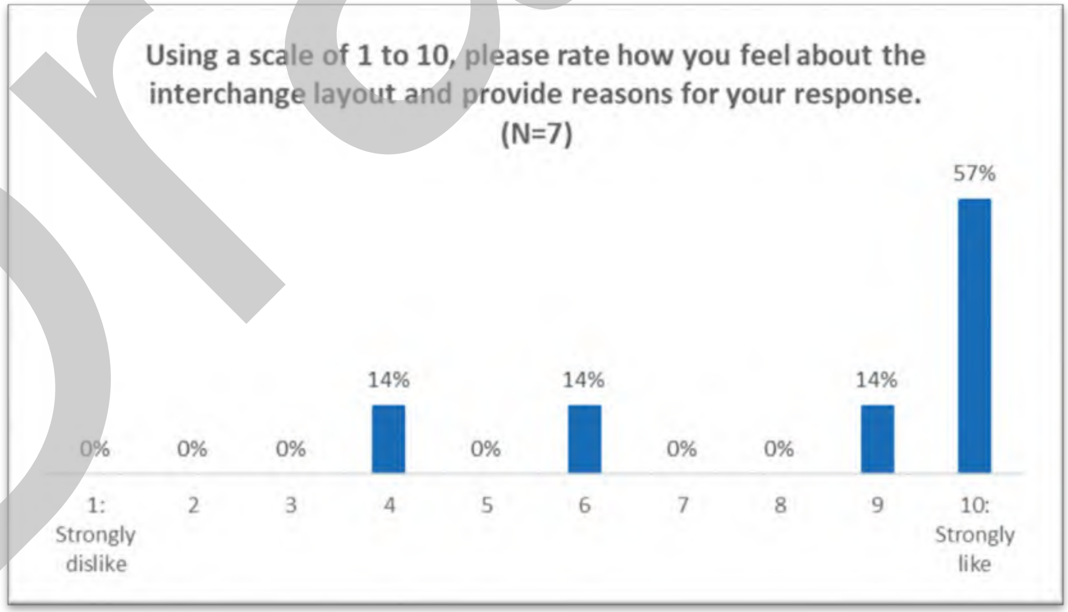
Yes – briefly explain how you are impacted:
No responses provided.

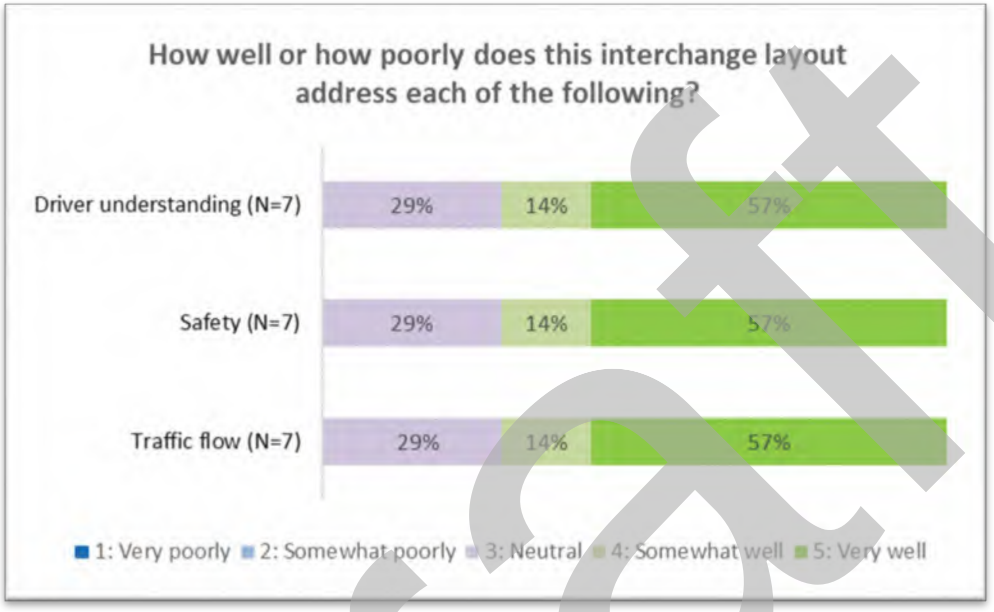
What, if anything, do you like best about this interchange:

- *Having a crossing at this location is a good idea even if there is no access.*
- *It gets the job done*

What, if anything, do you not like about this interchange:

- *The angle of the flyover may not align with future roads. This needs to be planned further with the City.*
- *The video was a bit long. I was like "yep this is what it's like driving on a highway in saskatchewan alright". The semis in your videos all seem to be broken down as well.*





Do you have any additional comments you would like to add about this interchange layout?

- *Looks great. It's nice to have highway 41 access without needing to get on the freeway. Hopefully this stays in*
- *no comment*

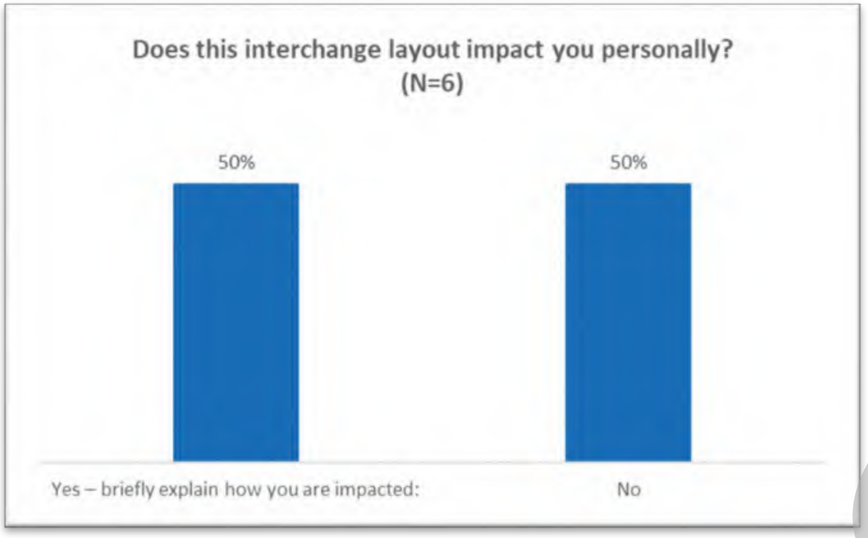
Ministry of Highways:

Saskatoon Freeway Functional Planning Study

Phase 2: Second Virtual Stakeholder Engagement Session

Room 3, Board 7:

Highway 41 Interchange Layout with Realigned Highway 41



Yes – briefly explain how you are impacted:

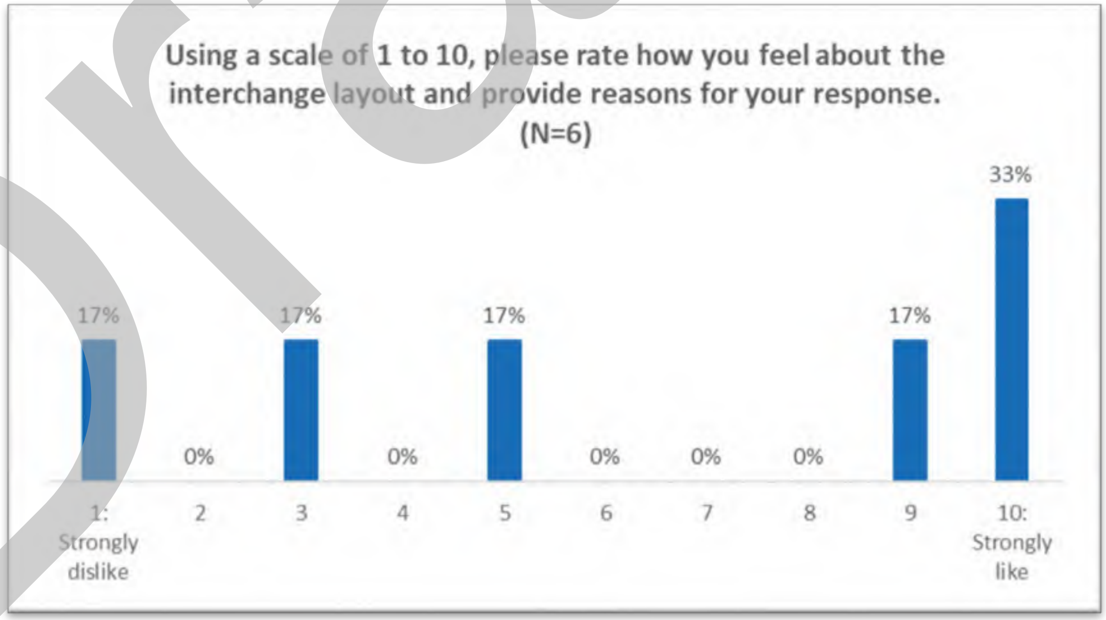
- *I own land on the north side of highway 41 I am not happy with the lack of Kilmany road access .I am very worried about possible water runoff problems*
- *Kilmeny road access to Highway 41 is eliminated. I live on Kilmeny Road.*
- *Realignment cuts across our research farm and reduces the number of experimental plots that we can run on our land. This also forces the relocation of our sewage sedimentation and evaporation ponds which are key to our facility.*

What, if anything, do you like best about this interchange:

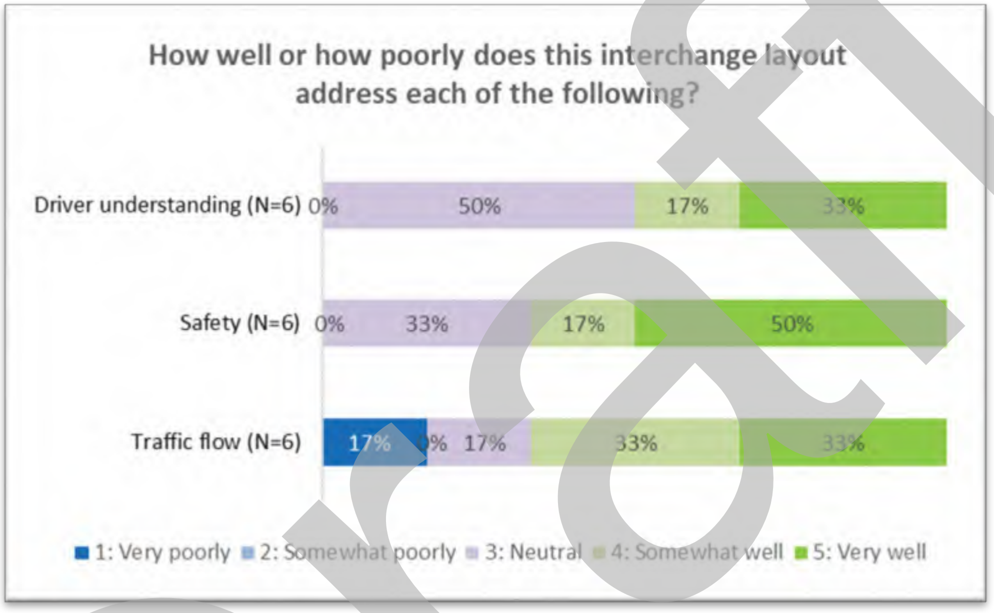
- *Progress*
- *The realignment of Highway 41 will reduce traffic flow past our facility which will give us more privacy*
- *Very simple, no lights or anything*

What, if anything, do you not like about this interchange:

- *Eliminates access from Kilmeny Road. Access from Kilmeny road to HWY5 is also eliminated. There is no access West from Kilmeny to get to Fleury/372 connecting to hwy41.*



- *The removal of research land forces us to rely more on leased land at other locations. This has costs other than just increased leasing costs.*
- *Why not all done at Highway 41 flyover location.*



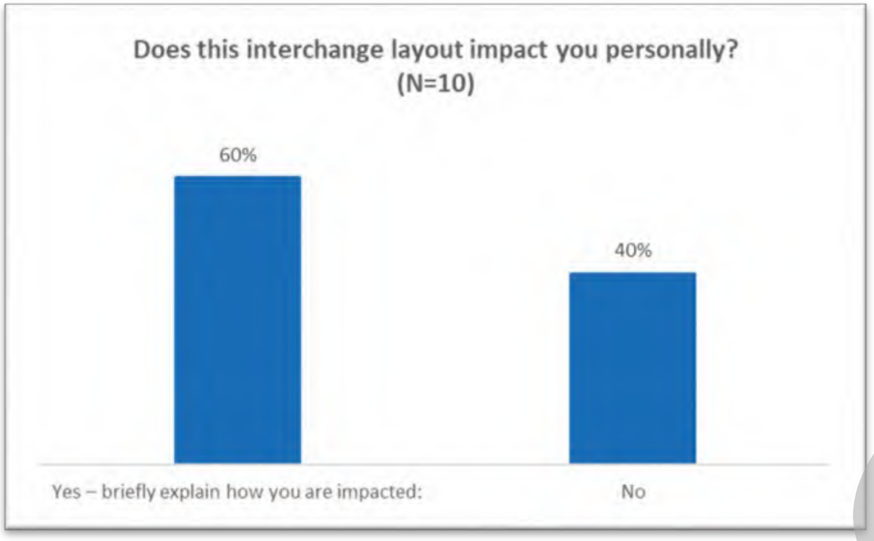
Do you have any additional comments you would like to add about this interchange layout?

- *Need for public in person exchanges*
- *Nice to still have this access for people going to wakaw*
- *Should not make access from kilmeny to Hwy 5 or 41 worse.*

Ministry of Highways:
Saskatoon Freeway Functional Planning Study
Phase 2: Second Virtual Stakeholder Engagement Session

Room 3, Board 8:

Highway 5 Interchange Layout



Yes – briefly explain how you are impacted:

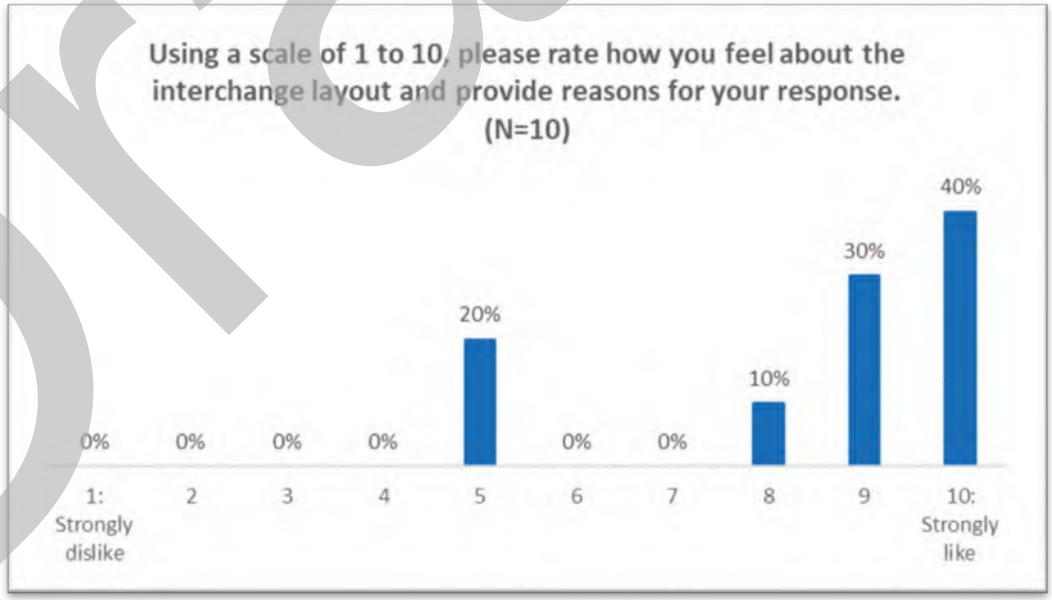
- *Cuts off access to our Home on winmill road.*
- *i Live east of the proposed freeway*
- *I live nearby and my preferred route to the city is Llewellyn road to highway 5*
- *I travel highway 5 east on a regular basis*
- *Impacts access to Kilmeny road likely with Hwy5 twinning.*
- *Travel hwy 5 daily into Saskatoon.*

What, if anything, do you like best about this interchange:

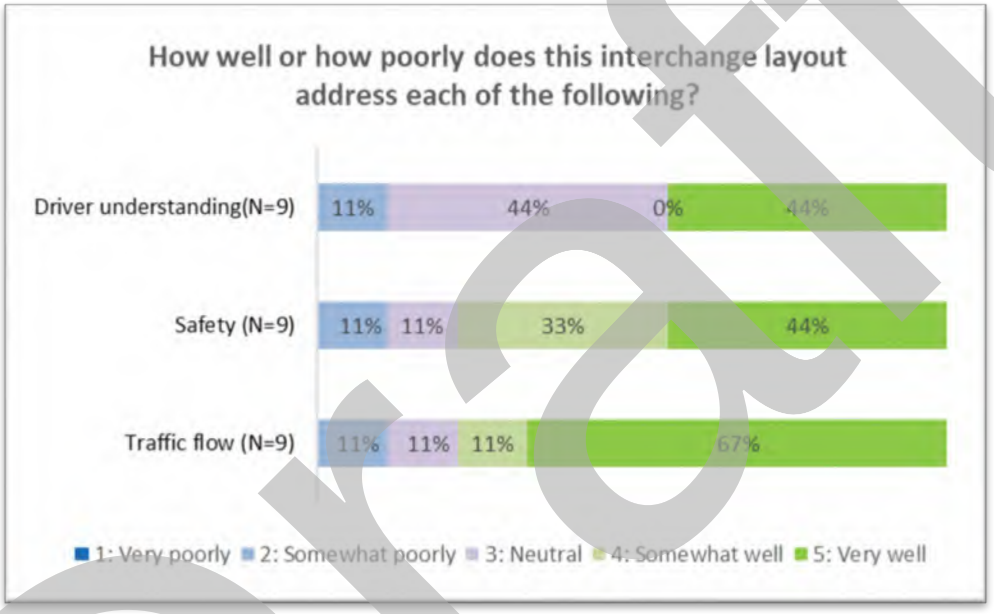
- *Free flow of hwy 5 east and westbound.*
- *free flow of traffic for both highway 5 and the saskatoon freeway*
- *good flow of traffic*
- *It's very ambitious. Looks expensive. Great traffic flow*
- *looks like it services all needs*

What, if anything, do you not like about this interchange:

- *a little complicated*
- *Impact on access and sound levels near my house.*



- *Likely to impact access to kilmeny road.*
- *nothing. It is the perfect design. Well done.*
- *Why use those big sweeping loops instead of a regular cloverleaf? I guess it helps not having people entering and exiting in the same area.*



Do you have any additional comments you would like to add about this interchange layout?

- *Should not impact access to Kilmeny road. Saskatoon Freeway should colaborate with Corman Park for access in this area as it is slated for future country residential development.*
- *Sooner the better.*

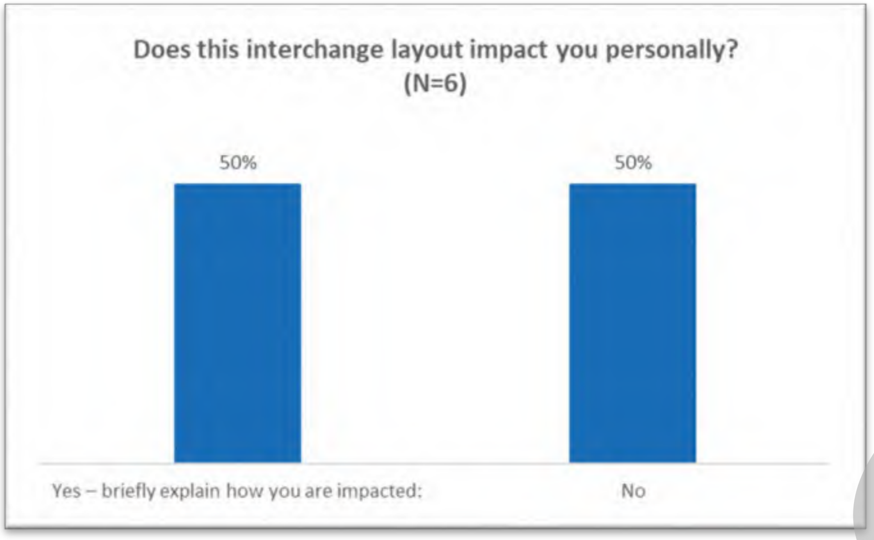
Ministry of Highways:

Saskatoon Freeway Functional Planning Study

Phase 2: Second Virtual Stakeholder Engagement Session

Room 4, Board 2:

8th Street Interchange Layout



Yes – briefly explain how you are impacted:

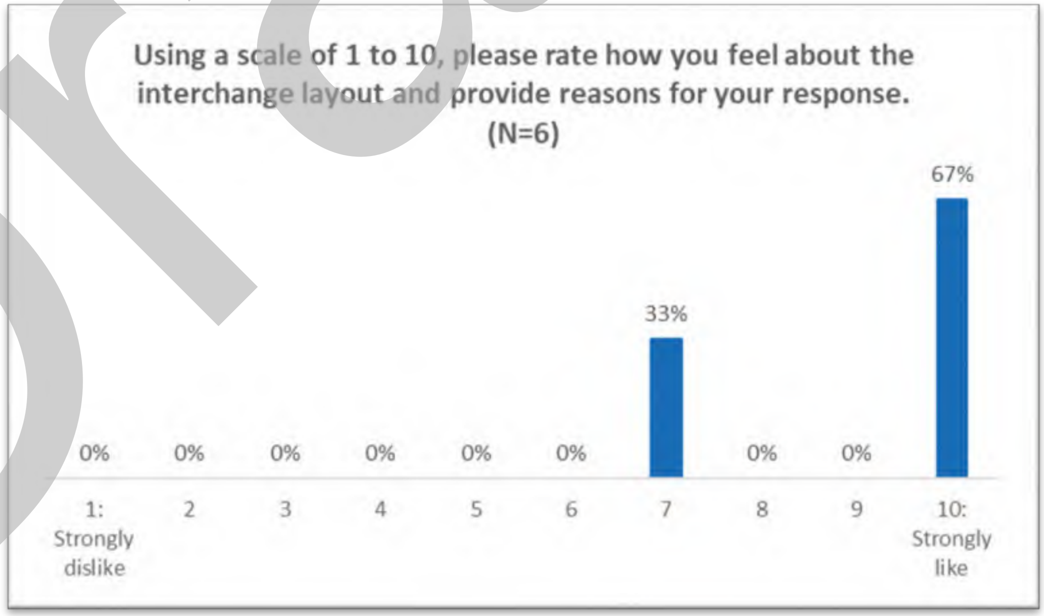
- *I live right next to it*

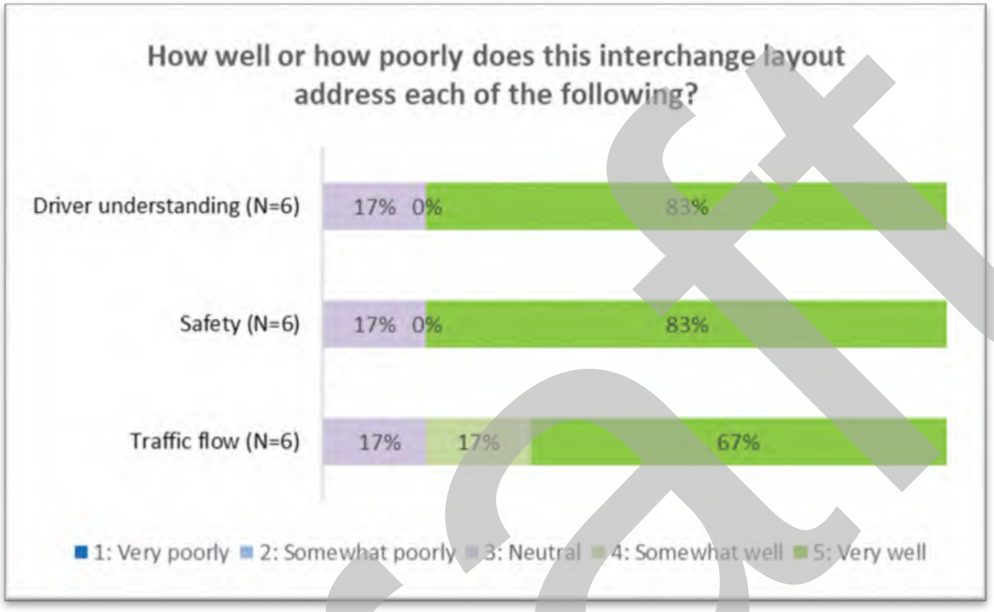
What, if anything, do you like best about this interchange:

- *It's pretty standard*

What, if anything, do you not like about this interchange:

- *I understand needing the interchange to connect to 8th street to the west, because that leads to the city. But the high speed ramps on the east side of the interchange? Who is using them? There isn't anything out there.*





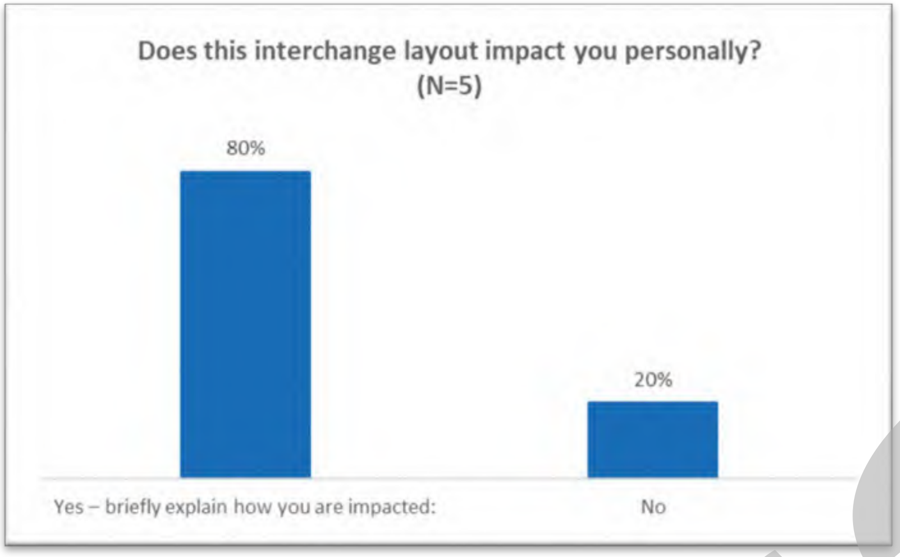
Do you have any additional comments you would like to add about this interchange layout?

No comments received.

Ministry of Highways:
Saskatoon Freeway Functional Planning Study
Phase 2: Second Virtual Stakeholder Engagement Session

Room 4, Board 3:

Highway 16 Interchange Layout



Yes – briefly explain how you are impacted:

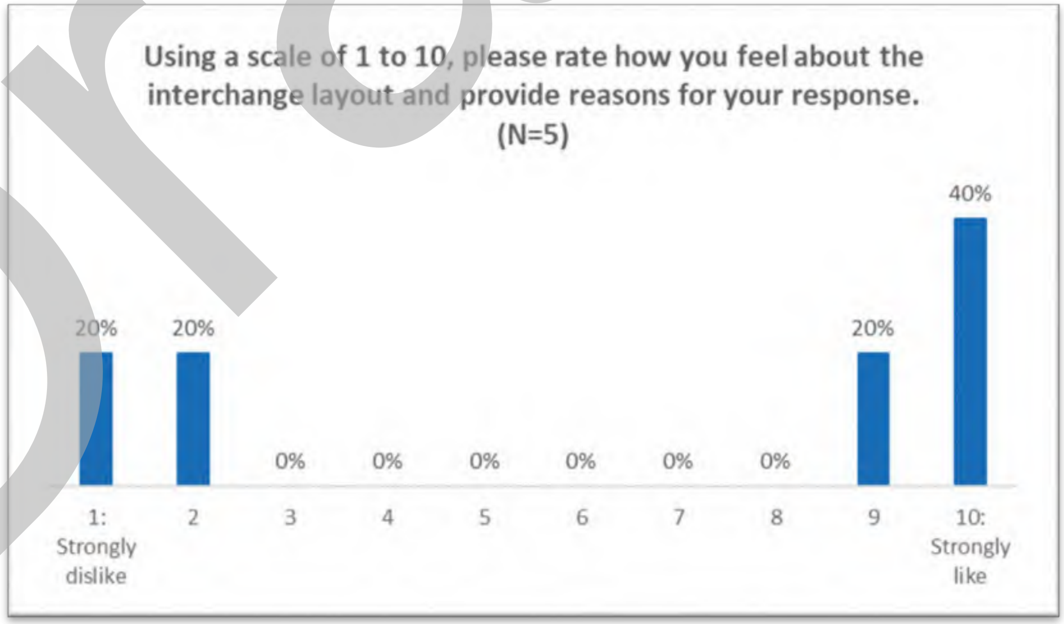
- *I drive through here a fair bit and have a store near the new costco*
- *I live east of this interchange on patience lake road. The non access will create additional local traffic for access to the City of Stoon yards and snow dump that is accessible Patience Lake Road. Will all that truck traffic need to access the snow dump via the Costco/Meadows Market area*
- *We live east on the patience lake highway. This plan cuts off our access to circle drive, and the Saskatoon freeway. There is no way for us to get onto either.*

What, if anything, do you like best about this interchange:

- *It's very ambitious. Lots of access and it's nice to see things like the patience lake road looked after*
- *Looks well constructed*
- *Maintains access to Meadows market area from Patience Lake Road and does not cut off the road as a through road.*

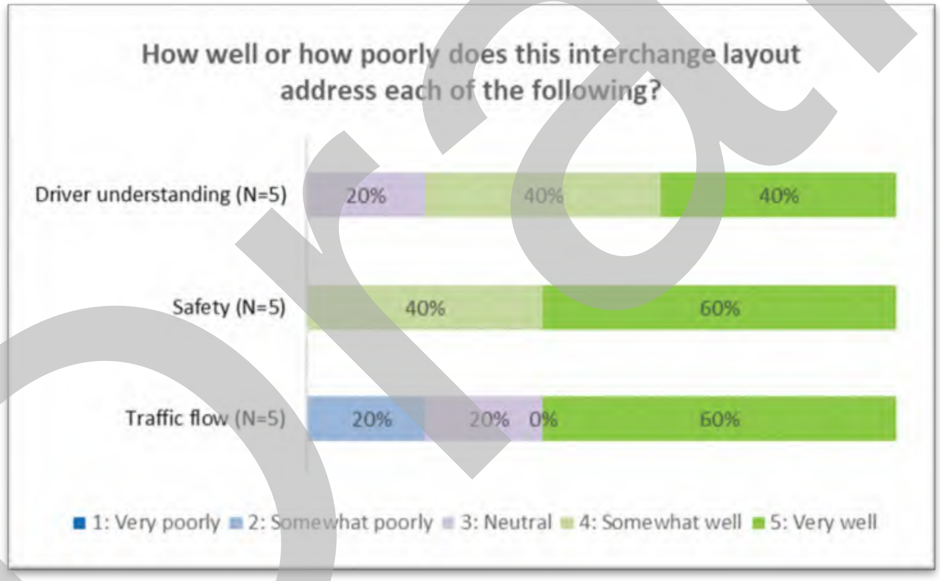
What, if anything, do you not like about this interchange:

- *It's very complicated, although in real life with signage it probably wouldn't be too*



bad. It might help if you offered a map that shows the entire interchange. It's hard to piece together from the video and individual shots that are zoomed in

- *Our biggest concern is loss of access to circle drive and the Saskatoon freeway from the patience lake highway. We would like to see off-ramps or services roads to have access to this as us and many people live in acreage communities east on the patience lake highway*
- *There is no direct access to the freeway from Patience Lake road. Addition of an on-ramp from P-L road to freeway and an offramp from H16-Free way ramp would seem to be minimal cost. This would allow for more options for residents living on P-L road, plus works at potash mine. Also, there is planned to be significant truck traffic to the City Snow Dump on P-L road east of interchange. If current preferred plan is adopted, would all the snow dump trucks be required to access P-L road through the Costco/Meadows Market area?*



Do you have any additional comments you would like to add about this interchange layout?

- *The patience lake highway is the primary access for many acreage communities east of Costco and this plan cuts off access from the patience lake highway to the Saskatoon freeway and circle drive*
- *Was the traffic needs of the City Snow dump taken into account in Freeway planning and considerations for access to Patience Lake road?*

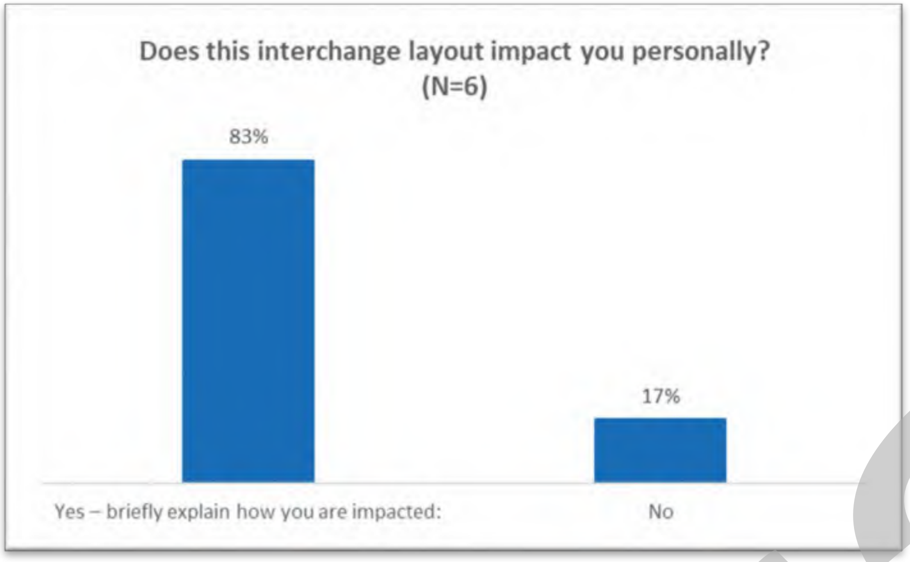
Ministry of Highways:

Saskatoon Freeway Functional Planning Study

Phase 2: Second Virtual Stakeholder Engagement Session

Room 4, Board 4:

Floral Road East Interchange Layout



Yes – briefly explain how you are impacted:

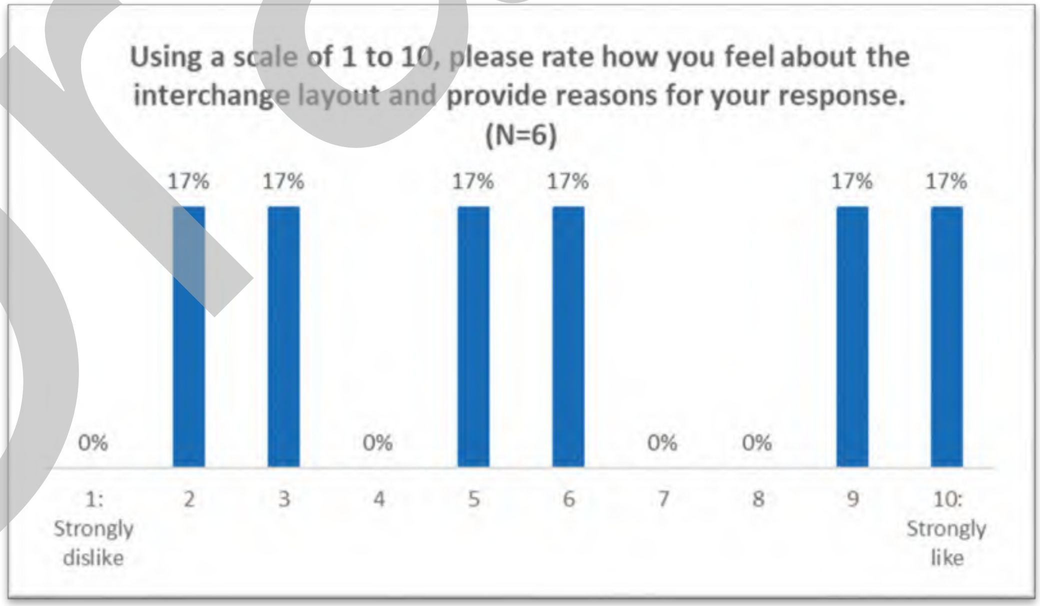
- *I live and work in the area*
- *I use Patience road every day to travel to my job in south downtown Saskatoon. Have you consulted with the RM of Blucher No. 343 regarding travel routes to the Cargill Plant and Nutrien Patience Lake Potash mine?*
- *live on patience lake highway so woudl need to use this to get to city or onto freeway*
- *Very close to my home.*
- *We live on Range Road 3044 and would like to know how this affects our access to Highway 16 in both directions.*

What, if anything, do you like best about this interchange:

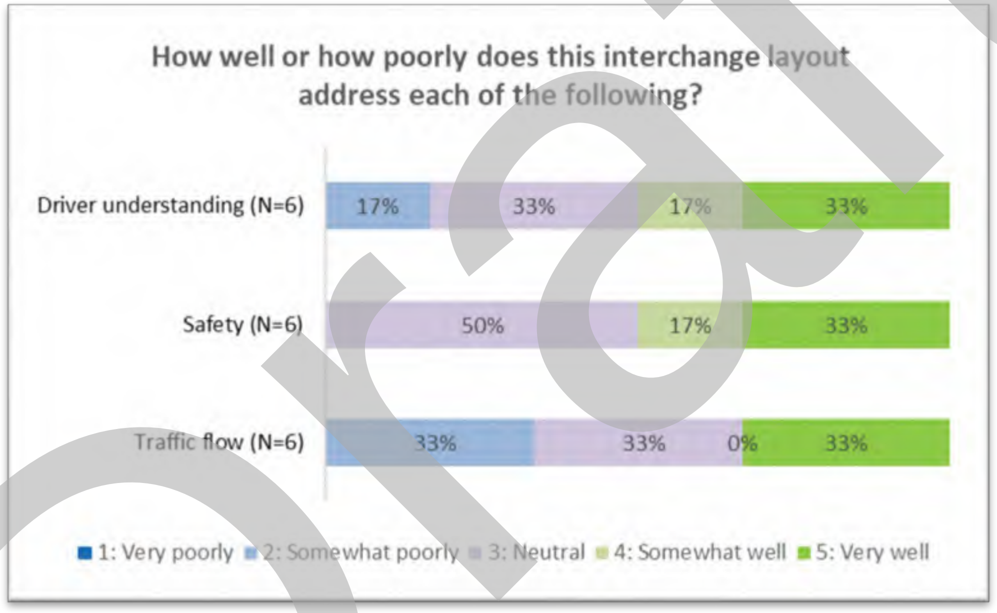
- *It allows easy access to highway 11.*
- *like the set up but not location of it*
- *The off ramp.*
- *We need to know more about how we are going to be able to access Highway 16, in both directions and also headed Northbound onto Zimmerman Road*

What, if anything, do you not like about this interchange:

- *I am not convinced with use of the round-about.*



- *Noise and light will impact us greatly. City access by Range Road 3050 very important. Hoping that is maintained.*
- *Seems like a lot of interchanges in this area. (hwy 16, zimmerman, floral, hwy 11). Do we need them all? I'm starting to feel broke haha. I think for Zimmerman nothbound you could get off at highway 16 and then get to zimmerman from there*
- *this interchange needs to be on patience lake road to allow access as more poeple lice and work on patiinece lake than zimmerman road so the interchange should be on patience lake*
- *We need more information about access from Range Road 3044*



Do you have any additional comments you would like to add about this interchange layout?

- *Contact the neighboring RM of Blucher as this impacts more than the City of Saskatoon and RM of Corman Park. From the overall plan it appears the designers wish the roadway to become part of the city.*
- *not what havent been said .*
- *Will the proposed municipal road which connects Range Road 3044 to Zimmerman Road and Highway 16, be paved or gravel? This municipal road is on the north side of our property, when are we going to be given further information about this?*

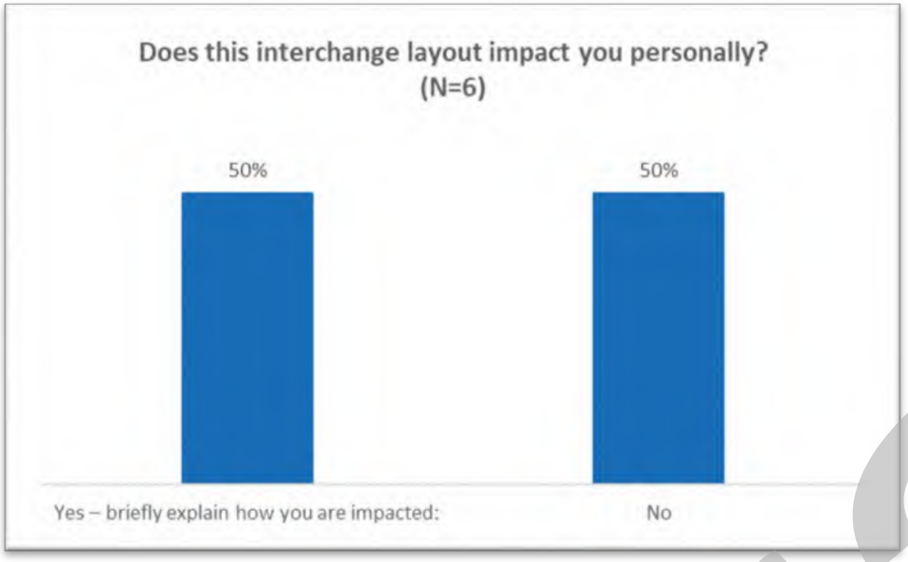
Ministry of Highways:

Saskatoon Freeway Functional Planning Study

Phase 2: Second Virtual Stakeholder Engagement Session

Room 4, Board 5:

Grasswood/Floral Road Interchange Layout



Yes – briefly explain how you are impacted:

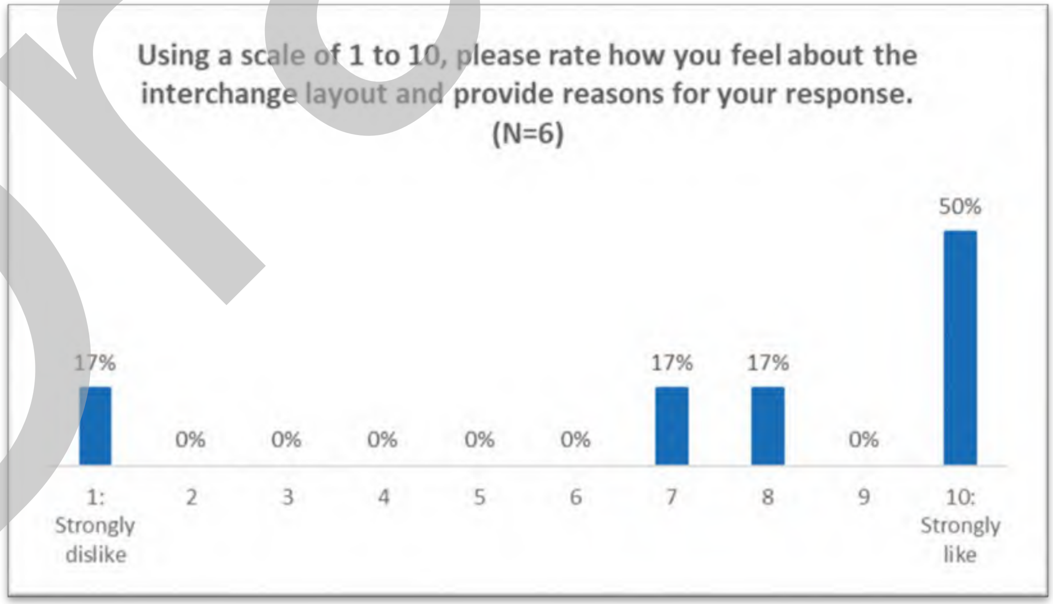
- *noise pollution*

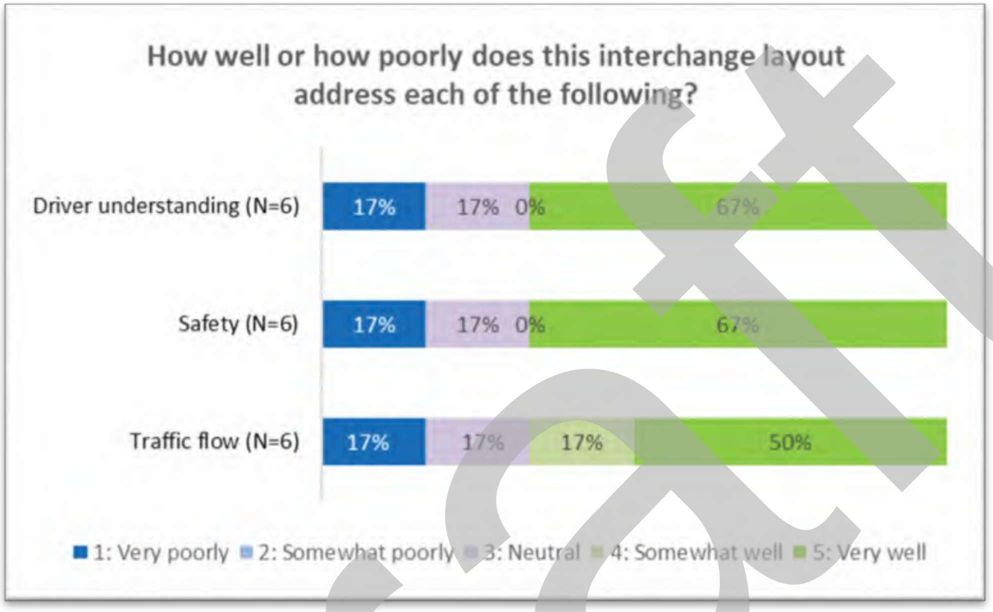
What, if anything, do you like best about this interchange:

No responses provided.

What, if anything, do you not like about this interchange:

- *Seems like there are too many interchanges here. If you need to get to grasswood, couldn't you get off at highway 11?*





Do you have any additional comments you would like to add about this interchange layout?
No responses provided.

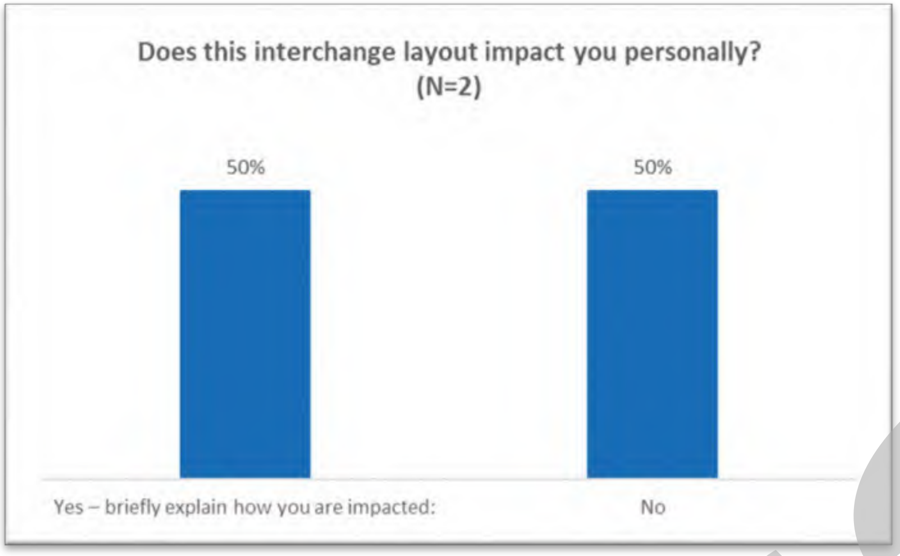
Ministry of Highways:

Saskatoon Freeway Functional Planning Study

Phase 2: Second Virtual Stakeholder Engagement Session

Room 4, Board 6:

Highway 11 Interchange Layout



Yes – briefly explain how you are impacted:

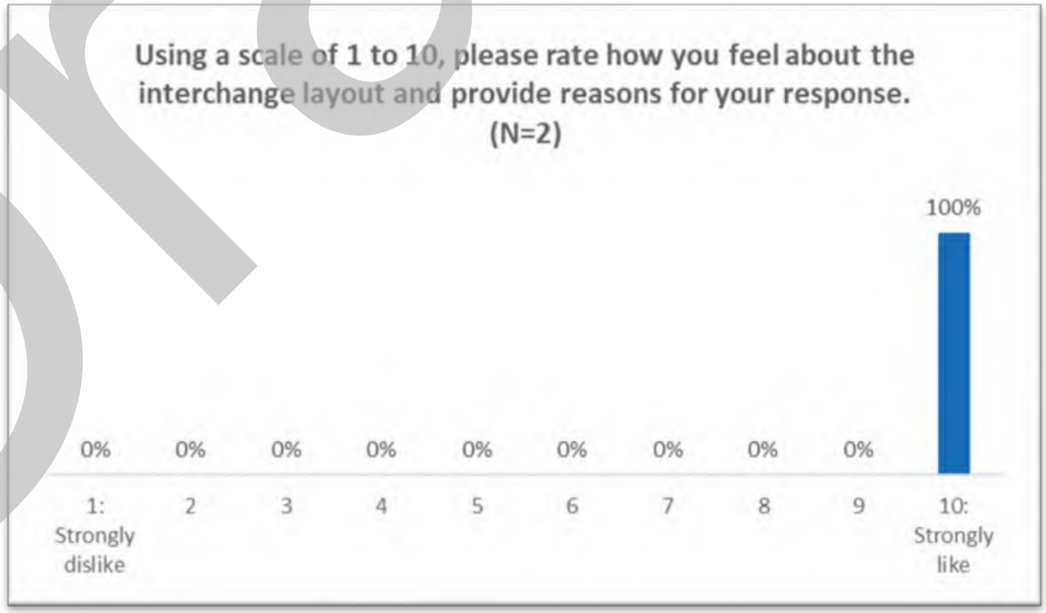
- *I go to Regina once in a while*

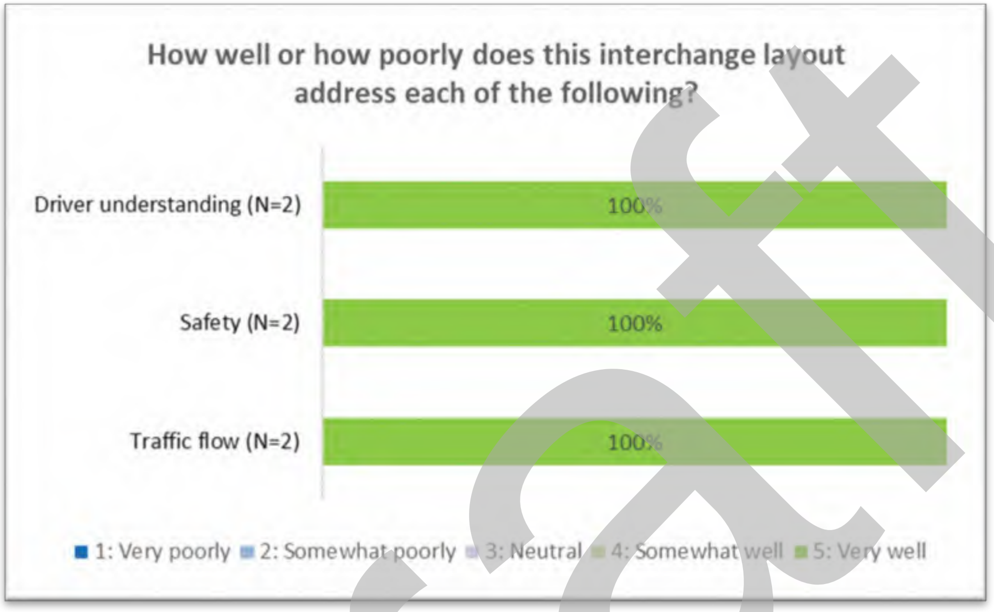
What, if anything, do you like best about this interchange:

- *Looks great, very simple, and now we still have access to the south end of the city coming back from Regina*

What, if anything, do you not like about this interchange:

No responses provided.





Do you have any additional comments you would like to add about this interchange layout?
No responses provided.

Ministry of Highways:
Saskatoon Freeway Functional Planning Study
Phase 2: Second Virtual Stakeholder Engagement Session

Room 5:

Bridge Concepts

Do you have a preference between the two bridge concepts? If so, please explain the reason(s) for your preference.

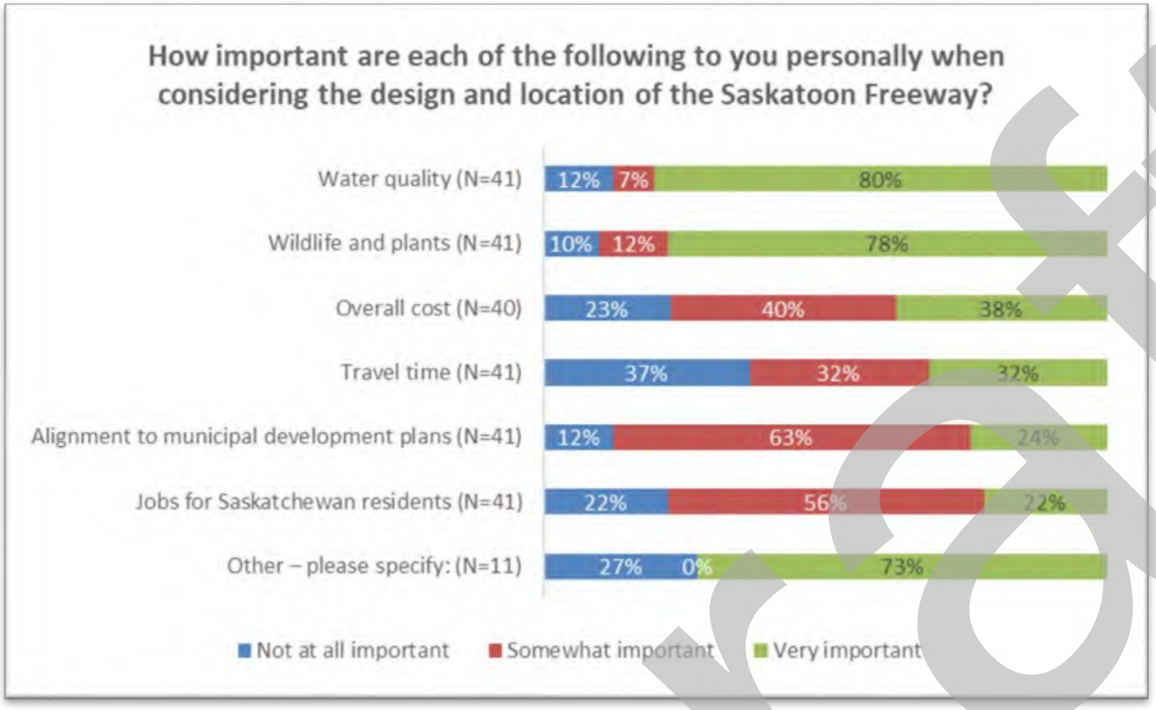
- *Cable stayed bridge, more impressive, we don't have one in the province yet.*
- *Concept 2 as every new bridge in Saskatoon needs to be a show piece*
- *concept 2 because it will be pretty.*
- *concept 2. Less impact to the river bed and surrounding vegetation*
- *No*
- *option 2 looks much nicer and has less posts in the water*
- *The cable-stayed bridge concept is more attractive and reduces disturbance to the Green Ash Forest on the riverbank.*
- *The steel plate girder bridge for sure. You said it best yourself in the evaluation: "the steel plate girder bridge was advanced for further analysis due to it being the typical bridge configuration used by the Ministry, and therefore the design and construction of a plate girder bridge is well known and less complex." I like the look of it because it's similar to our other bridges, and I like that it's a predictable, reliable design*
- *While I prefer the asthetic of the cable-stayed bridges I am concerned about frost, snow and ice forming on and falling from the overhead structures onto vehicles and people. This has been a problem in other parts of canada that have used these designs.*

Ministry of Highways:

Saskatoon Freeway Functional Planning Study

Phase 2: Second Virtual Stakeholder Engagement Session

Exit Survey



Other – please specify:

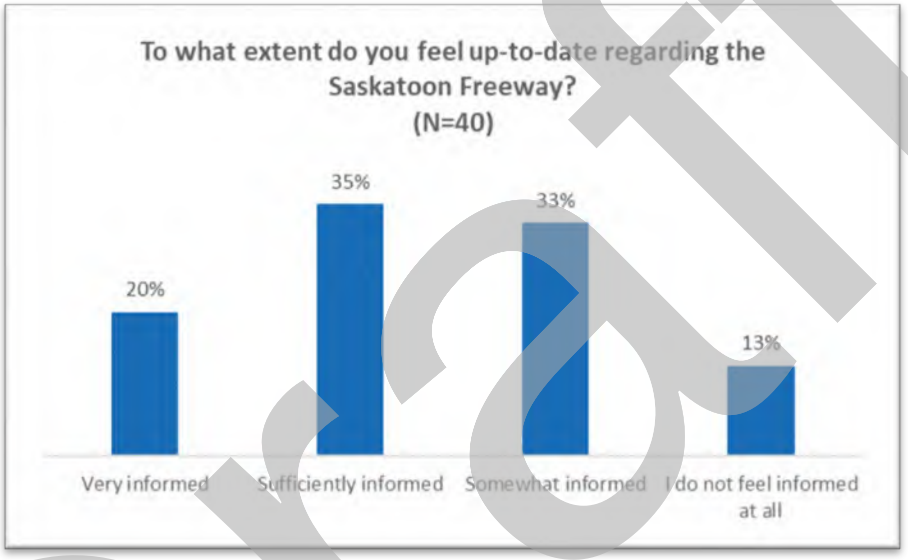
- *Finding Connection to Highway 5!*
- *Light Rapid Transit*
- *Preserving the cultural landscape as part of reconciliation with indigenous peoples*
- *Preserving wild spaces within the City of Saskatoon*
- *Protecting natural areas*
- *Reducing urban sprawl*
- *Rest areas for Truckers*
- *Save the swale*
- *Selecting the highest ranking bridge design*
- *water quantity as primary downstream receiver*

Do you have any other comments or questions you would like to share or submit?

- *A highway through the awakes will further fragment this important natural area. Before making a final decision on a route for the proposed freeway, you should undertake a full costs accounting business plan as suggested by very early consultations. You should undertake an environmental impact assessment that looks at cumulative effects of this proposed roadway in the context of other developments and their impacts.*
- *As the primary downstream land owners north of township road 374 which includes the northeast swale, we are concerned not only about water quality but water quantity as well. Major roadways are known to discharge contaminants from tire residue, exhaust and spills from accidents. Of greater concern is the quantity of water that will directed towards our lands. The city of Saskatoon has been unable to provide any estimates of how much flows will increase with the development of Aspen Ridge. This highway will have to deal with these flows and we are hoping that you can provide a better hydrological estimate of lows on a seasonal basis.*

- *Complete a full circle.   Do not leave a missing piece*
- *Habitat connectivity in the NE swale is very important to me. The recent road developments due to the Chief Mistawasis bridge and now the planned development of another major road in very close proximity seems like poor planning on the part off the city and the province. And it comes at the expense to the connectivity and degradation of the habitat of this area. Lights, noise, high speed traffic, etc will impact the habitat. I would like to know how these things will be mitigated.*
- *I'm concerned about the route. The project description says the highway goes around the city, but it goes through the city on the northeast side, and through sensitive habitat as well.*
- *It is frustrating that the worst ranked bridge design made it through to be one of the final two considered. This extensive assessment seems like a huge waste of time and money if results are ultimately ignored so that the literal WORST option can be selected.*
- *It is ridiculous that you feel this freeway needs be so close to McOrmond and cut through a sensitive wildlife corridor. Move the freeway out to Clarks Crossing where a year round road crossing the river would be useful or where it would come out at Warman where there is a new overpass not being used.*
- *Our natural grasslands are one of the most endangered ecosystems I. The world. If this city is so worried about the environment that it spends money making bike lanes then maybe it should protect and preserve some of the last natural grasslands and Praire ecosystems in the province.*
- *please think about how this would affect the flora and fauna living in the swale.(especially the birds that use the wetland!)*
- *Save the swale!*
- *This is a great idea but why are we staying with the traditional Saskatoon mindset of doing infrastructure half way? Make this road a true ring road around the entire city! If im coming up highway 11 and want to go to highway 14 west youre telling me i still have to go through the city? What sense does this make? Full ring road or dont bother at all.*
- *This is intended to be a bypass route for traffic that doesn't need to enter the City. Hopefully consideration will be given to providing rest areas for truckers along the S.F. route.*
- *This new highway has been amazing !!*
- *This project will alter this area dramatically, it should be scraped and the money that has been set aside for it should be used on preserving prairies, not destroying them.*
- *This seems like a waste of money when the government should be focusing on Bud Rapid Transit. I'm moving from Saskatoon to Calgary for their Light Rapid Transit.*

- *Yes, this highway should not be built at all through the Swale system. This is a remnant prairie and should be protected and restored and connected to other natural areas. We are in a biodiversity and climate emergency and all natural areas no matter how big or how small must be preserved. A highway should not be built through the North East and Small Swales, a bridge should not be cross and endanger a remnant native green ash forest. This project is ill conceived and should not proceed.*



Please explain what would help in making you feel more informed:

- *A facebook page*
- *For the coverage of the individual interchanges, it would be nice to have a map that's just a little more zoomed out, so you can see the whole picture for that interchange. As it stands the only maps available are ones that show multiple interchanges at once and it's hard to see everything, or ones that only show a piece of an interchange.*
- *Having access to the biological studies undertaken to date. It's will ne necessary to update studies of the impacts of the new preferred route on the land.*
- *I already said I was informed.*
- *i don't feel like i need anymore information but please consider how plopping a giant road on a wetland would affect the flora and fauna.*

- *I would like regular mailed out updates. Not just social media*
- *I'm not sure- but I've felt like I only happen across information occasionally shared via Facebook -*
- *Information*
- *Maybe more media exposure*
- *modelling results for water quality and quantity heading into the northeast swale north of Township road 374.*
- *More advertising, news*
- *more data on social media.*
- *More public notices*
- *More updates*
- *n/a*
- *Public consultation to date has been good.*
- *public meetings in which we can ask specific questions of the proponents, rather than trying to interpret the info online by oneself*

APPENDIX C

Design Criteria Memorandum

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Nathan Ruecker, SNC

Project name:
Saskatoon Freeway Function Planning Study

Project ref:
60594864

From:
Tim Sorochinsky

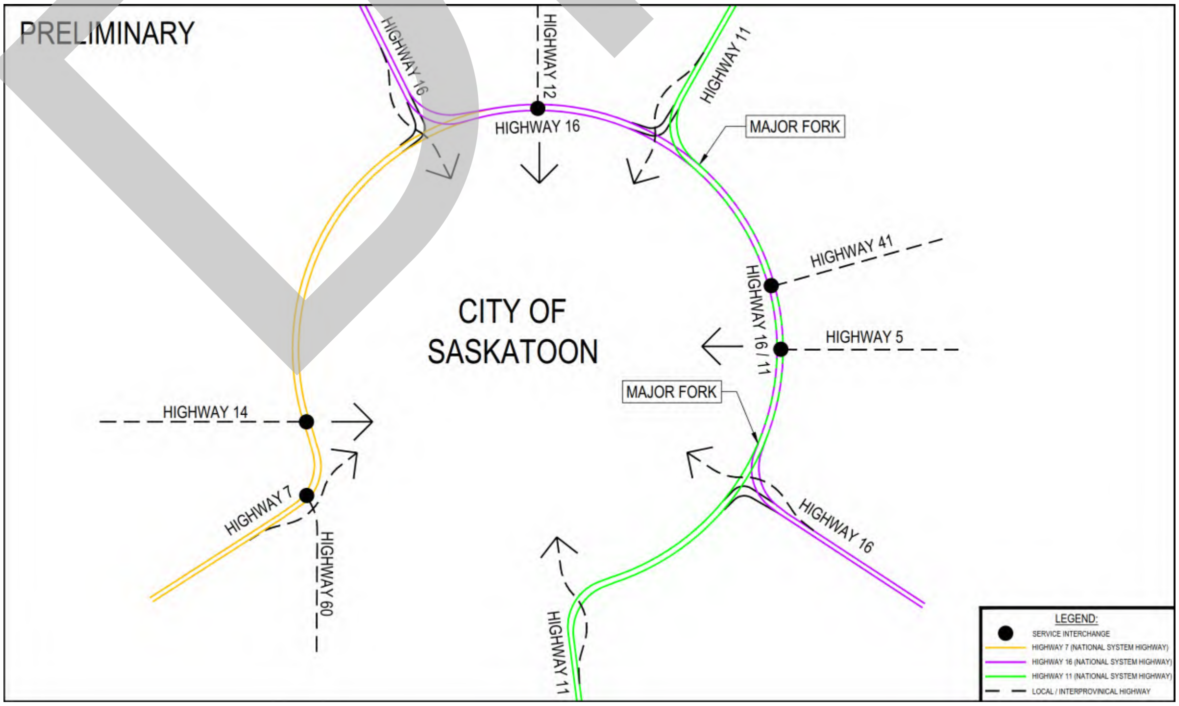
Date:
September 19, 2019

Memo

RE: Saskatoon Freeway Function Planning Study Design Criteria Memorandum

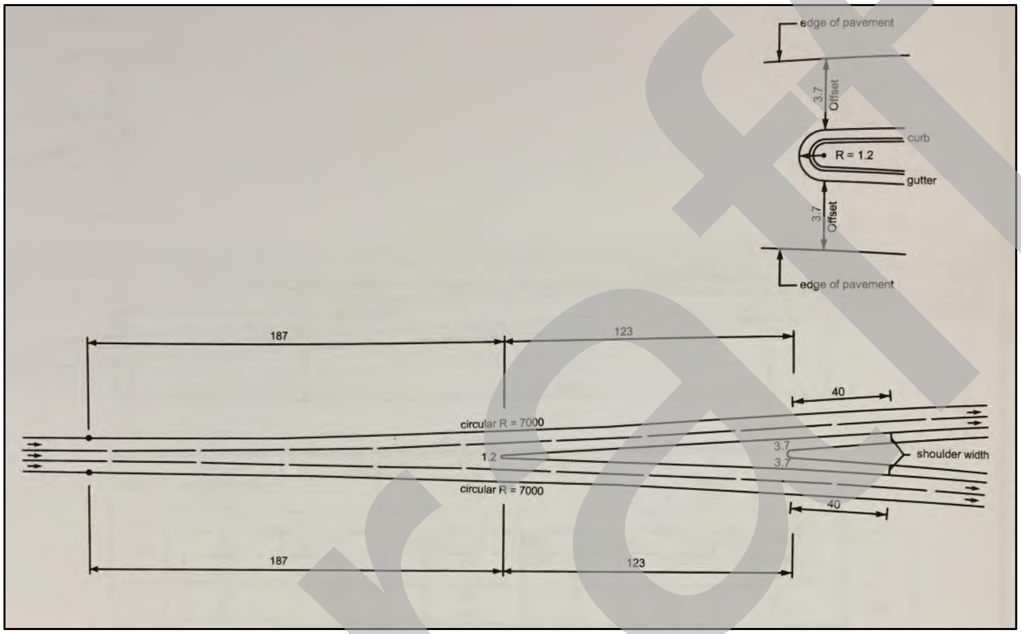
This memo documents the proposed design criteria for the future Saskatoon Freeway and surrounding road network. The Saskatoon Freeway will provide route continuity for Highways 11 and 16 which are part of the National Highway System. The Saskatoon Freeway will also function as a free-flow bypass of the City of Saskatoon. The Saskatoon Freeway will connect the south legs of Highway 11 and 16 with the corresponding north legs, allowing National Highway traffic to bypass the City of Saskatoon. This includes system level interchanges between Highways 11, 16 and 7 and the proposed Saskatoon Freeway. Furthermore, the Saskatoon Freeway will provide greater connectivity between the City of Saskatoon and the surrounding area. A schematic illustrating this concept is provided below in **Figure 1**.

Figure 1: Route Continuity Schematic



To maintain route continuity with a design speed of 130 km/h, key convergence and divergence points between National Highways 11 and 16 will be designed as a Major Fork (divergence) and a “Major” Connector (convergence). According to TAC Section 10.6.3.1, ‘*A major fork occurs when a terminating freeway/expressway divides into two directional ramps that connect to another crossing freeway or when a freeway branches into two connecting ramps to separate high-speed road routes of equal importance. In a major fork, there is effectively a left exit ramp and a right exit ramp with no through movement. A high ramp design speed should be provided.’* Figure 10.8.4 of the TAC Geometric Design Guide (illustrated below in **Figure 2**) details the typical design of a major fork.

Figure 2: TAC Figure 10.8.4 – Typical Design Major Fork



Ministry of Highways and Infrastructure Standards

The Saskatoon Freeway will be designed as a divided minimum four-lane freeway with a 130 km/h design speed. The Saskatoon Freeway will be classified as a D-130-7430 roadway, in accordance with SP20020. Provincial roadways crossing the Saskatoon Freeway include both divided and undivided highways, and are classified as D-130-7430 and U-110-7010. A summary of the geometric design standards are summarized below in **Tables 1 and 2**.

Table 1: Highway Standards – Saskatchewan Ministry of Highways and Infrastructure (Class 10)

		Geometric Design Standard	**Reference**
Functional Highway Classification		D-130-7430 (Divided) Provincial Highways Saskatoon Freeway	SP20020
Minimum ROW Width (m)		101.4m	SP21010
Equivalent Minimum "K" Factor	**Crest**	195	SP20250
	Sag	75	SP20255
Minimum Stopping Sight Distance (m)		290m	SP20250 / SP20255
Maximum Grade (%)	**Upgrade**	3%	SP20270
	Downgrade	5%	SP20270
Minimum Grade (%)		0%	DM302-5

Maximum Superelevation (m/m)		0.06	TAC Table 3.2.3
Minimum Radius (m)		950m	TAC Table 3.2.3
Minimum Spiral "A" Parameter (m)		300m	TAC Table 3.2.6
Number of Lanes		4	SP20020 / SP21010
Through Lane Width (m)		3.7m	SP21010
Shoulder Width (m)	**Inner**	1.0m	SP21010 / SP20020
	Outer	3.0m	SP21010 / SP20020
Standard Cross-Fall (m/m)	**Lanes**	0.02	SP20020
	Inner Shoulder	0.02	SP20020
	Outer Shoulder	0.05	SP20020
Median Width (m)		32m	SP21010
Surfacing Structure		Standard Pavement - Asphalt Concrete	SP20020

Table 2: Highway Standards – Saskatchewan Ministry of Highways and Infrastructure

		Geometric Design Standard	**Reference**
Functional Highway Classification		U-110-7010 (Undivided) Provincial Highways	SP21055
Minimum ROW Width (m)		46m	SP21050 / RM Primary Grid
Equivalent Minimum "K" Factor	**Crest**	125	SP20250
	Sag	55	SP20255
Minimum Stopping Sight Distance (m)		230m	SP20250 / SP20255
Maximum Grade (%)	**Upgrade**	3%	SP20270
	Downgrade	5%	SP20270
Minimum Grade (%)		0%	DM302-5
Maximum Superelevation (m/m)		0.06	TAC Table 3.2.3
Minimum Radius (m)		250m	TAC Table 3.2.3 (DS 80 km/h based on RM)
Minimum Spiral "A" Parameter (m)		125m	TAC Table 3.2.6
Number of Lanes		2	SP21055 / SP21050
Through Lane Width (m)		3.5m	SP21050
Shoulder Width (m)		1.0m	SP21055 / SP21050
Standard Cross-Fall (m/m)	**Lanes**	0.03	SP21055 / RM Primary Grid
	Shoulder	0.03	SP21055 / RM Primary Grid

Surfacing Structure	150mm minimum earth embankment thickness	SP21055

The geometric design standards for interchange ramps are summarized in **Table 3** below:

Table 3: Ramp Standards – Saskatchewan Ministry of Highways and Infrastructure

		Geometric Design Standard	**Reference**
Single Lane Ramp Width (m)	**Condition A**	4.0m	SKS20720
	Condition B	4.8m	SKS20720
	Condition C	5.0m	SKS20720
Shoulder Width (m)	**Left**	0.6m	SKS20720
	Right	2.5m	SKS20720
Minimum Design Speed of Loop Ramp (km/h)		50km/h	DM620
Minimum Radius of Curve (m)	**DS=50***	90m	TAC Table 3.2.3
	DS=60*	130m	TAC Table 3.2.3
	DS=70*	190m	TAC Table 3.2.3
	DS=80*	250m	TAC Table 3.2.3
	DS=90*	340m	TAC Table 3.2.3
	DS=100*	440m	TAC Table 3.2.3
	DS=110*	600m	TAC Table 3.2.3
	DS=120*	750m	TAC Table 3.2.3
	DS=130*	950m	TAC Table 3.2.3
Equivalent Minimum "K" Factor Crest (Sag)	**DS=50***	10 (10)	SP20250 / SP20255
	DS=60*	15 (15)	SP20250 / SP20255
	DS=70*	25 (25)	SP20250 / SP20255
	DS=80*	40 (30)	SP20250 / SP20255
	DS=90*	50 (35)	SP20250 / SP20255
	DS=100*	85 (45)	SP20250 / SP20255
	DS=110*	125 (55)	SP20250 / SP20255
	DS=120*	165 (65)	SP20250 / SP20255
	DS=130*	195 (75)	SP20250 / SP20255
Exit Terminal Speed Change Length (m)			SP26442
Entrance Terminal Speed Change Length (m)			SP26443

***Note:** A minimum 50 km/h design speed to be used for loop ramps only. 60 km/h – 90 km/h design speed to be used for Highway – Arterial connections. 100 km/h – 120 km/h to be used for Highway – Highway connections. 130 km/h Design speed to be used along Saskatoon Freeway and maintaining route continuity between National Highways (Highway 16, Highway 11, and Highway 7).

Miscellaneous

Design Vehicles: Critical interchange movements along the National Highway System will be designed to accommodate a WB-51 design vehicle while at-grade intersections will be designed to accommodate a WB-20 design vehicle.

Roundabouts: Roundabouts will be considered at ramp terminal intersections as an alternative to signalized intersections. If warranted, roundabouts will be designed in accordance with the Alberta Transportation Design Bulletin 68, Roundabout Design Guidelines on Provincial Highways.

Pavement Widening at Structures: Mainline pavement widening (including speed change lanes for ramps, forks, and connectors) adjacent to the South Saskatchewan River to begin a minimum of 100m from the structure abutments.

Interchange Spacing: Based on the Saskatchewan Roadside Management Manual (RSMM 430-30), the Saskatoon Freeway is considered 'U-1' access management level which represents the highest level of urban control and is considered a freeway standard. At-grade intersections are not permitted at this access management level and interchanges are to be spaced at a minimum of 3.2 km.

In addition to the interchange spacing standard provided in the Roadside Management Manual, Section 3.7.3.3 of TAC Geometric Design Guide for Canadian Roads recommends a minimum weaving length to ensure efficient operation on freeways. In particular, '*weaving length between a freeway interchange and an arterial interchange normally should be in the range of 800 m to 1000 m and between arterial interchanges in the range of 550 m and 700 m.*'

Rural Municipality of Corman Park Standards

The Rural Municipality of Corman Park surrounds the City of Saskatoon and includes over 1200 km of municipal roads spanning over 2000 km^2. The roadway standards for the Rural Municipality of Corman Park are summarized below in **Tables 4** through **6**.

Primary Grid Road: Standards for Graveled Primary Grid and Heavy Haul Roads.

Table 4: Corman Park Standards – Primary Grid Road

	Geometric Design Standard	Reference
Minimum Right-of-Way (m)	46.0m	RM Primary Grid: 3
Design Speed (km/h)	80km/h	RM Primary Grid: 4.1
Finished Top Width (m)	4.3m / lane	RM Primary Grid: 4.1
Standard Cross-Fall (m/m)	0.03 – 0.04	RM Primary Grid: 4.1
Minimum Radius (m)	250m	TAC Table 3.2.3
Side Slope	3:1 to 4:1	RM Primary Grid: 4.3
Ditch Bottom Width (m)	5.0m to 6.0m	RM Primary Grid: 4.4
Maximum Road Gradient (%)	6%	RM Primary Grid: 4.6
Stopping Sight Distance (m)	140m	RM Primary Grid: 4.6

Main Farm Access Road: Standards for Graveled Main Farm Access Roads.

Table 5: Corman Park Standards – Main Farm Access Road

	Geometric Design Standard	Reference
Minimum Right-of-Way (m)	30.0m	RM Farm Access: 3
Design Speed (km/h)	80km/h	RM Farm Access: 4.1
Finished Top Width (m)	3.5m / lane	RM Farm Access: 4.1
Standard Cross-Fall (m/m)	0.03 – 0.04	RM Farm Access: 4.1
Minimum Radius (m)	250m	TAC Table 3.2.3
Side Slope	3:1	RM Farm Access: 4.3
Ditch Bottom Width (m)	4.0m to 6.0m	RM Farm Access: 4.4
Maximum Road Gradient (%)	9%	RM Farm Access: 4.6
Stopping Sight Distance (m)	140m	RM Farm Access: 4.6

Industrial Paved Road: Standards for Industrial Paved (Asphalt Concrete) Roads.

Table 6: Corman Park Standards – Industrial Paved Road

	Geometric Design Standard	Reference
Minimum Right-of-Way (m)	46.0m	RM Industrial: 3
Design Speed (km/h)	100km/h	RM Industrial: 4.7
Finished Top Width (m)	4.5m / lane	RM Industrial: 4.1
Standard Cross-Fall (m/m)	0.02	RM Industrial: 4.1
Minimum Radius (m)	440m	TAC Table 3.2.3
Side Slope	3:1 to 4:1	RM Industrial: 4.3
Ditch Bottom Width (m)	4.0m to 7.0m	RM Industrial: 4.4
Maximum Road Gradient (%)	5%	RM Industrial: 4.6
Stopping Sight Distance (m)	200m	RM Industrial: 4.6

City of Saskatoon Standards

The City of Saskatoon uses a road classification system that considers land service and traffic characteristics including vehicular mix and destination. The classification system is summarized below in **Table 7** and key City of Saskatoon Design Standards are summarized below in **Tables 8** through **12**.

Table 7: City of Saskatoon Standards – Roadway Classification

Roadway Type	Daily Service Volume (veh/day)	Design Speed	Posted Speed (Maximum)
Freeways and Expressways	>20,000	20km/h above posted	100km/h
Arterials	5,000 to 30,000	10km/h above posted	70km/h
Collectors	1,000 to 15,000	10km/h above posted	50km/h

Local Streets	<1,000	50km/h	50km/h
Lanes	None specified	30-40km/h	20km/h

Freeways and Expressways: Intended to accommodate heavy volumes of traffic moving at high speeds under free-flow conditions. Urban sections should be considered where the ROW is less than 100m

Table 8: City of Saskatoon Standards – Freeways and Expressways

		Geometric Design Standard	Reference
Minimum Right-of-Way (m)		100m	Saskatoon 3.4.3
Minimum Number of Lanes		4	Saskatoon 3.4.4
Minimum Lane Width (m)		3.60m	Plan 102-0029-002r003
Minimum Radius (m)		670m	Saskatoon 3.4.6
Minimum length of Spiral (m)		50m	Saskatoon 3.4.6
Minimum Cross-Slope (%)		2.5%	Saskatoon 3.4.2
Interchange Ramp Width (m)	**Ramp**	4.0m	Saskatoon 3.4.2
	Loop	5.0m	Saskatoon 3.4.2
Interchange Inside (Outside) Shoulder Width (m)	**Ramp**	1.0m (2.5m)	Saskatoon 3.4.2
	Loop	1.0m (2.5m)	Saskatoon 3.4.2
Maximum Longitudinal Gradient (%)		5%	Saskatoon 4.1
Minimum Longitudinal Gradient (%)		0.5%	Saskatoon 4.1
K-Value of Vertical Curve		None Specified	Saskatoon 4.2
Superelevation (m/m)		0.06	Saskatoon 4.3

Arterials: Intended to carry large volumes of all types of traffic moving at medium speeds. They expedite movement of through traffic to major traffic generators and from subdivision to subdivision.
Class A: 6 lanes, divided
Class B: 4 lanes, divided
Class C: 4 lanes, undivided

Table 9: City of Saskatoon Standards – Arterial Roads

		Geometric Design Standard	Reference
Minimum Right-of-Way (m)	**Class A**	38m	Saskatoon 3.5.3
	Class B	32m	Saskatoon 3.5.3
	Class C	30m	Saskatoon 3.5.3
Minimum Number of Lanes		4	Saskatoon 3.5.4
Minimum Lane Width (m)		3.60m	Plan 102-0029-004r003
Minimum Radius (m)		250m (400 to 5,000m preferred)	Saskatoon 3.5.6
Minimum length of Spiral (m)		50m	Saskatoon 3.5.6
Minimum Cross-Slope (%)		2.5%	Saskatoon 3.5.2
Preferred Intersection Spacing (m)		450m (250m minimum)	Saskatoon 3.5.7
Maximum Longitudinal Gradient (%)		5%	Saskatoon 4.1

Minimum Longitudinal Gradient (%)	0.5%	Saskatoon 4.1
K-Value of Vertical Curve	As per Engineer's design	Saskatoon 4.2

Collectors: Intended to provide both traffic movement and land access. They carry traffic between local and arterial streets.
Class A: 2 lanes, undivided, parking lane on both sides
Class B: 2 lanes, undivided, parking lane on one side
Class C: 2 lanes, undivided, no parking lanes

Table 10: City of Saskatoon Standards – Collector Roads

		Geometric Design Standard	Reference
Minimum Right-of-Way (m)	**Class A**	22m	Saskatoon 3.6.3
	Class B	22m	Saskatoon 3.6.3
	Class C	20m	Saskatoon 3.6.3
Number of Lanes (see parking requirements above)		2	Saskatoon 3.6.4
Minimum Lane Width (m)		3.60m	Plan 102-0029-008r003
Minimum Radius (m)			TAC Table 3.2.3
Minimum Cross-Slope (%)		2.5%	Saskatoon 3.6.2
Minimum Intersection Spacing (m)		60m	Saskatoon 3.6.6
Maximum Longitudinal Gradient (%)		5%	Saskatoon 4.1
Minimum Longitudinal Gradient (%)		0.5%	Saskatoon 4.1
K-Value of Vertical Curve		20	Saskatoon 4.2

Locals: Intended to provide land access. Not intended to carry large volumes of traffic.
Class A & B: Preferred. Class B is less than 500m in length
Class C: Serving Cul-de-sacs

Table 11: City of Saskatoon Standards – Local Roads

		Geometric Design Standard	Reference
Minimum Right-of-Way (m)	**Class A**	18m	Saskatoon 3.7.3
	Class B	16m	Saskatoon 3.7.3
	Class C	15m	Saskatoon 3.7.3
Number of Lanes		2 traveled + minimum 1 parking	Saskatoon 3.7.4
Minimum Lane Width (m)		4.5m	Plan 102-0029-011r003
Minimum Cross-Slope (%)		2.5%	Saskatoon 3.7.2
Maximum Longitudinal Gradient (%)		5%	Saskatoon 4.1
Minimum Longitudinal Gradient (%)		0.5%	Saskatoon 4.1
K-Value of Vertical Curve		10	Saskatoon 4.2

Industrial Roads: Intended to provide both traffic movement and land access within industrial zoned areas. These roadways may be classified as arterials, collectors, or locals.

Table 12: City of Saskatoon Standards – Industrial Roads

	Geometric Design Standard	Reference
Minimum Right-of-Way (m)	20m	Saskatoon 3.8.3
Number of Lanes	2 traveled + 2 parking	Saskatoon 3.8.4
Minimum Through Lane Width (m)	4m	Plan 102-0029-007r003
Minimum Parking Lane Width (m)	3.5m	Plan 102-0029-007r003
Minimum Cross-Slope (%)	2.5%	Saskatoon 3.8.2
Maximum Longitudinal Gradient (%)	5%	Saskatoon 4.1
Minimum Longitudinal Gradient (%)	0.5%	Saskatoon 4.1
K-Value of Vertical Curve	20	Saskatoon 4.2

APPENDIX D

Structure Design Criteria Summary

Saskatoon Freeway Functional Planning Study

Structure Design Criteria Summary

Saskatchewan Ministry of Highways

September 29, 20210

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Notice to Reader

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The findings, conclusions and recommendations in this report (i) have been developed in a manner consistent with the level of skill normally exercised by professionals currently practicing under similar conditions in the area, and (ii) reflect SNC-Lavalin's best judgment based on information available at the time of preparation of this report. No other warranties, either expressed or implied, are made with respect to the professional services provided to the Client or the findings, conclusions and recommendations contained in this report. The findings and conclusions contained in this report are valid only as of the date of this report and may be based, in part, upon information provided by others. If any of the information is inaccurate, new information is discovered or project parameters change, modifications to this report may be necessary.

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Rev.	Item	Description
	Geometry	
	Spans:	Site specific. Continuous superstructure for multi-span bridges.
0	**Vertical Alignment:**	For deck drainage purposes, a minimum longitudinal grade of 0.5% shall be provided on bridge decks that are not on vertical curves. Bridges may be located on vertical curves, for this situation, it is desirable that the crest of the vertical curve shall be located beyond the length of the superstructure and approach slabs, and in no case shall more than a 20 m length of the bridge have a gradient less than 0.5% (see Bridge Design Criteria BD100-Ver 2018-1 (Section 4.2)). Vertical Clearance requirements: Minimum 5.3 m clear from top of underlying roadway to underside of superstructure. Minimum 7.31 m clear from top of rail to underside of superstructure at railway overpasses. Navigation requirements (stream crossings): Navigation vessel clearance TBD. 0.3 freeboard from 1:100 flood levels. Navigation requirements (river crossings): Navigation vessel clearance TBD. 2.5 m freeboard from 1:100 flood levels. Refer to site specific roadway alignment drawings.
0	**Horizontal Alignment:**	Refer to site specific roadway alignment drawings.
0	**Skew:**	Refer to Design Manual Part 1 Standard Plans 20150 and 20152, and TAC Geometric Design Guide Supplement SKS2.2.10-A.
0	**Lanes, Widths and Clearance:**	Site specific.
0	**Overall Width of Structure:**	N/A
0	**Future requirements:**	

Rev.	Item	Description
	Design Parameters	
0	**Live Load:**	Cl-750 truck loading plus dynamic load allowance as defined in CHBDC. No adjustments are required for the 9 kN/m uniformly distributed load for lane load. (see BD100 CL 1.2).
0	**Fatigue Design:**	Class A Highway requirements as defined in CSA-S6 Clause 1.4.2.2.
0	**Temperature Range:**	Site specific according to CSA-S6:19.
	Structural Materials	
0	**Concrete:**	Deck Concrete: Type DC, 45 MPa at 28 days, 5-7% air, w/c=0.38. Superstructure and Substructure: Type C, 35 MPa at 28 days, 5-7% air, w/c=0.40.
0	**Reinforcing Steel:**	CAN/CSA- G30.18, Grade 400. Stainless Steel ASTM A276 and ASTM A955/A955M – UNS S24100, S31653, S31603, S31803, S30400, or S32304. Low carbon/chromium reinforcing steel ASTM. A1035/A1035M, with min. CR content of 9.2% and min. yield strength of 690 MPa.
0	**Structural Steel:**	Girders, and all welded attachments: CAN/CSA G40.2 M, Grade 350 AT, Category 3. Bracing material bolted to girders: CAN/CSA G40.2 M, Grade 350 A.
0	**Concrete Cover:**	Concrete Cover: Refer to MHI document “BD100- Bridge Design Criteria” section 6.3.

Rev.	Item	Description
	Abutments	
0	**Type:**	Integral, Semi-integral, or conventional reinforced concrete abutment with wing wall perpendicular to the abutment.
0	**Foundation:**	TBD
0	**Approach Slabs:**	0.300 m thick, extend to the end of parallel wingwalls or minimum 4800 mm long measured parallel to centreline of roadway.
0	**Finishes and Sealing:**	An approved Type 1 c sealer shall be applied to all concrete surfaces that are susceptible to deterioration by water and de-icing salts.
0	**Slope Protection:**	All concrete slope protection shall be done in accordance with Alberta Transportation Standard Drawing S-1409-99 (Concrete Slope Protection).
0	**Abutment Seat:**	Tops of abutment seat shall have a wash slope of 3%.
	Piers	
0	**Type:**	Solid concrete multiple circular column piers with rectangular pile cap and rectangular pier cap. Piers with three columns or less shall have a minimum cross-section area of 2.8 m^2 for each column. Piers with 4 or more columns shall have a minimum cross-section area of 1.8 m^2 for each column.
0	**Foundation:**	TBD
0	**Finishes and Sealing:**	An approved Type 1c sealer shall be applied to all concrete surfaces that are susceptible to deterioration by water and de-icing salts.
0	**Abutment Seat:**	Tops of pier cap shall have a wash slope of 3%.

Rev.	Item	Description
	Bearings	
0	**General:**	Bearings to be replaceable by jacking the superstructure. Abutment and Pier bearing seats shall be designed to allow for an appropriate area for jacking.
0	**Abutments:**	Proposed fixed, unidirectional (longitudinal) and multidirectional reinforced elastomeric bearings with Teflon / stainless steel sliding plate. Pot bearings to be considered if warranted due to load demands.
0	**Orientation W.R.T Skew:**	Primary movement parallel with girder centerline.
	Steel Girders	
0	**Analysis Type:**	Simplified Method of Analysis in accordance with CHBDC CAN/CSA-S6:19.
0	**Type:**	Welded plate girder, straight, nominal web depth based on span. Nelson shear studs to be provided for composite action with concrete deck.
0	**Number and Spacing:**	spans < 50 m - minimum of 4 girder lines. spans > 50 m - minimum of 3 girder lines.
0	**Continuity:**	Non-composite girders under self- weight and deck self-weight, composite girders under superimposed dead load and live loads.
0	**Yield Strength, F_y:**	350 MPa.
0	**Section Properties:**	Before composite action: Bare steel girder only (S). After composite action 1 x n: Live Loads (S_n). After composite action, 3 x n: dead loads applied after composite action, to account for creep and shrinkage (S_{3n}).

Rev.	Item	Description
0	**Diaphragms:**	Girders cross- frame maximum spacing 8.0 m. Integral and Semi-Integral Abutment diaphragms: 0.80 m wide full depth concrete sections. Minimum gap between the diaphragm and abutment is 0.020 m to allow jacking of the superstructure where applicable.
	Prestressed Concrete Girders	
0	**Analysis Type:**	Simplified Method of Analysis in accordance with CHBDC CAN/CSA-S6:19.
0	**Type:**	NU precast prestressed concrete girders, depth based on spans.
0	**Number and Spacing:**	Spans < 50 m - minimum of 4 girder lines. Spans > 50 m - minimum of 3 girder lines.
0	**Continuity:**	Simple span non-composite girders under self-weight and deck self-weight, continuous composite girders under superimposed dead load and live loads.
0	**Design:**	Zero tension in girders under service load after all losses.
0	**Precast Concrete:**	Type G, Air content = 5-7%, w/c = 0.38, minimum 35 MPA.
0	**Reinforcement:**	CAN/CSA-G30.18, Grade 400.
0	**Prestressing Steel:**	CAN/CSA-G279, Grade 1860 low relaxation.
0	**Lateral Stressing:**	N/A
0	**Stressing Ducts:**	N/A
0	**Grouting:**	N/A

Rev.	Item	Description
0	**Diaphragms:**	Integral and Semi-Integral Abutment diaphragms: 0.80 m wide full depth concrete sections. Intermediate diaphragms: 0.30 m wide full depth concrete sections or steel bracing with maximum spacing 13.0 m. Minimum gap between the diaphragm and abutment is 0.020 m to allow hacking of the superstructure where applicable.
	<u>Deck</u>	
0	**Construction:**	Cast-in-place conventional reinforced concrete deck.
0	**Nominal Thickness:**	Minimum slab thickness to be the greater of the girder c/c spacing divided by 15.0 or 225 mm. Slab thickness shall be increased 70 mm over the girders to allow for formwork adjustment.
0	**Crossfall:**	Nominal 2% cross fall each way from center crown.
0	**Wearing Surface:**	Standard deck protection and wearing surface system has a total thickness of 90 mm consisting of a nominal 5 mm thick rubberized asphalt waterproofing membrane, plus 3 mm protective board, plus two 40 mm lifts of asphaltic concrete pavement.
0	**Sidewalks:**	None.
0	**Median:**	TBD
0	**Curbs:**	Curb control joints spaced maximum 2.5 m. Tops of curbs and barriers shall have a wash slope of 3%.
0	**Deck Drains:**	Both sides.
0	**Utilities/Lighting:**	Two 100 mm diameter PVC ducts complete with pull wires in each curb on each side of bridge.
0	**Deck Joints**	Site specific.
0	**Bridge Railing**	See BD100 Clause 16.

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APPENDIX E

Phase 1 and Phase 2 Combined Roll Plan

DRAFT / CONCEPTUAL

AECOM	SNC·LAVALIN	SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY	PHASE 2 - CONCEPTUAL DESIGN	DATE JUNE 2023	SCALE 1000m 0m 1km

APPENDIX F

Drainage Catchment Areas and Culvert Details

Table G1: Drainage Path Acronyms

Drainage Path Acronyms	
RDD	River Direct Drainage
SSD	Small Swale Drainage
NSD	Northeast Swale Drainage
SSS	Saskatoon Storm Sewer
LLP	Local Low Point or Terminal Basin
BCTB	Beaver Creek Watershed

Table G2: Catchment Areas

Catchment	Area (ha)	Drainage Path	Characteristics, Assumptions, & Recommendations
A	11	RDD	A height of land is located at Station 28+060 near the intersection of Range Road 3051 and an undeveloped extension of Township Road 374. Runoff west of this point will flow directly to the South Saskatchewan River. The City of Saskatoon has proposed a stormwater utility corridor on the southwest side of the Freeway alignment.
B	26	LLP	A small area east of Range Road 3051 will drain northeast across the Freeway to a large local low area. Satellite imagery shows little to no standing water even in wet years and the presence of gravel pits in the area suggests potential for high infiltration. Trapped water could spill south towards McOrmond Drive around 489.5 masl. There is insufficient LiDAR data to confirm a spill elevation to the North. This functional design recommends that the Freeway ditch capture any runoff and divert it directly to the North Saskatchewan River.
C-1	3	SSD	The proposed Freeway alignment crosses the Small Swale at a natural high point. Catchment C-1 drains to the south section of the swale while catchment C-2 drains to the north section. It is recommended that runoff from these catchments not cross the Freeway. Refer to **Section 9.4 Drainage** for more detail.
C-2	9	SSD	
D	75	SSD	Runoff will flow northwest across the proposed Freeway alignment. The natural runoff would flow to the Small Swale; however, Range Road 3050 and Township Road 374 may currently be blocking the flow. Historically these roads were minimally built up with shallow ditches that may have allowed runoff to overtop them. However, the roads were recently paved, and evidence of culverts was not found during the culvert survey. It is expected that the Freeway ditches will capture most of the flow and convey it directly to the Small Swale, effectively restoring the natural drainage path.

E	3	NSD	The ridge that separates the Small and Northeast Swales is approximately 940 m east from the profile high point near Station 25+400 to Station 24+460. It is made up of three small ridges that create two small sub catchments. These ridges run parallel to the swales and direct flow northeast. However, Township Road 374 and Range Road 3045 are intercepting the flow and do not appear to have culverts to pass it. The small upstream portion of Catchment E feeds an existing dugout next to a farmyard north of the Freeway. Managing flow from this small area may be influenced by land negotiations and the neighboring roads. The proposed culverts may not be required. Given the negligible runoff this can be addressed during detailed design. Catchment F has a slightly larger upstream area that flows northeast then naturally drains east to the Northeast Swale near the proposed Freeway alignment. The Freeway ditch should maintain this drainage path.
F	25	NSD	
G	902	NSD	Some uncertainties may influence the effective flow area for catchment G: First, while most of the Northeast Swale flows northeast, a portion of it flows southwest. The drainage split is not well-defined, and the LiDAR data does not extend far enough south to accurately identify it; the location was estimated based on the NRCAN topographic data. Secondly, the Aspen Ridge development (currently under construction) appears to straddle the natural catchment boundary and could have altered that boundary. A well-defined drainage ditch has been constructed. The ditch leads to a detention pond which spills into the Northeast Swale. The drainage ditch and pond appear to capture and throttle runoff from approximately 580 ha to the south. Detailed information on the development's stormwater management plans were not available from the City of Saskatoon.
H	1708	NSD	Catchment H includes flow from catchments I through Z. Between Station 23+200 and Station 23+800 there are several well-defined drainage paths criss-crossing the proposed alignment from both the north and south. This occurs along the edge of the Northeast Swale and within the proposed Freeway Right-of-Way. It is recommended that the Freeway ditches intercept this flow and convey it directly to the swale. This prevents the potentially significant flow of catchment H from crossing the Freeway twice and eliminates unnecessary culverts. Much of the catchment area lies within the hills east of Saskatoon where there is significant storage potential including two large water bodies in Catchment L. Flow from the hills will cross both existing and re-aligned Highway 41 before being intercepted by an unnamed tributary in Catchment H. This tributary generally parallels the South

			Saskatchewan River and appears to have a high point near Township Road 380 with runoff north of the grid flowing northeast. When full the sloughs along the tributary spill southwest to the Northeast Swale.
I	57	NSD	Catchment I is bordered by Blackley Road to the west and flows north towards the Highway 41 interchange and Blackley Road connection. Currently it appears that flow from catchment I is following Blackley Road north to the point where catchment H crosses Blackley Road. Maintaining this flow path through the Highway 41 interchange and Blackley Road connections will be challenging. It may be beneficial to consider modifying this flow path during detailed design.
J	468 - 493	NSD	Catchment J is primarily overland flow with the southeast boundary in the hills and the majority covered by flatter farmland. Much of the farmland appears to be test crops including two ¼'s of Federal land. Flow crosses the existing Highway 41 alignment at several locations, generally moves northwest, and is captured by the constructed drainage ditch described in **Section 5.5.1.1.5.3 Proposed Drainage Ditch and Major Detention Pond**. An additional 25 ha area may be added to catchment J from a dynamic drainage area. For more information, refer to **Section 5.5.1.1.3 Altered and Dynamic Drainage.**
K	57	NSD	Catchment K is a small, narrow catchment located between the existing and re-aligned Highway 41. After crossing the proposed Highway 41 re-alignment at approximately Station 4+700 flow continues northwest to the Northeast Swale tributary.
L	1129	NSD	Catchment L covers a large area in the hills east of Saskatoon. It has substantial storage in the form of two large sloughs, many smaller sloughs, and some wetlands. When these waterbodies spill, they generally flow north to a large slough at the end of Township Road 372. Satellite imagery from May 2012 indicates that this slough spills around an adjacent farmyard and down towards existing Highway 41. Flow crosses the highway at two locations, combines in the farmland to the northwest, and crosses realigned Highway 41 at approximately Station 4+200. Flow then continues northwest to the Northeast Swale tributary in Catchment H.
M	10	NSD	Catchment M is a small area that may be trapped by the Highway 41 realignment. While ditch grading may be able to add this minor flow to one of the adjacent catchments, the minimum 800m culvert spacing will still require a culvert along this section. Flow travels northwest to the Northeast Swale tributary.

N	36	NSD	Catchment N is another small area that will be trapped by the Highway 41 re-alignment. Runoff flows northwest to the Northeast Swale tributary.
O	31	NSD	Catchment O is another area that will be trapped by the Highway 41 realignment. It is joined by flow from Catchment P. Both follow a fairly well-defined drainage path that will cross realigned Highway 41 at approximately Station 2+600. Flow continues northwest to the Northeast Swale tributary.
P	101	NSD	Catchment P originates in the hills and follows a well-defined drainage path north towards existing Highway 41. It crosses just southwest of the intersection of existing and realigned Highway 41 then joins Catchment O.
Q	19	NSD	Catchment P is a small drainage area cut off by the intersection of existing and re-aligned Highway 41. Flow will cross at this intersection then continue northwest to the Northeast Swale tributary.
R	285	NSD	Catchment R originates in the hills. A portion of the flow follows a fairly well-defined drainage path north to an existing Highway 41 culvert. The remaining watershed is captured by the Highway 41 ditch and conveyed southwest to the same culvert. New culverts will be required for the additional lanes that have been proposed. After crossing the highway flow continues northwest to the Northeast Swale tributary.
S	413	NSD	Catchment S is another larger catchment originating in the hills. Flow follows a well-defined drainage path that crosses Highway 41 just north of the intersection with Township Road 374. A culvert will be required for the additional lane that has been proposed. Several grid road and driveway culverts could throttle flow both up and downstream during major rainfall events. After crossing the highway flow continues northwest to the Northeast Swale tributary.
T	840	NSD	Catchment T includes flow from Catchments U through Z which cross the Freeway further upstream. Most of the runoff will consolidate just upstream from an existing culvert crossing Township Road 372. The flow then fans out in a field and travels north across the ¼ section. At the next ¼ flow is narrowed into a constructed drainage ditch which continues north, then crosses the proposed alignment from west to east at Station 21+100. The constructed ditch appears to follow the natural drainage patterns but with some constructed enhancements. After crossing the Freeway, it turns north and meanders along the east side of the alignment before tying into other major drainage paths near Station 23+100 (part of catchment H). As much of this existing ditch will be altered by Freeway construction, a dedicated drainage ditch has been recommended to manage the flow. For more detail,

			refer to **Section 5.5.1.1.5.3 Proposed Drainage Ditch and Major Detention Pond**. The City of Saskatoon has proposed a stormwater utility crossing along this drainage path. However, the original Freeway alignment has changed substantially along this section.
U	42 to 67	NSD	Flow in catchment U generally runs parallel to the Freeway alignment. However, Township Road 372 is redirecting flow west through an existing culvert at Range Road 3043. This falls within the Freeway alignment and will be altered. An additional 25 ha area may be added to catchment U from a dynamic drainage area. For more information, refer to **Section 5.5.1.1.3 Altered and Dynamic Drainage**.
V	172	NSD	Catchment V follows a well-defined drainage path from the east hills and includes most of the runoff from the Eagle Ridge acreage development. The drainage path intersects the proposed Freeway alignment near Station 19+000. Currently, runoff flows through an existing Highway 41 culvert between Range Road 3043 and the Freeway alignment. After crossing Highway 41 runoff feeds a triangular dugout on the north side. When the dugout spills, flow travels north to an existing culvert under Range Road 3043, then west along Township Road 372. All these features lie within the proposed Freeway alignment and will be whipped out. Approximately 1 km west of the Freeway flow joins several other drainage paths in catchment T then crosses Township Road 372 through a large culvert. This flow re-crosses the proposed Freeway alignment near Station 21+100.
W	68	NSD	Catchment W is located in the hills east of the Freeway. Flow in this area fills a slough, west of the proposed alignment near Station 18+400. The slough spills at approximately 519.75 and joins catchment T. The city of Saskatoon has proposed a stormwater utility crossing at Station 18+150.
X	37	NSD	Catchment X includes a well-defined drainage path flowing out of the hills which connects a series of small sloughs both upstream and downstream of the proposed Freeway alignment. After crossing the Freeway flow joins catchment T. It crosses Range Road 3043 through an existing culvert near Freeway station Station 17+800 and again through an existing Highway 41 culvert.

Y	41	NSD	Catchments Y and Z are part of a small area in the hills north and south of Highway 5. Currently, existing culverts at the intersection of Highway 5 and Range Road 3043 direct flow northwest into a series of large and small sloughs in catchment T. Twinning of Highway 5 (due to be completed in 2025) and the Freeway Interchange will both influence the detailed drainage paths.
Z	11	NSD	Flow from catchment Z will need to cross the entire interchange to maintain it's natural path. Given the small area it may be beneficial to consider modifying catchment Z's drainage path during detailed design of the interchange. The city of Saskatoon has proposed a stormwater utility crossing at Station 16+950.
AA	467	SSS	Runoff from the hills north of Highway 5 travels south and crosses the highway. This flow joins runoff from the east and follows a well-defined drainage path which crosses the proposed Freeway at approximately Station 15+500. After crossing the Freeway alignment, the drainage path turns northwest and crosses Range Road 3043 through an existing culvert. From there it connects numerous small sloughs, turns southwest, and enters a large slough in the new Brighton development. This slough will eventually be tied into the City's McOrmond Drive storm trunk. The City of Saskatoon has proposed stormwater utility crossings at Station 15+350 and Station 15+700.
BB	118	SSS	Catchment BB is a relatively small catchment originating in the hills east of the Freeway. Overland flow naturally concentrates into a series of sloughs west of the proposed alignment. The Freeway's east ditch will intercept overland flow and convey it to the proposed culverts at approximately Station 14+200. After crossing the Freeway flow will enter the natural slough located on either side of Range Road 3043. This slough spills west along several smaller sloughs before crossing Range Road 3044 and feeding a large slough next to the new Brighton development. An existing culvert could not be located in the slough along Range Road 3043. However, satellite imagery doesn't show any significant increase in the size of this slough during the wet years. It is likely that a submerged culvert is present. It is recommended that this be further investigated during detailed design as the watershed has a significant impact on the Brighton development. The small piece of land left between the Freeway and Range Road could be used to develop a small detention pond. The City of Saskatoon has proposed a stormwater utility crossing at Station 14+200.

CC	25	SSS	It is expected that most of the runoff from this small catchment is captured by the 8th Street ditch (Township Road 364). The remaining overland flow is intercepted by Range Road 3043 which also appears to flow south to the 8th street ditch. Flow passes through a culvert under the Range Road then continues west to a well-defined drainage path that flows northwest to a large slough next to the Brighton development. Detailed design of the 8th street interchange and the proposed service roads will have a significant impact on how this flow is managed.
DD	108	SSS	Catchment DD is bound by 8th Street (Township Road 364) to the north and Range Road 3042 to the east. Much of the watershed consolidates in a slough then follows a defined drainage path to the northwest. The remaining watershed is overland flow that will be intercepted by the Freeway ditch and conveyed across the Freeway at approximately Station 12+800. Range Road 3043 to the west is relatively undeveloped and it is expected that the roadway is currently overtopped during periods of peak runoff. This flow would then cross 8th Street and travel north where it joins flow from catchments BB and CC which flow into the large Brighton area slough. The City of Saskatoon has proposed a stormwater utility crossing at Station 13+000.
EE	73	SSS	Catchment EE has a relatively small area consisting primarily of overland sheet flow. The proposed Freeway ditch will intercept the flow and direct it to the proposed low point and culverts at approximately Station 11+830. After crossing the Freeway flow travels west towards Range Road 3043 then south to a well-defined drainage path. Catchment FF covers a large area that includes substantial upstream storage and multiple upstream culverts with potential to throttle flow. In drier years minimal flow is expected to reach the Freeway. However, when storage is near capacity a major rainfall event could result in significant runoff reaching the Freeway alignment. Most of this flow will be concentrated in a well-defined drainage path which intercepts the Freeway near Station 11+300. This point is not the proposed low point in the Freeway profile so consideration will need to be made in grading the ditch. After crossing the Freeway flow will continue to follow the defined drainage path west to Range Road 3043. An existing culvert in Range Road 3043 manages flow from catchments EE and FF. After crossing the grid flow continues to follow the defined drainage path west then north into a large local low area
FF	1488	SSS	

			that straddles Range Road 3044 (Blakley Road) in SE20 and SW21 36-04-W3. Satellite imagery shows this area to be dry prior to 2006. Upon reaching an elevation around 511 flow is spilling west where it crosses the CP railroad and Wess Road before entering a series of City storm ponds in the Briarwood neighborhood. These ponds are connected to the City of Saskatoon storm sewer system. The City of Saskatoon has proposed a stormwater utility crossing at Station 11+300.
GG	33	SSS	After crossing the Freeway alignment, flow from catchment GG travels west to an existing culvert on Range Road 3043 then on to slough that borders the east side of the CP Railroad. When this slough spills it drains north to culverts along Range Road 3044, then northwest where it joins with flow from catchments EE and FF and on into the Briarwood ponds described above.
HH	127	BCTB	Catchment HH lies north of Patience Lake Road and straddles Range Road 3042. Flow from both sides of the grid pass south, through an existing culvert under Patience Lake Road (west of RR 3042). This existing culvert is just east of the proposed interchange. Replacement of the culvert will depend on detailed design of the interchange and improvements to Patience Lake Road as well as the proposed access road to the south. Flow joins catchment II to the south.
II	268	BCTB	Flow from catchment HH joins runoff in catchment II and travels south along a fairly well-defined drainage path west of Range Road 3042. The drainage path turns southwest near Highway 16 and passes through a pair of existing culverts. This functional design proposed a re-alignment of this section of Highway 16 to accommodate the proposed interchange. New culverts will be required to pass flow southwest. After crossing the highway, flow continues southwest where it feeds some of the many sloughs that make up the Beaver Creek Terminal Basin.
JJ	10	BCTB	Catchment JJ is bordered by CP Rail to the north, Range Road 3042 to the east and Highway 16 to the southwest. Currently there are no culverts across the highway at this location. Runoff accumulates in a small slough along the highway and would spill southeast along the highway ditch. However, culverts are being proposed to meet the minimum 800m spacing. Runoff in the area flows southwest towards the many sloughs that make up the Beaver Creek Terminal Basin.
KK	760 - 895	BCTB	Catchment KK is a large area originating at the edge of Patience Lake Road to the north. An initial review of the topography suggested that roughly 135 ha north of Patience Lake Road might also be included in this catchment. However, subsequent culvert surveys could not identify any culverts along this section that could pass the flow south.

			The addition of a culvert along this section of highway might increase the size of this catchment. Two drainage areas flow south and southwest, converging just upstream of Highway 16 in the East Floral Industrial Park. This area is currently under development and includes numerous road ditches and retention ponds. A constructed drainage ditch directs flow to the highway ditch which appears to be diverting this flow approximately 750 meters southeast before it crosses the highway through existing culverts. This functional design is proposing new highway culverts where the constructed drainage ditch intersects the highway. This appears to be the natural drainage path and will be required to meet the minimum 800m culvert spacing. However, while flow will still end up in the Beaver Creek Terminal basin, the new culverts may significantly alter the drainage path and effect the volume of water reaching downstream ponds. A detailed review of this area is recommended.
LL	46	BCTB	Catchment LL is complex and difficult to accurately delineate. The proposed Freeway Right-of-Way will take up the majority of the catchment and runs parallel to the general direction of flow. There are already numerous existing structures influencing drainage including Highways 16, Patience Lake Road, CP Railroad, Range Roads 3043 and 3044, as well as several farmyards with long driveways. The terrain also changes drastically as the alignment transitions from the well graded hillside and enters the much flatter landscape of the Beaver Creek Terminal Basin. The LiDAR data in this area is incomplete and comes from two sources. This review was unable to confirm if the data sets are based on the same vertical datum. The proposed overpass at Highway 394 and Highway 16 interchange will further complicate the drainage patterns. It is recommended that detailed design include additional data collection and analysis of current drainage. Runoff from this catchment crosses Highway 16 through existing culverts then flows southwest to a large slough within the Beaver Creek Terminal Basin. The drainage path is unusual in that it appears to run both northwest and south. Detailed analysis of the LiDAR data revealed a subtle high point near the location where the proposed Freeway alignment crosses (Station 8+200). The south drainage path takes a much more direct route to the large slough and appears to be the natural path for runoff in catchment LL The City of Saskatoon has proposed stormwater utility crossings at Station 8+200 and Station 8+900.
MM	25	BCTB	Catchment MM makes up the northwest corner of the intersection of Highway 16 and Patience Lake Road. Runoff flows northwest to existing Highway 16 culverts then southwest into Catchment NN after crossing the highway. The location of a CP Railroad culvert could not be confirmed at this location.

NN	180	BCTB	Significant year-round standing water suggests poor drainage within Catchment NN and heavy vegetation effects the accuracy of the LiDAR derived topographic data. Numerous drainage paths, wetlands, and lagoons also make it difficult to determine the exact drainage paths around the Prairie Plant Systems facility. As discussed in Catchment LL, the defined drainage path at Station 8+200 appears to have a split with the portion residing in this catchment flowing northwest into the wetlands surrounding Prairie Plant Systems. The wetlands appear to spill into a slough that straddles Range Road 3044. When this slough spills, flow is expected to cross the Freeway alignment at approximately Station 7+350 and on into one of the large sloughs within the Beaver Creek Terminal Basin. The City of Saskatoon has proposed stormwater utility crossings at Stations 6+700, 7+300, and 8+200.
OO	334	BCTB	Highway 16 is the northern boundary for this catchment. The eastern boundary with Catchment NN is challenging to delineate as a drainage ditch starting at the farmyard in NE8-T36-R4-W3M may be directing some additional flow west into Catchment OO rather than southeast into Catchment NN. A large slough and wetland east of Range Road 3045 appears to be trapped in part by the grid road. A culvert across the grid could not be found during the culvert survey. Topographic data suggests that this slough should naturally spill to the wetland on the west side of the grid. However, given the small watershed and relatively large storage area a culvert may never have been needed. Alternatively, the area may spill south along the east ditch of Range Road 3045 and cross at another location. The more detailed LiDAR data does not extend far enough north to make a definite determination on these drainage patterns. A more thorough analysis is recommended during the detailed design phase. Flow west of Range Road 3045 will follow the wetlands south. Given the significant storage in this catchment it is likely that it only spills during very wet years. When it does spill, flow following the low ground will intersect the proposed Freeway alignment at approximately Station 5+050 and travel southeast to a large slough that covers much of NE27-35-04-W3. This low ground also represents a portion of the Beaver Creek Terminal basin. Refer to **Section 5.5.1.1.5.4 Beaver Creek Terminal Basin** for more detail on this area. The City of Saskatoon has proposed a stormwater utility crossing at Station 5+000.
PP	24	BCTB	Catchment PP is a small area is a small area feeding the same large slough as Catchment OO. The proposed culverts at Station 4+550 will intercept and direct runoff southeast to the slough.

N/A	-	BCTB LLP	From the Floral Road interchange to Station 4+250 the Freeway is roughly following the catchment boundary. Runoff on the south side of the Freeway alignment flows southeast. West of CN Railroad the runoff reaches some small sloughs which would spill into the Beaver Creek Terminal Basin. East of the CN railroad, flow travels east into the same large pond that Catchment OO drains to. Runoff on the north side of the Freeway alignment flows north along a series of sloughs that may eventually spill into the ponds at the Greenbryre Estates development. Construction of the interchange, connectors, and service roads could redirect significant runoff. The detailed design should carefully consider which direction roadway runoff is directed to.
QQ	86	LLP	Catchment QQ is a relatively small catchment. However, the proposed Floral Road Interchange will fill in a significant low point and slough that appears to store most of the runoff from catchment QQ. Currently, water levels in this low point would need to increase by approximately 3 meters to an elevation of 513.0 before spilling north towards the city. Given the relatively small catchment area it is unlikely this ever occurred. If this area were to spill north, it is intercepted by the CN Railroad. An existing culvert along the CN Railroad could not be confirmed. If flow crosses the railroad it is expected to make its way to the ponds in Greenbryre Estates. Detailed design of the Freeway profile at this location should consider that this area does not drain and will loose much of its current storage to the Freeway. A retention pond may be required to compensate for lost storage.
RR	51	LLP	Catchment RR is a relatively small catchment bound by Highway 11 to the west, Floral Road to the north, and the Proposed Freeway to the southeast. Runoff in this catchment is joined by flow from Catchment SS and makes its way north along the east side of the Grasswood development. An existing culvert could not be confirmed in Floral Road. An old, abandoned roadway has been breached in this location but may still influence the drainage path. Poor natural drainage in the area has resulted in a large wetland and slough that spreads into the Grasswood businesses and on all sides of the roadways. The LiDAR data does not have sufficient coverage of this area to accurately determine a spill elevation or drainage path. The Floral road ditches may influence drainage in this area. Satellite imagery of flooding during May 2012 suggests that the area will be very sensitive to additional runoff from the Freeway and proposed interchange. A retention pond is recommended to account for lost storage and decreased infiltration.
SS	154	LLP	Runoff in catchment SS collects in a series of sloughs that spill northwest and cross the Freeway alignment at approximately Station 1+800 where it joins Catchment RR.

TT	46	LLP	Runoff in Catchment TT flows west through an existing Highway 11 culvert at approximately Station 0+500. Upon crossing the highway flow travels southwest into the South Point acreage development. From there the drainage paths are not well-defined. The overall watershed in the area is dominated by acreage developments and it is likely that they have affected both drainage paths and storage. In wet years runoff would eventually make its way to a local low along Range Road 3051 (between the south ¼'s of Sections 23 and 24-T36-R04-W3). The relatively small size of this downstream wetland suggests substantial upstream storage. Water levels would need to increase 4-5 meters before this area could spill south.

Table G3: Culverts along Saskatoon Freeway

Station	Drainage Path	Areas Drained	Culvert Size
28+600	RDD	› Freeway right-of-way from Station 27+350 to river outfall. › Limited inflow from catchment A and catchment B. Runoff is generally parallel to the Freeway and most flow will come from the Freeway right-of-way itself. It is recommended that culverts direct flow from the median ditch to the outside ditches to reduce risk of bank erosion near the bridge structure. Refer to river outfall section for more detail. The CoS shows a stormwater utility corridor parallel to the Freeway on the south side.	Minor
27+880	RDD	› Freeway right-of-way from Station 27+350 to Station 27+880. › Catchment B. Catchment B naturally drains to a local low point. However, maintaining this drainage pattern would require raising the Freeway profile at this location. Recommend allowing this flow to follow the Freeway ditch directly to the river. Doing so would not require culverts at this location to achieve functional drainage but they are required to meet the maximum 800m spacing standard.	Minor
26+850	SSD	› Freeway right-of-way from Station 26+400 to Station 27+350. The Freeway alignment crosses at roughly the catchment boundary for C-1 and C-2 which divide the Small Swale into north and south sections (split drainage). Trying to maintain the natural catchment boundary would be difficult and has no real benefit. Instead, it is recommended that the Freeway be treated as a revised catchment boundary with no external runoff draining under the Freeway. At least one culvert will be required to drain the median ditch. Additional culverts and drainage considerations may be required during detailed design to accommodate the proposed pedestrian and wildlife crossings.	Minor
25+600	SSD	› Freeway right-of-way from Station 25+250 to Station 25+600. Extra culvert required to meet Ministry standard of maximum 800m culvert spacing. Exact location at the discretion of detailed design.	Minor

25+250 or 24+840	NSD	› Freeway right-of-way from Station 24+780 to Station 25+400. › Catchments E and F. Both of these small catchments naturally drain northeast to the Northeast Swale. No existing culverts were identified downstream along Range Road 3045 to the east or Township Road 374 to the north. Additional runoff from an increase in impermeable area could result in some minor ponding along the grids. Also, the grade of the proposed Freeway profile will send runoff west to the Small Swale instead of its natural drainage path. There are a few options for addressing this: › A short section of back graded ditch can be designed to direct flow from both catchments through culverts at Station 25+250 › A longer back graded ditch can be designed to direct flow from both catchments through culverts at Station 24+840. › All culverts could be eliminated with a ditch that is back graded all the way to the Northeast swale.	Minor
24+100	NSD	› West Freeway right-of-way from Station 21+100 to Station 25+400. › Southwest section of the Highway 41 interchange. › Blackley Road south of interchange. › Catchments G and I. Accurately delineating the extent of Catchment G was challenging due to the limited LiDAR coverage and unknowns associated with the drainage ditch and detention pond in the Aspen Ridge neighborhoods. The need and configuration of this culvert will be dictated by the detailed design of the swale crossing. A short span bridge may negate the need for roadway culverts but associated pedestrian and wildlife crossings might require additional culverts perpendicular to the roadway.	Major
23+300	NSD	› Freeway right-of-way from Blackley Road to Station 23+300. › Portions of the Blackley Road connection. A series of four culverts is required to drain the ditches between the Freeway and proposed access roads / ramps. Directing flow to the north prevents it from having to re-cross the Freeway at Station 21+100.	Minor

22+700	NSD	› Freeway right-of-way from Highway 41 interchange to Blackley Road. › East portions of Blackley Road. › Portions of the Highway 41 interchange. A series of six culverts is required to convey flow across the Freeway and proposed access ramps. These culverts take flow from the ditches and direct it to the proposed detention pond.	Minor
21+900	NSD	› Freeway right-of-way from Station 21+100 to Station 21+900. Three culverts are required to cross the Freeway and a proposed access ramp. Flow should be directed east into the proposed drainage ditch.	Minor
21+100	NSD	› Freeway right-of-way from Station 16+600 to Station 21+100. › North portion of the Highway 5 interchange. › Catchments T, V, W, X, Y, and Z. This is a major drainage path that includes combined flow from numerous catchments and a large section of the Freeway. Much of this Freeway runoff will initially join the upstream catchments which subsequently combine with catchment T before re-crossing the Freeway at this proposed culvert. The CoS was showing a stormwater utility crossing along the main consolidated drainage path prior to the alignment being changed.	Major
20+300	NSD	› Freeway right-of-way from Station 19+880 to Station 20+300. The proposed culvert is located within the wetlands southeast of the Inland yard. These culverts are only required to meet the Ministries standard, maximum 800 m culvert spacing. Flow should be directed to the east ditch where it can be intercepted by the proposed drainage ditch.	Minor
19+880	NSD	› Freeway right-of-way from Station 18+970 to Station 19+880. The proposed culvert is located at existing Township Road 372 (Agra Road). These culverts are only required to meet the Ministries standard, maximum 800 m culvert spacing as runoff could follow the ditches north to the culvert at Station 21+100. Ditch blocks may be required to direct flow into these culverts.	Minor

		The natural drainage path for catchment U crosses the Freeway alignment from east to west then immediately turns north and re-crosses the alignment. Rather than having flow cross the Freeway twice in a short distance it is recommended that flow from catchment U be directed to the east ditch where it can be intercepted by the proposed drainage ditch.	
18+970	NSD	› Freeway right-of-way from Station 18+450 to Station 18+970. › Catchment V. This section of the Freeway has a proposed constant grade of 0.50%. Ditch blocks or back grading may be required to direct flow into the culverts.	Minor
18+450	NSD	› Freeway right-of-way from Station 18+000 to Station 18+450. › Catchment W. This section of the Freeway has a proposed constant grade of 0.50%. Ditch blocks or back grading may be required to direct flow into the culverts. Culverts will drain to a slough west of the alignment and the slough with convey flow south to an existing culvert on Range Road 3043. The CoS has proposed a stormwater utility crossing at 18+150 (across from Range Road 3043 culvert).	Minor
18+000	NSD	› Freeway right-of-way from Station 17+580 to Station 18+000. › Catchment X. This section of the Freeway has a proposed constant grade of 0.50%. Ditch blocks or back grading may be required to direct flow into the culverts. The culvert will drain to a slough west of the proposed alignment and the slough will convey flow to an existing culvert on Range Road 3043.	Minor
17+580	NSD	› Freeway right-of-way from Highway 5 interchange to Station 17+580. › Catchment Y. › Portions of the Highway 5 interchange. This section of the Freeway has a proposed constant grade of 0.50%. Ditch blocks or back grading may be required to direct flow into the culverts. This section of Highway 5 is scheduled to be twinned by 2025 and construction may influence drainage in the area. Flow from the	Minor

		culvert will follow Range Road 3043 north to one of its existing culverts then west into a series of sloughs. The CoS has proposed a stormwater utility crossing on the north end of the Highway 5 interchange at Station 17+000.	
15+500	SSS	› Freeway right-of-way from 14+900 to Highway 5 interchange. › Possibly a portion of the Highway 5 interchange (subject to detailed design). › Catchment AA. Catchment AA is a larger watershed originating in the hills north of Highway 5. Multiple natural drainage paths converge at the proposed alignment. Flow will cross from east to west then northwest to an existing culvert on Range Road 3043. It continues west to a large slough in the Brighton development. Satellite images from 2012 show the upstream farm field acting as a large detention pond right where the proposed Freeway will cross. Detailed design may need to consider the capacity of the grid road culvert and what backed up flow will flood.	Major
-	SSS	Extra culvert required to meet Ministry standard of maximum 800 m culvert spacing. A height of land separates the proposed culverts at Station 15+500 and Station 14+200. Most watershed within both catchments will naturally flow to the proposed culverts. Exact location at the discretion of detailed design.	Minor
14+200	SSS	› Freeway right-of-way from 8th Street interchange to Station 14+900. › Possibly a portion of the 8th Street interchange ramps (subject to detailed design). › Catchment BB. Flow will cross from east to west into a slough that straddles Range Road 3043. A culvert is likely but could not be confirmed during survey. Imagery shows the slough dry some years. Flow continues west to a slough in the Brighton development. This culvert aligns with the CoS's proposed utility crossing location.	Minor
12+820	SSS	› Freeway right-of-way from Station 12+150 to Station 13+820. › Catchment DD.	Minor

		The proposed culvert location aligns with a well-defined natural drainage path. However, the proposed profile at this location is graded north from the high point at Station 12+150 and may require ditch blocks or back grading to direct flow to the culvert. Flow from this culvert and the interchange to the north will travel northwest, intercept the 8th Street ditch, then pass through an existing 8th Street culvert and northwest to a slough in the Brighton development. Range Road 3043 to the west is relatively undeveloped and does not have significant ditches or culverts. It is expected that flow overtops the roadway. The CoS has proposed a stormwater utility crossing roughly 280 m north around Station 13+100.	
-	SSS	Extra culvert required to meet Ministry standard of maximum 800 m culvert spacing. The proposed Freeway high point at Station 12+180 corresponds with the natural catchment break. There are no natural drainage paths between this point and the proposed culvert at Station 12+820. Exact location at the discretion of detailed design.	Minor
11+840	SSS	› Freeway right-of-way from Station 11+400 to Station 12+820. › Catchment EE. The culvert placement corresponds with the proposed profile low point. Flow passing the culvert will be captured by the Range Road 3043 ditch, pass through an existing culvert to the south, then flow northwest to a large slough. When this slough spills flow will make its way to the CoS storm ponds in the Briarwood Neighborhood.	Minor
11+300	SSS	› Freeway right-of-way from Station 10+500 to Station 11+400. › Catchment FF. Catchment FF is a large watershed originating in the hills north of Highway 5. It includes significant upstream storage that retains much of the runoff during dryer years. In wet years when the storage is full a significant flow can be expected at the proposed culvert. Flow follows several defined drainage paths that connect numerous upstream sloughs. Flow combines into a common, well-defined drainage path before crossing Range Road 3042 east of the Freeway. This culvert may currently throttle flow reaching the Freeway but theoretical flood mitigation for the neighboring farmyards could result in improved drainage for the area. After crossing the Freeway, flow will pass through and existing Range Road 3043 culvert to the west then flow northwest to a large slough. When this slough spills flow will make its way to the CoS storm ponds in the Briarwood Neighborhood.	Major

		The CoS has proposed a stormwater utility crossing at this location.	
10+500	SSS	› Freeway right-of-way from Patience Lake Interchange to Station 10+500. › Highway 394 interchange. › Catchment GG. A series of 4 culverts will be required to cross the Freeway and 2 proposed interchange ramps. Catchment GG is a small catchment. Flow will travel west to an existing culvert on Range Road 3043 then continue west to a low area at the intersection of Highway 394 and CP Railroad. When this low areas spills flow travels northwest and would eventually reach ponds in the CoS's Briarwood Neighborhood.	Minor
8+200	BCTB	› Freeway right-of-way from Station 8+250 to Highway 16 interchange. › Portion of the Highway 16 interchange. › Portion of Catchment LL. Drainage in this area was challenging to delineate. Runoff north of the Freeway is believed to flow north first then back around to the proposed culverts at Station 7+300. Refer to Catchment NN description in **Table G2** for more detail. These culverts are expected to primarily manage flow from the roadway with limited runoff from surrounding terrain. Flow from these culverts will go south to a series of small sloughs that spill to one of the larger sloughs in the Beaver Creek Terminal Basin. The CoS has proposed a stormwater utility crossing at this location.	Minor
7+300	BCTB	› Freeway right-of-way from Zimmerman Road interchange to Station 8+200. › East portion of Zimmerman Road interchange. › Northwest portion of the Highway 16 and Patience Lake Road interchange. › Catchments MM and NN. A slough straddling Range Road 3044 just north of the Freeway alignment appears to have a constructed drainage ditch directing flow southeast to a large slough that is part of the Beaver Creek Terminal Basin. Culverts would be placed at this ditch to maintain flow from the Catchment NN slough. The CoS has proposed a stormwater utility crossing at this location.	Minor

5+050	BCTB	› Freeway right-of-way from Station 4+550 to Zimmerman Road interchange. › West portion of Zimmerman Road interchange. › Catchment OO. Much of the runoff in Catchment OO appears to be trapped in a slough and large wetland. LiDAR data suggests that the wetland will spill south towards the Freeway at an elevation around 512. The large slough also appears to be trapped on the east side of Range Road 3045 and may only flow west to the wetland when it can overtop the grid road. Runoff that reaches this culvert will flow south into a large slough that is part of the Beaver Creek Terminal Basin. The CoS proposed a stormwater utility crossing on the original alignment at this station.	Minor
4+550	BCTB	› Freeway right-of-way from CN Railroad to Station 4+550. › Catchment PP. Flow passing the culverts will make its way to the same large slough that the culvert at Station 5+050 drains to.	Minor
N/A	LLP & BCTB	The CN overpass at Station 3+700 appears to lie on the natural catchment boundary that “zig-zags” along the proposed alignment between Station 3+100 and Station 4+000. The profile high point above the CN railroad will serve as a split in the drainage. Roadway southwest of the highpoint will drain southwest while roadway northeast of the highpoint will drain northeast. The existing railroad ditches below the proposed overpass will also retain their current drainage path.	N/A
3+140	LLP	› Freeway right-of-way between Floral Road interchange and CN overpass. › Possibly catchment Q (depending on detailed design of Floral Road interchange drainage). Flow passing these culverts will travel north along a series of small sloughs. An existing culvert along the CN Railroad could not be confirmed. If flow crosses the railroad it is expected to make its way to the ponds in Greenbryre Estates.	Minor
1+800	LLP	› Freeway right-of-way from Highway 11 interchange to Station 2+220. › North portion of the Highway 11 Interchange. › Catchment SS.	Minor

		Flow passing these culverts will join Catchment RR and travel north towards the east Grasswood development. Wetlands and slough straddle Floral Road immediately east of the Grasswood development and satellite imagery shows evidence of historic flooding. A detention pond is recommended to intercept and manage some of this flow.	
0+490	LLP	› Freeway right-of-way from Station 0+000 to Highway 11 interchange. › South half of the Highway 11 Interchange. › Catchment TT. A series of 3 culverts are required to cross the Freeway and interchange ramp. The proposed location is aligned with the existing Highway 11 culverts. Property limits for the existing South Point acreage development are only 120 m downstream and the natural drainage path cuts right through the development. Construction of the Highway 11 interchange increases the impervious area of this catchment resulting in higher peak flow volumes. Detaining these peak flows will be important and can be achieved by sizing culverts to throttle the increased flow and temporarily store it in the upstream Freeway ditches.	Minor

Table G4: Culverts along the re-aligned Highway 41

Station	Drainage Path	Areas Drained	Culvert Size
0+050	NSD	› Highway right-of-way from Station 0+000 to Station 0+100. › Catchment S. A well-defined drainage path intersects the Highway at Station 0+050. However, the existing Highway 41 culvert is at Station 0+100 and feeds a dugout. A culvert was not found on Township Road 374 near this intersection. A culvert is required for the second embankment and the existing culvert may also need to be replaced. Specific location will be at the discretion of the detailed design. Given the size of Catchment S and well-defined drainage path, a larger culvert may be required.	Major
0+800	NSD	› Highway right-of-way from Station 0+100 to Station 0+800. › Catchment R. An existing highway culvert is at this location and may need to be replaced. At least 2 culverts will be required to pass flow through the new embankments.	Minor
1+000	NSD	› Highway right-of-way from Station 0+800 to Station 1+580. › Catchment Q. An existing highway culvert is at this location and may need to be replaced. At least 3 culverts will be required to pass flow through the new embankments.	Minor
N/A	NSD	› Roughly 400 m of Highway right-of-way. › Catchment P. At least 1 new culvert will be required on existing Highway 41 just southwest of the interchange. Placement will be influenced by the detailed design of the transition from double to single lane. Flow passing this culvert is added to catchment O.	Minor
1+650	NSD	› Portion of highway right-of-way from Station 1+000 to Station 1+580. While not required to pass flow from any significant catchment, this pair of culverts can manage some interchange runoff and meet the maximum culvert spacing of 800 m.	Minor

2+630	NSD	› Highway right-of-way from Station 1+650 to Station 2+630. › Catchments O and P. Pair of culverts at a fairly well-defined drainage path.	Minor
3+030	NSD	› Highway right-of-way from Station 2+630 to Station 3+030. › Catchment N. Pair of culverts for small catchment.	Minor
3+570	NSD	› Highway right-of-way from Station 3+030 to Station 3+740. › Catchment M. Pair of culverts for small catchment.	Minor
4+170	NSD	› Highway right-of-way from Station 3+740 to Station 4+200. › Catchment L. In very wet years this pair of culverts is expected to manage flow from a large catchment. If the upstream storage is full the culverts could receive substantial flow. Refer to **Table G2** for details regarding Catchment L.	Major
4+500	NSD	› Highway right-of-way from Station 4+200 to Station 4+500. › Catchment K. Pair of culverts for small catchment.	Minor
5+300	NSD	› Highway right-of-way from Station 4+500 to Highway 41 interchange. › Freeway right-of-way from Station 16+500 to Highway 41 interchange. › North portion of Highway 5 interchange. › Existing Highway 41 overpass. › Catchments J, T, U, V, W, X, Y, Z. In addition to managing flow from Catchment J, this pair of culverts will pass flow from the proposed drainage ditch to the proposed detention pond northeast of the Re-aligned Highway 41 interchange.	Major

Table G5: Culverts along Highway 16

Distance (m)	Drainage Path	Areas Drained	Culvert Size
North 1830	SSS	› Ditch and area between CP Railroad and the extension of the proposed highway 16 service road. A single culvert at the end of the service road is required (where it connects to the Patience Lake highway service road). Flow will make its way north and could eventually reach the storm ponds in the Briarwood neighborhood.	Minor
North 1125	BCTB	› The portion of the interchange between Catchment MM and existing Patience Lake Road. Four culverts will be required to cross the service road, connector, and two highway lanes. There are an existing pair of culverts on Highway 16 at this location. It is expected that they will need to be replaced. Flow travels northwest to a culvert on Melville St. A constructed drainage ditch appears to direct flow from this culvert south into catchment NN. The location of a CP Railroad culvert could not be confirmed at this location. Land on both sides of the highway right-of-way show significant standing water and the additional embankments will further alter drainage. Significant drainage improvements may be required for this area.	Minor
South 50	BCTB	› Northeast portion of Highway 16 interchange. › Most of Catchment LL. There are a pair of existing Highway 16 culverts at this location. Both will likely be replaced in addition to a third culvert for the service road.	Minor
South 870	BCTB	› South portion of Highway 16 interchange. › A small portion of catchment LL. There are several existing culverts at this location for both the highway and the grid road intersections. It is expected that all existing culverts will be replaced, and 5 new culverts will be required.	Minor
South 1340	BCTB	› Roughly 800 m of the new Highway 16 right-of-way. › Catchments HH and II. The existing culverts align with a CP Railroad culvert 250 m north. They are feeding a dugout which spills 150 m southeast to a well-defined drainage ditch. The new proposed Highway 16 embankments will fill the	Minor

		slough. Four culverts will be required to pass the upstream flow and capture flow from the highway ditches to the northwest. Runoff from the combined catchments and roadways could be significant. However, the current Railroad culvert is likely throttling flow from the catchments. One additional culvert will be required upstream on the service road where the well-defined drainage path in Catchment II crosses.	
South 2330	BCTB	› Catchment JJ. A pair of culverts adjacent to the slough in Catchment JJ. Given the small catchment size and available storage these culverts will see little flow. However, they are required to meet the maximum culverts pacing of 800 m.	Minor
South 3620	BCTB	› Roughly 500 m of Highway 16 right-of-way. › A portion of the Floral Road interchange. › Flow from the East Floral Industrial Park. › Catchment KK. A pair of culverts at this location will restore the natural drainage path. Currently flow reaching the Highway 16 ditch is traveling 700 m southeast to an existing pair of culverts. These culverts are filling a large slough in SW 26-35-4-W3. The NRCAN topographic data suggests that restoring this natural drainage path would send flow to the large slough in NE 27 and SE 34-35-4-W3. Further investigation and consideration are recommended for detailed design.	Major

Table G6: Culverts along proposed access roads and connectors

Access Road Location and Areas Drained	Drainage Path	No. Minor Culverts	No. Major Culverts
Central Avenue south connector: At least one culvert will be required to convey runoff west to the south section of the Small Swale. This runoff includes Catchment D and the east side of the Central Avenue connector. More than one culvert along Central may be desirable depending on detailed design.	SSD	2	-
Blackley Road north connector: This will be the first culvert downstream of the proposed detention pond. It will pass flow from Catchments T through Z, as well as roughly 6.5 km of Freeway right-of-way, all of re-aligned Highway 41, and several interchanges. It may be desirable to use this culvert to throttle and control flow spilling from the proposed detention pond.	NSD	-	1
Blackley Road south connector: Culvert to handle flow from catchment I.	NSD	1	-
Highway 41 access roads: Located southwest of the intersection of Highway 41 and re-aligned Highway 41.	NSD	1	-
8th Street connectors: Culverts to handle flow from Catchments BB and CC. Both areas are relatively small.	NSD	2	-
Updated Patience Lake Road and east connector: To the east an existing culvert may need to be replaced and the connector will need a corresponding culvert. These will handle flow from Catchment HH. Additional culverts are expected to receive minimal flow.	NSD	5	-
Patience Lake connection to Market Dr: Culvert required at the slough south of the Highway 16 service road intersection. Another culvert will likely be required near the connection to Market Drive.	SSS	2	-
Highway 16 service road connection to Range Road 3043: One culvert required at this intersection. Flow from a portion of Catchment LL will cross southeast then cross Highway 16.	BCTB	1	-
Floral Road west connection (to Highway 16 & Floral Road interchange): A culvert will be required at the intersection of Range Road 3042.	BCTB	1	-
Zimmerman Road north of interchange (including connectors): Most of this roadway lies within catchments NN and OO, both of which are relatively flat with significant local ponding. North of Highway 16 the roadway is expected to be tied into the CoS Storm sewer system.	BCTB	7	-
Zimmerman Road south of overpass: Minimal flow through these culverts is expected. They will help prevent localized ponding.	BCTB	2	-
Boychuck Drive east connection: This road runs generally parallel to the direction of flow. Little flow is expected, and culverts are only required to prevent localized ponding.	BCTB	3	-

Boychuck Drive west connection (to Freeway): These culverts drain approximately 115 ha of farmland between the Freeway and access road. The center culvert will be larger and is expected to pass flow from catchments QQ, RR, and SS as well as Freeway right-of-way from Highway 11 interchange to Station 2+220, and the Floral Road interchange.	LLP	2	1
Floral Road west connection: Culvert required to pass flow from Catchments SS and RR as well as Freeway right-of-way from Highway 11 interchange to Station 2+220, North portion of the Highway 11 Interchange, and possibly some of the Floral Road interchange (depending on detailed design). A detention pond is recommended upstream so this culvert may be used to throttle flow.	LLP	1	-
Floral Road east connection: Culvert required to pass flow from catchment QQ and a portion of the Floral Road interchange.	LLP	1	-

Table G7: Interchange culverts

Interchange	Culverts	Notes
Central Avenue	2	Runoff can be directed west along the Freeway ditches to the Small Swale.
Blackley Road overpass	0	Runoff from this overpass can follow the Freeway ditches to the proposed culverts at Station 22+700 and Station 23+300
Realigned Highway 41	5	Wherever possible, flow should be directed to the proposed detention pond to the north.
Existing Highway 41 overpass	3	Upgrade/replacement of 3 existing culverts may be required.
Highway 5	12	Highway 5 straddles a major catchment boundary with south watershed flowing to the large sloughs in Brighton and north watershed flowing to the Northeast Swale. Catchment Z is cut off by the interchange. Diverting runoff from catchment Z to the south will alter it's natural drainage path but will be easier than trying to cross the interchange.
8th Street	10	Runoff from Catchment CC and the adjacent service road is expected to pass through the interchange. It may be possible to divert this flow north along the Freeway ditch instead.
Patience Lake Road	5	Runoff should be directed northwest where possible.
Highway 16	N/A	Refer to Highway 16 table above.
Floral Road & Highway 16	6	Several existing culverts will need to be replaced.
Zimmerman Road	5	Culverts may pass some additional flow from a portion of Catchments NN and OO as well as some ditch flow from Zimmerman Road.
Floral Road	4	Flow from Catchment Q is expected to pass along the northeast side of the interchange.
Highway 11	4	Culverts required at the interchange to meet maximum 800m culvert spacing.

APPENDIX G

Bridge Option Study Reports

Leonhardt, Andrä und Partner

Functional Planning Study for the Saskatoon Freeway Project

Phase 1

Inhaltsverzeichnis

Seite

1 Introduction

LAP has been contracted by SNC Lavalin to perform an option study for the Saskatoon Freeway Project As part of the functional planning study we were asked to assess the possible bridge types for a crossing of the South Saskatchewan River North of the city of Saskatoon shown in the circle below. This river crossing is part of a new Freeway to be planned around the City of Saskatoon. It is a signature element of the project.

The crossing has a span length of 460 m from top of bank to top of bank. The river span at the water's edge is about 230 m. The elevation difference from top of bank to water's edge is about 35m on the West approach and 20 m on the East approach. The river is likely 10m deep, on average.

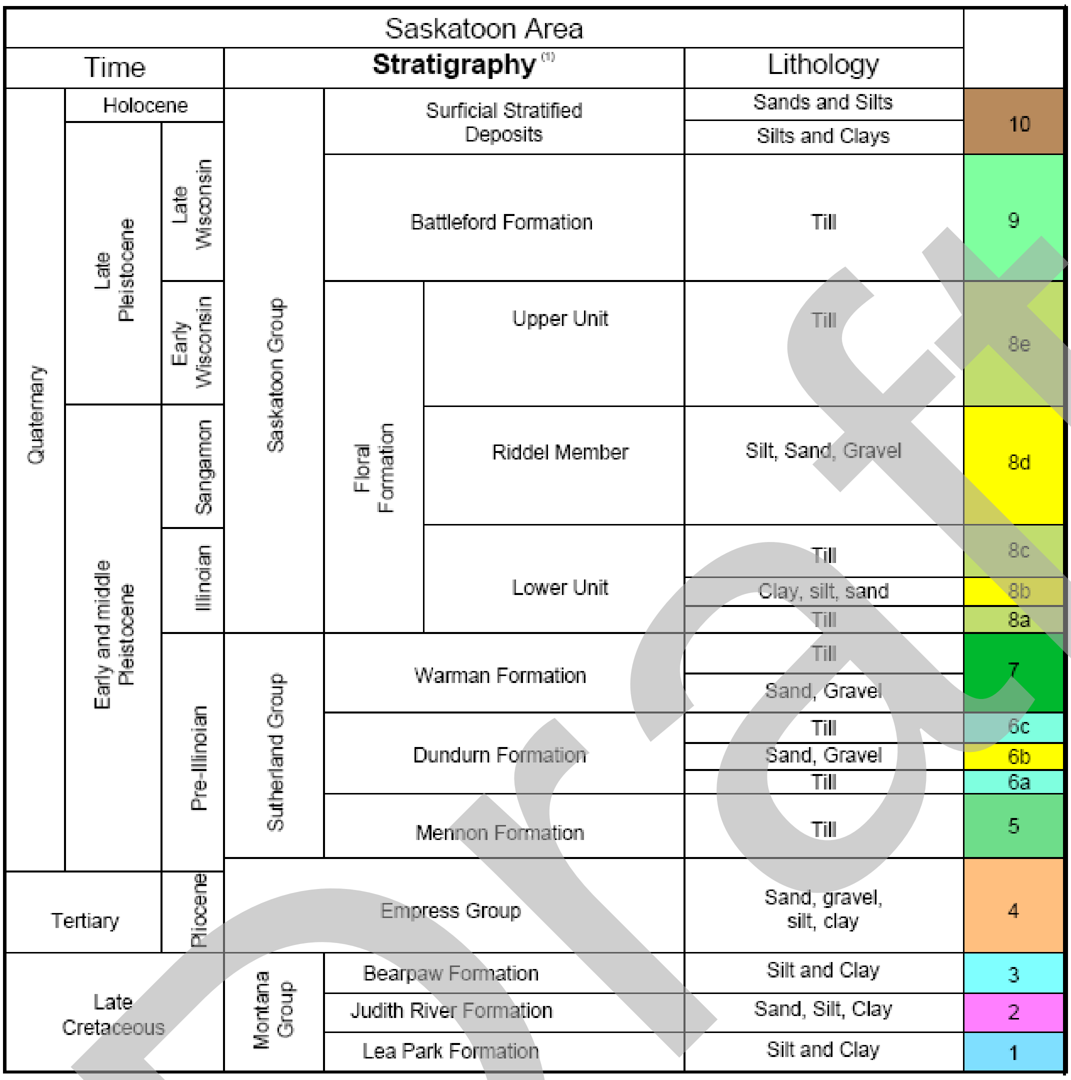
The valley walls are prone to landslide activity and often the Ministry will cut the slope on the approach and place the abutments part way up the valley walls. These abutments tend to have stability problems and become a possible future maintenance issue due to creep movements from the landslides. Also, the Valleys are known cultural and heritage sensitive areas, so the Environmental aspects may dictate a top of bank to top of bank solution.

Also, it is becoming more difficult to place multiple piers in the river due to Environmental and fisheries issues.

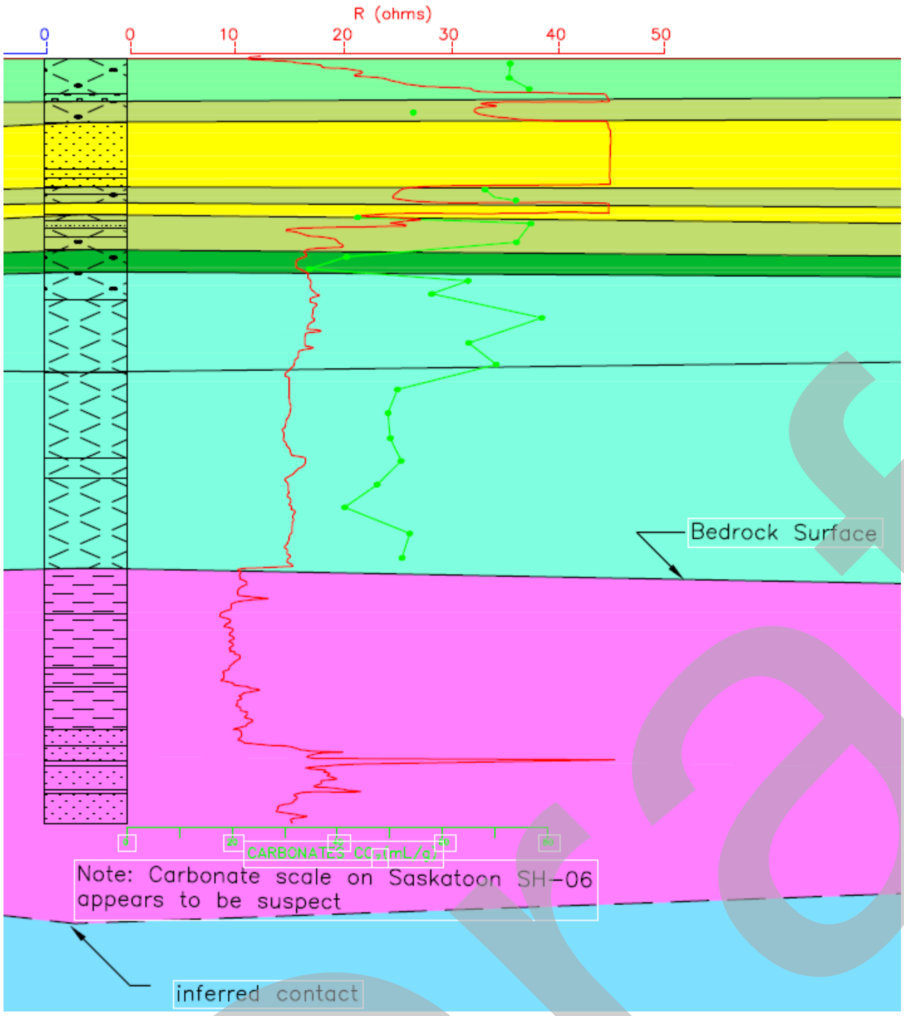
The typical bridge type usually selected in Saskatchewan is plate girder with multiple spans in the river like the one shown below:

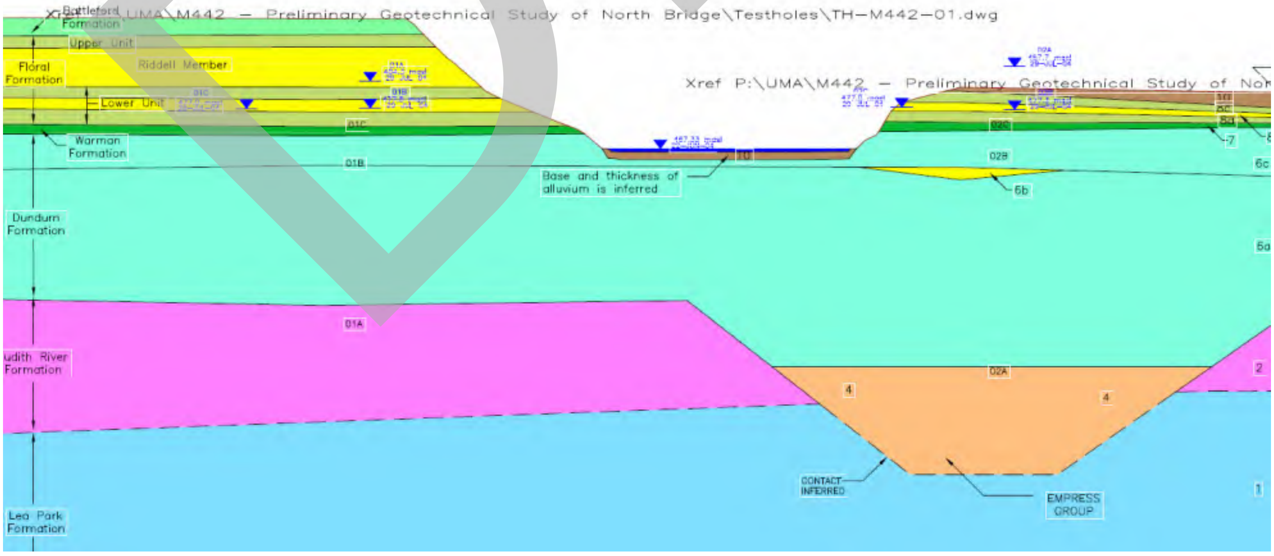
Given the Environmental and landslide type risks, the Ministry may want to look at options for a signature bridge unlike what is currently constructed in Saskatchewan.

2 Geotechnic



Saskatoon Area							
Time			Stratigraphy (1)			Lithology	
Quaternary	Holocene		Saskatoon Group	Surficial Stratified Deposits		Sands and Silts	10
						Silts and Clays	
	Late Pleistocene	Late Wisconsin		Battleford Formation		Till	9
		Early Wisconsin		Floral Formation	Upper Unit	Till	8e
	Early and middle Pleistocene	Sangamon			Riddel Member	Silt, Sand, Gravel	8d
		Illinoian			Lower Unit	Till	8c
						Clay, silt, sand	8b
						Till	8a
		Pre-Illinoian	Sutherland Group	Warman Formation		Till	7
						Sand, Gravel	
				Dundurn Formation		Till	6c
						Sand, Gravel	6b
						Till	6a
				Mennon Formation		Till	5
Tertiary		Pliocene	Empress Group			Sand, gravel, silt, clay	4
Late Cretaceous			Montana Group	Bearpaw Formation		Silt and Clay	3
				Judith River Formation		Sand, Silt, Clay	2
				Lea Park Formation		Silt and Clay	1


R (ohms)
0
0
10
20
30
40
50
Bedrock Surface
CARBONATES CO2 mL/g
Note: Carbonate scale on Saskatoon SH-06 appears to be suspect
inferred contact


Xref P:\UMA\M442 – Preliminary Geotechnical Study of North Bridge\Testholes\TH-M442-01.dwg
Xref P:\UMA\M442 – Preliminary Geotechnical Study of No
Battleford Formation
Upper Unit
Riddell Member
Floral Formation
Lower Unit
Warman Formation
Dundurn Formation
udith River Formation
Lea Park Formation
01A
01B
01C
02A
02B
02C
Base and thickness of alluvium is inferred
6b
6c
6a
7
2
4
4
1
CONTACT INFERRED
EMPRESS GROUP

3 Options

3.1 General

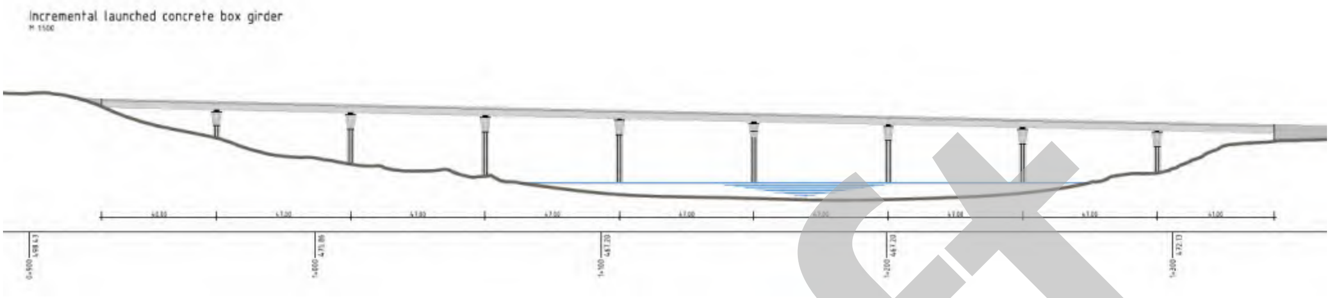
All the options below are described in more detail in the matrix, additional information such as examples and better quality sketches are listed below

Tentative roadway arrangement:

All options shown below allow to add a future MUP on a light steelwork, attached to the side

3.2 Option 1- Prestressed Concrete Girder

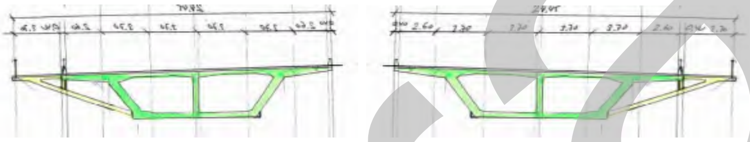
3.2.1 Layout



Girder Bridge with 10 spans, 41-7x47-40 = 410, four piers in the water, 2 at shore and 2 at westbank

3.2.2 Cross Sections

A) Twin Box Girder, prestressed.



B) Feasible alternative would be AASHTO Girder Bridge (Precast T- beams with 45m spans)

3.2.3 Construction

A) Twin Box Girder would allow incremental launching from one side,

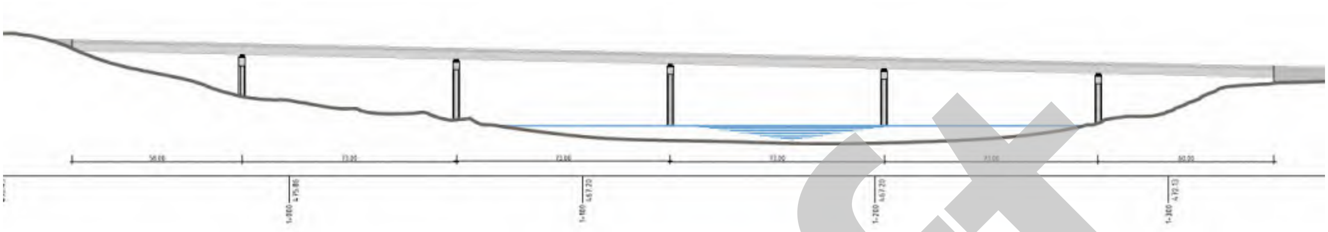
B) PC girders would need to be placed by cranes, which is possibly not in accordance with environmental restriction (access all along needed)

Concrete boxes, incrementally launched, would be the first choice in Europe, since it is the most economical and robust type for shorter spans. But many piers in the water increases constructability problems

MUP added later on light steel structure –this is valid for all options below

3.3 Option 2 – Steel Composite Girder

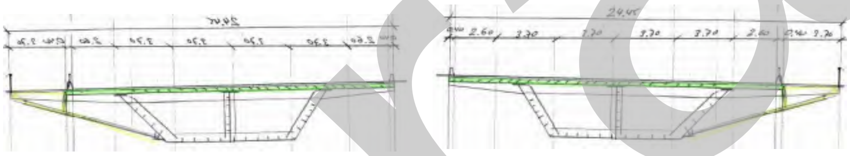
3.3.1 Layout



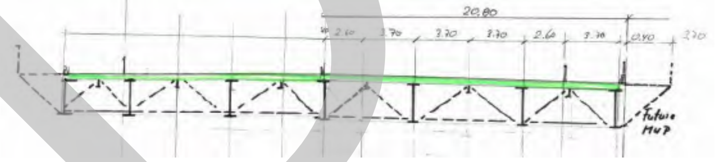
Girder Bridge with 6 spans of 60-4x73-58 = 410m with 2 Piers in the water, two on shore, one on the westbank

3.3.2 Cross Section

A) Composite Box Girder (Twin Boxes) --> European preference



B) Multiple Steel Plate Girder --> likely local preference



for Alt A)

3.3.3 Example

for Alt 1

for Alt 2

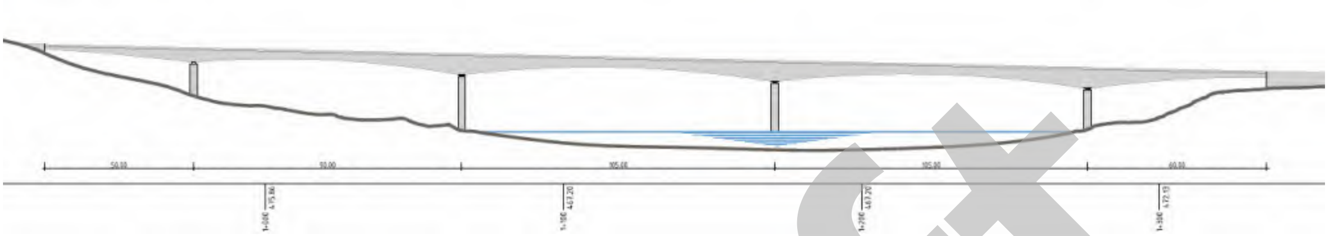
3.3.4 Construction

A) Box girders and steel plate girders with constant depth could be launched from one side.
Note, that bottom flanges needs to be welded for launching

B) Steel plate girder could be placed by cranes in a spanwise erection on auxiliary piers, but that’s possibly not in accordance with environmental restrictions, since access is needed all along.

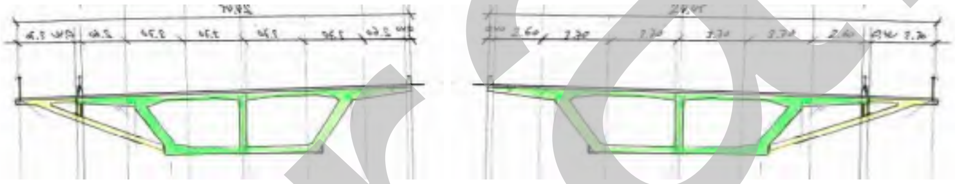
3.4 Option 3 – Haunched Prestressed Concrete Girder Bridge

3.4.1 Layout



Concrete box girder with 5 spans, 60- 2x105-90-50 = 410, 1 pier in the water, 2 on shore, 1 in the westbank

3.4.2 Cross Section



Inclined webs provide some geometrical problems with the haunch, probably vertical webs are more appropriate

MUP added later on light steel structure

3.4.3 Example

Rheinfelden, River Rhine, Germany, Mainspan 101m

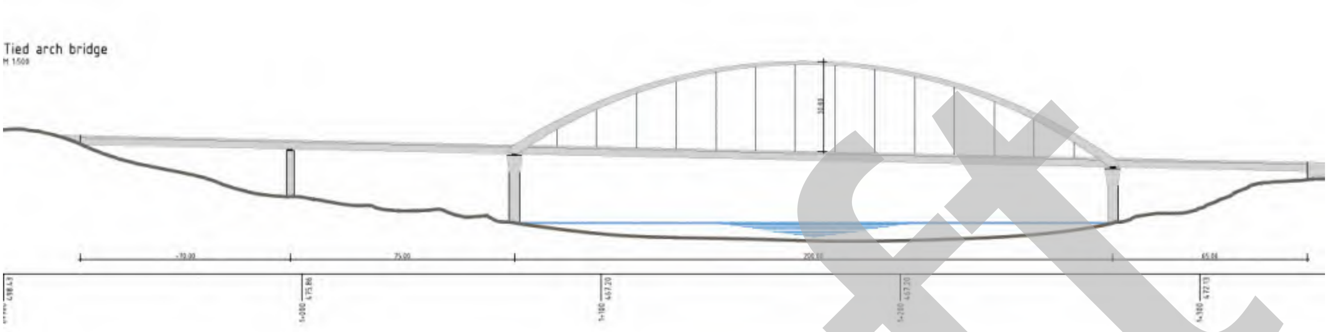
3.4.4 Construction

CIP Segmental Free Cantilever Construction by a Formtraveler.

Delivery of material at the piers (access needed)

3.5 Option 4 – Tied Arch Bridge

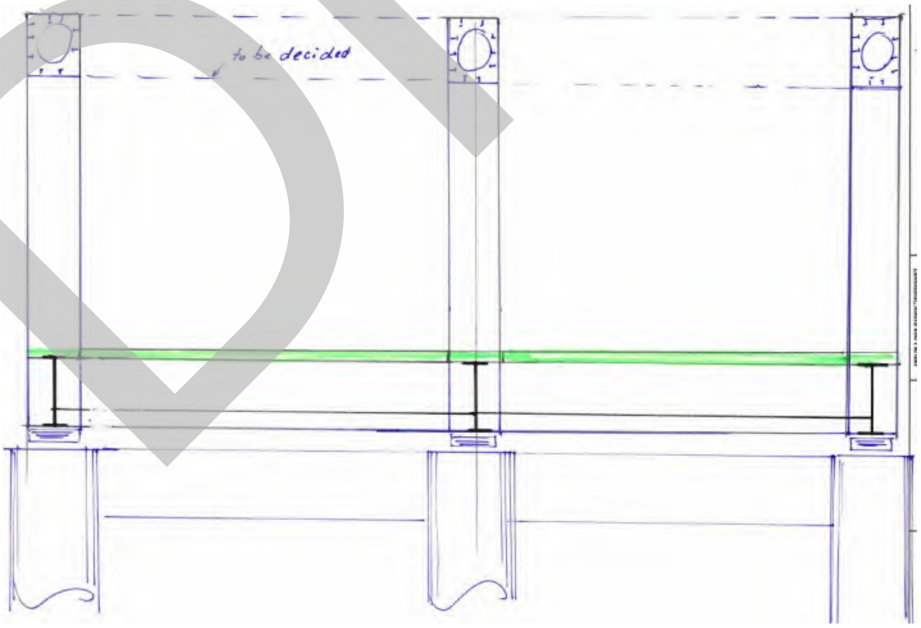
3.5.1 Layout



Tied arch bridge with spans of 65-200-75-70 = 410, 2 piers at shore, 1 pier in the west bank, none pier in the water

Note: Piers at shore might be a bit too close to the water, with a 215m span this situation would improve and the cost would increase only marginal

3.5.2 Cross Section



The example below does not have any crossbeam on top. However, with a span over 200m those may very well be needed.

Other alternatives are twin arches (e.g a doubling of the below shown Nijmegen Bridge) or inclined arches as shown for option 6 below

3.5.3 Example

A) Tripple Arch

B) Twin Arch

Two of those would be needed for Option 4

C) Inclined Arches

Waterdale Bridge, Edmonton

Here the legs are carried down to the ground, for a true tied arch bridge they rest on the pier, however, the appearance is similar

3.5.4 Construction

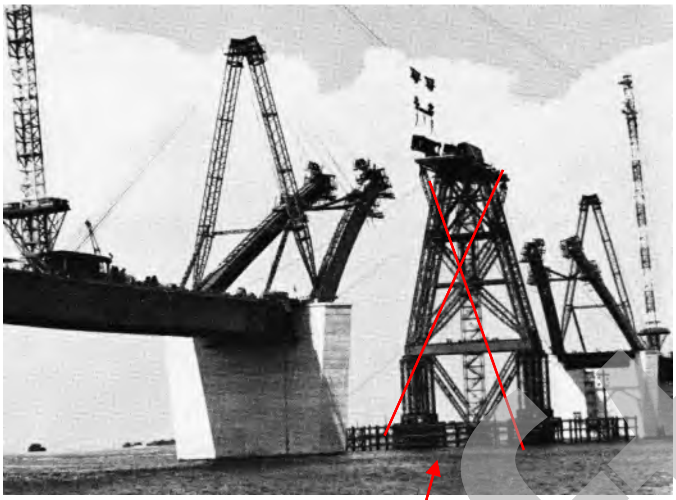
Alt A:

- Incremental launching of plate girder with two auxiliary pier in the water (additional steel in the longitudinal girder needed),
- placement of roadway slabs (precast panels),
- casting of stiches
- erection of arches on the finished deck

Alt B:

Free cantilever erection, supported by temporary stay, deck and arch being erected parallel

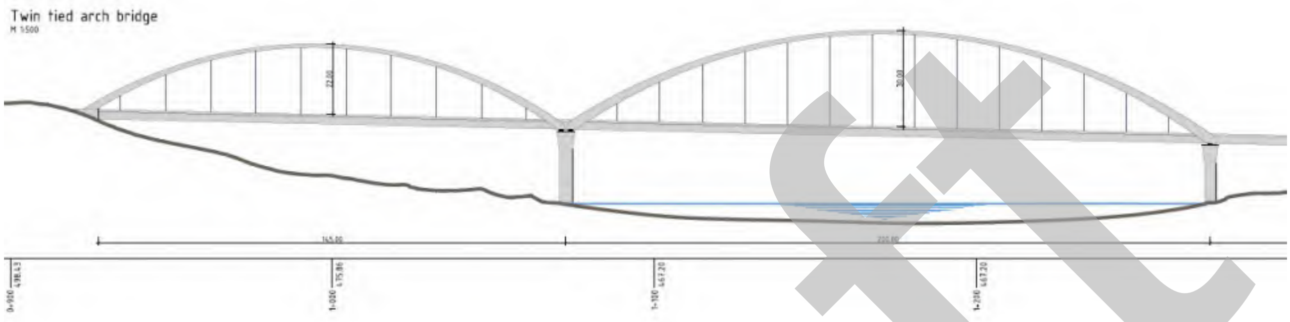
Example form Fehmarnbelt crossing – centre pier not needed for Saskatoon



This auxiliary pier is not required

3.6 Option 5 – Tied Dual Arch Bridge

3.6.1 Layout



Same as Option 4, but with another arch to bridge the westbank pier-free, resulting in spans spans of 65-200 *) -145= 410

*) better go to 215 m

3.6.2 Cross Section

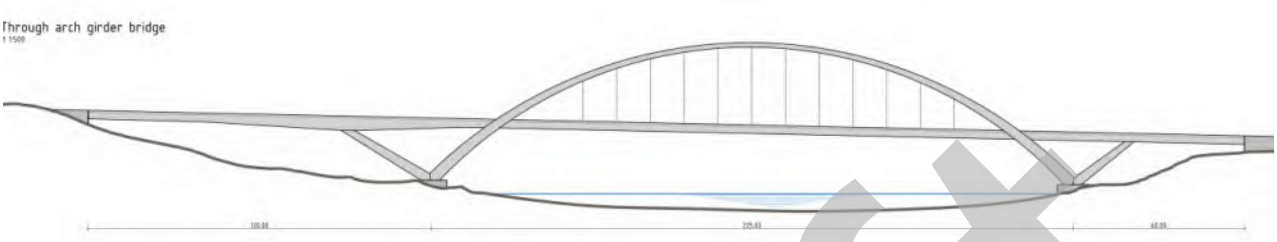
see option 4 above

3.6.3 Construction

- Incremental launching of plate girder with two auxiliary pier in the water (additional steel in the longitudinal girder needed),
- one in the westbank, placement of roadway slabs (precast panels),
- casting of stiches
- erection of arches on the finished deck

3.7 Option 6 – Through Arch Bridge

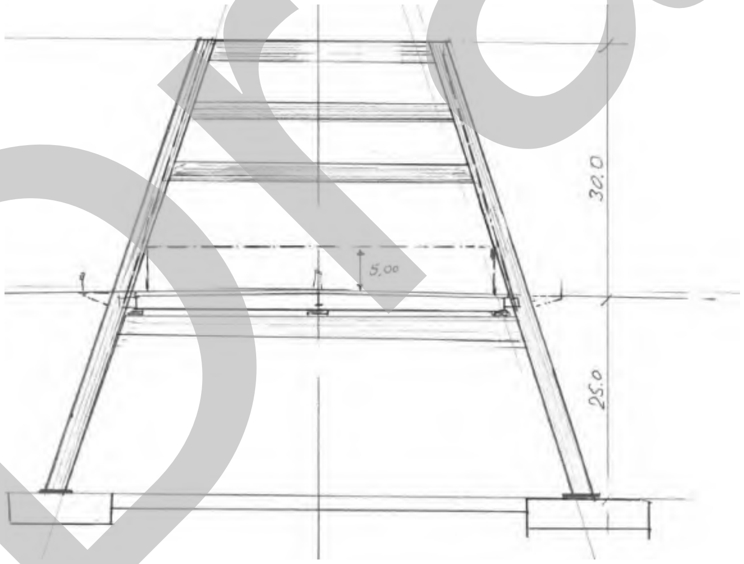
3.7.1 Layout



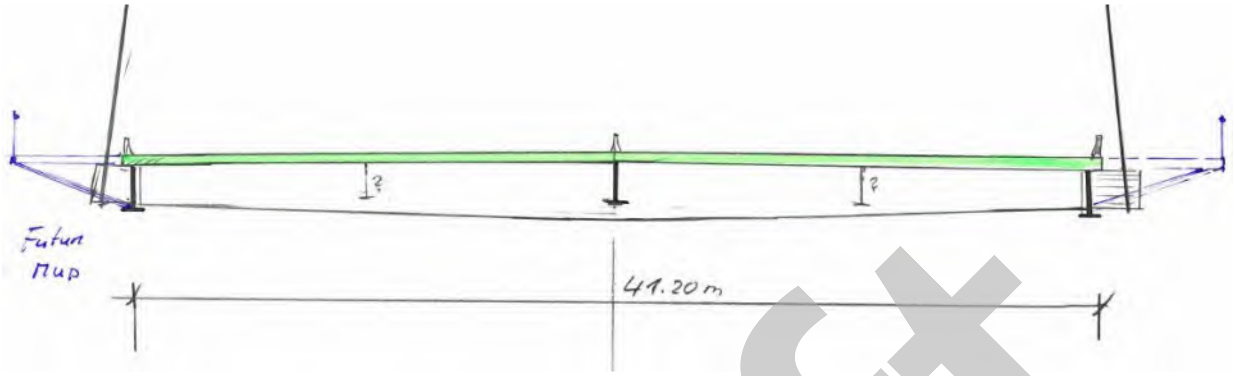
Through Arch Bridge with spans of 60-225-120= 410. Only two piers/foundations needed

The large span on the west bank requires haunched plate girders

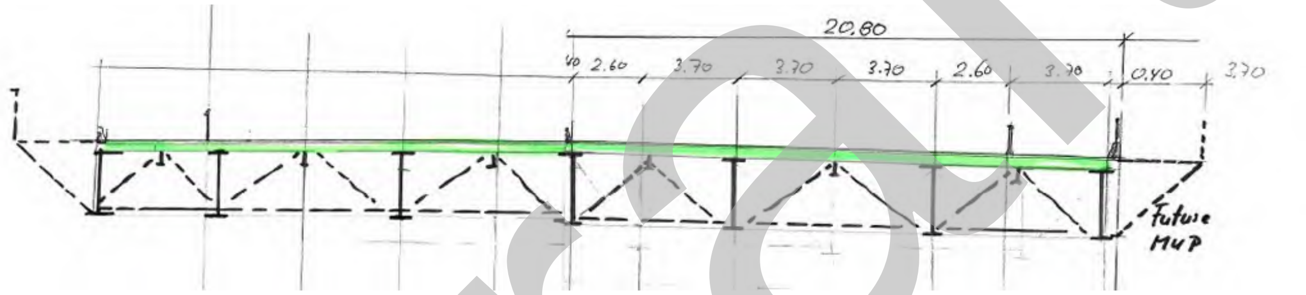
3.7.2 Cross Section



Cross section at the arch: Two inclined arches

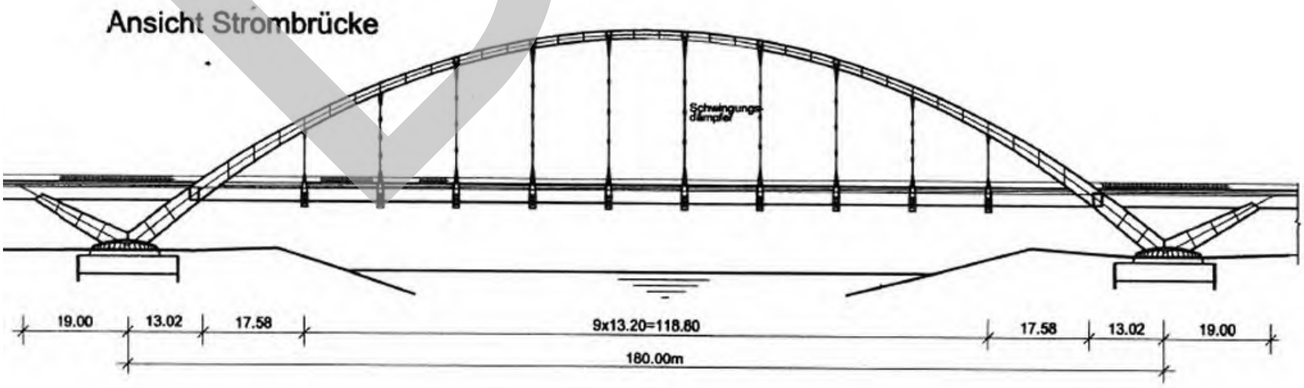


Alternative cross section at the sidespans



3.7.3 Examples

A) Saalebrücke Beesedau



Competition Design Svinesund Bridge

Layout under the deck is diferent, but above the deck very similar to option 6

3.7.4 Construction

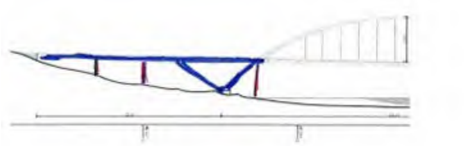
Alt A)

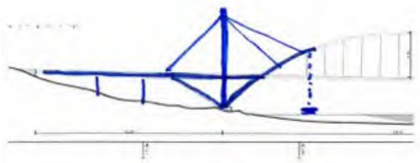
Because of the required haunch, incremental launching of the sidespan West is on a first view not possible and the plate girder needs to be erected on auxiliary piers by cranes.

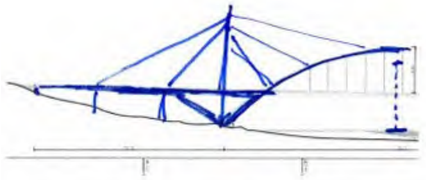
The mainspan could be launched from the east, but two auxiliary piers are needed in the water (also additional steel in the longitudinal girder needed). Therefore a span-wise erection on aux piers is most likely the best choice, followed by placement of roadway slabs (PC Panels), casting of stiches and erection of arches on the finished deck

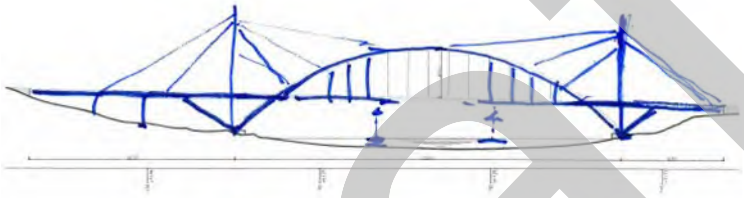
Alt B)

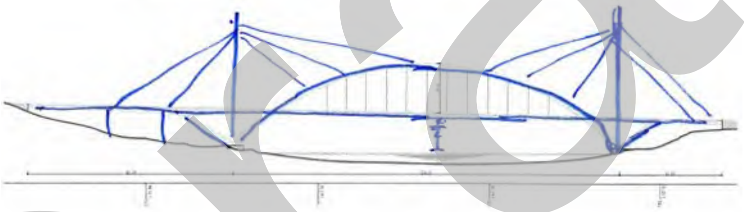
Free Cantilever erection supported by temporary stay and Tower, small Segments delivered to lifting point and assembled a site





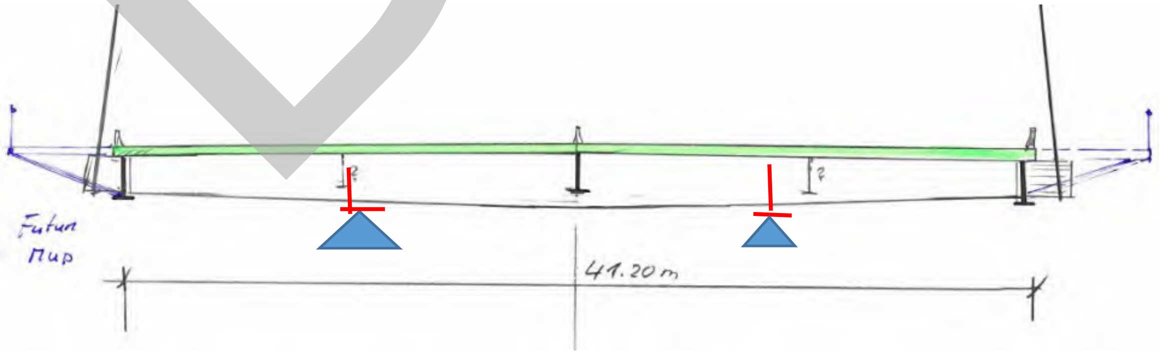




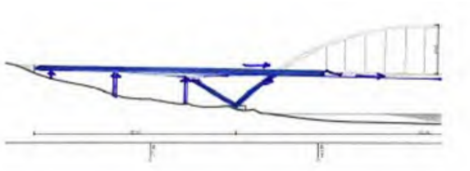


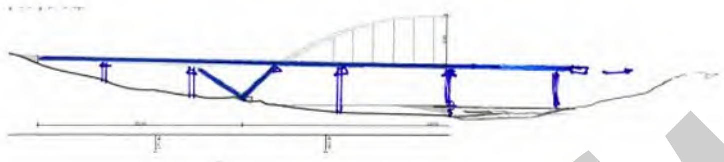
Alt C)

However, if the launching bearings are not placed under the edge girder, but under the secondary beams, launching all over the crossing from west to east would be possible.



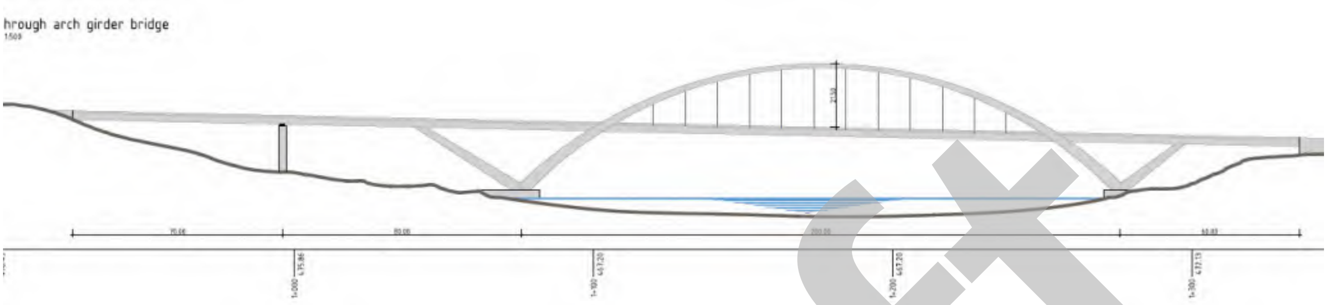
Of course, some temporary piers are needed in a distance of about 50m





3.8 Option 7 - Through Arch Bridge

3.8.1 Layout



Through Arch Bridge with spans of 60-200-80-70= 410.

In order to reduce the length of the sidespan on the westbank, another pier is placed in the banks

Cross Sections, Examples and construction as for Option 5. One temporary pier less is needed

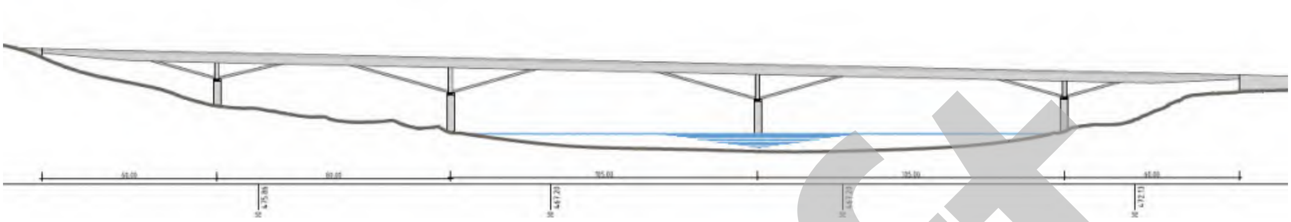
3.8.2 Construction

As option 6 above, but because the edge girder has a constant depth, launch bearing can be placed there.

On the other hand, for connection of the underdeck struts to the edge girder it may very well be of advantage, to have the launching bearings under secondary girders further inside.

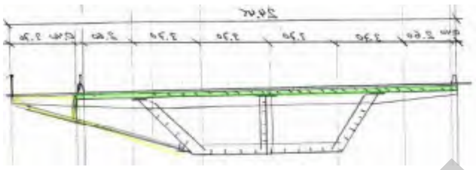
3.9 Option 8- Braced Box Girder Bridge

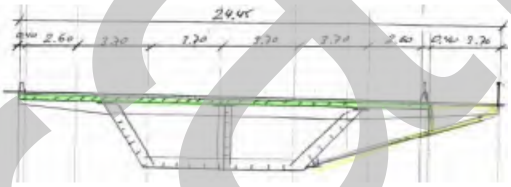
3.9.1 Layout



Braced girder with span of 60-105-105-80-60= 410m

3.9.2 Cross Section





3.9.3 Example

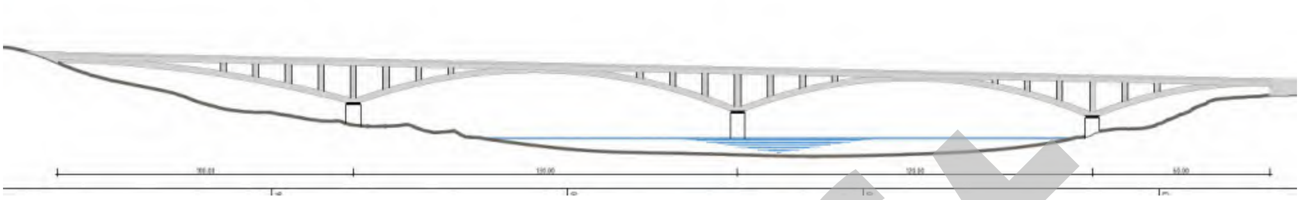
The example Sundsvall has only one composite box girder, but due to the extreme width, we would need two individual box girders

3.9.4 Construction

Erection of box girders on auxiliary piers, span by span or incrementally launched, erection of bracing under the finished deck

3.10 Option 9 – Spandial Arch Bridge

Layout

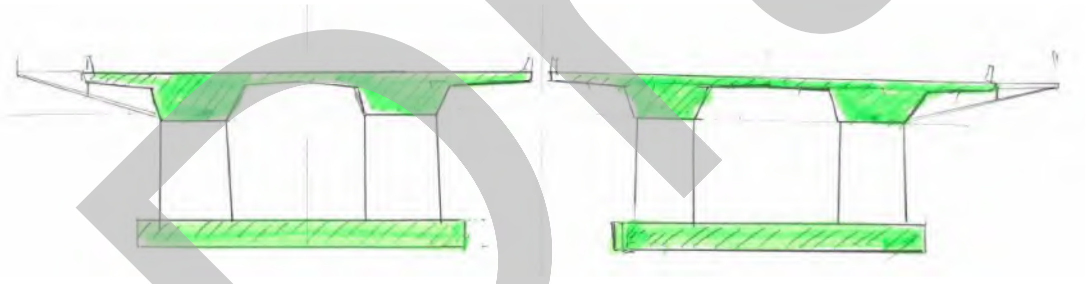


Underdeck Arch Bridge with spans of 60-105-105-80-60= 410m

These type of arch bridges are usually made of concrete, but also steel boxes and steel columns, in combination with a composite deck, are feasible and has been constructed

3.10.1 Cross Section

A) Concrete



B) Steel Composite would be also a feasible option with piers in concrete or steel

3.10.2 Examples

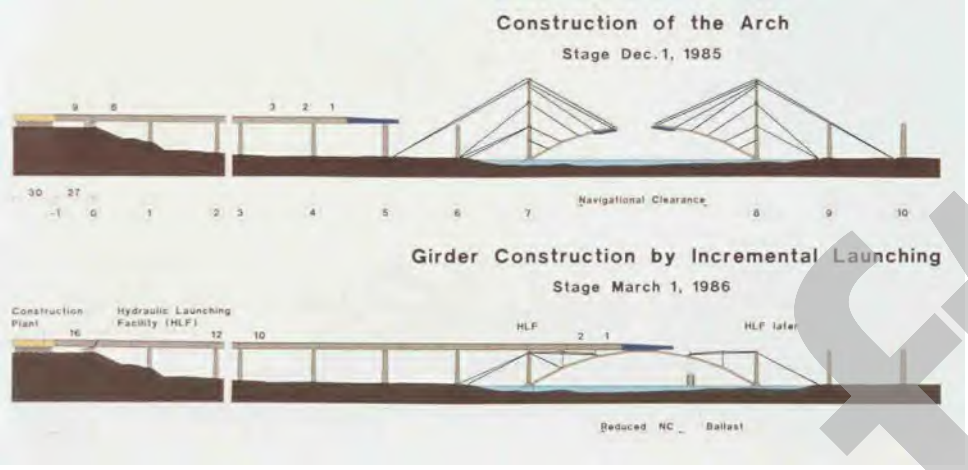
Neckarbrücke Hochberg near Stuttgart (last century)

Filstal Option Study (modern type)

3.10.3 Construction

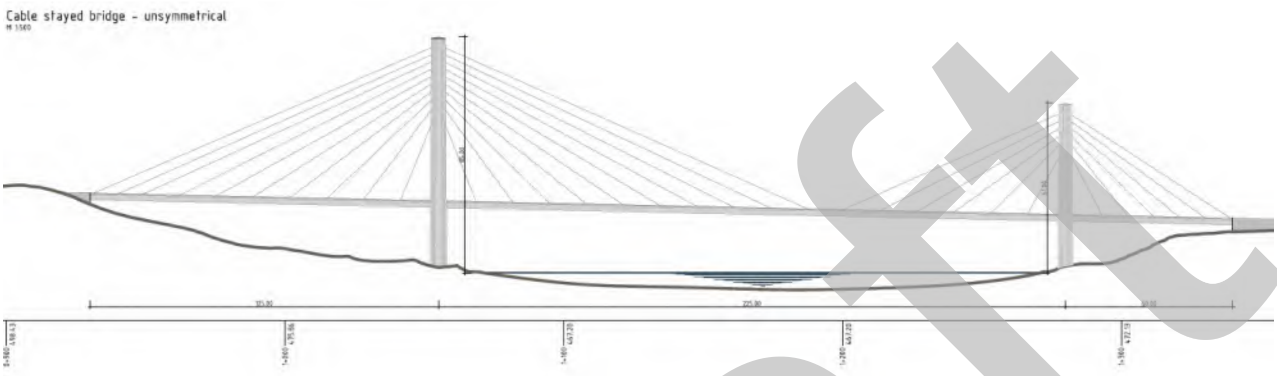
- arch in segments on auxiliary piers or stay cable supported
- Erection of Piers
- Steel Grid Placement span by span or incrementally launched
- Roadway slabs (PC Panels)

Construction Example _ Mainbridge Veitshöchheim

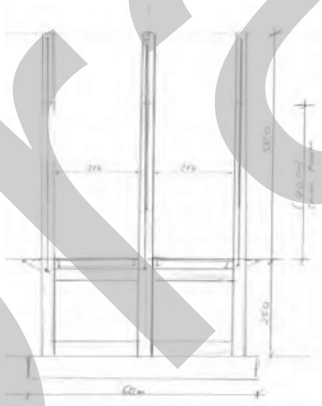


3.11 Option 10 – Unsymmetrical Stay Cable Bridge

3.11.1 Layout



Unsymmetrical stay cable bridge with spans of 60-225-125 = 410m



It is desirable to place the two pylons on shore and avoid piers in the critical hill on the left. The logical consequence is an asymmetrical two-tower cable stayed bridge.

Whether the towers will have two legs or three needs to be developed further. Also the cable arrangement can be modified from the fan type shown above, it could be a harp type or bundled cables. Those (the bundled) need, however, a rather deep superstructure to cope with bending between the cables.

3.11.2 Tower Material and Stay Anchorages

Material for the tower could be concrete or steel (boxes). In order to keep the dimensions small, stay anchorages saddles would have to be arranged as saddle

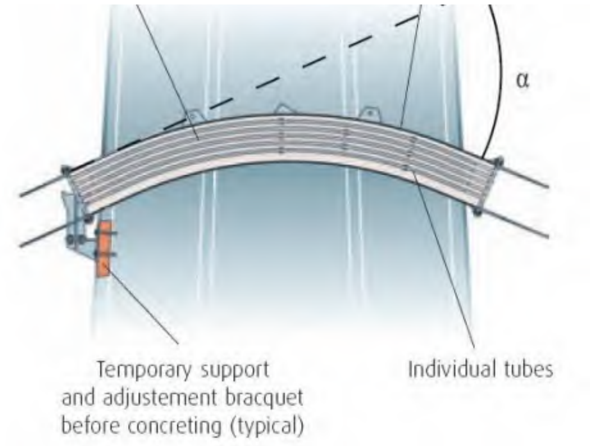


Fig: Freyssinet Saddle

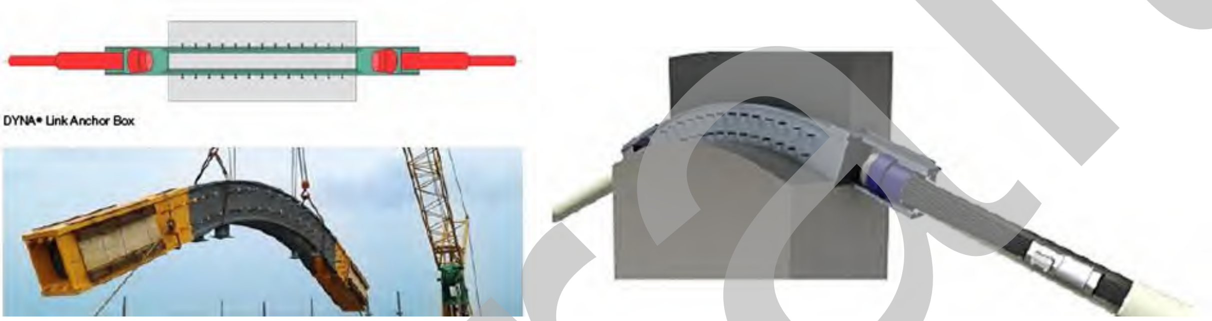


Fig: Dynalink Box Type saddle from DSI – as used at Champlain Bridge

or fork type anchor connected to plate extensions

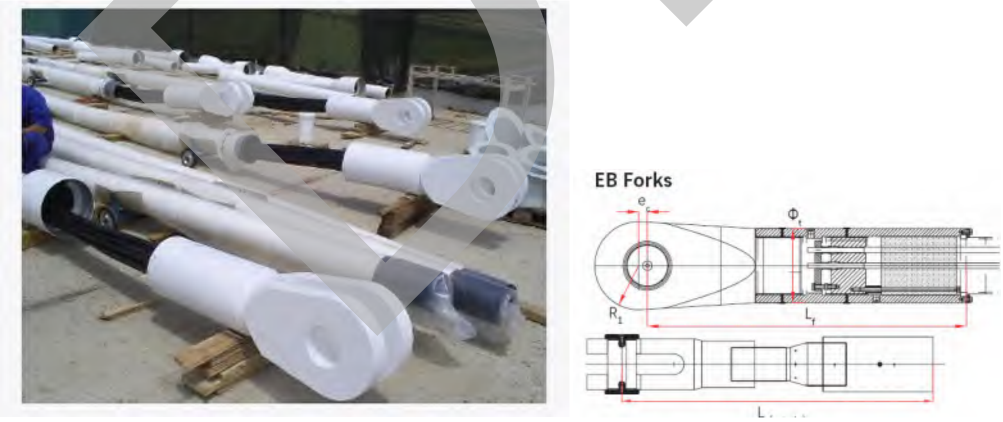
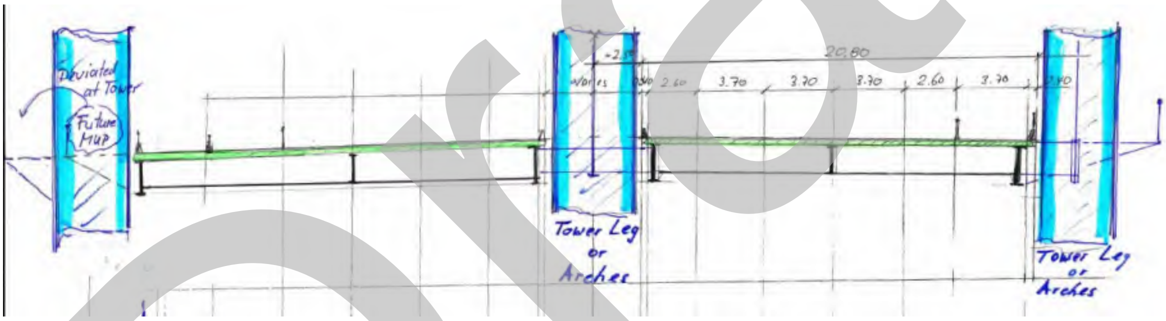


Fig: Fressinet H 2000 Fork

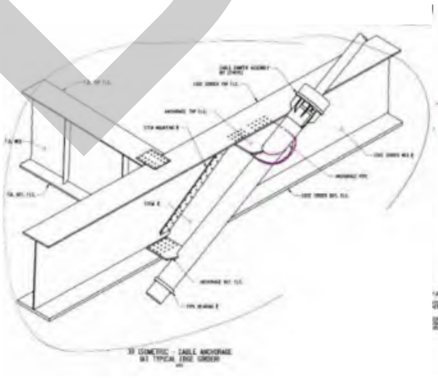
Fig: Clevis Cable Anchorage from DSI

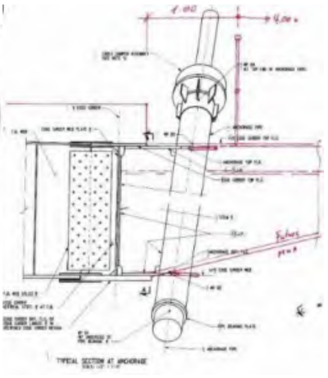
3.11.3 Cross Section

Feasible cross section would be a plate girder type, similar to the one for the Tappan Zee Bridge, split in the center to allow the mid tower passing through the deck

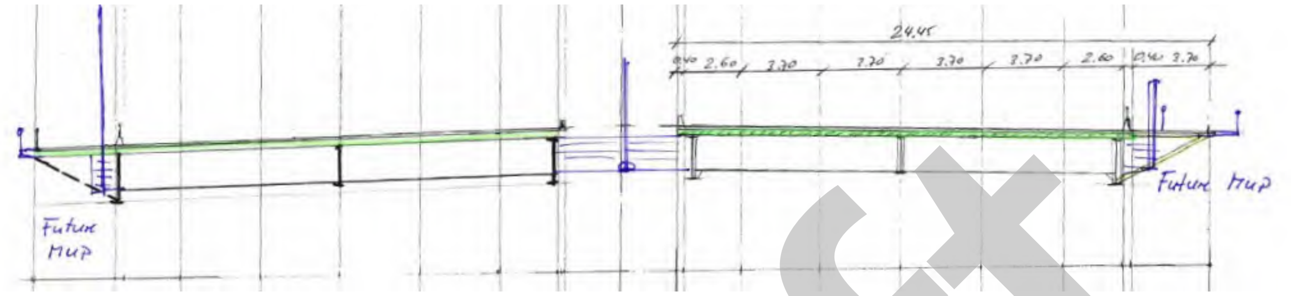


Cables are attached to brackets, connected to the main girders by bolting or welding





In the future configuration an MUP is attached as a light steel structure at each side and the roadway expanded to the barriers. A gap needs to be provided between roadway and MUP structure to pass the stay cables through



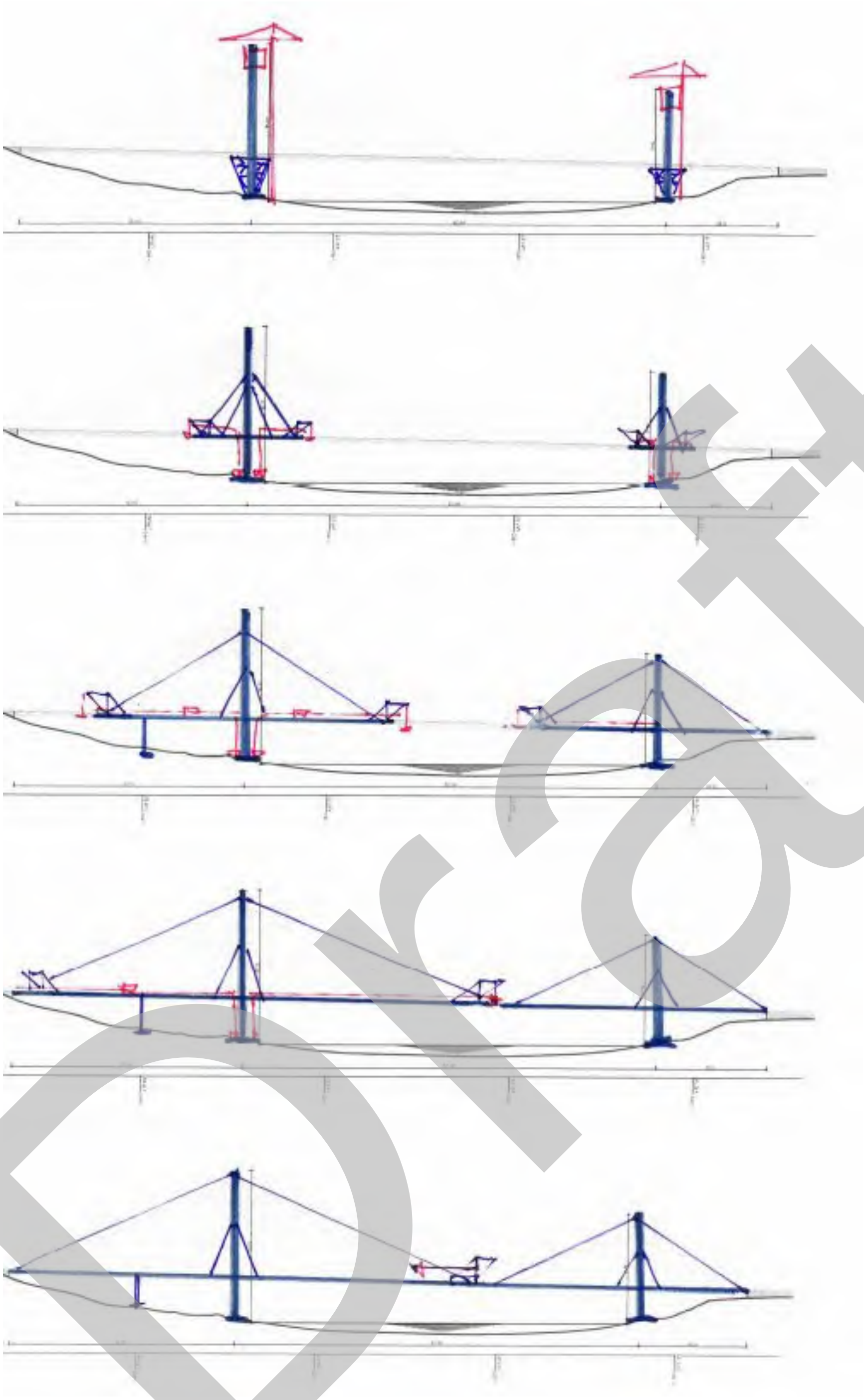
3.11.4 Example

A nice example is shown below with a mainspan of 205m (Norderelbebrücke, winning option in a bridge design competition in Hamburg)

3.11.5 Construction

Alt A)

- erect tower starter segments on falsework
- deliver steelwork segments in pieces to the tower,
- lift by heavy tower crane or mobile crane placed on the starter segments
- carry elements or fully assembled segment to the erection front,
- position it by a mobile crane (or derrick) followed by bolting of the splices.



Note: the Tower Crane needs to remain in place also for stay erection (not shown above).

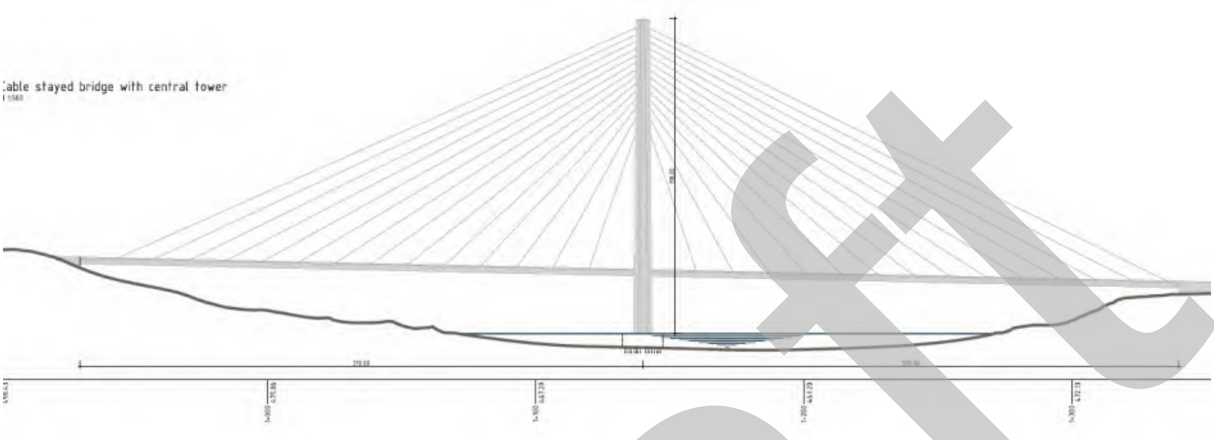
Alt B)

Alternatively the sidespan could be constructed first on auxiliary piers and the mainspan segments carried over the sidepan for erection by derrick or mobile cranes.

Example: Lifting Derrick of the Udevalla Bridge, Sweden

3.12 Option 11- Central Tower Cable Stayed Bridge

3.12.1 Layout

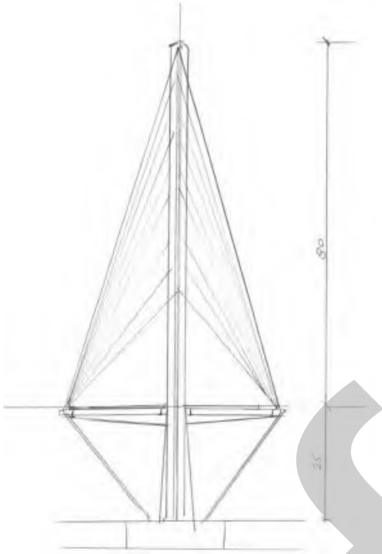


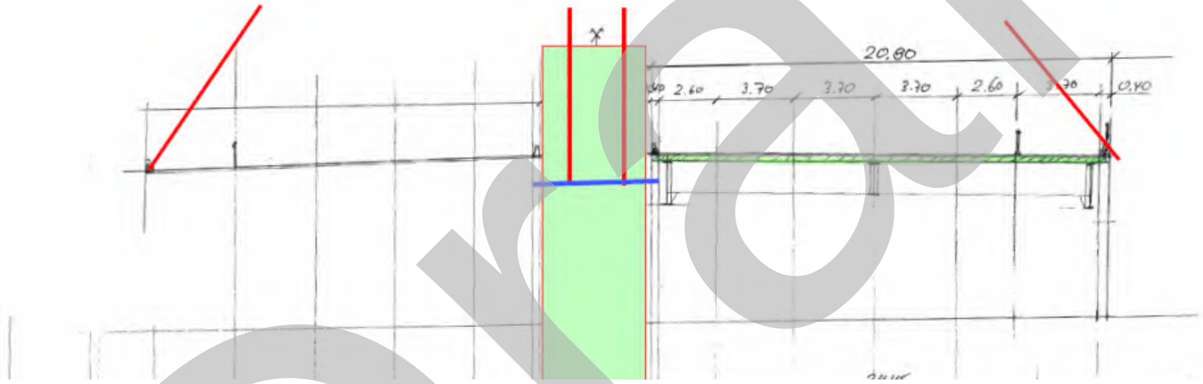
Single Tower stay cable bridge with spans of 200-210 = 410m

This option has just one pier in the river, no other piers are needed. The fixed /restraining point would be on the right with a heavy ballast abutment to cope with uplift. Bearing loads on the left are small, depending on the distance of the last cable to the abutment. It is a question of fine-tuning how much bearings loads will occur on the left. Slight uplift under ULS may be acceptable, so that the compression loads are minimized, which should be beneficial for the abutment

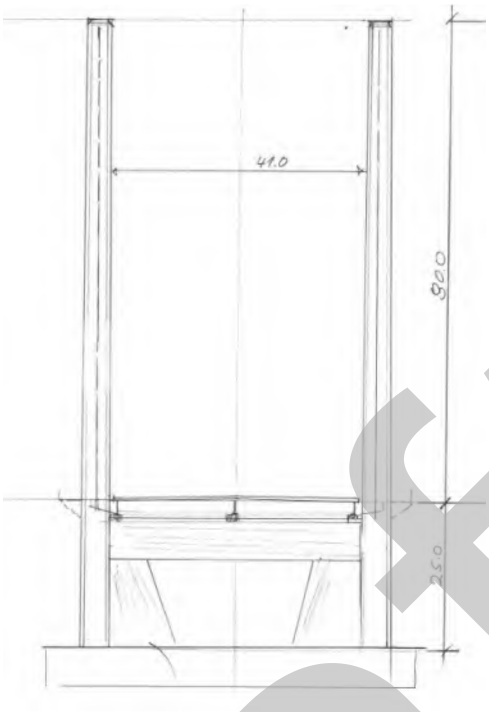
3.12.2 Cross Section

The stay cable configuration would be a tent like type as for the Port Mann Bridge in Vancouver.





An H-Type Tower might be also feasible. Quite likely a cross beam above the deck is not required since seismic loads are small. That means the tow tower option would be a goal post type. However, the proportions are not quite nice, it would look better with a three-leg tower, too, as option 10 above



3.12.3 Example

Port Mnn Bridge, Vancouver

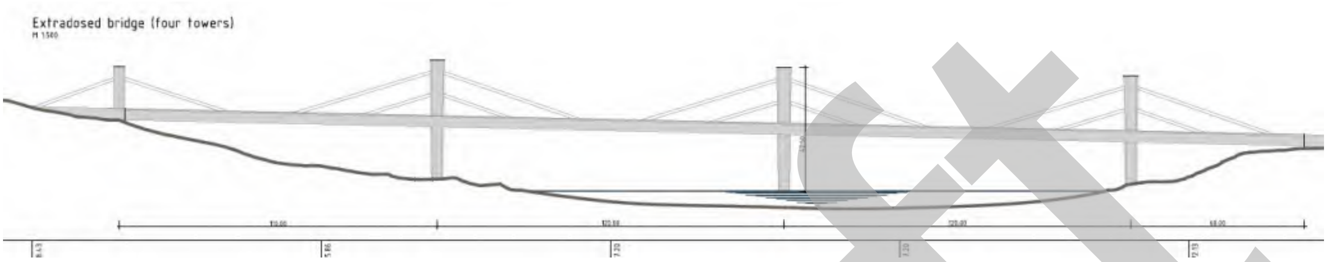
3.12.4 Construction

Alt A)
Stay cable supported free cantilever erection of about 13.50m long segments. Segments could be assembles on shore, floated in below the cantilever and lifted by a derrick, followed by Stay Cable installation and

Alt B)
If floating-in of segments is not possible, small steelwork segments have to be delivered to the tower, lifted by heavy tower crane or a mobile crane, placed on the starter segments, and launched to the erection front, positioned by a mobile crane (or derrick), followed by bolting of the splices – same as Alt A) for Option 10

3.13 Option 12 - Extradosed Bridge (4 Towers)

3.13.1 Layout



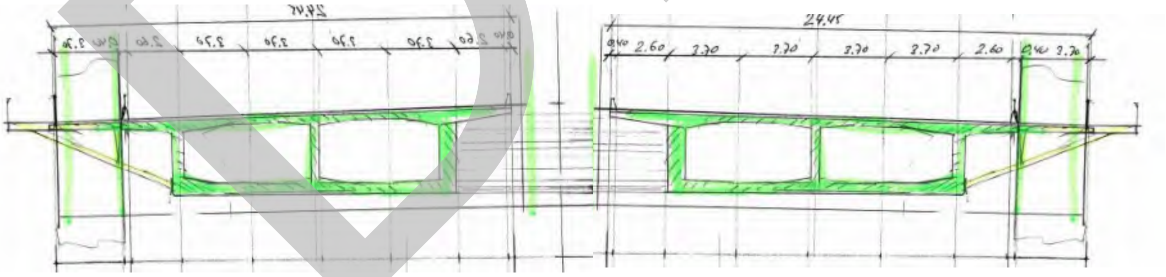
Stay supported concrete girder bridge with spans of 60-120-120-110 = 410m

The usual girders for Extradosed Bridges are concrete box girders, however, steel boxes are also possible as selected for the Golden Ears Bridge, which is actually a Stay Cable Bridge, but considered also as Extradosed Bridge in many publications due to the very low inclination of the stay cables, which is around 17degree, while standard stay cable bridges are above 20deg

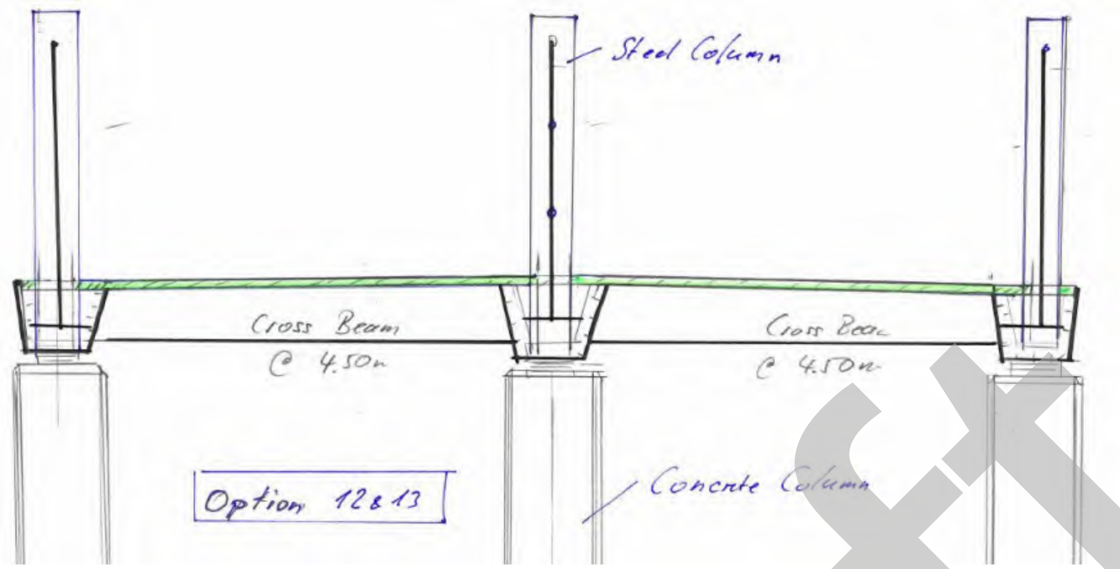
3.13.2 Cross Section

Standard sections for Extradosed bridges are concrete box girder; however, some are made of steel also

A) Concrete Box Girder



B) Small Steel Composite Box Girders

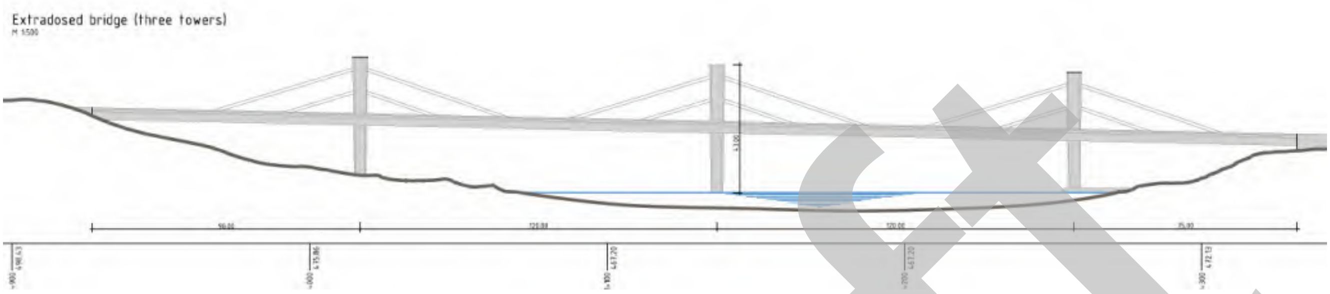


3.13.3 Construction

Free cantilever CIP segmental construction with Formtraveller, cantilever supported by final stays

3.14 Option 13- Extradosed Bridge (3 Towers)

3.14.1 Layout



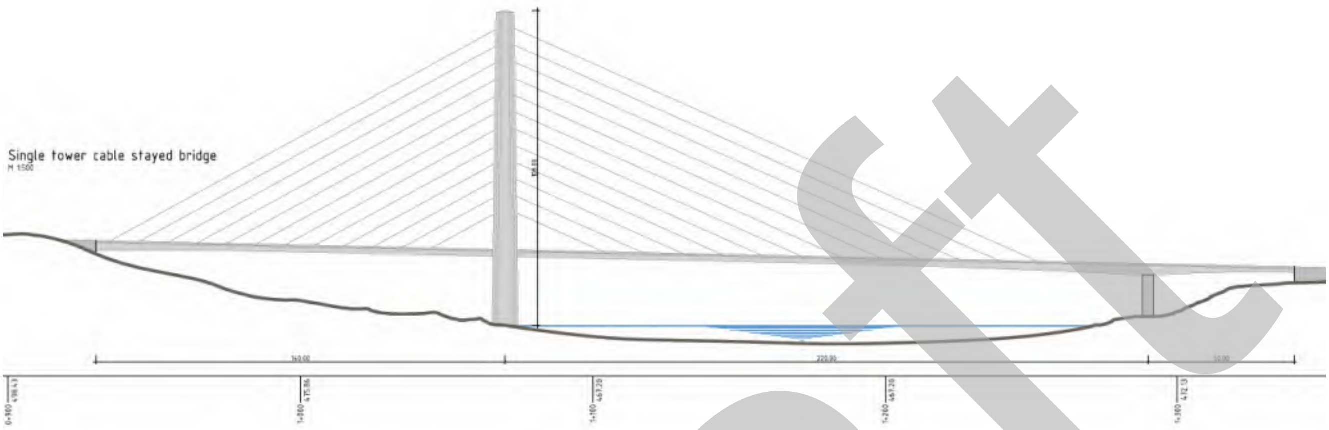
Stay supported concrete girder bridge with spans of 75-120-120-90 = 405m

Similar as option 12 but without tie-up of the endspan, but piers shifted further to the left, so that the left Pier is placed more into the hillside, the right one a bit into the water

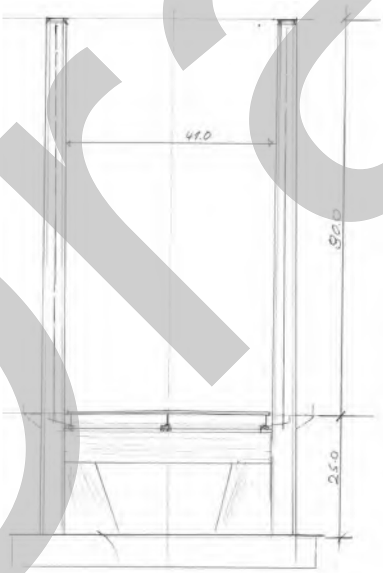
Same applies on Cross Section and Construction as for Option 12 above.

3.15 Option 14 – Unsymmetrical Single Tower Stay Cable Bridge

3.15.1 Layout



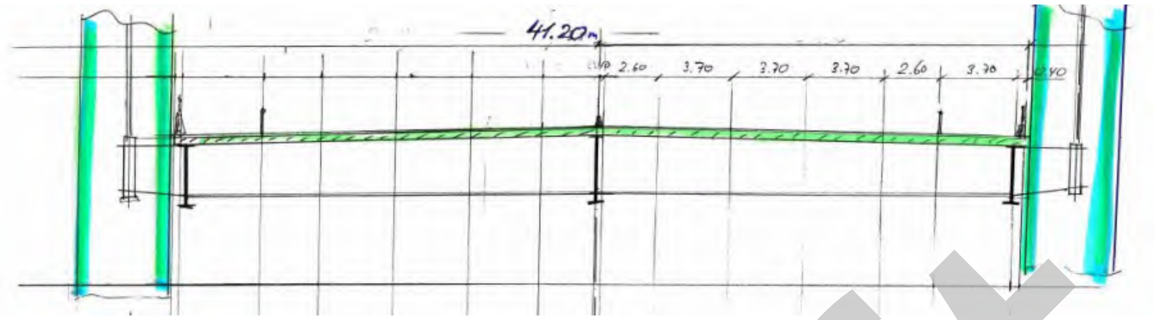
Single Tower stay cable bridge with spans of 60-225-125= 410



Single Tower Stay Cable Bridge with one Pylon on shore. The Pylon could be a pin tower, an H-Tower or a goalpost type, as shown in the sketch above

The abutment on the left will be provided with ballast concrete to cope with the uplift. Most likely, the fixed point needs to be on the left, not at the tower, this facilitates to cope with uplift.

3.15.2 Cross section



3.15.3 Example for Goalpost Type Stay Cable Bridge

Öresund Bridge, Denmark, Example for Goalpost Tower

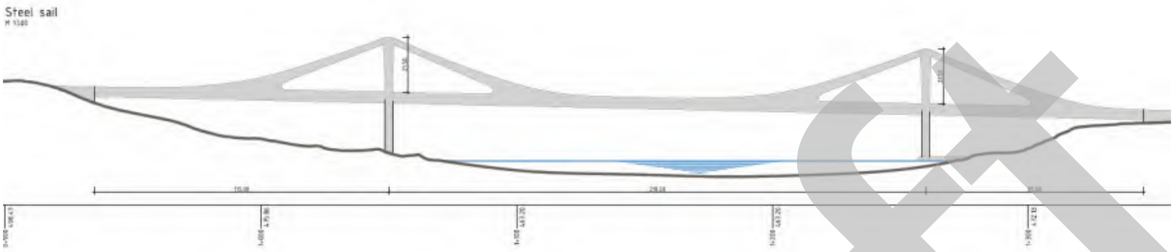
3.15.4 Construction

Balanced Cantilever Construction is the traditional construction procedure for stay cable bridges. If access is possible over the water, the segments may be installed by floating cranes or lifted directly from barges. In case access from the water is not given, the mainspan needs to be erected in the same manner as the sidespan:

- erect tower starter segments on falsework
- deliver steelwork segments in pieces to the tower,
- lift by heavy tower crane or mobile crane placed on the starter segments
- carry elements or fully assembled segment to the erection front,
- position it by a mobile crane (or derrick) followed by bolting of the splices.

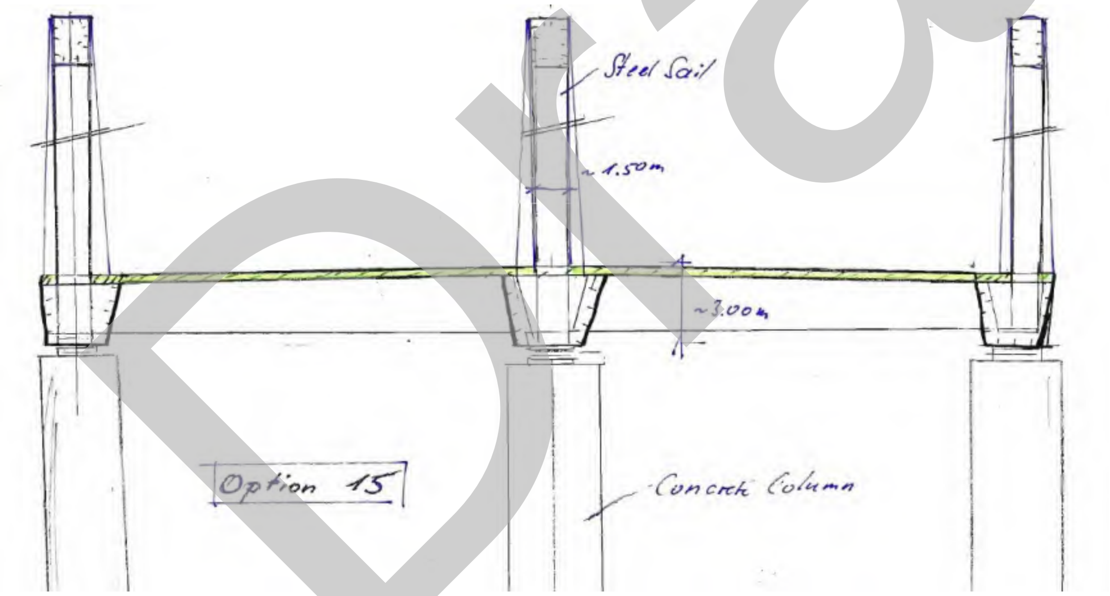
3.16 Option 15- Steel Girder Bridge with External Sail

3.16.1 Layout



Iconic bridge with spans of   85 – 210 -115 = 410m

This is a type of Extradosed bridge, where the Cables are replaced by a steel fin – or plate



3.16.2 Example

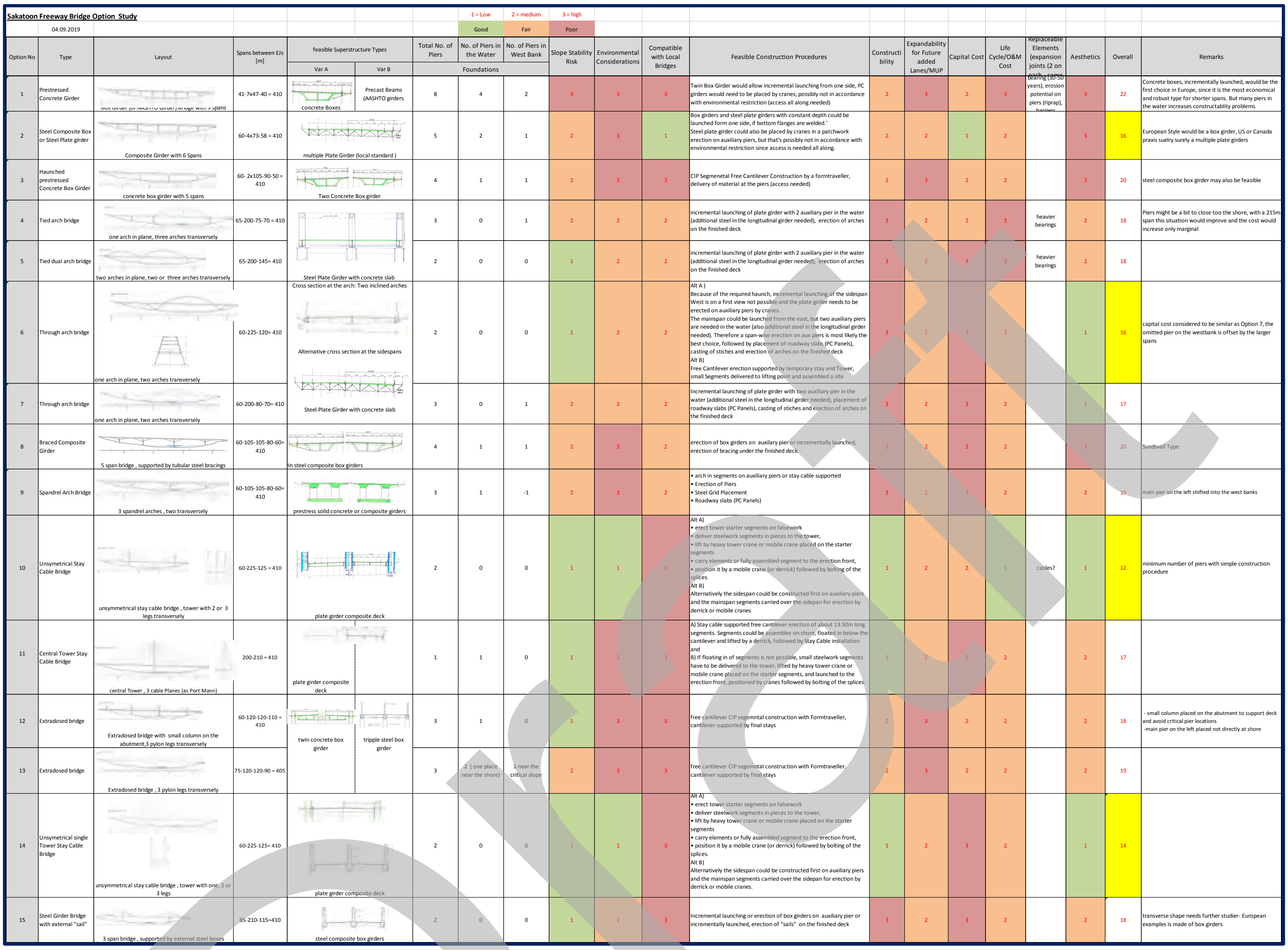
Neckarbrücke Stuttgart

3.16.3 Construction

Incremental Launching as illustrated below

Alternative: erection of box girders on auxiliary pier or incrementally launched, erection of "sails" on the finished deck

4 Summary_Matrix



Sakatoon Freeway Bridge Option Study

04.09.2019

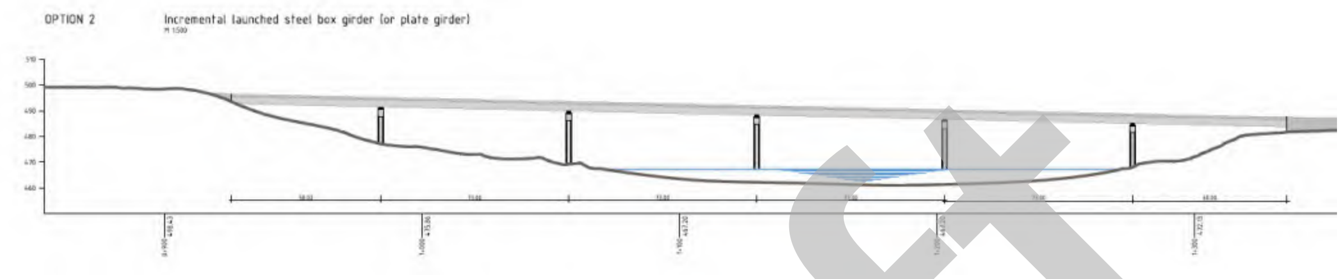
1 = Low	2 = medium	3 = high
Good	Fair	Poor

Option No	Type	Layout	Spans between EJs [m]	feasible Superstructure Types		Total No. of Piers	No. of Piers in the Water	No. of Piers in West Bank	Slope Stability Risk	Environmental Considerations	Compatible with Local Bridges	Feasible Construction Procedures	Constructibility	Expandability for Future added Lanes/MUP	Capital Cost	Life Cycle/O&M Cost	Replaceable Elements (expansion joints (2 on each, same	Aesthetics	Overall	Remarks
				Var A	Var B	Foundations														
1	Prestressed Concrete Girder	Box Girder (or AASHTO Girder) Bridge with 9 spans	41-7x47-40 = 410	concrete Boxes	Precast Beams (AASHTO girders	8	4	2	3	3	3	Twin Box Girder would allow incremental launching from one side, PC girders would need to be placed by cranes, possibly not in accordance with environmental restriction (access all along needed)	2	3	2	3	bearing (30-50 years), erosion potential on piers (riprap), barriers	3	22	Concrete boxes, incrementally launched, would be the first choice in Europe, since it is the most economical and robust type for shorter spans. But many piers in the water increases constructablity problems
2	Steel Composite Box or Steel Plate girder	Composite Girder with 6 Spans	60-4x73-58 = 410	multiple Plate Girder (local standard)		5	2	1	2	3	1	Box girders and steel plate girders with constant depth could be launched form one side, if bottom flanges are welded.’ Steel plate girder could also be placed by cranes in a patchwork erection on auxiliary piers, but that’s possibly not in accordance with environmental restriction since access is needed all along.	2	2	1	2		3	16	European Style would be a box girder, US or Canada praxis suelry surely a multiple plate girders
3	Haunched prestressed Concrete Box Girder	concrete box girder with 5 spans	60- 2x105-90-50 = 410	Two Concrete Box girder		4	1	1	2	3	3	CIP Segmenetal Free Cantilever Construction by a formtraveller, delivery of material at the piers (access needed)	2	3	2	2		3	20	steel composite box girder may also be feasible
4	Tied arch bridge	one arch in plane, three arches transversely	65-200-75-70 = 410	Steel Plate Girder with concrete slab		3	0	1	2	2	2	incremental launching of plate girder with 2 auxiliary pier in the water (additional steel in the longitudinal girder needed), erection of arches on the finished deck	3	2	2	3	heavier bearings	2	18	Piers might be a bit to close too the shore, with a 215m span this situation would improve and the cost would increase only marginal
5	Tied dual arch bridge	two arches in plane, two or three arches transversely	65-200-145= 410			2	0	0	1	2	2	incremental launching of plate girder with 2 auxiliary pier in the water (additional steel in the longitudinal girder needed), erection of arches on the finished deck	3	2	3	3	heavier bearings	2	18	
6	Through arch bridge	one arch in plane, two arches transversely	60-225-120= 410	Cross section at the arch: Two inclined arches Alternative cross section at the sidespans		2	0	0	1	2	2	Alt A) Because of the required haunch, incremental launching of the sidespan West is on a first view not possible and the plate girder needs to be erected on auxiliary piers by cranes. The mainspan could be launched from the east, but two auxiliary piers are needed in the water (also additional steel in the longitudinal girder needed). Therefore a span-wise erection on aux piers is most likely the best choice, followed by placement of roadway slabs (PC Panels), casting of stiches and erection of arches on the finished deck Alt B) Free Cantilever erection supported by temporary stay and Tower, small Segments delivered to lifting point and assembled a site	3	2	3	2		1	16	capital cost considered to be similar as Option 7, the omitted pier on the westbank is offset by the larger spans
7	Through arch bridge	one arch in plane, two arches transversely	60-200-80-70= 410	Steel Plate Girder with concrete slab		3	0	1	2	2	2	Incremental launching of plate girder with two auxiliary pier in the water (additional steel in the longitudinal girder needed), placement of roadway slabs (PC Panels), casting of stiches and erection of arches on the finished deck	3	2	3	2		1	17	
8	Braced Composite Girder	5 span bridge , supported by tubular steel bracings	60-105-105-80-60= 410	in steel composite box girders		4	1	1	2	3	2	erection of box girders on auxilary pier or incrementally launched, erection of bracing under the finished deck	3	2	3	2		3	20	Sundsvall Type
9	Spandrel Arch Bridge	3 spandrel arches , two transversely	60-105-105-80-60= 410	prestress solid concrete or composite girders		3	1	-1	2	3	2	• arch in segments on auxiliary piers or stay cable supported • Erection of Piers • Steel Grid Placement • Roadway slabs (PC Panels)	3	2	3	2		2	19	main pier on the left shifted into the west banks
10	Unsymetrical Stay Cable Bridge	unsymmetrical stay cable bridge , tower with 2 or 3 legs transversely	60-225-125 = 410	plate girder composite deck		2	0	0	1	1	3	Alt A) • erect tower starter segments on falsework • deliver steelwork segments in pieces to the tower, • lift by heavy tower crane or mobile crane placed on the starter segments • carry elements or fully assembled segment to the erection front, • position it by a mobile crane (or derrick) followed by bolting of the splices. Alt B) Alternatively the sidespan could be constructed first on auxiliary piers and the mainspan segments carried over the sidepan for erection by derrick or mobile cranes	1	2	2	1	cables?	1	12	minimum number of piers with simple construction procedure
11	Central Tower Stay Cable Bridge	central Tower , 3 cable Planes (as Port Mann)	200-210 = 410	plate girder composite deck		1	1	0	1	3	3	A) Stay cable supported free cantilever erection of about 13.50m long segments. Segments could be assembles on shore, floated in below the cantilever and lifted by a derrick, followed by Stay Cable installation and B) If floating in of segments is not possible, small steelwork segments have to be delivered to the tower, lifted by heavy tower crane or mobile crane placed on the starter segments, and launched to the erection front, positioned by cranes followed by bolting of the splices.	1	2	3	2		2	17	
12	Extradosed bridge	Extradosed bridge with small column on the abutment,3 pylon legs transversely	60-120-120-110 = 410	twin concrete box girder	tripple steel box girder	3	1	0	1	3	3	free cantilever CIP segemntal construction with Formtraveller, cantilever supported by final stays	2	3	2	2		2	18	- small column placed on the abutment to support deck and avoid critical pier locations -main pier on the left placed not directly at shore
13	Extradosed bridge	Extradosed bridge , 3 pylon legs transversely	75-120-120-90 = 405			3	2 (one place near the shore)	1 near the critical slope	2	3	3	free cantilever CIP segemntal construction with Formtraveller, cantilever supported by final stays	2	3	2	2		2	19	
14	Unsymetrical single Tower Stay Cable Bridge	unsymmetrical stay cable bridge , tower with one, 2 or 3 legs	60-225-125= 410	plate girder composite deck		2	0	0	1	1	3	Alt A) • erect tower starter segments on falsework • deliver steelwork segments in pieces to the tower, • lift by heavy tower crane or mobile crane placed on the starter segments • carry elements or fully assembled segment to the erection front, • position it by a mobile crane (or derrick) followed by bolting of the splices. Alt B) Alternatively the sidespan could be constructed first on auxiliary piers and the mainspan segments carried over the sidepan for erection by derrick or mobile cranes.	1	2	3	2		1	14	
15	Steel Girder Bridge with external "sail"	3 span bridge , supported by external steel boxes	85-210-115=410	steel composite box girders		2	0	0	1	2	3	Incremental launching or erection of box girders on auxiliary pier or incrementally launched, erection of "sails" on the finished deck	3	2	3	2		2	18	transverse shape needs further studier- European examples is made of box girders

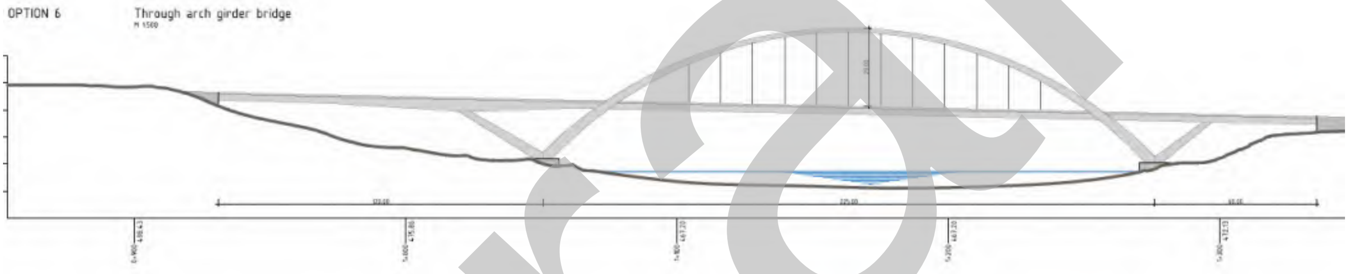
5 Conclusion

Four of the options are carried to Phase 2, which are

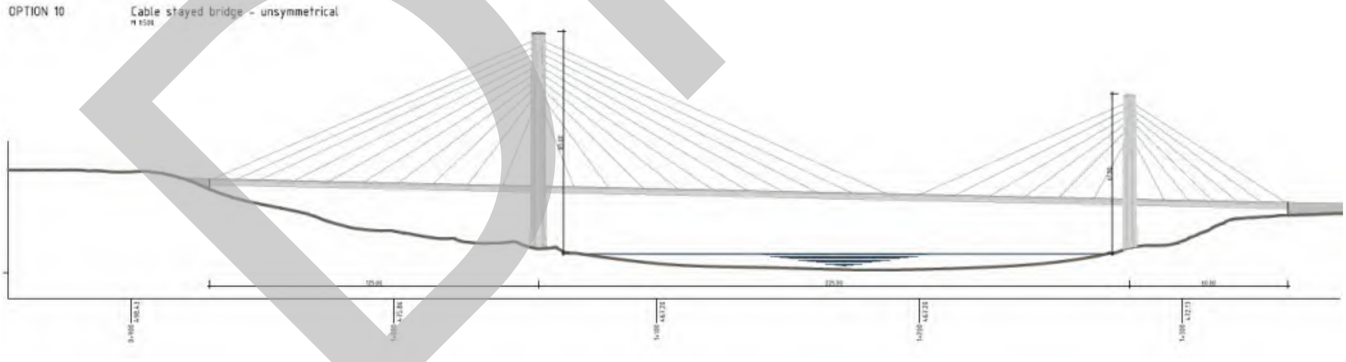
Option 2:



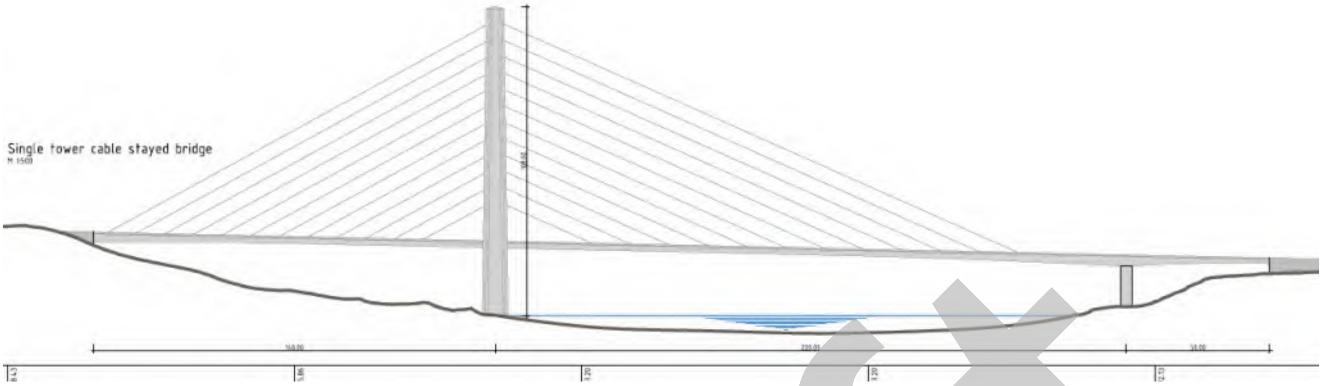
Option 6:



Option 10:



Option 14:



In Phase 2 those 4 options will be evaluated further, mainly with respect to cost.

To identify a fair cost relation, the main quantities will be evaluated based on experience and some simple calculations.

The cost for the foundations will be determined by SNC Lavalin based on foundation loads provided by LAP.

Leonhardt, Andrä und Partner

Functional Planning Study for the Saskatoon Freeway Project

Phase 2

Revision	Title	By	Reviewed	Date
Rev 0	First Issue. Loads and Reactions (Quantities Pending)	RRM	MM	20.09.2019
Rev 1	Quantities and several amendments	Hf	RRM	18.10.2019
Rev 2	General Revision, Issues discussed in the 25th Oct workshop added	Hf	RRM	06.11.2019
Rev 3	Update to take into account Nov 2019 discussions	Hf	Hf	12.12.2019
Rev 4	Update for Comments of Dec 13, 2019	Hf/RRM	Hf	08.01.2020

Table of contents

1 Introduction

1.1 Roadway Layout

As explained in Phase 1 Report, the roadway consist initially in each bound of 3 Traffic Lanes (3.70m ea.), 2 shoulders (2,60m ea) and one MUP (3.70m wide).

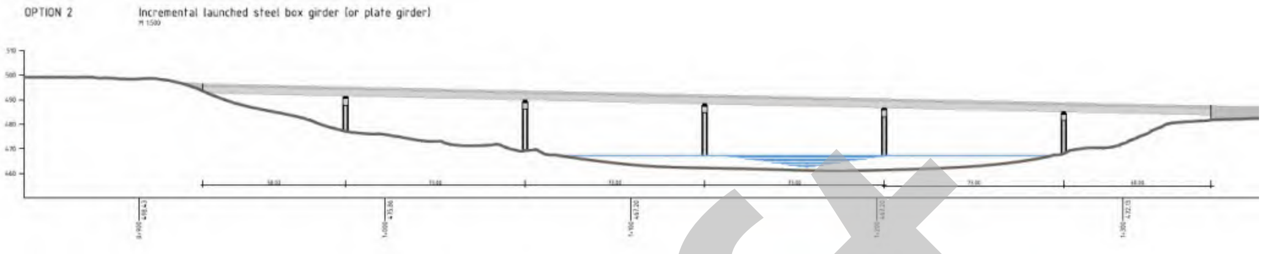
The future configuration may be changed to 4 Lanes and the MUP attached to the deck on each side.

1.2 Structures

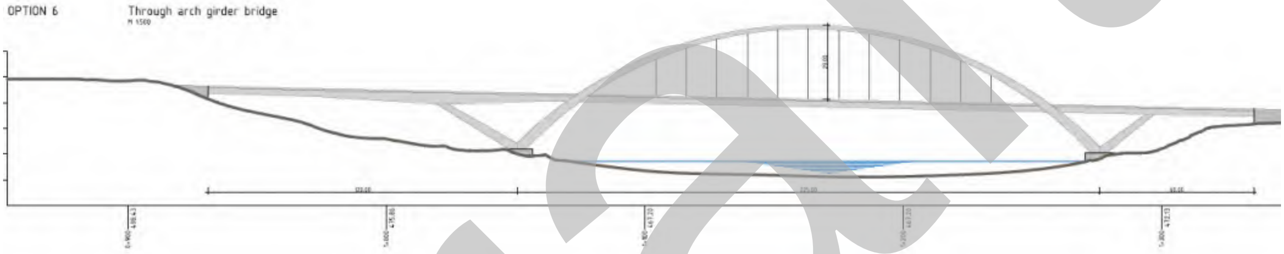
LAP has been contracted by SNC Lavalin to perform an option study for the Saskatoon Freeway Project As part of the functional planning study we were asked to assess the possible bridge types for a crossing of the South Saskatchewan River North of the city of Saskatoon. This river crossing is part of a new Freeway to be planned around the City of Saskatoon. It is a signature element of the project.

In Phase1 a qualitative evaluation of 15 different options was performed (see report *Functional Planning Study Phase 1*). Four of those 15 options have been carried into Phase 2, those are

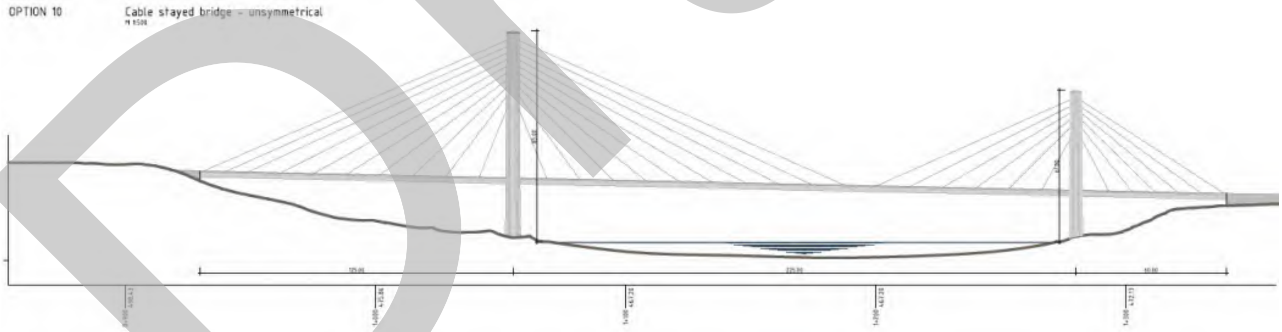
Option 2:



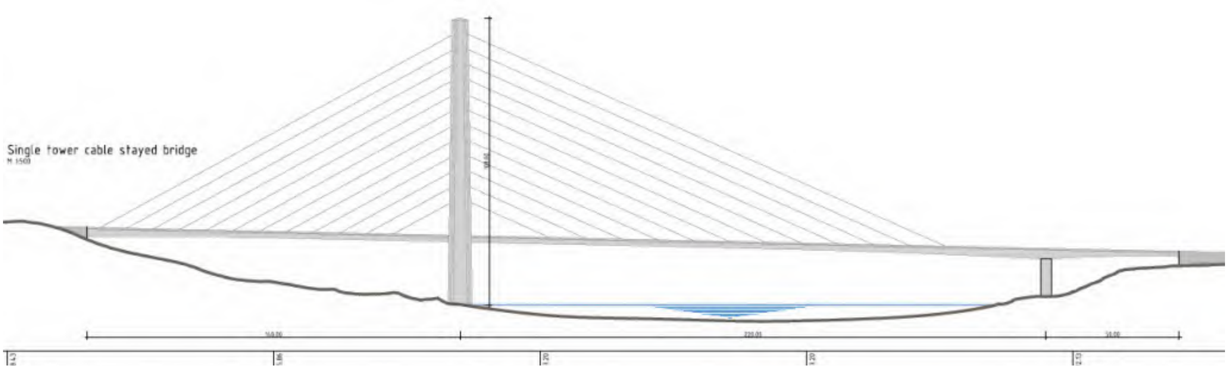
Option 6:



Option 10:



Option 14:



In the current report, these four options are evaluated further, mainly with respect to cost, bearing configuration and some construction details. For this purpose, the main quantities are evaluated based on experience and some simplified 3D calculations.

1.3 Loads

Foundation loads are provided in order to serve as a basis for the foundation cost analysis, which will be carried out by SNC-Lavalin.

For all four solutions, the following load combination factors have been considered:

Permanent Loads

Self weight	SW Lower Pylon legs		SLS	ULS1	ULS2	ULS3	ULS4
	SW Piers		1.00	1.20	1.20	1.20	1.20
	SW Concrete slab main span		1.00	1.11	1.11	1.11	1.11
	SW Concrete slab side spans		1.00	1.17	1.17	1.17	1.17
	SW Steel main span		1.00	1.10	1.10	1.10	1.10
	SW Steel side spans		1.00	1.10	1.10	1.10	1.10
	SW Arches/Upper Pylon		1.00	1.10	1.10	1.10	1.10
	SW Cables/hangers		1.00	1.10	1.10	1.10	1.10
	SW future MUP +3cm wearing srf		1.00	*1.23*	*1.23*	*1.23*	*1.23*
	SDL TOT		1.00	*1.40*	*1.40*	*1.40*	*1.40*
		10 cm asphalt c. overlay	1.00	1.50	1.50	1.50	1.50
		parapets (x4)	1.00	1.10	1.10	1.10	1.10
		Others (Utilities, railing…)	1.00	1.10	1.10	1.10	1.10

Note: Factors for SW of Pylon are shown for a steel pylon (ULS factor for cast in place concrete Pylon would be 1,20). Factors for concrete deck are interpolated values provided that different factor is to be considered for the precast panel and for the cast in place part.

Variable Loads						
Live Load	2x5 lanes 3.00 m wide/DLL - Design LL	0.90	1.70	1.60	1.40	0.00
	MUP pedestrian load	0.00	1.70	1.60	1.40	0.00
	Design Truck	0.90	1.70	1.60	1.40	0.00
Wind	Design horizontal Wind (Wh)	0.00	0.00	0.00	0.45	1.40
	Design vertical Wind (Wv)	0.00	0.00	0.00	0.45	1.40
	Wind on Pylons/arch	0.00	0.00	0.00	0.45	1.40
	Wind on Vehicles (WL)	0.00	0.00	0.00	0.45	1.40
	Wind on Piers	0.00	0.00	0.00	0.45	1.40
Temperature	TU Composite					
	TU+	0.80	0.00	1.15	1.00	1.25
	TU-	0.80	0.00	1.15	1.00	1.25
	TG Composite					
	TG+	0.80	0.00	1.15	1.00	1.25
	TG-	0.80	0.00	1.15	1.00	1.25
Bearing Friction		1.00	1.00	1.00	1.00	1.00

Note: the Design truck CL-W is defined in CAN-CSA S6 14 to be a 500 kN truck when considered simultaneously with uniform traffic load, and to be used with a ULS factor of 1,7. According to the project requirements, the truck CL-750 is also to be considered. This truck was defined in CAN-CSA S6 88 to be a 740 kN to be used with a ULS factor of 1.6 (740 x 1,6=1184 kN). For the analysis of the four options, a 750 kN truck with factor 1.7 has been considered (750 x 1,7=1275 kN), which would mean an implicit dynamic load allowance of 1275/1184=1.076 > 1.00 with respect to the truck of norm CAN-CSA S6 88, which is a conservative assumption. The truck load is affected by a 0.8 factor if considered together with uniform load (0.8 x 750 = 600kN).

1.4 Durability and Maintenance

The following general measures for an improved durabilty are recommended and considered in the BoQ evaluation for all options:

- Most important for a durable structure is a proper inspection and maintenance in short intervals. The tables below are based on German practice and European recommendations, but contains also elements from the Pattullo bridge in BC

- Durability of the deck is improved by implementing measures which are required in the BC supplement and/or requested for the Pattullo Bridge design
    - waterproof membrane
    - 100mm wearing surface
    - stainless steel rebars in the upper zone of the roadway slab as a general requirement
    - stainless steel rebars in full depth of the roadway slab in cables stayed spans

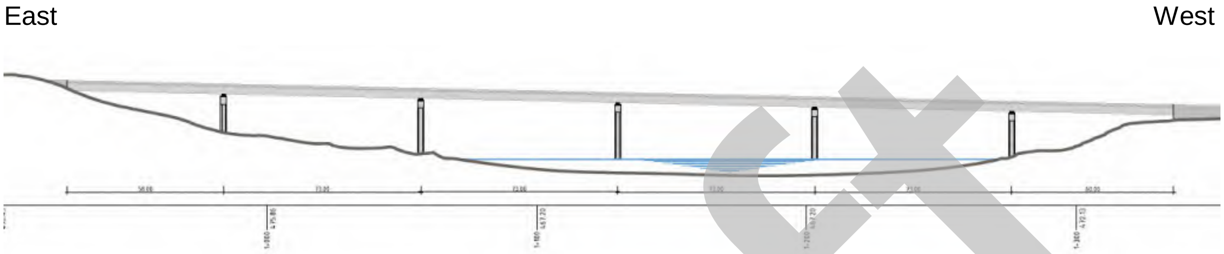
- A weathering steel is used for the superstructure, acc. to the BC supplement for bridge design no loss due to corrosion has to be taken into account

- provide access to bearings, design for force introduction of hydraulic jacks and mark the position of those on the sub/superstructures

2 Selected Options

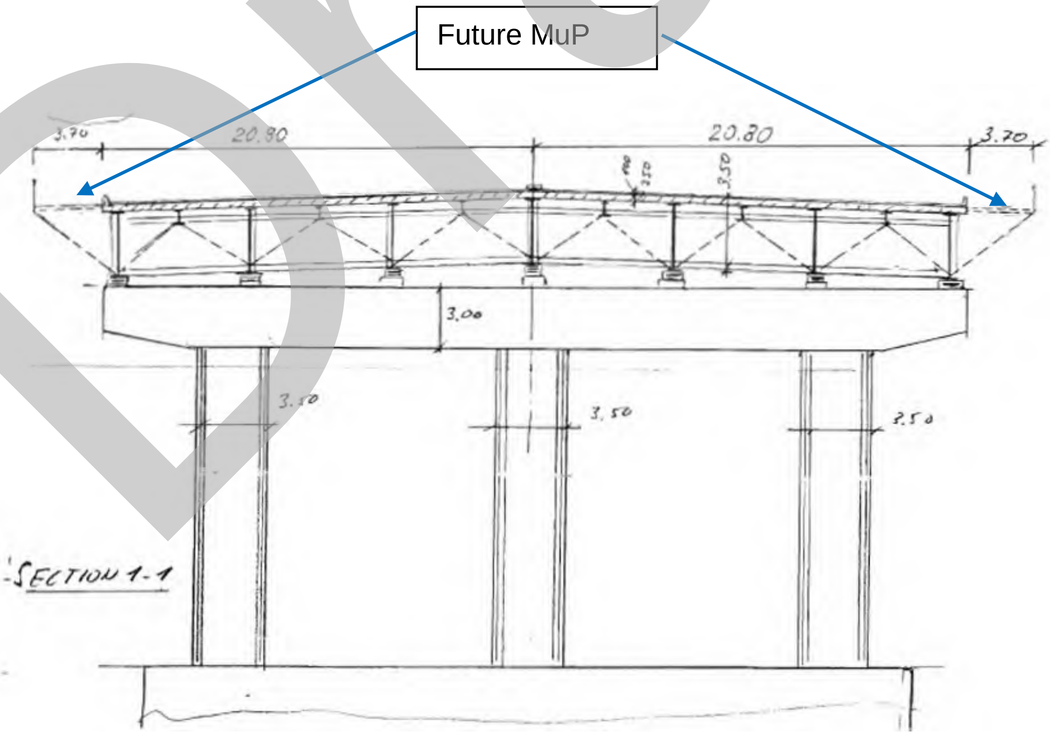
2.1 Option 2 – Steel Composite Girder

2.1.1 Layout



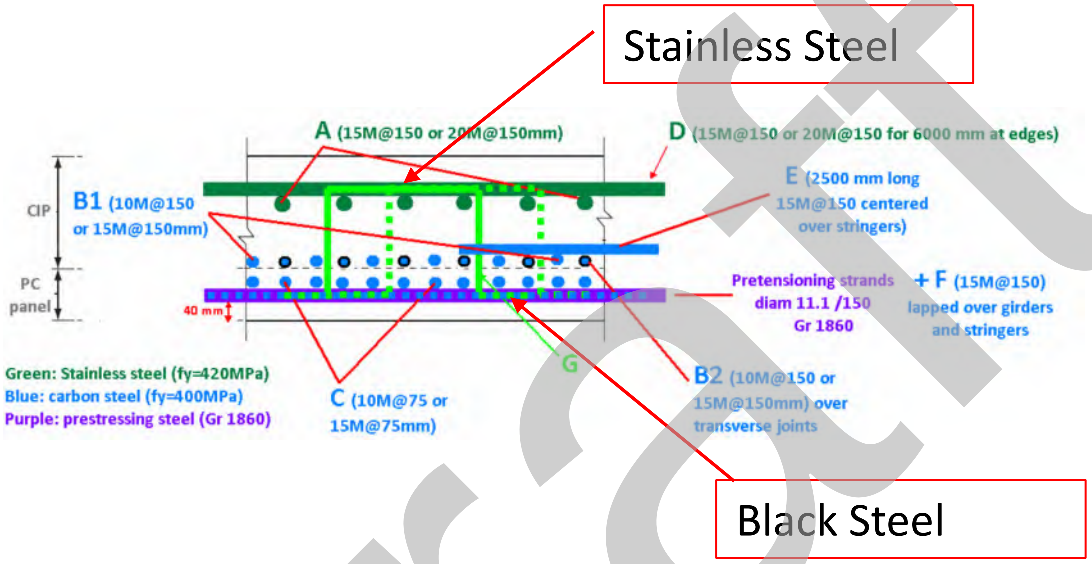
Girder Bridge with six spans of 58 - 4 x 73 - 60 = 410m with two Piers in the water, two on shore, and one on the West bank.

For the cross section, a Multiple Steel Plate Girder has been considered. The total depth is about 3.50m, the depth of the steel plate girder about 3.20m



The deck consists of concrete slab with 350 mm total thickness, were the formwork is made with 120 mm pre-stressed precast panels spanning around from 3.4 to 3.7 meters in transverse direction between main girders and a longitudinal stringer placed between the main girders. That allows a distance of around 7 meters for the heavy plate girders. A transverse bracing spaced from five to 7 meters needs to be provided. An average steel weight of 3.0 kN/m2 (including provision for transverse diaphragms at supports) is assumed based on experience with similar solutions.

In order to enhance durability the upper layer of reinforcement will be made of stainless steel (that’s how it is considered in the BoQ and cost evaluation



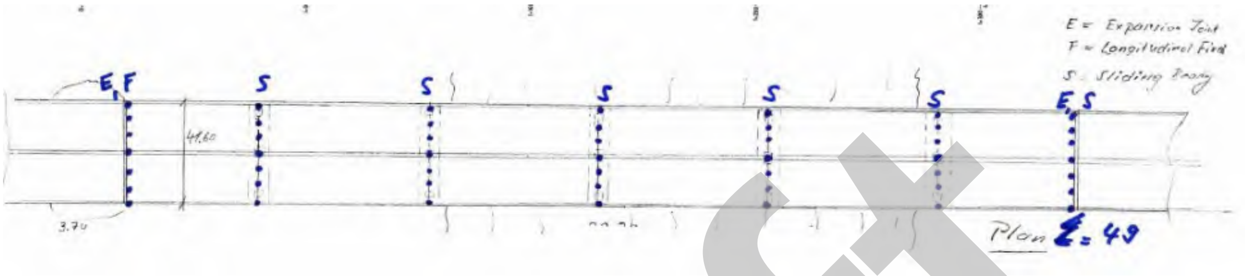
Variations in the deck configuration:

a) The more traditional Canadian way is a layout without stringers, so that 13 plate girders instead of only seven girders would be needed. It is a simpler layout, but needs likely more structural steel and much more bearings. The influence on the total cost is minor, but a value Engineering for verification of the best alternative would be appropriate in the next stage.

b) For the time being, a single deck superstructure has been considered, since it simplifies attachment of the future MuP: the loads would be more evenly distributed to the plate girders. Two independent superstructures for North- and Southbound could also be envisaged. It would have an advantage in case elements such as deck slabs have to be exchanged (traffic to be relocated to the superstructure **not** under construction). This option (twin deck) may have some problems with attachment of the future MuP: The fixing to one edge only would create torsion and may cause uplift in the inner bearings. Also the deformation caused by the eccentric weight of the future MuP needs to be addressed. It will change the crossfall, so either it’s made a bit larger initially and is correct in future, or have it at 2% initially and a bit smaller in future – or average it out.

Cost wise, both options are quite similar, therefore they have not been distinguished in the BoQ

Bearing Scheme



The deck is supported by elastomeric bearings at every pier and at the abutments: one vertical bearing under each plate girder. Longitudinal fixation is provided at Abutment 1 (this arrangement is currently considered in the foundation loads). Alternatively, the fixed point could also be shifted to the two central piers.

A fixation for movements in transverse direction is assumed for every pier, provided by one or more laterally fixed bearings.

Exchange of the bearings is possible pier by pier. All bearings on one pier have to be jacked up by about 10mm, this is sufficient to pull them out and new ones in. This jack up (negative bearing settlement) is usually considered in the detailed design (not here in the concept study) as temporary situation and combined with full traffic loads (standard loads, not extreme ones)

2.1.2 Example

2.1.3 Summary of assumed Loads

LOADS				
			OPTION 2	
Perm Loads				
	Self weight	SW Piers	327	kN/m
		SW Concrete slab main span	9.1	kN/m2
		SW Concrete slab side spans	9.1	kN/m2
		SW Steel main span	3.0	kN/m2
		SW Steel side spans	2.5	kN/m2
		SW Arches/Pylon	-	-
		SW Cables/hangers	-	-
		SW future MUP +3cm wearing srf	2.2	kN/m2
		SDL TOT	3.1	kN/m2
Var Loads	Live Load			
		2x5 lanes 3.00 m wide/DLL - Design Lane Load	3.0	kN/m2
		2x3.6m MUP pedestrian load	1.3	kN/m2
		Design Truck (*)	600	kN
	Wind			

	Design horizontal Wind (Wh)	8.0	kN/m
	Design vertical Wind (Wv)	20.0	kN/m
	Wind on Pylons/arch	-	-
	Wind on Vehicles (WL)	4.0	kN/m
	Wind on Piers	10.0	kN/m
Temperature			
	TU+	50	K
	TU-	-50	K
	TG+(**)	10	K
	TG-(**)	-10	K
Friction **)		4	%

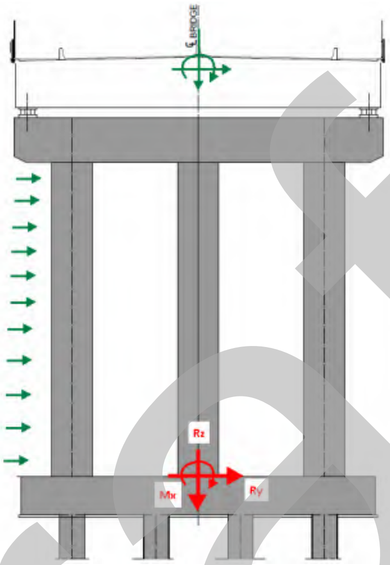
(*) Value of design truck to be considered together with lane load

(**) 10°C Gradient over the complete deck height assumed (similar effect as a 30°C gradient over the concrete slab depth)

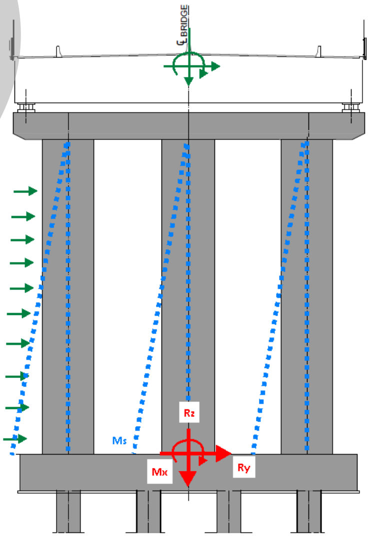
(***) 4 % friction in combination with max vertical load, no influence study for lower loads has been performed yet, needs to be done in coming design stages.

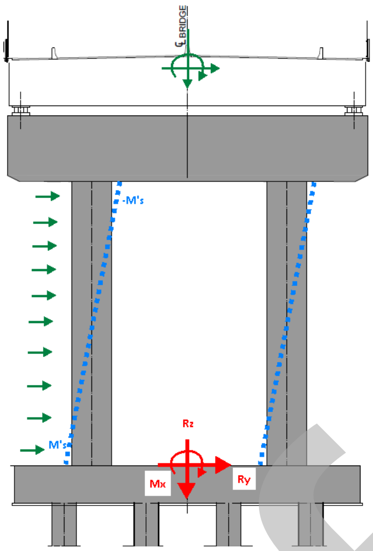
2.1.4 Foundation Reactions

Following tables show an estimate of the reaction on top of foundation (weight of foundation not included). The reactions are given for the full width (both bounds, so both traffic directions), at the midpoint between both bounds. An estimation of the weight of the pier shafts, wind on piers and bearing friction has been added to the loads coming from the deck, so that the reactions shown in the table below (in red in the following sketch) includes o provision for those effects.

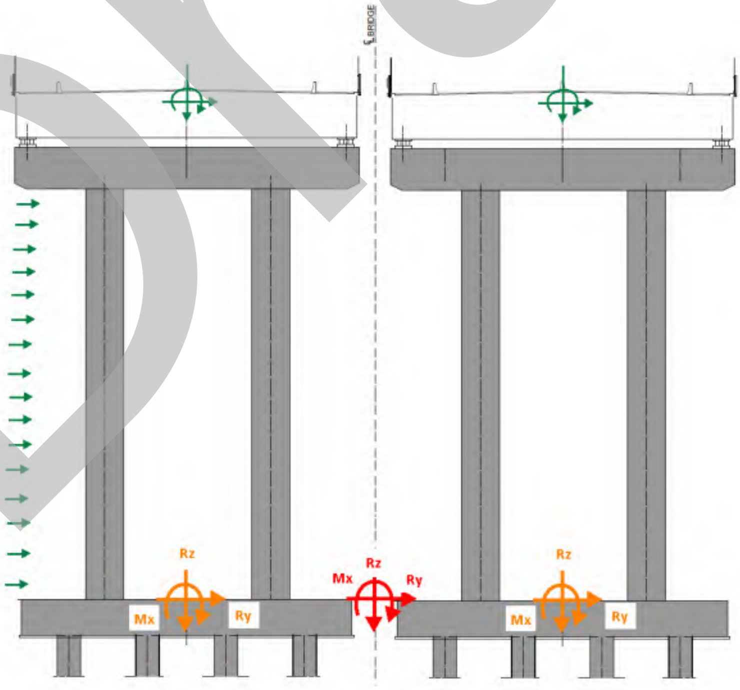


The above sketch shows the proportions of a possible solution for the substructure. It is to be noted that the section forces at the substructure (for example bending moments at the pile shafts) may vary significantly depending on the later design of the piers (see sketch below for two – exaggerated- different solutions). Nevertheless, assuming that the foundation is stiff enough, the reactions given in the tables below (in red in the sketch) should fairly represent the resulting reactions at the midpoint, on top of foundation.





For two independent superstructures two independent foundations could be envisaged. The reactions given below are still those corresponding to the midpoint of a fictive common foundation (in red). The independent reactions can be estimated from the ones given for the midpoint (but such an estimation is out of the scope of this report, provided the still large number of design options for each substructure).



	Abutment 1 (fix point)				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**22.91**	0.00	0.00	0.00	0.00
TOT Traffic	**4.93**	0.00	**0.70**	**41.89**	**3.50**
TOT Wind	**0.45**	**0.41**	**0.87**	**6.86**	**4.29**
TOT Temp	**0.14**	0.00	0.00	0.00	0.00
SLS	**27.30**	**0.80**	**0.70**	**38.70**	**3.20**
ULS	**36.00**	**1.40**	**1.40**	**76.10**	**6.90**

	P1/P5 (external piers)				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**59.28**	0.00	0.00	0.00	0.00
TOT Traffic	**8.04**	0.00	0.00	**62.64**	0.00
TOT Wind	**1.48**	**0.96**	**0.16**	**30.38**	**1.71**
TOT Temp	**0.17**	0.00	0.00	0.00	0.00
SLS	**66.00**	**2.20**	**2.20**	**83.20**	**34.90**
ULS	**85.00**	**3.90**	**3.10**	**151.90**	**47.80**

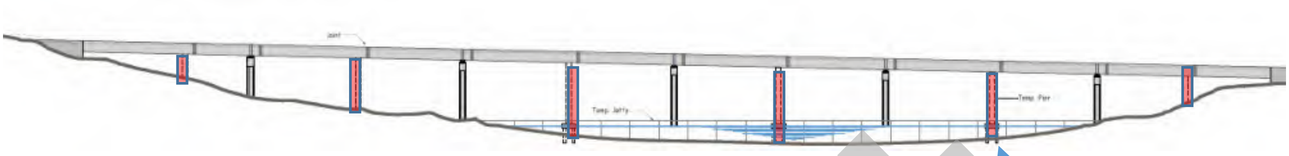
	P2/P4 (internal piers)				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**60.60**	0.00	0.00	0.00	0.00
TOT Traffic	**8.25**	0.00	0.00	**64.05**	0.00
TOT Wind	**1.46**	**1.10**	**0.22**	**38.25**	**3.23**
TOT Temp	**0.04**	0.00	0.00	0.00	0.00
SLS	**67.40**	**2.20**	**2.20**	**96.70**	**47.50**
ULS	**86.90**	**4.00**	**3.20**	**170.60**	**66.30**

	P3 (central pier)				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**62.56**	0.00	0.00	0.00	0.00
TOT Traffic	**8.31**	0.00	0.00	**64.44**	0.00
TOT Wind	**1.46**	**1.16**	**0.28**	**45.45**	**5.23**
TOT Temp	**0.02**	0.00	0.00	0.00	0.00
SLS	**69.40**	**2.20**	**2.20**	**109.90**	**60.50**
ULS	**89.40**	**4.10**	**3.20**	**189.30**	**85.90**

	Abutment 2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**22.91**	0.00	0.00	0.00	0.00
TOT Traffic	**4.93**	0.00	0.00	**41.89**	0.00
TOT Wind	**0.45**	**0.41**	**0.05**	**6.86**	**0.17**
TOT Temp	**0.14**	0.00	0.00	0.00	0.00
SLS	**27.30**	**0.80**	**0.80**	**38.70**	**3.70**
ULS	**36.00**	**1.40**	**1.10**	**76.10**	**5.10**

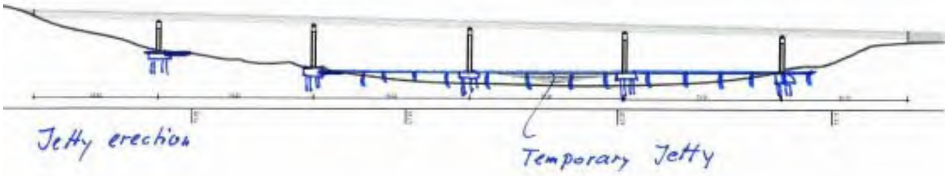
2.1.5 Construction

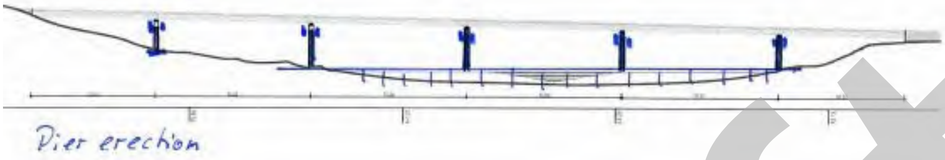
One feasible erection procedure is elaborated below

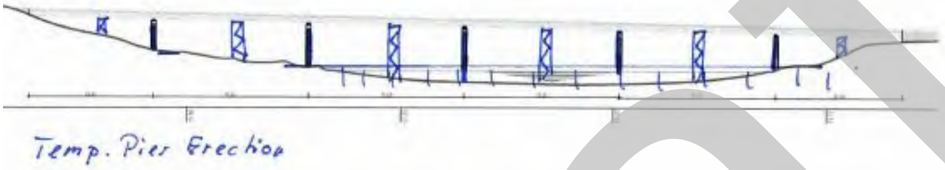


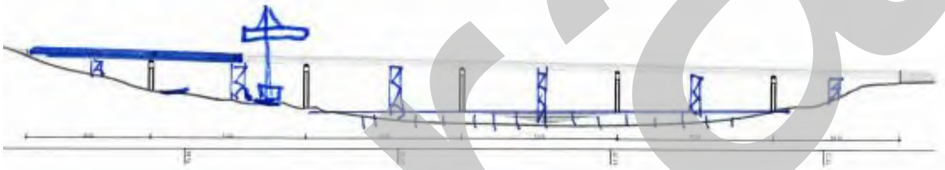
Erection Sequence

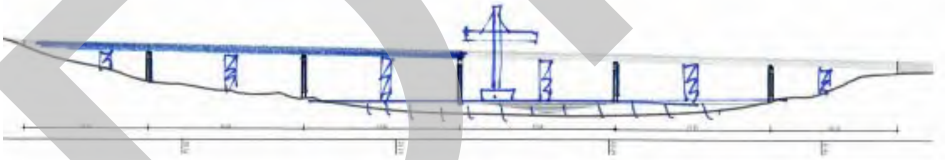
- for access in the river a **temporary jetty** or a **cofferdam** needs to be constructed
- access to the slopes is required either from the shore or from the banks
- foundation and piers erection in a conventional method
- since the span of 70 m is too large for erection of the girders, quite likely 6 temporary piers are needed
- erection of the steel plate girder by mobile cranes running on the jetty/coffer dam or placed next to the pier in the slope – care for access of the cranes
- place roadway slabs in a sequence which reduces tensile stresses above the piers as much as possible
- dismantle temporary piers
- dismantle jetty/coffer dam


Jetty erection
Temporary Jetty


Pier erection


Temp. Pier Erection





Construction Alternative:

Theoretically, construction by Incremental Launching would also be an option. This would omit the need of a jetty/cofferdam. However

- the same amount of temporary and final piers is needed, with access requirements to all of the piers in the river
- top flanges needs to be strengthened considerably
- temporary lateral bracing in the top and bottom flanges is needed
- launching bearings should be placed at two girders only, the others would need to be connected by strong vertical bracing
- bottom flanges should better be welded, since launching over splice plates is quite complicated, but can be done. Filler plates between the splice plates would be needed, with holes at location of the bolts. Those filler plates need to be fixed by bolting or clamps.

Therefore launching has not yet been considered further, but could be done in the next phase

2.1.6 Slope Stability

One permanent pier and two temporary piers are placed in the critical slope and need to be protected against hill sliding. For the temporary piers this is not such a critical issue, any vertical movement can be compensated by jacks placed on the piers, horizontal movement needs to be corrected or sufficient tolerances provided in the load introduction zone.

For the permanent pier this is a bit more critical and mitigation measures need to be developed to cope with any movement. Soil pressure could by high acting on pile foundations and have to be taken into account in the design of the pile footing

2.1.7 Durability and Maintenance

The concrete deck runs over five permanent piers and at each point tensile stresses in the concrete are high, leading surely to cracks. With a perfect waterproof membrane and stainless steel rebars on the upper half of the slab (also shear hoops or any rebar entering the upper half of the slab), the durability will be rather high, so the replacement period for the deck could be extended to say 70 or so. However, in order to guarantee such a good function, inspection has to be done very careful, any sign of leaking water has to be reported, and repair works performed immediately. In the table below it’s assumed that the deck have to be replaced once in 100 year, taking into account that inspection and maintenance is never done perfect.

A weathering steel is used for the superstructure, acc. to the BC supplement for bridge design no loss due to corrosion has to be taken into account. However, since the superstructure consists of many small parts in the cross frames, it is assumed that some of those have to be exchanged once in 100 years = 3 % of the structural steel

The superstructure rests on about 49 elastomeric bearings. Some are just plain pads, but 35 of them (as a minimum) are provided with a sliding surface, which is more sensitive and may need to be replaced more often, say in an interval of about 30. As an average 35years are assumed.

Access need to be provided to the bearings for exchange from the bottom up – i.e. from the river. This may become a quite costly exercise.

Item	frequency of Inspection			design service/lifetime [years]	replacement [times]
	visual, from a distance (authority/client)	visual (specialist)	"hands on" inspection / non. destructive testing		
structural weathering steel, superstructure	1 time / year	1 time / 3 years	1 time / 6 years	100	-
steel coating systems (not considered so far)	1 time / year	1 time / 3 years	1 time / 3 years	35	2
concrete deck slab girder bridge	1 time / year	1 time / 3 years	-	50	1
concrete deck slab stay cable bridge	1 time / year	1 time / 3 years		100	-
concrete pier	-	1 time / 3 years	-	100	-
concrete pile cap	-	-	-	100	-
concrete piles	-	-	-	100	-
elastomeric bearings	1 time / year	1 time / 3 years	1 time / 6 years	35	2
expansion joint	1 time / year	1 time / 3 years	1 time / 6 years	35	2
wearing surface	1 time / year	1 time / 3 years	1 time / 3 years	25	3
drainage	1 time / year	1 time / 3 years	-	35	2
Joint seals, sliders and springs	1 time / year	1 time / 3 years	-	15	6
Structural Health Monitoring Systems	1 time / year	1 time / 3 years	1 time / 6 years	25	3
galvanized steel barriers	1 time / year	1 time / 3 years	-	40	2
galvanized steel railing	1 time / year	1 time / 3 years	-	40	2
concrete barriers	1 time / year	1 time / 3 years	-	40	2
Sign support structures	1 time / year	1 time / 3 years	-	50	1
lamp post	1 time / year	1 time / 3 years	1 time / year (luminance test)	50 / upon need	1

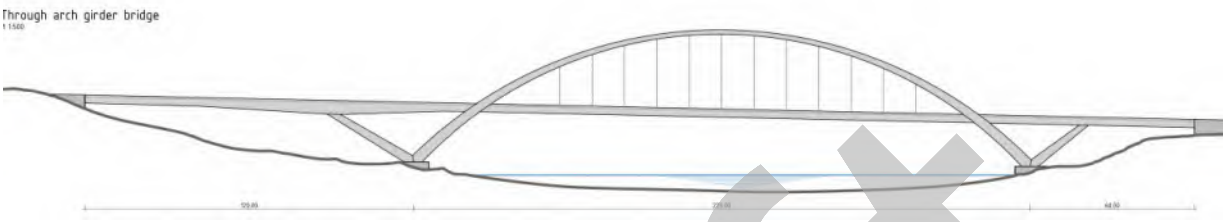
Items, which are different to the other options

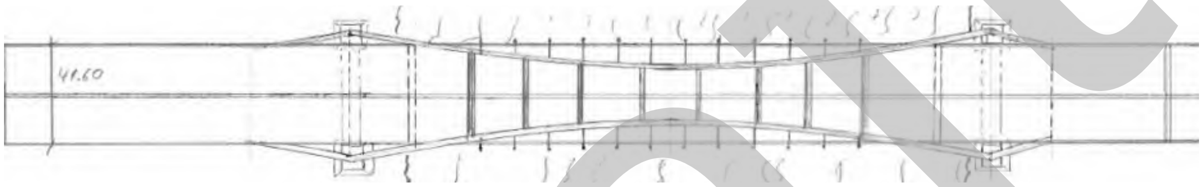
- Full deck slab on 410m length needs likely to be exchanged once in 100y
- About 49 Elastomeric Bearings need to be exchanged twice (with difficult access in the river)

2.2 Option 6 – Through Arch Bridge

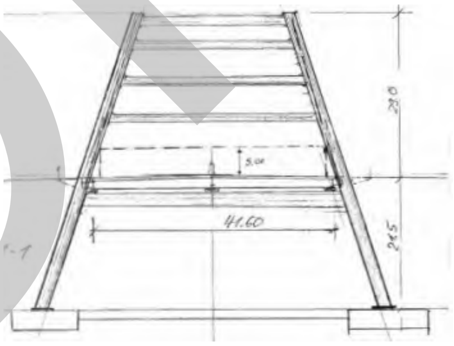
2.2.1 Layout

East West

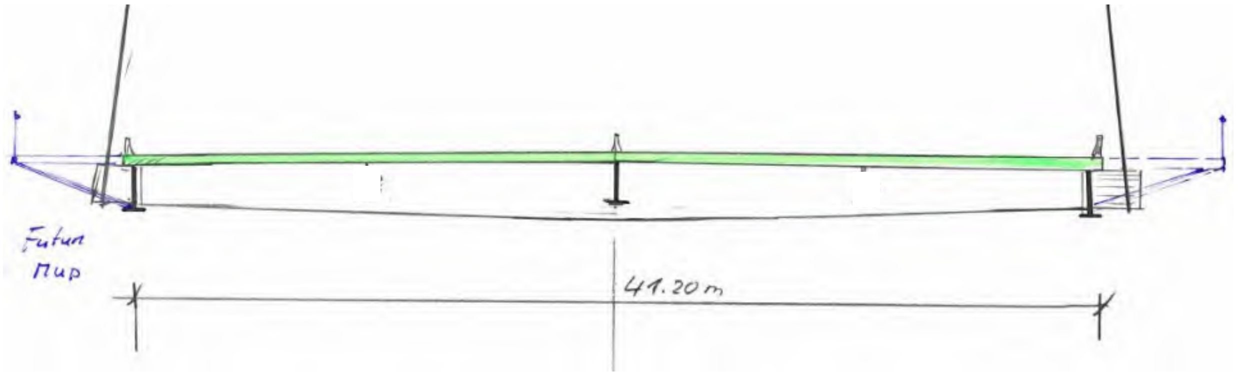




Option 2 consists of a Through-Arch Bridge with spans of 120 – 225 – 65 = 410 m. Only two piers/foundations would be needed. The large span on the w bank requires haunched plate girders (variable depth).



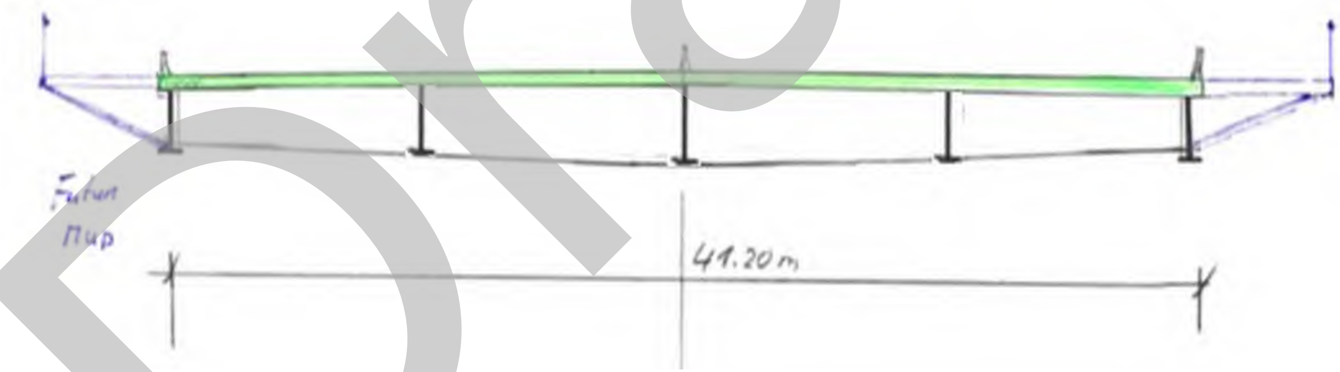
The cross section at the main span consists of three longitudinal steel main girders, connected by transverse cross girders spaced around four meters. The concrete slab is assumed to have a thickness of 270 mm, spanning longitudinally between cross girders. An average steel weight of 2.75 kN/m2 is assumed for the deck (arch not included), based on experience with similar solutions.



Cross section of the mainspan

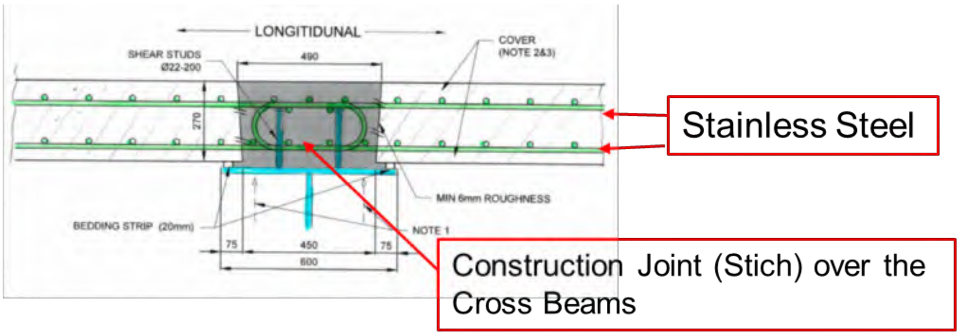
At sidespans a similar cross section is considered (with a 270mm slab), but with two additional longitudinal girders placed between the edge girders and the central one. The depth of the longitudinal girders need to be increased over the pier on the east side.

An average steel weight of 3.5 kN/m2 is considered for the longest sidespan, and 2.90 kN/m2 for the shorter one.



Cross Section of the Sidespan

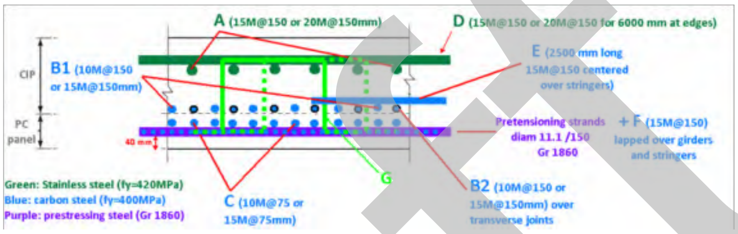
Suspended Deck at the Arch, about 290m long



Stainless Steel

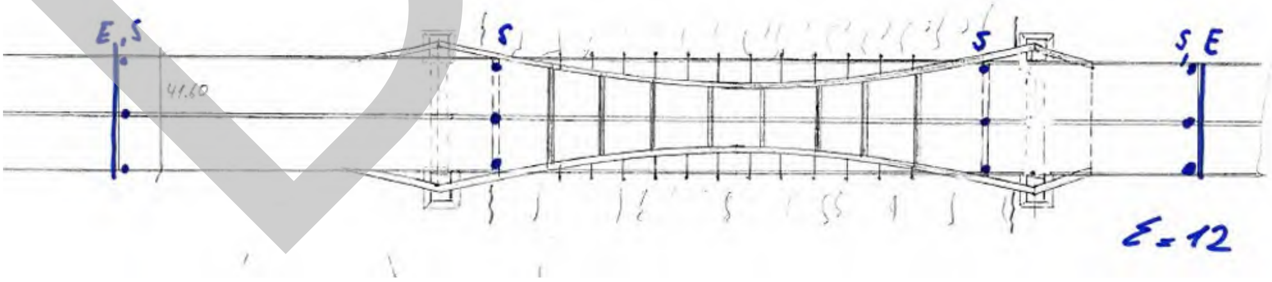
Construction Joint (Stich) over the Cross Beams

Girder Deck, about 120 m long



At Phase 1 it was noted, that an alternative cross section at the sides pans is possible (similar to that of Option 1). By removing the transverse girders and providing some lighter bracing instead some steel would be saved. A thicker slab would be needed, though, spanning in transverse direction and supported on extra longitudinal stringers, similar to Option 1. However, the side span is likely not long enough to justify a different design (that would mean also different construction means for execution of concrete slab, for example).

<u>Bearing Scheme:</u>



The deck is assumed to be fully fixed (integral) at both sides to the laterally inclined struts. At the abutments and cross beams (at arch to deck crossing) elastomeric bearings and expansion joints are considered.

2.2.2 Example

Saalebridge Beesedau

2.2.3 Summary of assumed Loads

LOADS

			OPTION 6	
Perm Loads				
	Self weight	SW Piers	0	kN/m
		SW Concrete slab main span	7.0	kN/m2
		SW Concrete slab side spans	7.0	kN/m2
		SW Steel main span	2.75	kN/m2

		SW Steel side spans	3.5	kN/m2
		SW Arches	85	kN/m
		SW Cables/hangers	0.03	kN/m2
		SW future MUP +3cm wearing srf	2.2	kN/m2
		SDL TOT	3.1	kN/m2
Var Loads	Live Load			
		2x5 lanes 3.00 m wide/DLL - Design Lane Load	3.0	kN/m2
		2x3.6m MUP pedestrian load	1.3	kN/m2
		Design Truck (*)	600	kN
	Wind			
		Design horizontal Wind (Wh)	8.0	kN/m
		Design vertical Wind (Wv)	10.0	kN/m
		Wind on Pylons/arch	18.0	kN/m
		Wind on Vehicles (WL)	4.0	kN/m
		Wind on Piers	10.0	kN/m
	Temperature			
		TU+(**)	40.0	K
		TU-(**)	-40.0	K
		TG+(***)	10.0	K
		TG-(***)	-10.0	K
	Friction		4	%

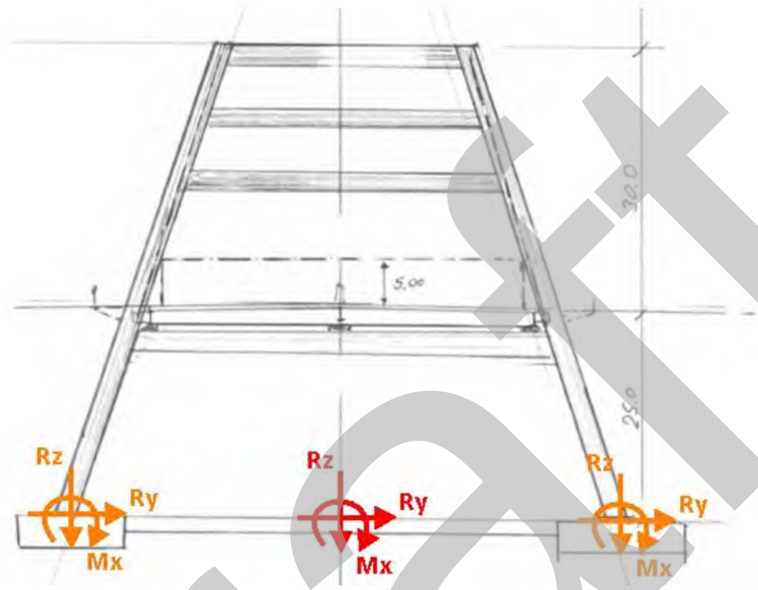
(*) Value of design truck to be considered together with lane load

(**) 40°C assumed (instead of 50°C) applied to a system with infinite rigid supports, in provision for foundation flexibility

(***) 10°C Gradient over the complete deck height assumed (similar effect as a 30°C gradient over the concrete slab depth)

2.2.4 Foundation Reactions

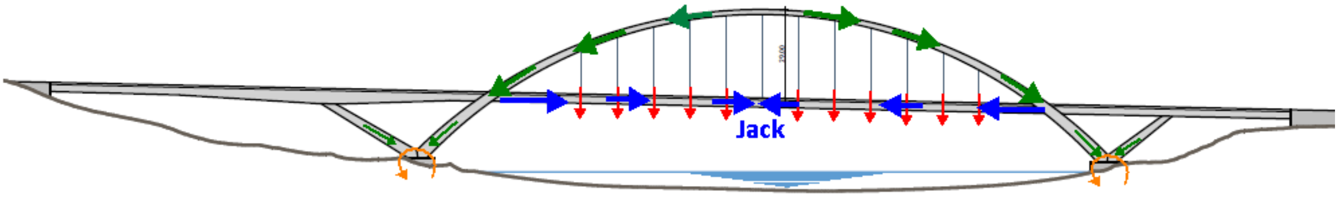
Following tables show an estimate of the reaction on top of foundation (weight of foundation not included). The reactions are given for the full width (both bounds, so both traffic directions), at the midpoint between both bounds (in red in sketch below).



For the two supports next to the shore (the supports of the arch) two separated foundations (probably linked with a transverse tie, with reactions as shown in orange) are likely the most suitable solution. Nevertheless, for sake of consistency with the other solutions (and ease of comparisons between them) the reactions are in this case also given as resultant forces at the mid-point, top of foundation (in red). The independent reactions can be estimated from the ones given for the midpoint.

With this format, the reactions at the midpoint shown in the following tables do not give any information about the tensile force in the transverse tie connecting both foundations. Therefore, a column for the tie force T_{tie} has been added to the tables for this option.

It is to be noted that the horizontal longitudinal Reactions Rx at the arch supports, as well as the bending moment My, highly depend on the construction sequence. Without any manipulation, the weight of the side spans (introduced by inclined legs into the foundation, and therefore introducing an horizontal component in opposite direction to the reaction from the arch) already compensates partially the horizontal reaction of the arch. Additionally, the remaining horizontal reaction at the support may be removed by different manipulations, such as a horizontal stressing at deck closure at the midpoint of the main span.



With such manipulation, the axial force at the two lower legs can be calibrated so that they compensate each other. Therefore, a horizontal force Rx close to zero and a bending moment My also close to zero could be obtained for permanent loads.

Nevertheless, at such an early stage it may be too audacious to assume such a reduction. Therefore, the reactions Rx and My of a situation without a construction manipulation (thus, the reactions obtained under the assumption of the whole bridge “magically” erected simultaneously) have been included in the tables below.

Should these two components of the permanent load reactions (marked in yellow in the tables below) penalize much the design of the foundations, a certain reduction/redistribution could be taken into account.

	Abutment 1				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**37.57**	0.00	0.00	0.00	0.00
TOT Traffic	**5.55**	0.00	0.00	**33.66**	0.00
TOT Wind	**0.38**	**0.89**	**0.05**	**4.93**	**0.17**
TOT Temp	**0.85**	0.00	0.00	0.00	0.00
SLS	**38.60**	**1.20**	**1.20**	**32.40**	**6.00**
ULS	**49.10**	**2.50**	**1.70**	**65.00**	**8.00**

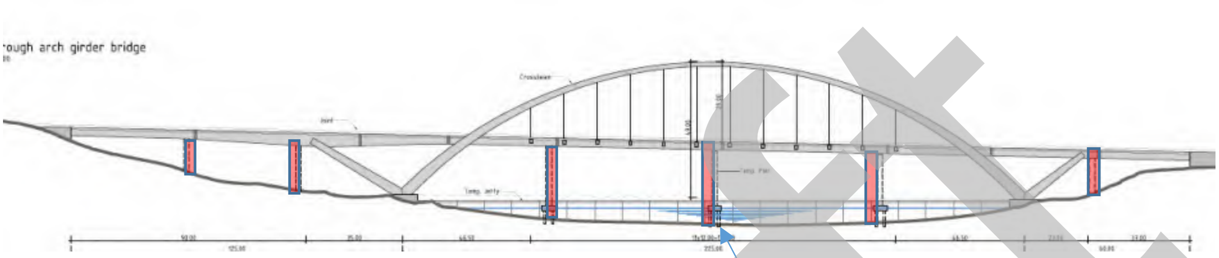
	Support 1					
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]	Ttie [MNm]
TOT Perm Loads	**123.40**	0.00	**16.87**	0.00	**97.65**	**41.41**
TOT Traffic	**15.22**	0.00	**11.74**	**98.12**	**25.20**	**3.45**
TOT Wind	**1.91**	**5.32**	**1.17**	**177.99**	**34.97**	**0.57**
TOT Temp	**0.77**	0.00	**11.51**	0.00	**49.75**	0.00
SLS	**136.10**	**0.00**	**35.50**	**67.90**	**158.20**	**44.10**
ULS	**170.00**	**6.50**	**51.90**	**254.00**	**225.80**	**54.50**

	Support 2					
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]	Ttie [MNm]
TOT Perm Loads	**99.98**	0.00	**16.87**	0.00	**145.20**	**26.59**
TOT Traffic	**12.92**	0.00	**11.74**	**82.73**	**31.08**	**2.60**
TOT Wind	**1.54**	**5.05**	**1.17**	**166.65**	**34.97**	**0.37**
TOT Temp	**2.15**	0.00	**11.51**	0.00	**37.17**	0.00
SLS	**112.00**	**0.00**	**35.50**	**58.00**	**200.10**	**28.60**
ULS	**139.90**	**6.20**	**51.90**	**232.80**	**266.90**	**35.70**

	Abutment 2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**23.34**	0.00	0.00	0.00	0.00
TOT Traffic	**4.61**	0.00	0.00	**27.35**	0.00
TOT Wind	**0.22**	**0.65**	**0.05**	**3.57**	**0.17**
TOT Temp	**2.06**	0.00	0.00	0.00	0.00
SLS	**24.70**	**0.70**	**0.70**	**25.60**	**3.20**
ULS	**32.40**	**1.50**	**0.90**	**50.70**	**4.40**

2.2.5 Construction

The most feasible option seems to be to erect the deck first including the roadway and construct the arch on top of the finished superstructure. Temporary piers are needed for that construction procedure.

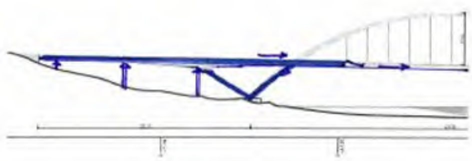


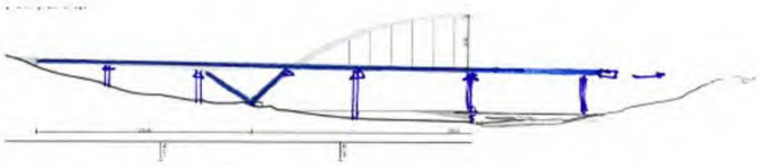
Sequence:

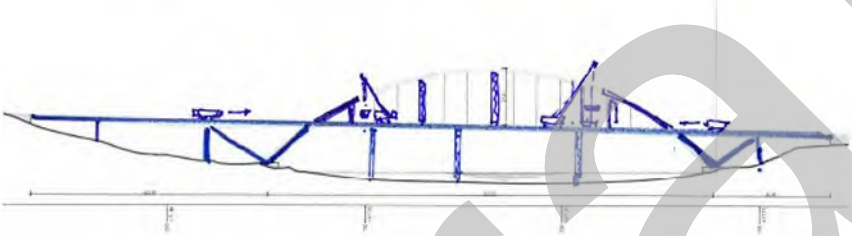
- erect plate girder of the superstructure span by span on temporary piers from jetty/cofferdam
- place deck panels and cast stiches

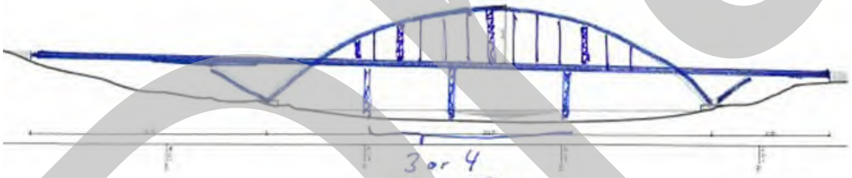
(same procedures as for Option 2)

- erect the arches on top of the finished deck









3 or 4
Temp. Piers.

Erect the Arch on top of the finished Deck by Mobile Cranes

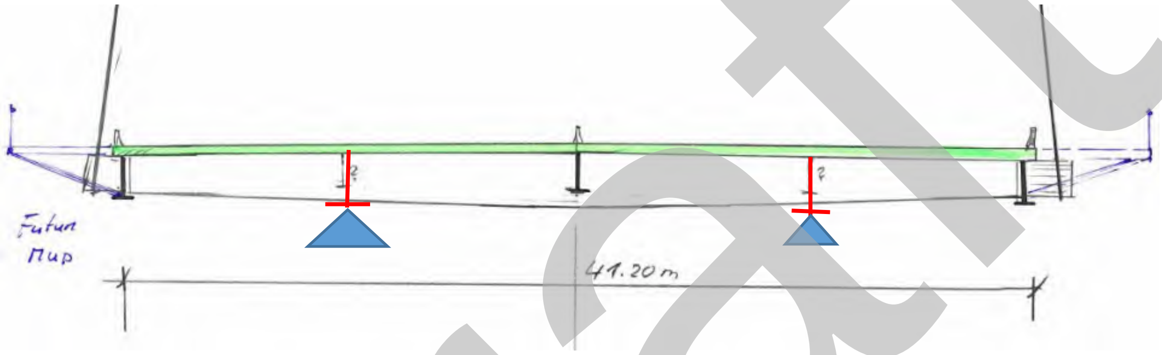
Finished Deck

Alternative Procedure

Theoretically, construction by Incremental Launching would also be an option. This would omit the need of a jetty/dam.

However

- At least 2 temporary piers would be needed in the river
- launching bearings should be placed at two girders only, since the main girders are haunched, secondary girders would be needed
- the bottom flanges of the secondary girder should better be welded, since launching over splice plates would be quite difficult, alternatively filler plates needs to be attached to the BF



2.2.6 Slope Stability

Slope stability is not a big issue here, since no permanent pier is placed in this zone. Depending on the erection procedure, temporary piers may be needed there, but for those it is not really a problem since any vertical movement can be compensated by jacks placed on the piers, horizontal movement needs to be corrected or sufficient tolerances provided in the load introduction zone.

2.2.7 Durability and Maintenance

The concrete deck would be under tension over a rather long area. However, the construction sequence mentioned above assures that stresses under permanent loads are rather low. Anyway, cracking has to be assumed. With a perfect waterproof membrane and stainless steel rebar's for the full depth of the slab in the main span, the durability will be rather good and 100y are assumed for the central part of 285 m length.

The remaining girder part (about 30% of the total), were tensile stresses are even higher and stainless steel is placed in the upper zone only, the slab may need to be replaced once.

The superstructure rests on only 12 elastomeric bearings with relative large loads. Those have to be replaced at an interval of about 30 to 40 years. Access should not be such a problem, since the bearings are close to the shore or at the abutment only.

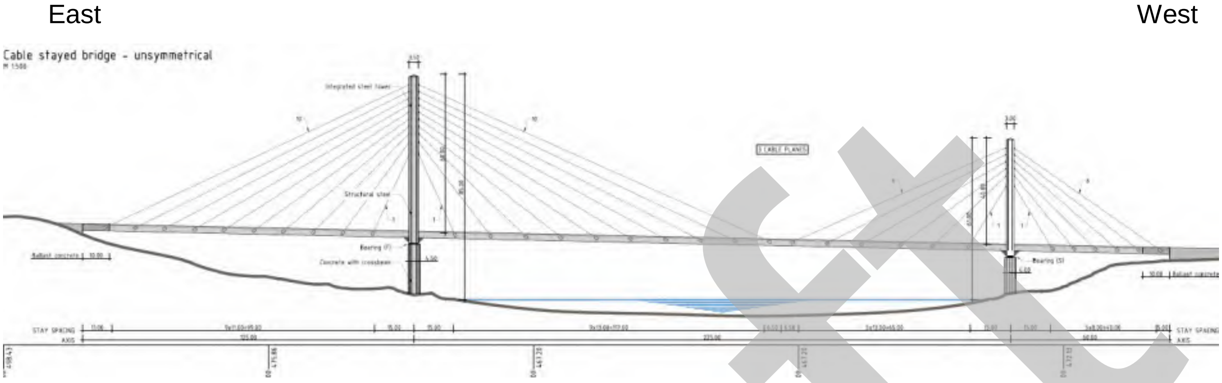
Item	frequency of Inspection			design service/lifetime [years]	replacement [times]
	visual, from a distance (authority/client)	visual (specialist)	"hands on" inspection / non. destructive testing		
structural weathering steel, superstructure	1 time / year	1 time / 3 years	1 time / 6 years	100	-
structural weathering steel in the arch	1 time / year	1 time / 3 years	1 time / 6 years	100	-
steel coating systems (not considered so far)	1 time / year	1 time / 3 years	1 time / 3 years	35	2
concrete deck slab arch zone (285m long)	1 time / year	1 time / 3 years	-	100	-
concrete deck slab remaining are a (30% of the total)	1 time / year	1 time / 3 years		50	1
concrete pile cap	-	-	-	100	-
concrete piles	-	-	-	100	-
elastomeric bearings	1 time / year	1 time / 3 years	1 time / 6 years	35	2
expansion joint	1 time / year	1 time / 3 years	1 time / 6 years	35	2
wearing surface	1 time / year	1 time / 3 years	1 time / 3 years	25	3
drainage	1 time / year	1 time / 3 years	-	35	2
Joint seals, sliders and springs	1 time / year	1 time / 3 years	-	15	6
Hangers	1 time / year	1 time / 3 years	1 time / 6 years	50	1
Structural Health Monitoring Systems	1 time / year	1 time / 3 years	1 time / 6 years	25	3
galvanized steel barriers	1 time / year	1 time / 3 years	-	40	2
galvanized steel railing	1 time / year	1 time / 3 years	-	40	2
concrete barriers	1 time / year	1 time / 3 years	-	40	2
Sign support structures	1 time / year	1 time / 3 years	-	50	1
lamp post	1 time / year	1 time / 3 years	time / year (luminance tes	50 / upon need	1

Items which are different to the other options

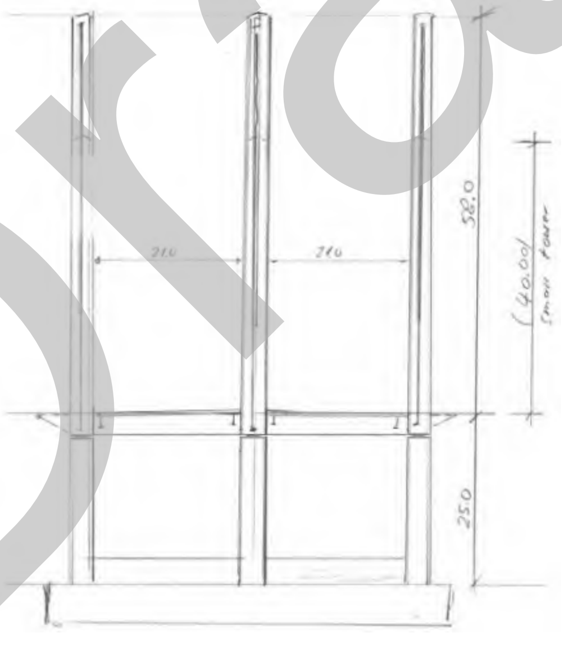
- 30% of deck slab (120m) needs to be exchanged once in 100y
- 12 Elastomeric Bearings with relative large loads need to be exchanged twice
- 24 Hangers need to be exchanged once

2.3 Option 10 – Unsymmetrical Stay Cable Bridge

2.3.1 Layout

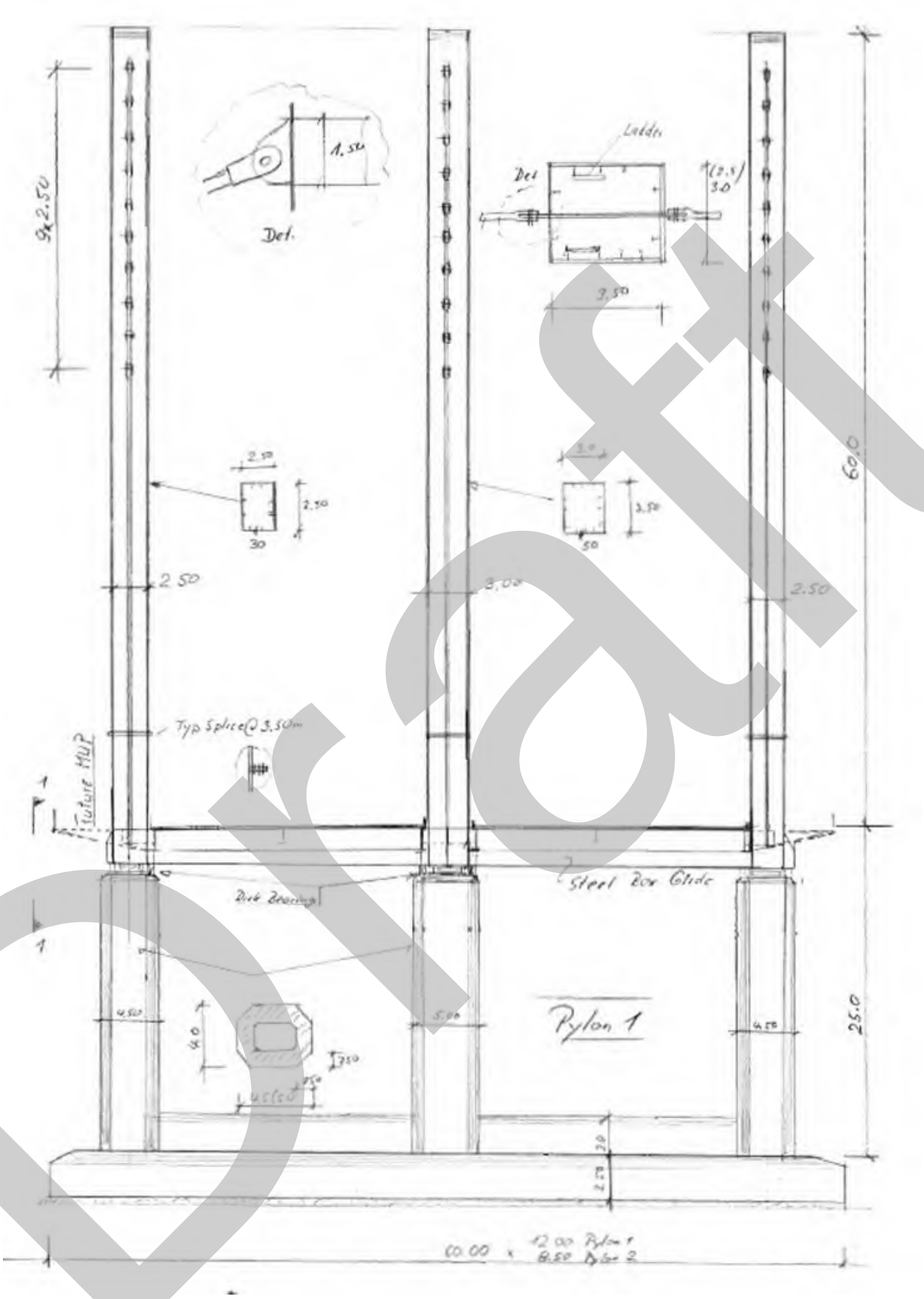


Option 10 is an unsymmetrical stay cable bridge with spans of 125 – 225 - 60 = 410 m.
Two Pylons with three legs has been assumed, a taller one on the East and a smaller one on the West.

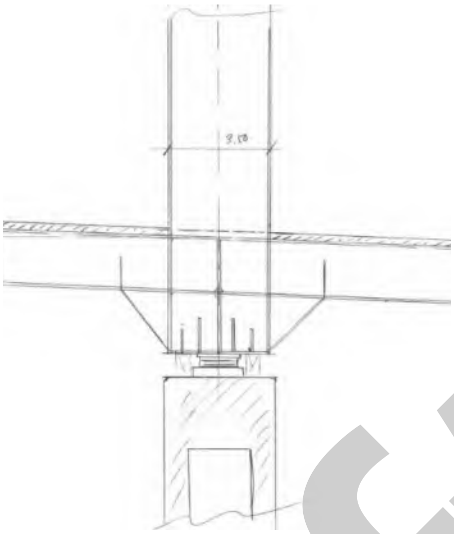


Several solutions for the pylon-to-deck fixation are possible. For the basic configuration, called option 10a, upper tower legs made of steel have been assumed, which are fully fixed to the deck (displacements and rotations). The integrated structure deck/pylon rests on bearings on top of a concrete frame **pier** (following the example of recent experiences such as New Duisburg Bridge or Nord Elbe Bridge). The fix point for longitudinal movements is assumed to be at the (taller)

East Pylon (fixed bearing in longitudinal direction; sliding bearing for East Pylon), with expansion joint at both abutments.



Pylon Layout with Details



Elevation at Deck Level – Section 1-1

Cost estimate for disc bearings under the tower columns is based on a current German Project:

Option 10 a		Loads [MN]		Maurer		
		SLS	ULS	Cost	Installation (33%)	Total
Large Tower	Outer	50	75	27'500 €	9'075 €	36'575 €
	Inner	100	150	82'500 €	27'225 €	109'725 €
	Outer	50	75	27'500 €	9'075 €	36'575 €
Large Tower	Outer	33	50	20'000 €	6'600 €	26'600 €
	Inner	66	99	36'500 €	12'045 €	48'545 €
	Outer	33	50	20'000 €	6'600 €	26'600 €
		332	498	214'000 €	70'620 €	284'620 €
average						47'437 €

Note, that this option requires quite heavy bearings (2x50MN plus 100MN at the large tower and 2x30+60MN at the small tower), therefore another solution with legs fixed to the substructure and not to the superstructure, have been looked into – see option 10b and c below.

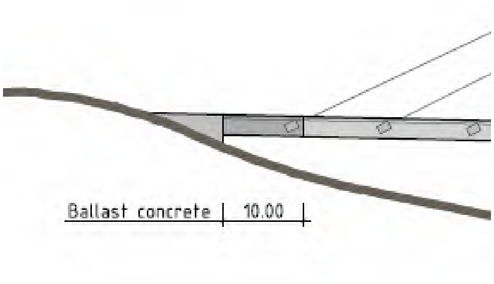
Potential Uplift at the Bridge Ends (Abutments

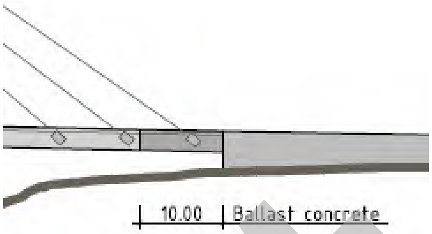
In order to cope with the unbalance of permanent and variable loads, in many stay cable bridges holddown cables/tendons are provided, mostly built up like the stay cables and prestressed so that no uplift occurs in the bearings under SLS or ULS loads (depending on the conditions of the clients).

Two measures have been adopted to avoid uplift:

1. For balance of dead weight the concrete slab is made thicker in the backspan

2. For balance of live load ballast concrete is placed at the end and considered in the BoQ, This concrete is place over 10 m length of the deck and the full width between the edge girders.





Both measures together are designed so that no uplift occurs under full ULS loads in the elastomeric bearings provided at the abutments.

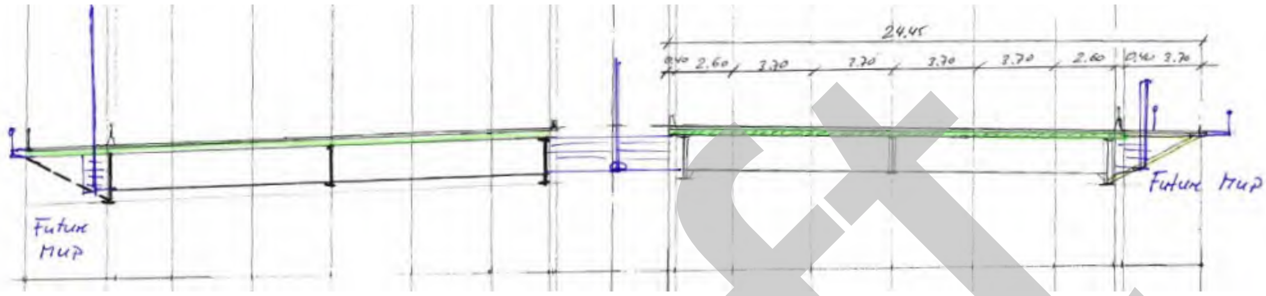
Deck Layout

The deck itself is assumed to be a plate girder type, similar to the one for the Tappan Zee Bridge, with cross girders spaced around 4,5 m, split in the center to allow the mid tower passing through the deck. The slab thickness is taken 270 mm, and the resulting average weight of steel 2.5 kN/m2:

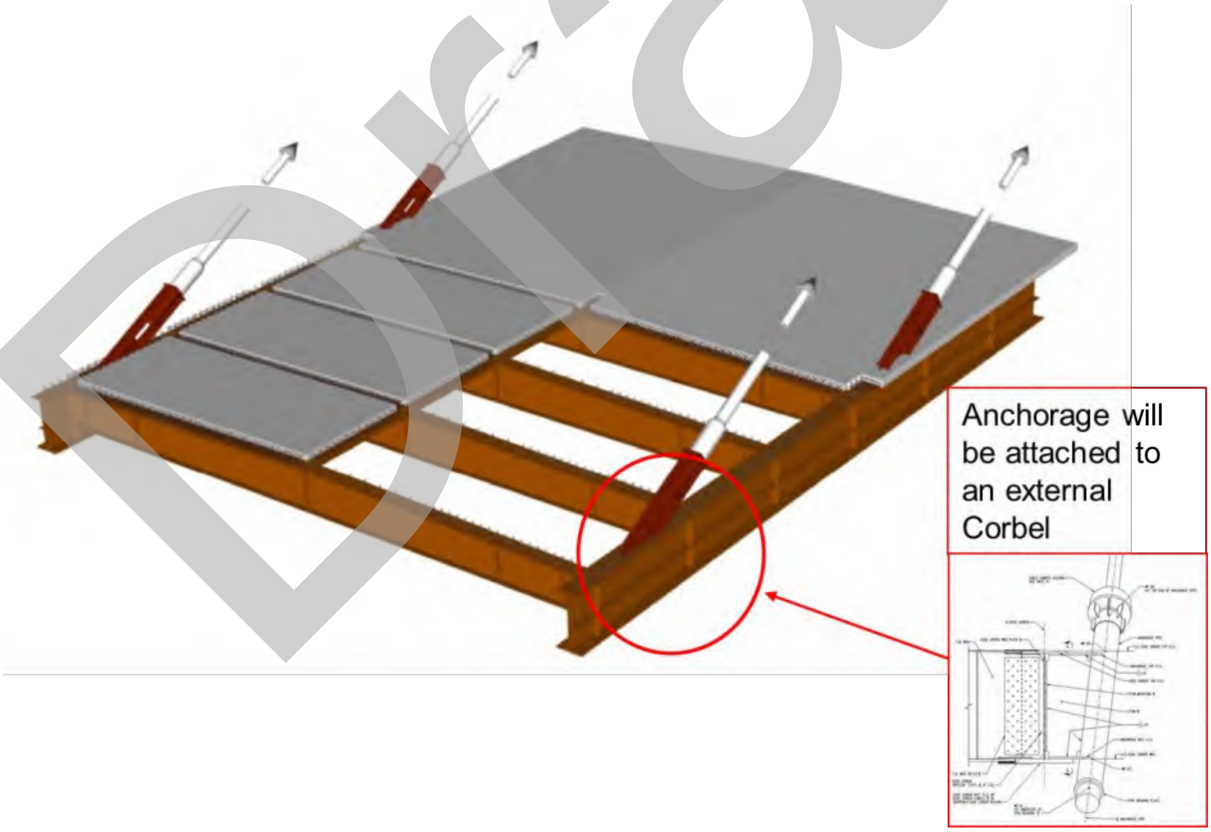
In the future configuration an MUP is attached as a light steel structure at each side and the roadway expanded to the barriers. A gap needs to be provided between roadway and MUP structure to pass the stay cables through. The concrete slab for the main span is assumed to be a full depth precast panel spanning longitudinally between cross girders, with 270 mm depth. For the side spans, a total depth of 400 mm for the larger back span and 600 mm for the shorter backspan is assumed, with 1/3 of the depth being precast panel and 2/3 of the depth cast in place concrete. With this arrangement, the higher permanent loads of the main span are partially balanced with the weight of backspans. In order to compensate the remaining part and to cope with the uplift forces that would appear at the abutments with traffic loads only at the main span, end transverse concrete beams of around 1230 tons and 1870 tons for West and East abutments respectively are assumed (with a depth of around 3.5 m and full 40 m width, the needed length for this concrete end beam is around 3.5 m and 5.3 m respectively).

In many other stay cable bridges, the ballast is replaced by hold-down cables. Those cable need a certain length to cope with the deformations, so this is not a feasible solution here. Also provision of pendulum link bars may be an option, but that is quite tricky in the detailing. Whatever solution is adopted, the Influence on total cost is minor.

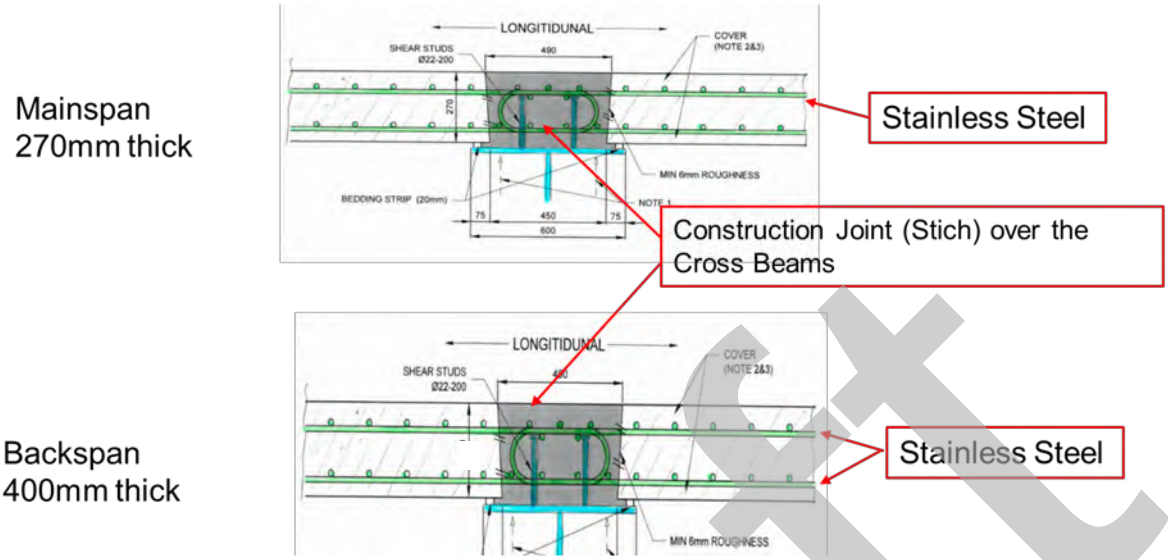
The central cable can be anchored to transverse brackets linking the superstructures of both bounds, or this cable could instead be split in two, one for each bound, without needing these brackets and having then two independent decks. For this variant, the two bounds need to be separated enough to leave room for the anchorages of both bounds.



These two central planes of cables can be anchored to one only central tower, or this central tower can also be split in two thinner ones (as done for both New Duisburg Bridge and Nord Elbe Bridge), allowing then a fully independent construction of both bounds.

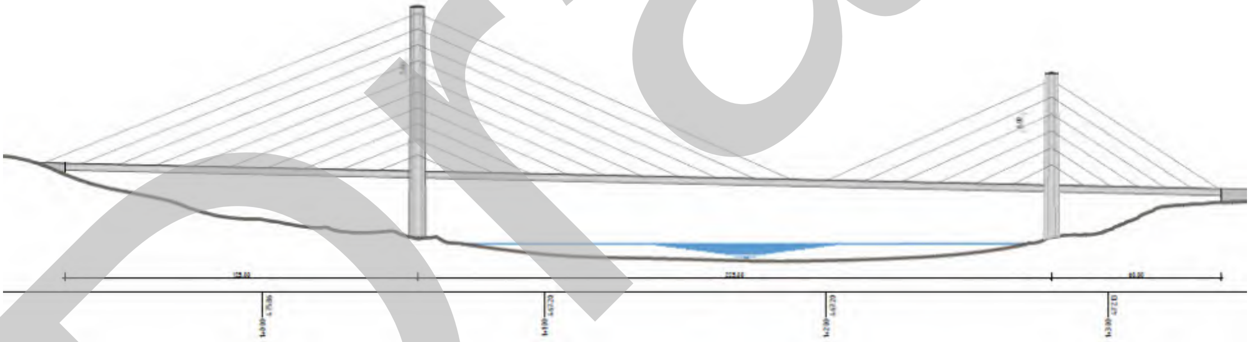


Upper and lower rebars are made of stainless steel, in the mainspan as well as in the sidespan



Modification of Stay Cable Configuration

The cable arrangement can be modified from the fan type shown above, to a harp type:

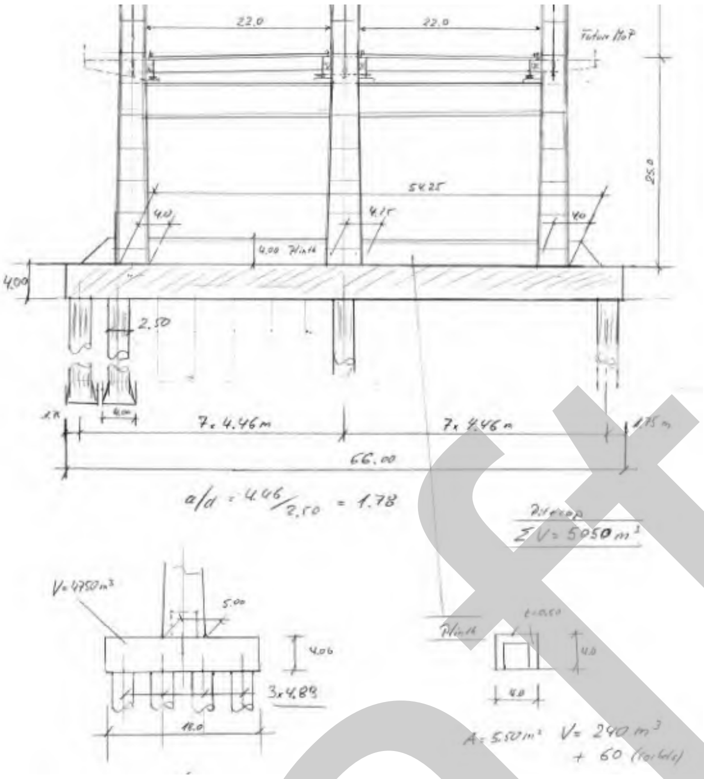


In this case, the 370 tons of steel on cables estimated for the fan solution would increase to around 400 tons (or around 390 tons if the shorter cables of each tower were removed). Other than this, the cable arrangement has no relevant influence in the reactions given below.

Foundation Layout

Initial concept: Pile Foundation with a pilecap of

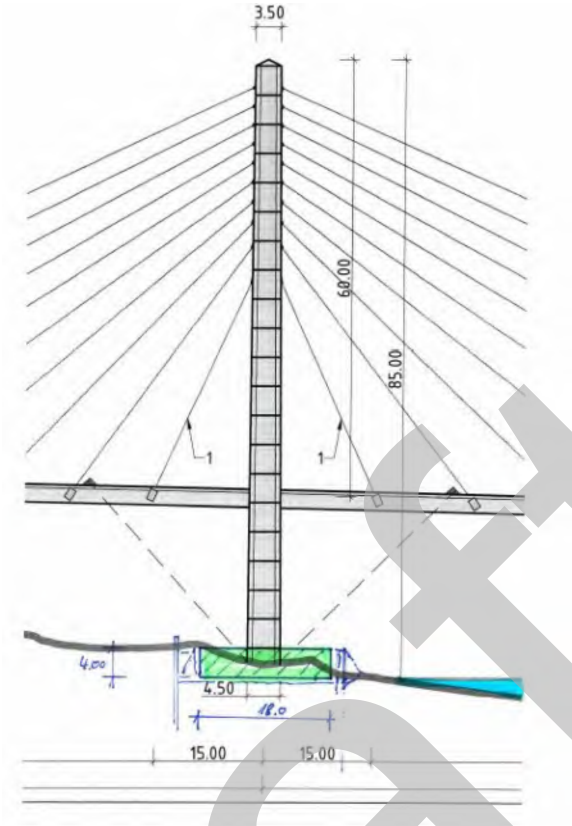
- 18.0 x 66.0 x4.00m at Pylon 1 (shown below)
- 12.0 x 66.0 x3.50m at Pylon 2



Optimization: Spread Footing

OPTION 10a - UNSYMMETRICAL STAY CABLE BRIDGE (SPREAD FOOTING FOR PYLON FOUNDATIONS)

Substructure Element	Length (m)	Width (m)	Thickness (m)	Concrete Volume (m3)
Pylon 1	60.00	12.00	3.50	2520
Pylon 2	60.00	8.50	3.50	1785
			Totals	**4305**



The distance of the pylon to the shoreline is sufficient to allow pilecap construction incl. temporary works without entering the river, even for the extreme width of a pilecap. The spread footing is less critical, since it has a max. width of 12.00m only. The final distance can be optimized in the next phase.

2.3.2 Example

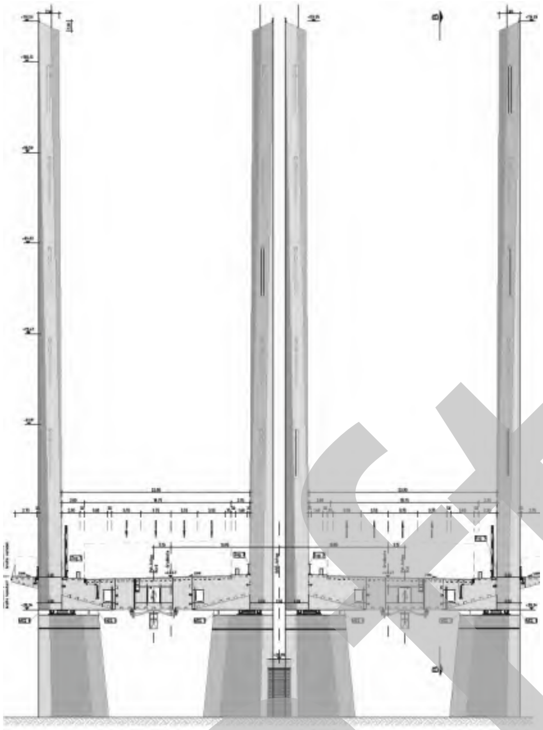
Norderelbebrücke, Hamburg

2.3.3 Feasible Variants

a) Independent Superstructures with 4 Tower legs

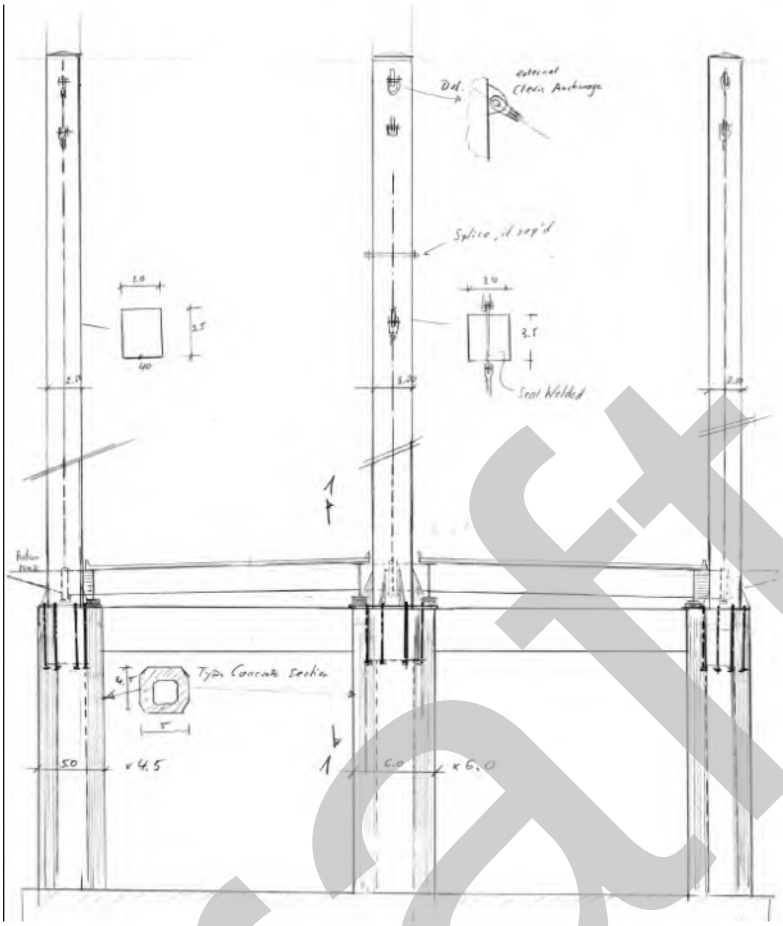
This is the concept of the example from Norderelbe. The central legs are close together, so that it looks like one leg from a distance. Two independent structures have the advantage that one bound could be closed and traffic diverted to the other bound in case a real heavy repair works (e.g. fully replacement after 100y) would be needed.

However, this bears one problem: in case of adding the future MUP on one side of the superstructure, the loads will go to one cable plane only (even a bit more and the other gets de-loaded). This could be considered in the design, but additional deformation downward may create a problem for the crossfall- may get too big. It may not be possible to increase the slope initially, so that it is correct after adding the future MuP, a compromise may have to be found: a bit more initially and a bit lower in the future. This can only be addressed in detail with further calculations. For the time being we will proceed with a combined superstructure and three tower legs, integrated into that one.



Typical Layout of German Stay Cable Bridges with Twin Deck

b) Steel Tower Legs **not** integrated into the superstructure but stressed by PT bars to the top of the concrete legs and the superstructure is continuous between the legs, provided with small elastomeric bearings. This option is named Option 10b in the following.



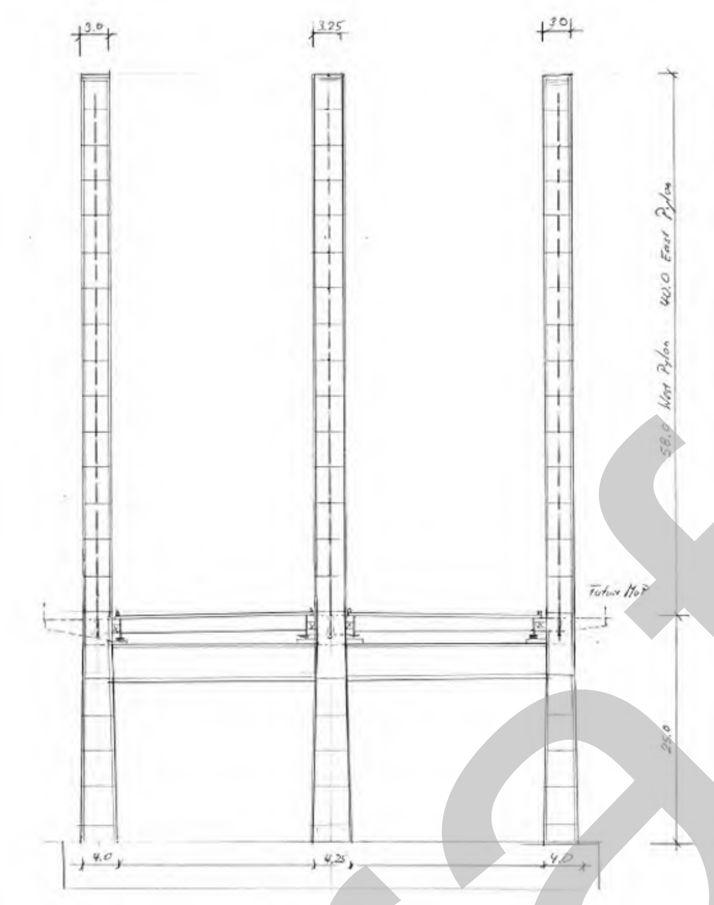
Option 10 b

Placement and replacement of bearings is much simpler for such a solution, construction slightly more difficult (accurate placement of the first steel element is essential for the tower geometry.). Tower bending and Mx Moments (longitudinal bending) at Top of Foundations are higher than for option 10a.

This option is called Option **10b** in the BoQ and Matrix below

c) Concrete Tower Legs

This option, named 10 c, would look quite similar as the option 10b above, but steel would be replaced by concrete columns. These concrete columns could be made of precast elements, placed by the tower crane or mobile cranes, tied together by vertical PT bars.

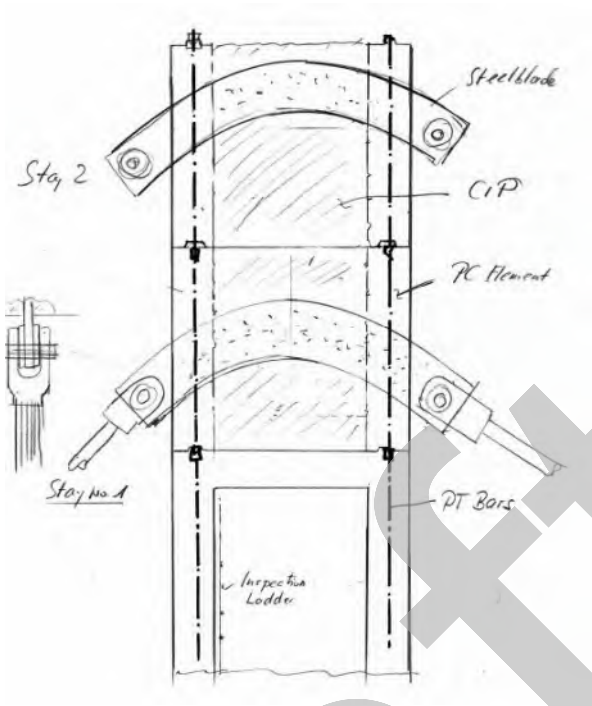


Option 10 c

Stay Anchor Zone

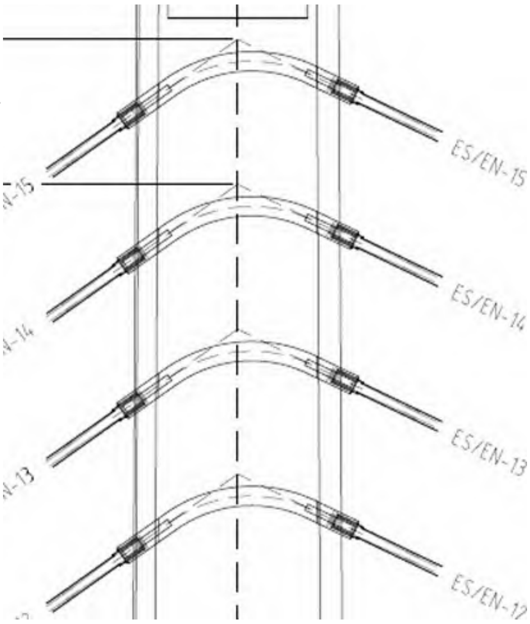
The stay cable anchorages in the upper zone are fixed to steel blades extending beyond the wall – see example from Champlain.

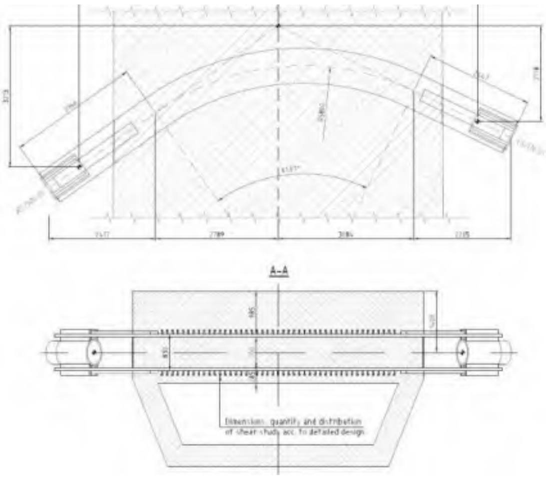
If done as precast segments, those would be light with say 400mm thick walls, filled with CIP Concrete after placement.

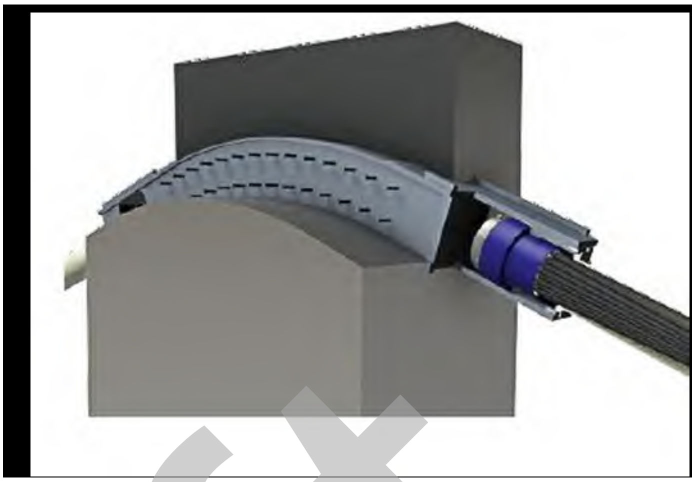


Concrete Tower Leg- Stay Anchor Zone

Example from Champlain



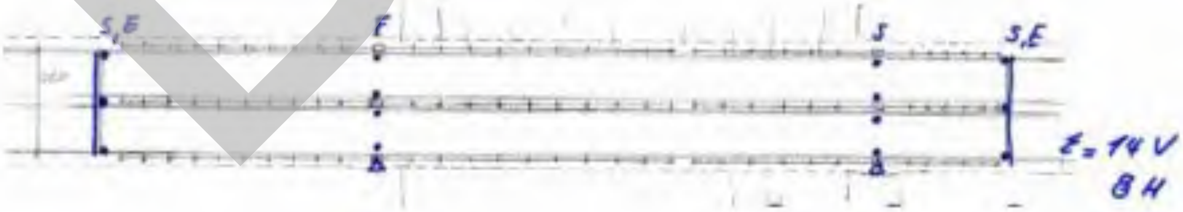




Stay Anchorages Champlain – System Dyna Link form DSI

Foundation loads will increase as shown in section 2.3.4 below

<u>Bearing Scheme - Option 10 b and c</u>
(Option 10 a has only three bearings in one axis)



Longitudinal Fixing is at East Pylon (1), all the others are sliding bearings, in total 14 vertical elastomeric bearings are needed plus 8 horizontal (wind) bearings (two on each side of one of the twin decks)

2.3.4 Summary of assumed Loads

Option 10a and 10b

LOADS			OPTION 10	
Perm Loads				
	Self weight	SW Pylon lower legs	508	kN/m
		SW Concrete slab main span	7.0	kN/m2
		SW Concrete slab side spans (*)	10.4	kN/m2
		SW Steel main span	2.5	kN/m2
		SW Steel side spans	2.5	kN/m2
		SW upper Pylon (**)	128	kN/m
		SW Cables	0.25	kN/m2
		SW future MUP +3cm wearing srf	2.2	kN/m2
		SDL TOT	3.1	kN/m2
Var Loads	Live Load			
		2x5 lanes 3.00 m wide/DLL - Design LL	3.0	kN/m2
		2x3.6m MUP pedestrian load	1.3	kN/m2
		Design Truck (***)	600	kN
	Wind			
		Design horizontal Wind (Wh)	8.0	kN/m
		Design vertical Wind (Wv)	10.0	kN/m
		Wind on Pylons/arch	18.0	kN/m
		Wind on Vehicles (WL)	4.0	kN/m
		Wind on Piers	10.0	kN/m
	Temperature			
		TU+/	50.0	K
		TU-	-50.0	K
		TG+(****)	10.0	K
		TG-(****)	-10.0	K
	Friction		4	%

(*) Value for west side, East side: 15.6 kN/m2

(**) Value for west side, East side: 88 kN/m

(***) Value of design truck to be considered together with lane load

(****) 10°C Gradient over the complete deck height assumed (similar effect as a 30°C gradient over the concrete slab depth)

Option 10c

LOADS

			OPTION 10	
Perm Loads				
	Self weight	SW Pylon lower legs	508	kN/m
		SW Concrete slab main span	7.0	kN/m2
		SW Concrete slab side spans (*)	10.4	kN/m2
		SW Steel main span	2.5	kN/m2
		SW Steel side spans	2.5	kN/m2
		SW upper Pylon (**)	700	kN/m
		SW Cables	0.25	kN/m2
		SW future MUP +3cm wearing srf	2.2	kN/m2
		SDL TOT	3.1	kN/m2
Var Loads	Live Load			
		2x5 lanes 3.00 m wide/DLL - Design Lane Load	3.0	kN/m2
		2x3.6m MUP pedestrian load	1.3	kN/m2
		Design Truck (***)	600	kN
	Wind			
		Design horizontal Wind (Wh)	8.0	kN/m
		Design vertical Wind (Wv)	6.0	kN/m
		Wind on Pylons/arch	18.0	kN/m
		Wind on Vehicles (WL)	4.0	kN/m
		Wind on Piers	10.0	kN/m
	Temperature			
		TU+	50.0	K
		TU-	-50.0	K
		TG+(****)	10.0	K
		TG-(****)	-10.0	K
	Friction		4	%

(*) Value for west side, East side: 15.6 kN/m2

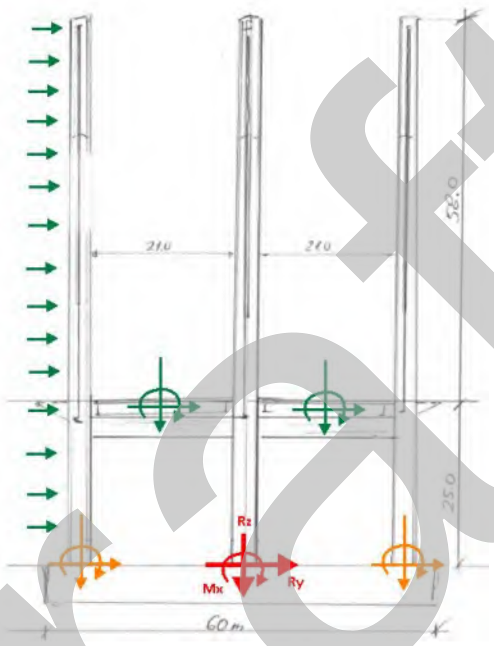
(**) Average value between lower part (precast hollow box) and upper part (including cast in place filling)

(***) Value of design truck to be considered together with lane load

(****) 10°C Gradient over the complete deck height assumed (similar effect as a 30°C gradient over the concrete slab depth)

2.3.5 Foundation Reactions

Following tables show an estimate of the reaction on top of the foundation (weight of foundation not included). The reactions are given for the full width (both bounds, so both traffic directions), at the midpoint between both bounds. An estimation of the weight of the pylon shafts, wind on pylon and bearing friction has been added to the loads coming from the deck, so that the reactions shown in the table below (in red in the following sketch) includes o provision for those effects.



There would be several options to design the foundations. Even independent foundations for each leg (maybe liked together by a bottom beam) could be envisaged. For the reactions given below a common foundation for the three legs was assumed, those being referred to the midpoint of both bounds (in red). In case of independent foundations, the independent reactions (in orange) can be estimated from the ones given for the midpoint.

Regarding the design options explained in the previous chapter (regarding the central tower and central plane of cables - one common tower and cable plane for both bounds or independent ones), the differences of the reactions at the midpoint of the foundation between each option are negligible at the current stage of the analysis.

Option 10a

	Abutment 1				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**18.08**	0.00	0.00	0.00	0.00
TOT Traffic	**5.65**	0.00	0.00	**40.58**	0.00
TOT Wind	**0.40**	**1.85**	**0.05**	**10.37**	**0.17**
TOT Temp	**0.1**	0.00	0.00	0.00	0.00
SLS	**23.00**	**0.60**	**0.60**	**35.00**	**2.90**
ULS	**31.30**	**2.50**	**0.90**	**72.70**	**4.00**

	Pylon 1 (Fix Point)				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**190.57**	0.00	0.00	0.00	0.00
TOT Traffic	**19.65**	0.00	**0.70**	**149.45**	**16.10**
TOT Wind	**2.29**	**3.45**	**1.05**	**125.02**	**22.48**
TOT Temp	**0.15**	0.00	0.00	0.00	0.00
SLS	**206.10**	**7.50**	**0.70**	**276.50**	**14.50**
ULS	**259.70**	**13.60**	**1.50**	**500.50**	**32.70**

	Pylon2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**132.77**	0.00	0.00	0.00	0.00
TOT Traffic	**13.38**	0.00	0.00	**100.65**	0.00
TOT Wind	**1.16**	**2.66**	**0.18**	**70.20**	**2.16**
TOT Temp	**0.2**	0.00	0.00	0.00	0.00
SLS	**143.60**	**5.10**	**5.10**	**163.60**	**91.80**
ULS	**180.00**	**9.60**	**6.90**	**297.30**	**122.40**

	Abutment 2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**16.90**	0.00	0.00	0.00	0.00
TOT Traffic	**4.77**	0.00	0.00	**33.73**	0.00
TOT Wind	**0.25**	**1.85**	**0.05**	**10.37**	**0.17**
TOT Temp	**0.15**	0.00	0.00	0.00	0.00
SLS	**21.20**	**0.50**	**0.50**	**30.10**	**2.50**
ULS	**28.40**	**2.40**	**0.80**	**60.60**	**3.50**

Option 10b

	Abutment 1				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**18.08**	0.00	0.00	0.00	0.00
TOT Traffic	**5.65**	0.00	0.00	**40.58**	0.00
TOT Wind	**0.40**	**1.85**	**0.05**	**10.37**	**0.17**
TOT Temp	**0.1**	0.00	0.00	0.00	0.00
SLS	**23.00**	**0.60**	**0.60**	**35.00**	**2.90**
ULS	**31.30**	**2.50**	**0.90**	**72.70**	**4.00**

	Pylon 1 (Fix Point)				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**192.12**	0.00	0.00	0.00	0.00
TOT Traffic	**19.65**	0.00	**9.65**	**149.45**	**294.58**
TOT Wind	**2.29**	**3.45**	**2.17**	**125.02**	**86.20**
TOT Temp	**0.15**	0.00	0.00	0.00	0.00
SLS	**207.70**	**1.20**	**7.50**	**129.40**	**230.50**
ULS	**261.70**	**5.30**	**16.50**	**309.20**	**500.80**

	Pylon2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**134.32**	0.00	0.00	0.00	0.00
TOT Traffic	**13.38**	0.00	**8.01**	**100.65**	**251.09**
TOT Wind	**1.16**	**2.66**	**0.95**	**70.20**	**34.40**
TOT Temp	**0.2**	0.00	0.00	0.00	0.00
SLS	**145.10**	**1.10**	**7.20**	**90.00**	**213.40**
ULS	**182.00**	**4.30**	**15.00**	**201.60**	**450.50**

	Abutment 2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**16.90**	0.00	0.00	0.00	0.00
TOT Traffic	**4.77**	0.00	0.00	**33.73**	0.00
TOT Wind	**0.25**	**1.85**	**0.05**	**10.37**	**0.17**
TOT Temp	**0.15**	0.00	0.00	0.00	0.00
SLS	**21.20**	**0.50**	**0.50**	**30.10**	**2.50**
ULS	**28.40**	**2.40**	**0.80**	**60.60**	**3.50**

Option 10c

	Abutment 1				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**18.08**	0.00	0.00	0.00	0.00
TOT Traffic	**5.65**	0.00	0.00	**40.58**	0.00
TOT Wind	**0.40**	**1.85**	**0.05**	**10.37**	**0.17**
TOT Temp	**0.1**	0.00	0.00	0.00	0.00
SLS	**23.00**	**0.60**	**0.60**	**35.00**	**2.90**
ULS	**31.30**	**2.50**	**0.90**	**72.70**	**4.00**

	Pylon 1 (Fix Point)				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**227.36**	0.00	0.00	0.00	0.00
TOT Traffic	**19.65**	0.00	**10.34**	**149.45**	**352.89**
TOT Wind	**2.29**	**3.45**	**2.17**	**125.02**	**86.20**
TOT Temp	**0.15**	0.00	0.00	0.00	0.00
SLS	**242.90**	**1.20**	**8.20**	**129.40**	**283.00**
ULS	**300.40**	**5.30**	**17.60**	**309.20**	**600.00**

	Pylon2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**151.12**	0.00	0.00	0.00	0.00
TOT Traffic	**13.38**	0.00	**8.69**	**100.65**	**309.39**
TOT Wind	**1.16**	**2.66**	**0.95**	**70.20**	**34.40**
TOT Temp	**0.2**	0.00	0.00	0.00	0.00
SLS	**161.90**	**1.10**	**7.80**	**90.00**	**265.90**
ULS	**200.40**	**4.30**	**16.10**	**201.60**	**549.70**

	Abutment 2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**16.90**	0.00	0.00	0.00	0.00
TOT Traffic	**4.77**	0.00	0.00	**33.73**	0.00
TOT Wind	**0.25**	**1.85**	**0.05**	**10.37**	**0.17**
TOT Temp	**0.15**	0.00	0.00	0.00	0.00
SLS	**21.20**	**0.50**	**0.50**	**30.10**	**2.50**
ULS	**28.40**	**2.40**	**0.80**	**60.60**	**3.50**

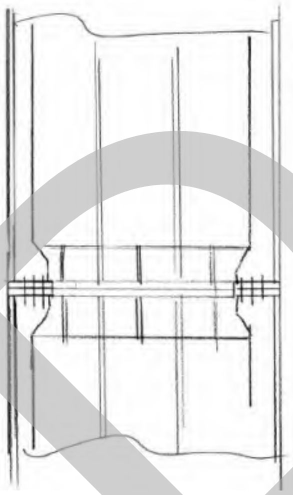
2.3.6 Construction

2.3.6.1 Tower erection

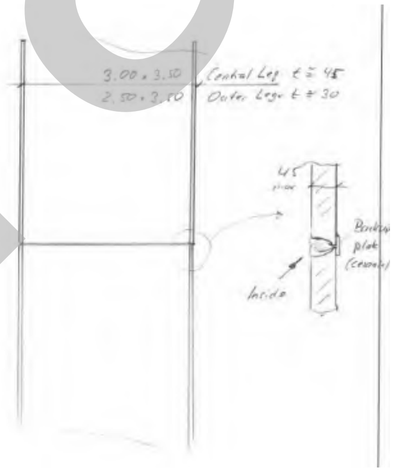
Option 10a

The legs below the deck are conventional piers and constructed as those. Only the legs above the deck are made of structural steel.

This option has no concrete crossbeam, the steel crossbeam (a box girder) is integrated into the deck and will be lifted after placement of bearings by a mobile crane on top of those, temporarily stressed down to the falsework. Immediately after the crossbeam is fixed and secured, the erection of the upper legs can proceed. The 3.50m high box segments will come to site in two halves (U-shaped, max dimension 3.50 x 3.50 x 1.50m. The two halves will be welded together to a box (3.50 x 3.50 x 3) with a max weight of 21mt at the base (50mm average wall thickness, incl. splice plates for the head to head splice. Segment 2 (45mm thick) will weigh 19mt incl. splices. The segments are lifted by a crawler crane and fixed together by a bolted head to head splice



Bolted Splice



Welded Splice

In case site welding would be possible in a protected environment, the welded splices could be arranged in a way that allows welding from the inside. The only work form outside would be the removal of the backing plate. Since the structure is built up by weathering steel it could even be considered to leave the backing plates in. Aesthetics would not be harmed much.

Option 10b:

Erection of the legs in a similar ways as option 10, lower leg in concrete, upper leg in structural steel. Concrete crossbeam on falsework, supported down to the foundation.

Erection of the starter elements:

- Tower legs starter segment is placed on the concrete legs, the gaps grouted and later, after curing of the grout, PT bars are stressed, further segments as for option 10a
- Deck starter segment placed on the concrete crossbeam – as for option 10 c

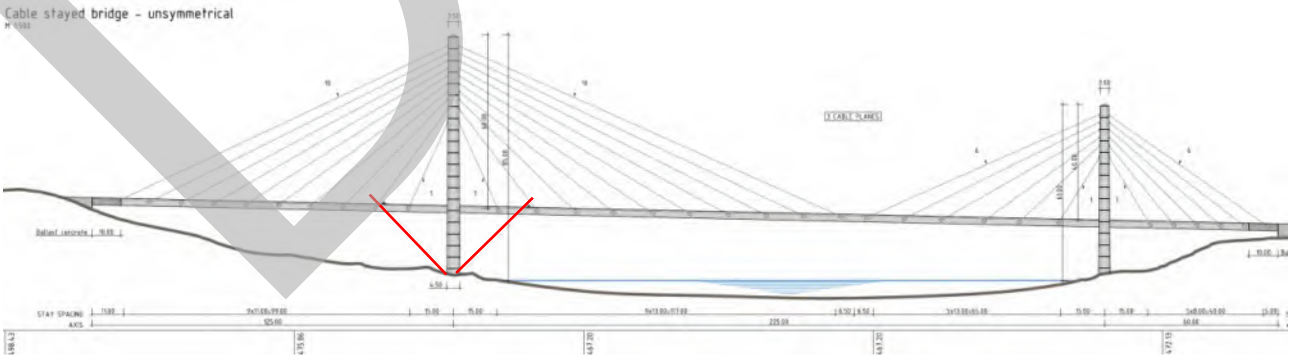
Option 10c:

Lower leg as for Option 10b.

Upper legs proposed with precast segmental construction, segments stressed together by PT bars in such a way that no tension occurs during erection and in the final stage (SLS). Legs below the stay anchorage zone may remain hollow, legs at anchorage zone should be filled by CIP concrete.

CIP Construction by a jumpform is also possible, slipforming is not recommended – and not feasible in the anchorage zone.

2.3.6.2 Superstructure erection



No temporary piers are needed for erection of the deck. For aerodynamic stability likely some diagonal ties are required in pylon 1 (East Pylon) , as shown in red above. Pylon 2 has a rather short cantilever, so it likely will be stable w/o any temporary tie downs.

General Sequence

1 erect tower starter segments on falsework (Option 10b and 10c may need only a fixation by PT bars to the crossbeam below), Option 10a has no concrete crossbeam and a falsework is needed.

2 deliver steelwork segments in pieces to the tower

3 lift by heavy tower crane or mobile crane placed on the starter segments

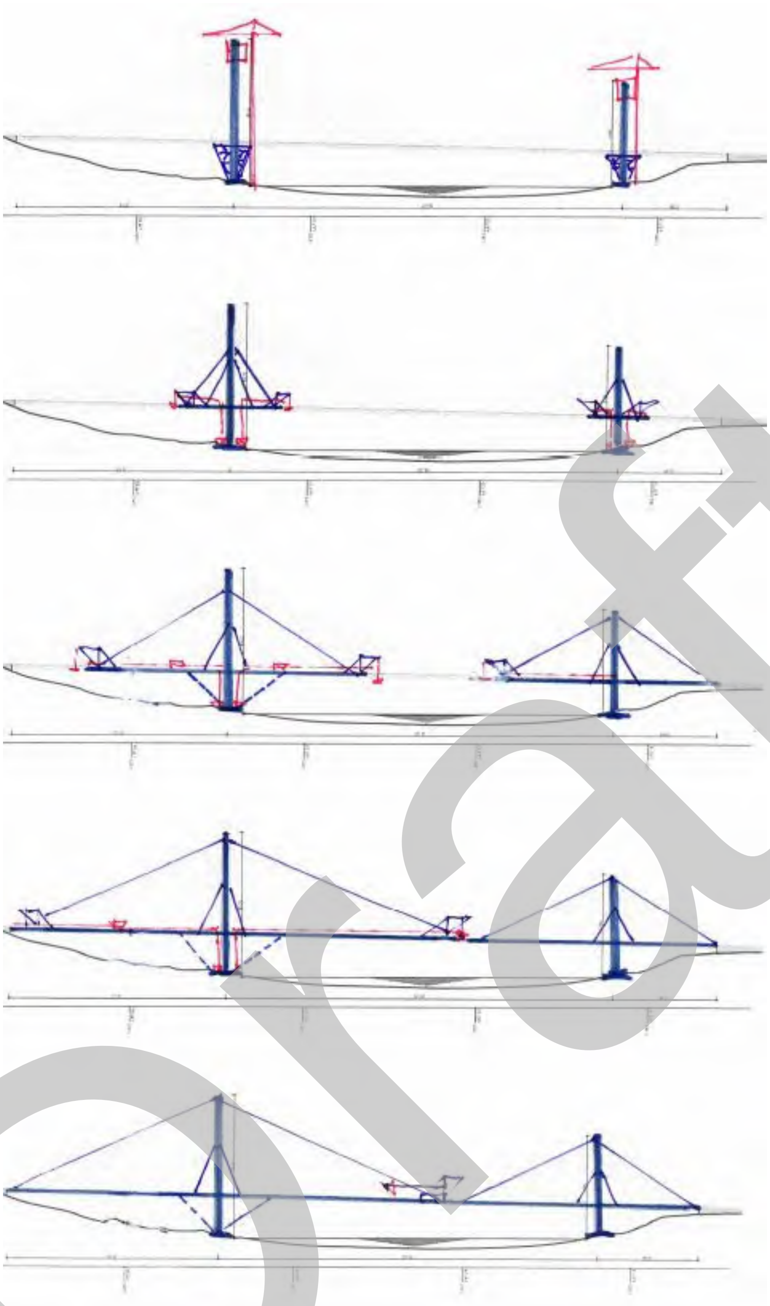
4 carry elements or fully assembled segment to the erection front

5 position it by a mobile crane (or derrick) followed by bolting of the splices

6 install stay cable

7 place deck panels and cast stiches

9 restress stay cables



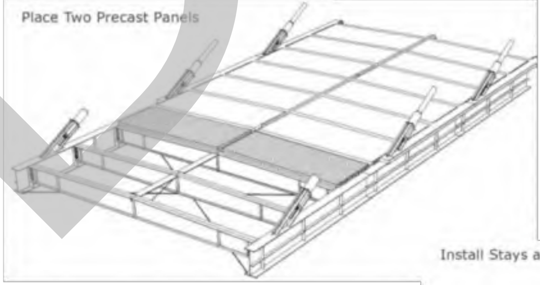
Note: the Tower Crane needs to remain in place also for stay erection (not shown above).

- Erect Pier Table
- Lift elements at the Tower by Tower Crane or Mobile Crane

Carry elements to the front e.g. with heavy duty modules

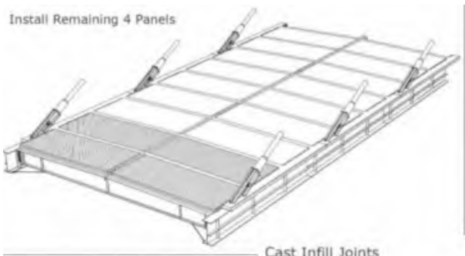
<u>Deck Erection Sequence</u>

Erect structural steel



Place Two Precast Panels

Install and Stress Stay to level 1

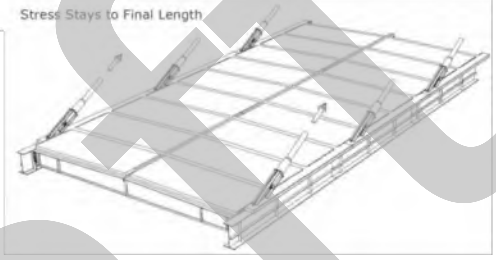


Install Remaining 4 Panel

(another stay stressing may be needed after panel placement)

Cast Infill Joints

Stress Stay to Final Length



<u>Deck Plate Erection</u>

Stay Cable Installation

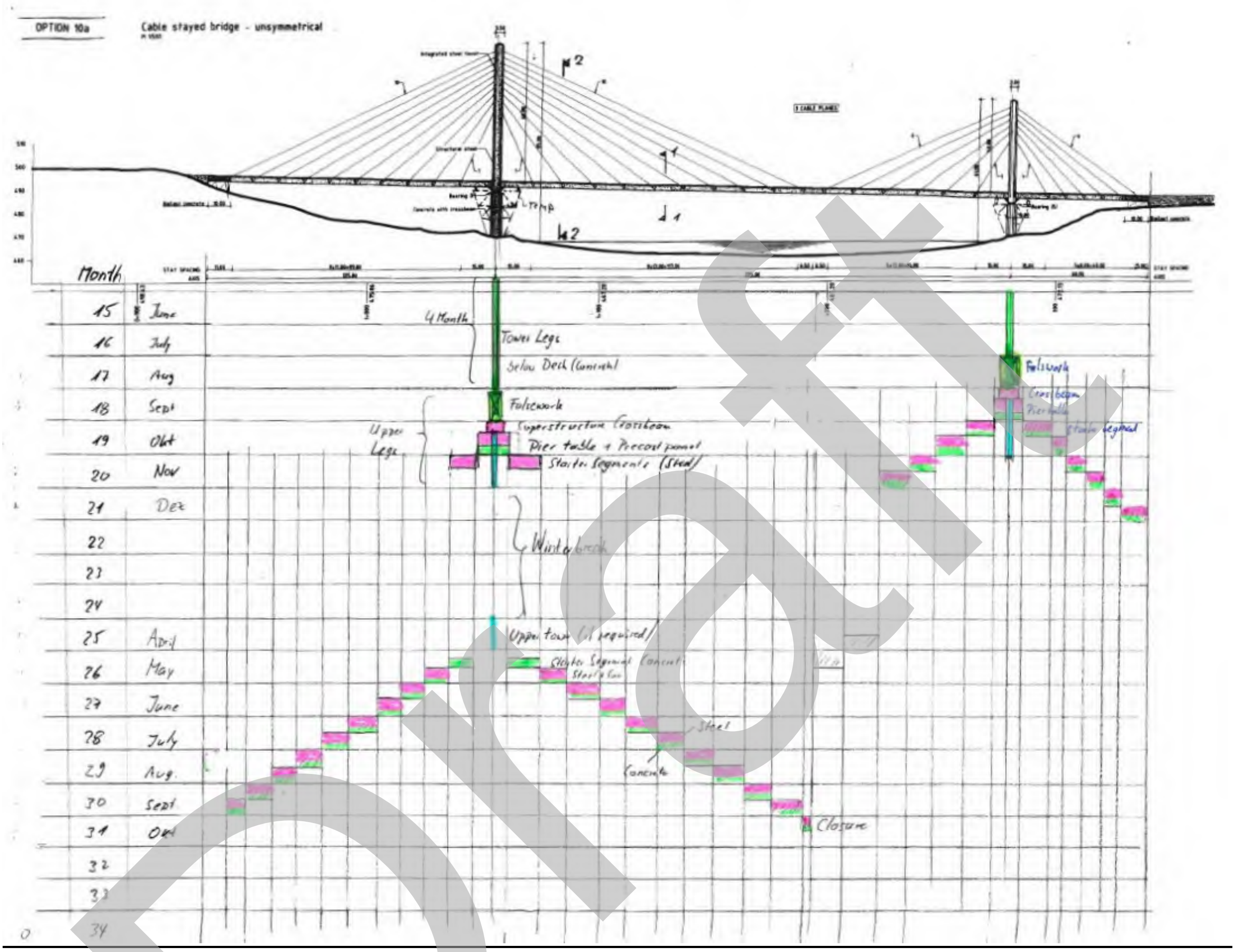
HDPE Duct gets inserted

Pull –In and Stress Strands, one after the other

Feasible Schedule

The below schedule for the free cantilever construction of Option 10a is based on

- Tower below deck are simple box structures, like the piers of Option 02 without cross beams. They should be done in max 3 month (in my opinion even faster)
- Towers above deck is a bolted steelwork, quickly to erect and not very critical w.r.t. temperature.
- Superstructure is made of a steel grid with full depth concrete panels in the mainspan and in the Backspan. Casting of stiches has to be done immediately after the steelwork and stay cables are erected. Curing of stiches may be done in winter with warmed up concrete aggregates and heating blanket cover (as been done for the Forth Bridge). This is likely not required, since the cantilever of Pylon 1 can be finished within 5 months, assuming a cycle of one twin segment (North and Southbound) in two weeks. Quite often such 13m segments have be done within 10 days, but a 4 day margin to cope with bad weather conditions and achieve a little stagger to the neighbor deck would be beneficial.


OPTION 10a
Cable stayed bridge - unsymmetrical
2 CABLE PLANES
Temp
Month
15 June
16 July
17 Aug
18 Sept
19 Okt
20 Nov
21 Dez
22
23
24
25 April
26 May
27 June
28 July
29 Aug.
30 Sept
31 Okt
32
33
34
4 Month
Tower Legs
below Deck (Concrete)
Falsework
Upper Legs
Superstructure Crossbeam
Pier table + Precast panel
Starter Segments (Steel)
Winterbreak
Upper tower (if required)
Starter Segment Concrete
Steel
Concrete
Closure
Falswork
Crossbeam
Pier table
Starter segment

2.3.7 Slope Stability

Not an issue since no pier is placed in this zone, also no temporary pier

2.3.8 Durability and Maintenance

2.3.8.1 Pylons

The lower legs can be accessed through doors, openings at top of foundations. They also could be filled with lean concrete, so that no access is needed.

No stay anchorages are provided inside of the leg, so access is only needed for a 5-10 year interval inspection. Ladders with platforms are placed in the boxes.

On top of the pylon a hoist system (like window cleaners have it at highrise buildings) is placed for access to the stay anchorages.

2.3.8.2 Superstructure

The action forces in that option would be adjusted in such a way, that almost no tension will occur in the concrete deck, only a small area near the abutment may be under tension, but that could be compensated by a light longitudinal prestressing. Not much cracking has to be assumed and inspection could be concentrated to the area near the abutments. With stainless steel rebars for the full slab depth over the whole length of the bridge, the durability will be very high and no deck replacement is envisaged over the design period of 100 years.

2.3.8.3 Stay Cables

Stay cables are provided with 3 barriers against corrosion: galvanizing, wax and HDPE sheet. Most of the suppliers are confident that they last the 100y without replacement. Nevertheless, replacement of individual cables must be possible in case something goes wrong. This is done the inverted way from the erection: taking out strand-by-strand, only small jack are needed for that work (monostrand jacks). Acc. to most suppliers it should even be possible to take one strand out and pull a new one in at the same place. Since the probability of a replacement is low, but not zero, it is difficult to address any cost for that issue. In the table below it is assumed that 10% of the strands are to be replaced once in 100y. No full bridge closure is needed for such a replacement, just one lane close next to the stay cables need to be closed, all other lanes can be used without any load restrictions (except for super heavy trucks)

Other elements of a stay cable bridge are essential for a good function

- HDPE Duct – outer sheathing: These ducts are exposed to sun radiation full time. The durability has been tested and is not any more a problem, but fading of the color, therefore bright colors (close to white/light grey) are a good choice.
- Dampers: depending on the type they may last 30 to 50 years. Exchange is rather simple. Since the cables in option 10 are rather short we do not expect to have dampers in more the 50% of the stays.
- Ice removal system: If stay cables with small ducts are used (e.g. parallel wire systems or ropes) the risk of ice accumulation decreases considerably. Many suppliers perform currently many researches and are close to a solution to mitigate that problem completely, so at the time the bridge is built, this is surely no issue any more.

The issue of bearing exchange depends on the sub- option. Option 10a is more complex, since it rest on heavy disc bearings, which are quite expensive and difficult to exchange.
Option 10 b and 10 c are much better in that respect, therefore they are recommended for further developments. The superstructure of those options rests on only 14 rather small elastomeric bearings

- abutments 2x3 = 6 Pcs
- at towers 2x4 vertical = 8 Pcs
- plus 2 x 4 wind bearing = 8 Pc

The 14 vertical bearings have to be replaced at an interval of about 30 to 40 years. However, access should not be a problem, since the bearings are on shore or at the abutment only.

The 8 wind bearings are not heavily loaded and may last much longer

structural weathering steel, pylon (0a and b)	1 time / year	1 time / 3 years	1 time / 6 years	100	-
steel coating systems (not considered so far)	1 time / year	1 time / 3 years	1 time / 3 years	35	2
concrete pylon (10c)	-	1 time / 3 years	-	100	-
concrete deck slab stay cable bridge	1 time / year	1 time / 3 years		100	-
concrete pier	-	1 time / 3 years	-	100	-
concrete pile cap	-	-	-	100	-
concrete piles	-	-	-	100	-
elastomeric bearings	1 time / year	1 time / 3 years	1 time / 6 years	35	2
disc bearing bearings (10a only)	1 time / year	1 time / 3 years	1 time / 6 years	50	1
expansion joint	1 time / year	1 time / 3 years	1 time / 6 years	35	2
wearing surface	1 time / year	1 time / 3 years	1 time / 3 years	25	3
drainage	1 time / year	1 time / 3 years	-	35	2
Joint seals, sliders and springs	1 time / year	1 time / 3 years	-	15	6
stay cables [1)]	-	1 time / 3 years	1 time / 6 years	100	0.1
Sheaths for Stay cables [2)]	1 time / year	1 time / 3 years	1 time / 6 years	100	0.1
Dampers for Stay Cables	1 time / year	1 time / 3 years	1 time / 6 years	50	1
Structural Health Monitoring Systems	1 time / year	1 time / 3 years	1 time / 6 years	25	3
galvanized steel barriers	1 time / year	1 time / 3 years	-	40	2
galvanized steel railing	1 time / year	1 time / 3 years	-	40	2
concrete barriers	1 time / year	1 time / 3 years	-	40	2
Sign support structures	1 time / year	1 time / 3 years	-	50	1
lamp post	1 time / year	1 time / 3 years	time / year (luminance tes	50 / upon need	1

Items that are different to the other options

- Deck slab needs **not** to be exchanged
- 14 Elastomeric Bearings (with moderate to small loads) need to be exchanged twice
- 8 Elastomeric Windbearings need to be exchanged once
- Around 10% of the strands may need to be replaced along the structure lifetime
- Using bright colors (white or nearly white) will increase the lifetime of the sheets considerably (getting close to 100y). We assume that not more than 10 % of the sheets need to be replaced within the 100y

Inspection Services of Stay Cables are provided by some specialized firms, for example by Alpintechnik :

https://www.alpintechnik.com

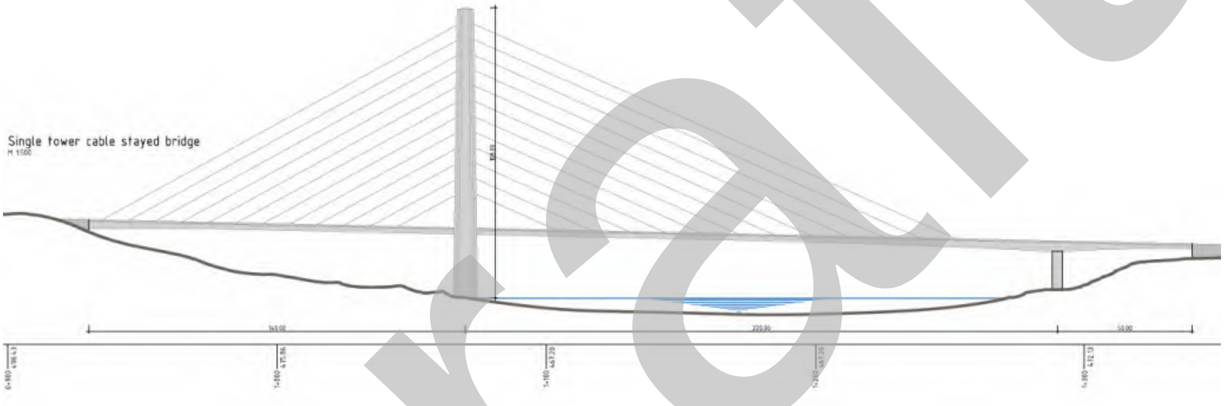
2.4 Option 14 – Single Tower Stay Cable Bridge

2.4.1 Layout

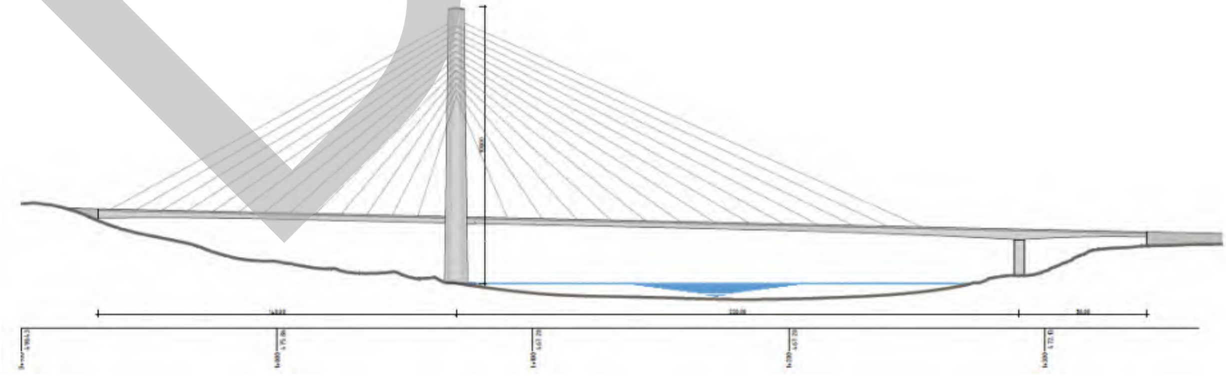
The following layout was shown as Option 14 in Phase 1, consisting of a Single Tower Stay Cable Bridge with spans 140– 220 – 50 = 410 m and only one Main Pylon on shore, with 2 x 12 cables at each side:

A small pier with a haunched plate girder superstructure is placed on the East bank.

East West



As for option 10, also, the alternative design with fan arrangement was analyzed; with 2 x 13 cables at each side (This option would be preferred).



The cable arrangement has no relevant effect on the reactions given below. The quantities given for steel on cables (455 tons in 2x2x13 cables) is the one estimated for the fan arrangement (the second from the two above). For the harp arrangement, a slightly higher tonnage has been estimated (490 tons in 2x2x12 cables).

Two different variants have been estimated, which differ in the tower design:

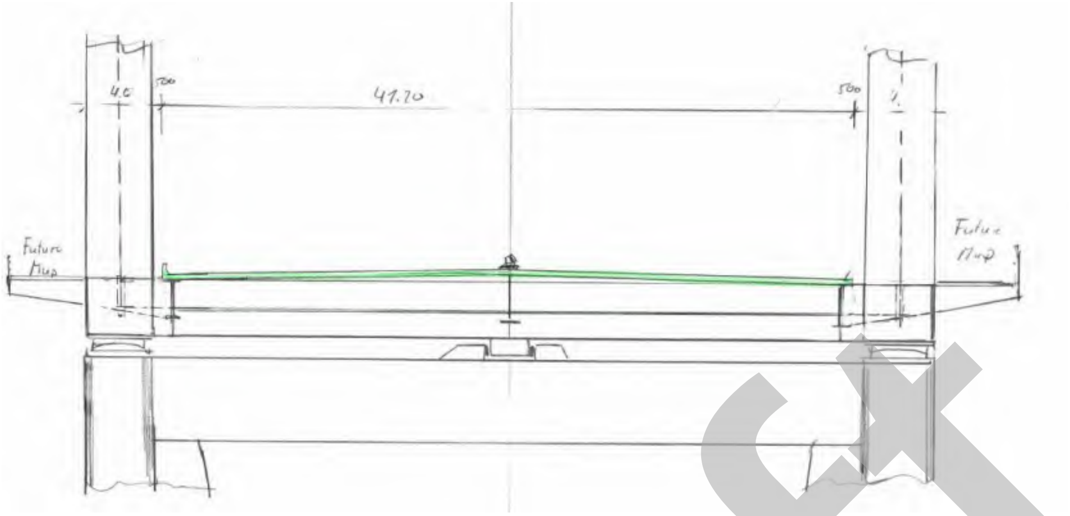
Option 14a has similar towers as option 10a, thus two upper steel arms rigidly connected to the deck, and supported over heavy sliding disc bearings on a lower concrete frame (sliding bearings for East Tower, fixed in longitudinal direction for West Tower).

Option 14b is provided with a full concrete H Pylon. For this option, the deck lays on the cross beam over elastomeric bearings.

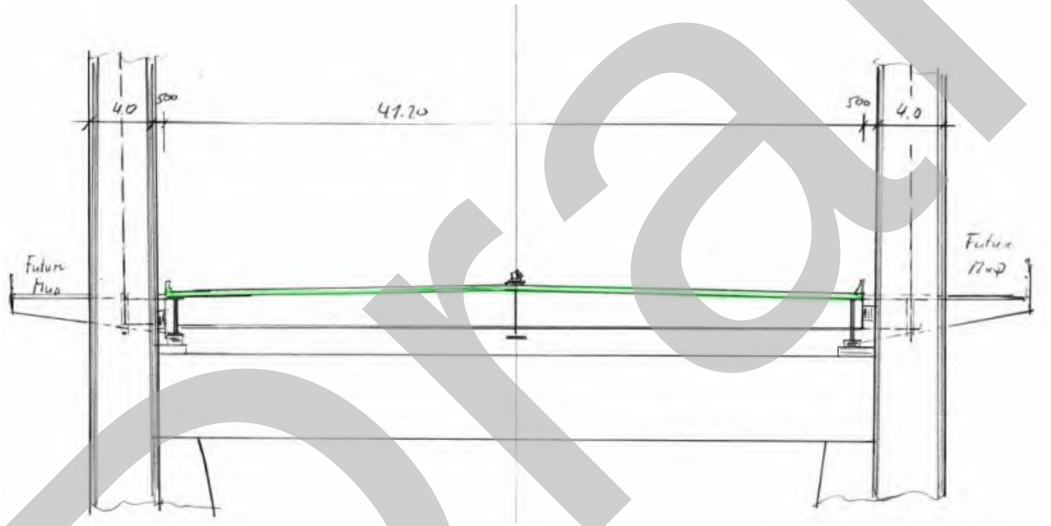
For both cases, a fixed point for longitudinal movements is provided at the Pylon (where the large vertical loads come down), with expansion joint and sliding bearings at both abutments. On the west pier the deck is supported by elastomeric bearings (sliding), one under each plate girder.

The cross section at the main span consists of three longitudinal steel main girders, connected by transverse cross girders spaced at around 4.5 meters. The concrete slab is assumed to have a thickness of 270 mm at main span, spanning longitudinally between cross girders. An average steel weight of 2.75 kN/m2 is assumed, slightly more than for Option 10, taking into account that for the adopted layout the cross beams have to span more than 40 m between the two external cables - while Option 10 is supported additionally by a central cable.

Option 14a



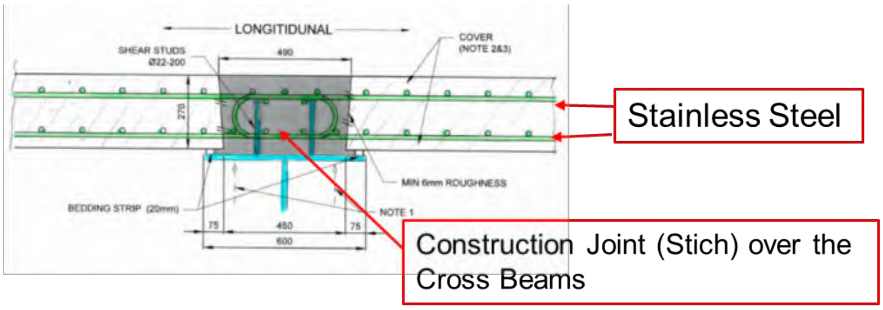
Option 14b



The depth of the slab is increased for the back span at the East to 500 mm. With this arrangement, the permanent loads are almost balanced between main and backspan. In order to cope with the uplift forces that would appear at the abutments in case traffic loads are only placed over the full length of the main span, transverse concrete beams of around 3000 tons (East) and 1900 tons (West) are provided , with a depth of around 3.5 m and full 40 m width. The required length for this concrete end beam is around 8.6 m and 5.4 m respectively.

Deck Rebar Layout

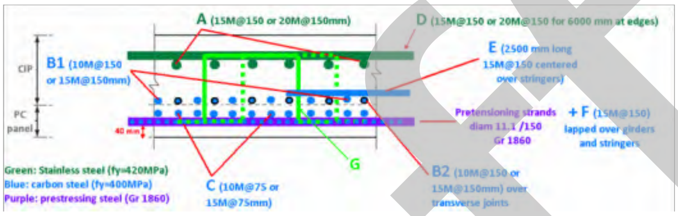
Cable Suspended Deck



Stainless Steel

Construction Joint (Stich) over the Cross Beams

Girder Deck, about 80m long



2.4.2 Example

As an example for a goalpost tower, the Öresund Bridge in Denmark is shown above.

2.4.3 Summary of assumed Loads

Option 14 a

LOADS	-	-	-	-	-	-
-	-	-	-	-	OPTION 14a	
Perm Loads						
	Self weight	SW Lower Pylon legs			570	kN/m
		SW Piers			327	kN/m
		SW Concrete slab main span			7.0	kN/m2
		SW Concrete slab side spans			13.0	kN/m2
		SW Steel main span			2.75	kN/m2
		SW Steel side spans			2.75	kN/m2
		SW Upper Pylon			165	kN/m
		SW Cables			0.30	kN/m2
		SW future MUP +3cm wearing srf			2.2	kN/m2
		SDL TOT			3.1	kN/m2
Var Loads	Live Load					
		2x5 lanes 3.00 m wide/DLL - Design				
		Lane Load			3.0	kN/m2
		2x3.6m MUP pedestrian load			1.3	kN/m2
		Design Truck (*)			600	kN
	Wind					
		Design horizontal Wind (Wh)			8.0	kN/m
		Design vertical Wind (Wv)			10.0	kN/m
		Wind on Pylons/arch			18.0	kN/m
		Wind on Vehicles (WL)			4.0	kN/m
		Wind on Piers			10.0	kN/m
	Temperature					
		TU+			50.0	K
		TU-			-50.0	K
		TG+(**)			10.0	K
		TG-(**)			-10.0	K
	Friction				4	%

(*) Value of design truck to be considered together with lane load

(**) 10°C Gradient over the complete deck height assumed (similar effect as a 30°C gradient over the concrete slab depth)Option 14 b

LOADS

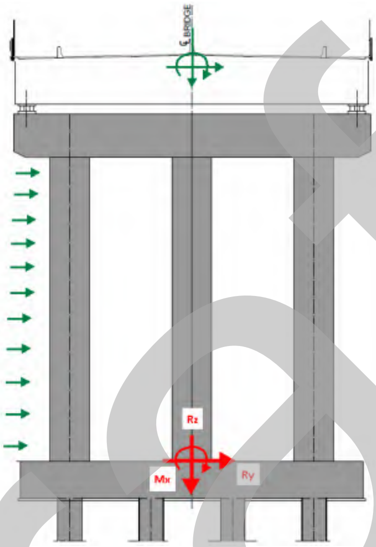
			OPTION 14b	
Perm Loads				
	Self weight	SW Lower Pylon legs	600	kN/m
		SW Piers/lowe Pylon legs	327	kN/m
		SW Concrete slab main span	7.0	kN/m2
		SW Concrete slab side spans	13.0	kN/m2
		SW Steel main span	2.75	kN/m2
		SW Steel side spans	2.75	kN/m2
		SW Upper Pylon	420	kN/m
		SW Cables	0.30	kN/m2
		SW future MUP +3cm wearing srf	2.2	kN/m2
		SDL TOT	3.1	kN/m2
Var Loads	Live Load			
		2x5 lanes 3.00 m wide/DLL - Design Lane Load	3.0	kN/m2
		2x3.6m MUP pedestrian load	1.3	kN/m2
		Design Truck (*)	600	kN
	Wind			
		Design horizontal Wind (Wh)	8.0	kN/m
		Design vertical Wind (Wv)	10.0	kN/m
		Wind on Pylons/arch	18.0	kN/m
		Wind on Vehicles (WL)	4.0	kN/m
		Wind on Piers	10.0	kN/m
	Temperature			
		TU+	50.0	K
		TU-	-50.0	K
		TG+(**)	10.0	K
		TG-(**)	-10.0	K
	Friction		4	%

(*) Value of design truck to be considered together with lane load

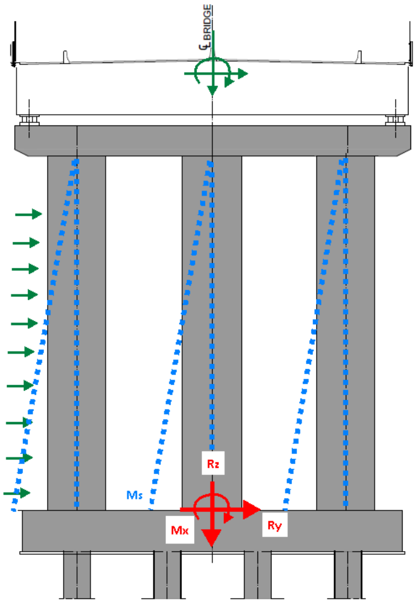
(**) 10°C Gradient over the complete deck height assumed (similar effect as a 30°C gradient over the concrete slab depth)

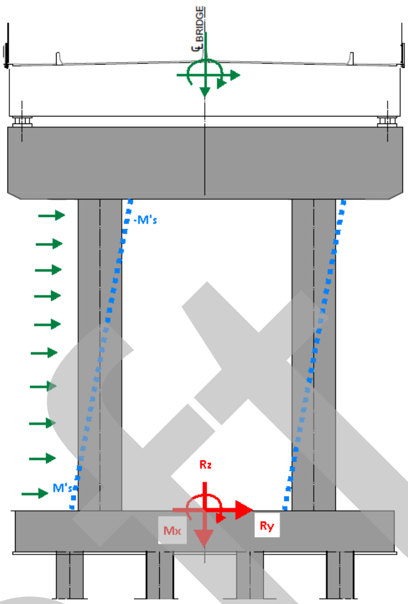
2.4.4 Foundation Reactions

Following tables show an estimate of the reaction on top of foundation (weight of foundation not included). The reactions are given for the full width (both bounds, so both traffic directions), at the midpoint between both bounds. An estimation of the weight of the pylon/pier shafts, wind on pylon/pier and bearing friction has been added to the loads coming from the deck, so that the reactions shown in the table below (in red in the following sketch) includes o provision for those effects.



Previous sketch show the proportions of a possible solution for the substructure of East pier. It is to be noted that the section forces at the substructure (for example bending moments at the pile shafts) may vary significantly depending on the later design of the piers (see sketch below for two –exaggerated- different solutions). Nevertheless, assuming that the foundation is stiff enough, the reactions given in the tables below (in red in the sketch) should fairly represent the resulting reactions at the midpoint, on top of foundation.





Option 14 a

	Abutment 1				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**23.37**	0.00	0.00	0.00	0.00
TOT Traffic	**6.24**	0.00	0.00	**38.38**	0.00
TOT Wind	**0.50**	**1.13**	**0.05**	**6.29**	**0.17**
TOT Temp	**0.5**	0.00	0.00	0.00	0.00
SLS	**29.00**	**0.90**	**0.90**	**33.60**	**4.10**
ULS	**38.70**	**2.20**	**1.20**	**70.50**	**5.50**

	Pylon (Fix Point)				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**274.28**	0.00	0.00	0.00	0.00
TOT Traffic	**25.47**	0.00	**0.70**	**167.17**	**17.50**
TOT Wind	**2.89**	**4.29**	**1.07**	**198.03**	**24.77**
TOT Temp	**0.1**	0.00	0.00	0.00	0.00
SLS	**294.20**	**2.70**	**0.70**	**178.70**	**15.80**
ULS	**367.40**	**8.50**	**1.60**	**423.10**	**35.70**

	Pier				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**47.51**	0.00	0.00	0.00	0.00
TOT Traffic	**8.88**	0.00	0.00	**56.08**	0.00
TOT Wind	**0.46**	**1.89**	**0.18**	**34.08**	**2.16**
TOT Temp	**0.25**	0.00	0.00	0.00	0.00
SLS	**55.00**	**1.70**	**1.70**	**70.60**	**29.70**
ULS	**71.50**	**4.00**	**2.40**	**134.60**	**41.70**

	Abutment 2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**27.74**	0.00	0.00	0.00	0.00
TOT Traffic	**5.06**	0.00	0.00	**30.52**	0.00
TOT Wind	**0.30**	**0.41**	**0.05**	**3.29**	**0.17**
TOT Temp	**0.2**	0.00	0.00	0.00	0.00
SLS	**29.30**	**0.90**	**0.90**	**28.60**	**4.10**
ULS	**38.40**	**1.50**	**1.20**	**57.30**	**5.60**

Option 14 b

	Abutment 1				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**23.37**	0.00	0.00	0.00	0.00
TOT Traffic	**6.24**	0.00	0.00	**38.38**	0.00
TOT Wind	**0.50**	**1.13**	**0.05**	**6.29**	**0.17**
TOT Temp	**0.5**	0.00	0.00	0.00	0.00
SLS	**29.00**	**0.90**	**0.90**	**33.60**	**4.10**
ULS	**38.70**	**2.20**	**1.20**	**70.50**	**5.50**

	Pylon (Fix Point)				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**296.76**	0.00	0.00	0.00	0.00
TOT Traffic	**25.47**	0.00	**10.50**	**167.17**	**310.95**
TOT Wind	**2.89**	**4.29**	**2.57**	**198.03**	**130.32**
TOT Temp	**0.1**	0.00	0.00	0.00	0.00
SLS	**316.70**	**2.60**	**8.20**	**174.90**	**241.70**
ULS	**396.00**	**8.30**	**17.90**	**418.10**	**528.70**

	Pier				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**42.05**	0.00	0.00	0.00	0.00
TOT Traffic	**8.88**	0.00	0.00	**56.08**	0.00
TOT Wind	**0.46**	**1.89**	**0.18**	**34.08**	**2.16**
TOT Temp	**0.25**	0.00	0.00	0.00	0.00
SLS	**49.50**	**1.70**	**1.70**	**70.60**	**29.70**
ULS	**64.90**	**4.00**	**2.40**	**134.60**	**41.70**

	Abutment 2				
	Rz [MN]	Ry [MN]	Rx [MN]	Mx [MNm]	My [MNm]
TOT Perm Loads	**27.74**	0.00	0.00	0.00	0.00
TOT Traffic	**5.06**	0.00	0.00	**30.52**	0.00
TOT Wind	**0.30**	**0.41**	**0.05**	**3.29**	**0.17**
TOT Temp	**0.2**	0.00	0.00	0.00	0.00
SLS	**29.30**	**0.90**	**0.90**	**28.60**	**4.10**
ULS	**38.40**	**1.50**	**1.20**	**57.30**	**5.60**

2.4.5 Construction

Balanced Cantilever Construction is the traditional construction procedure for stay cable bridges.

- erect tower starter segments on falsework
- deliver steelwork segments in pieces to the tower,
- lift by heavy tower crane or a mobile crane placed on the starter segments
- carry elements or fully assembled segment to the erection front,
- position it by a mobile crane (or derrick) followed by bolting of the splices
- install stay cable
- place deck panels
- cast stiches
- restress stay cables

Actually, the same is valid as for Option 10, except that the east span is erected by mobile cranes.

2.4.6 Slope Stability

Not an issue since no pier is placed in this zone, also no temporary pier

2.4.7 Durability and Maintenance

The action forces in that option would be adjusted in such a way, that almost no tension will occur in the concrete deck, only a small area near the abutment may be under tension, but that could be compensated by a light longitudinal prestressing. Not much cracking has to be assumed and inspection could be concentrated onto the area near the abutments. With stainless steel rebars for the full slab depth for the whole length of the bridge, the durability will be very high and no deck replacement is envisaged over the design period of 100 years in this area. The part over the east pier acts like a girder bridge and has stainless steel in the upper zone only. Therefore, an exchange after 50 year is taken into account.

Stay cables are provided with 3 barriers against corrosion: galvanizing, wax and HDPE sheet. Most of the suppliers are confident that they last the 100y without replacement. Nevertheless, replacement of individual cables must be possible in case something goes wrong. This is done the inverted way from the erection: taking out strand-by-strand, only small jack are needed for that work (monostrand jacks). Acc. to most suppliers it should even be possible to take one strand out and pull a new one in at the same place. Since the probability of a replacement is low, but not zero, it is difficult to address any cost for that issue. In the table below it is assumed that 10% of the strands are to be replaced once in 100y. No full bridge closure is needed for such a replacement, just one lane close next to the stay cables need to be closed, all other lanes can be used without any load restrictions (except for super heavy trucks)

Other elements of a stay cable bridge are essential for a good function

- HDPE Duct – outer sheathing: These ducts are exposed to sun radiation full time. The durability has been tested and is not any more a problem, but fading of the color, therefore bright colors (close to white/light grey) are a good choice.
- Dampers: depending on the type they may last 30 to 50 years. Exchange is rather simple. Since the cables in option 10 are rather short we do not expect to have dampers in more the 50% of the stays.
- Ice removal system: If stay cables with small ducts are used (e.g. parallel wire systems or ropes) the risk of ice accumulation decreases considerably. Many suppliers perform currently a lot of researches and are close to a solution to mitigate that problem completely, so at the time the bridge gets built, this is surely no issue any more.

The issue of bearing exchange depends on the option. 14a is much more complex, since it rest on very heavy bearings, which are quite expensive on difficult to exchange. Option 14b is much better in that respect. Therefore, that are recommended for further developments. The superstructure of those option rests on only 12 elastomeric bearings and has 2 windbearings

- 2 bearing at west abutment,
- 2 vertical bearing the tower plus 2 windbearings
- 4 at east pier
- 4 at east abutment.

The vertical bearings have to be replaced at an interval of about 30 to 40 years. However, access should not be a problem, since the bearings are on shore or at the abutment only.
The windbearings (4 Pcs) are not heavily loaded and may last much longer

Item	frequency of Inspection			design service/lifetime [years]	replacement [times]
	visual, from a distance (authority/client)	visual (specialist)	"hands on" inspection / non. destructive testing		
structural weathering steel, superstructure	1 time / year	1 time / 3 years	1 time / 6 years	100	-
structural weathering steel, pylon (0a and b)	1 time / year	1 time / 3 years	1 time / 6 years	100	-
steel coating systems (not considered so far)	1 time / year	1 time / 3 years	1 time / 3 years	35	2
concrete pylon (14b)	-	1 time / 3 years	-	100	-
concrete deck slab girder bridge (80m)	1 time / year	1 time / 3 years	-	50	1
concrete deck slab stay cable bridge (330m)	1 time / year	1 time / 3 years		100	-
concrete pier	-	1 time / 3 years	-	100	-
concrete pile cap	-	-	-	100	-
concrete piles	-	-	-	100	-
elastomeric bearings	1 time / year	1 time / 3 years	1 time / 6 years	35	2
disc bearing bearings (14a only)	1 time / year	1 time / 3 years	1 time / 6 years	50	1
expansion joint	1 time / year	1 time / 3 years	1 time / 6 years	35	2
wearing surface	1 time / year	1 time / 3 years	1 time / 3 years	25	3
drainage	1 time / year	1 time / 3 years	-	35	2
Joint seals, sliders and springs	1 time / year	1 time / 3 years	-	15	6
stay cables 1)	-	1 time / 3 years	1 time / 6 years	100	0.1
Sheaths for Stay cables 2)	1 time / year	1 time / 3 years	1 time / 6 years	100	0.1
Dampers for Stay Cables	1 time / year	1 time / 3 years	1 time / 6 years	50	1
Structural Health Monitoring Systems	1 time / year	1 time / 3 years	1 time / 6 years	25	3
galvanized steel barriers	1 time / year	1 time / 3 years	-	40	2
galvanized steel railing	1 time / year	1 time / 3 years	-	40	2
concrete barriers	1 time / year	1 time / 3 years	-	40	2
Sign support structures	1 time / year	1 time / 3 years	-	50	1
lamp post	1 time / year	1 time / 3 years	1 time / year (luminance test)	50 / upon need	1

Items that are different to the other options

- Deck slab needs to be exchanged **on about 80m** length once
- 14 Elastomeric Bearings (with moderate to small loads) need to be exchanged twice
- Elastomeric Windbearings need to be exchanged once
- Around 10% of the strands may need to be replaced along the structure lifetime
- Using bright colors (white or nearly white) will increase the lifetime of the sheets considerably (getting close to 100y). We assume that not more than 10 % of the sheets need to be replaced within the 100y

3 Foundations

3.1 Initial Design

An initial Design was prepared by Aecom based on the loads listed above

Saskatoon Freeway - River Bridge Preliminary Foundation Design Summary 15-Oct-19

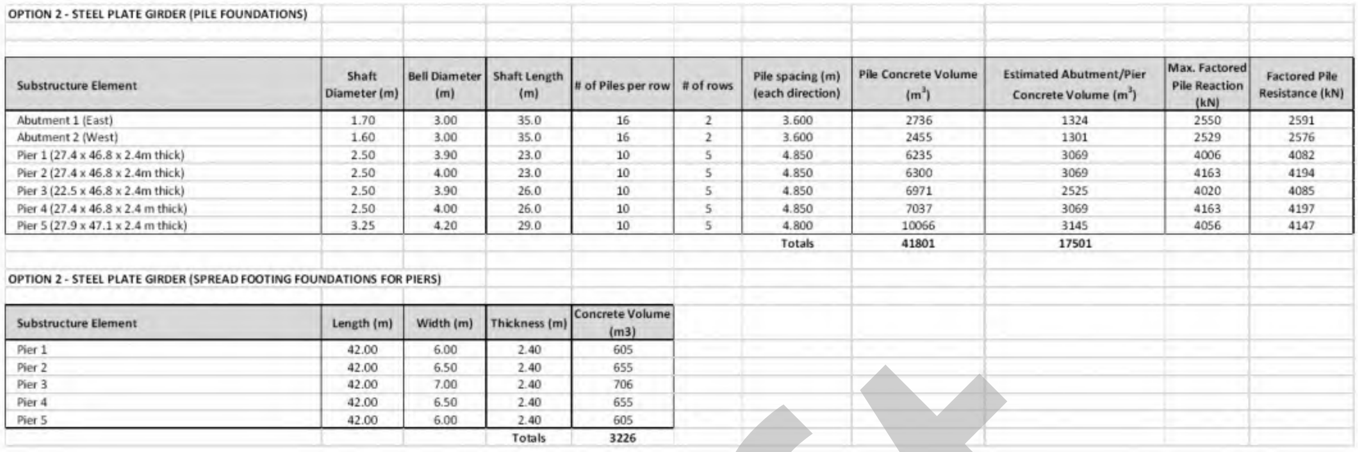
Option 14 - Unsymmetrical Single Tower Stay Cable Bridge		**Concrete Volumes (m^3)**	
Pylon	5 rows of 18 piles (90 piles)		
	2500 mm dia. shaft c/w 3500mm dia. bell founded at 23 mbgs	10373	
	Pile cap = 30m x 90m x 2.4m thick	6480	
Pier	3 rows of 15 piles (45 piles)		
	2500 mm dia. shaft c/w 3600mm dia. bell founded at 22 mbgs	4990	
	Pile cap = 20m x 65m x 2.4m thick	3120	
Abutment 1	2 rows of 12 piles (24 piles)		
	1500 mm dia. shaft, no bell x 29m long	1230	
	Abutment Pile cap = 42m x 4m wide x 3.8m high c/w wingwalls and abutment walls	779	
Abutment 2	2 rows of 12 piles (24 piles)		
	1800 mm dia. shaft, no bell x 30m long	1832	
	Abutment Pile cap = 42m x 4m wide x 3.8m high c/w wingwalls and abutment walls	779	
	Total	**29583**	m^3

Option 10 - Unsymmetrical Stay Cable Bridge		
Pylon 1	4 rows of 15 piles (60 piles)	
	2500 mm dia. shaft c/w 4000mm dia. bell founded at 23 mbgs	7119
	Pile cap = 18m x 66m x 2.4m thick	2851
Pylon 2	3 rows of 15 piles (45 piles)	
	2000 mm dia. shaft c/w 4000mm dia. bell founded at 22 mbgs	3534
	Pile cap = 12m x 66m x 2.4m thick	2851
Abutment 1	2 rows of 12 piles (24 piles)	
	1500 mm dia. shaft, no bell x 30m long	1272
	Abutment Pile cap = 48m x 4m wide x 3.8m high c/w wingwalls and abutment walls	894
Abutment 2	2 rows of 12 piles (24 piles)	
	1500 mm dia. shaft, no bell x 29m long	1230
	Abutment Pile cap = 48m x 4m wide x 3.8m high c/w wingwalls and abutment walls	894

	Total	**20646**	m^3
Option 6 - Through Arch Bridge			
Support 1	3 rows of 15 piles (60 piles)		
	2500 mm dia. shaft c/w 4000mm dia. bell founded at 23 mbgs	7119	
	Pile cap = 21m x 66m x 2.4m thick	3326	
Support 2	3 rows of 15 piles (45 piles)		
	3000 mm dia. shaft c/w 4200mm dia. bell founded at 22 mbgs	7499	
	Pile cap = 12m x 66m x 2.4m thick	3326	
Abutment 1	2 rows of 21 piles (42 piles)		
	1500 mm dia. shaft, no bell x 31m long	2301	
	Abutment Pile cap = 54m x 4m wide x 3.8m high c/w wingwalls and abutment walls	993	
Abutment 2	2 rows of 18 piles (36 piles)		
	1500 mm dia. shaft, no bell x 29m long	1845	
	Abutment Pile cap = 54m x 4m wide x 3.8m high c/w wingwalls and abutment walls	993	
	Total	**27402**	m^3
Option 2 - Steel Composite Girder			
Pier 1	3 rows of 7 piles (21 piles)		
	2000 mm dia. shaft c/w 4000mm dia. bell founded at 23 mbgs	1715	
	Pile cap = 16m x 41m x 2.4m thick	1574	
Pier 2	3 rows of 7 piles (21 piles)		
	2000 mm dia. shaft c/w 4000mm dia. bell founded at 23 mbgs	1715	
	Pile cap = 16m x 41m x 2.4m thick	1574	
Pier 3	3 rows of 7 piles (21 piles)		
	3000 mm dia. shaft c/w 4250mm dia. bell founded at 26 mbgs	3953	
	Pile cap = 16m x 41m x 2.4m thick	1574	
Pier 4	3 rows of 7 piles (21 piles)		
	3000 mm dia. shaft c/w 4250mm dia. bell founded at 26 mbgs	3953	
	Pile cap = 16m x 41m x 2.4m thick	1574	
Pier 5	3 rows of 7 piles (21 piles)		
	2000 mm dia. shaft c/w 4000mm dia. bell founded at 22 mbgs	1649	
	Pile cap = 16m x 41m x 2.4m thick	1574	
Abutment 1	2 rows of 18 piles (36 piles)		
	1200 mm dia. shaft, no bell x 30m long	1221	
	Abutment Pile cap = 42m x 4m wide x 3.8m high c/w wingwalls and abutment walls	779	

3.2 Iteration

An iteration was performed with more accurate foundation loads (the initial one was done with Option 10a loads, not 10c) and spread footings were included

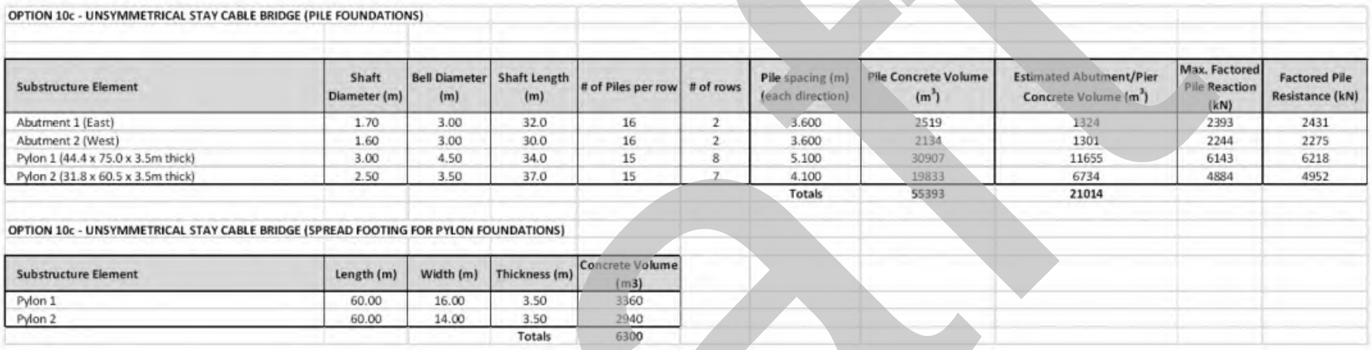


OPTION 2 - STEEL PLATE GIRDER (PILE FOUNDATIONS)

Substructure Element	Shaft Diameter (m)	Bell Diameter (m)	Shaft Length (m)	# of Piles per row	# of rows	Pile spacing (m) (each direction)	Pile Concrete Volume (m^3)	Estimated Abutment/Pier Concrete Volume (m^3)	Max. Factored Pile Reaction (kN)	Factored Pile Resistance (kN)
Abutment 1 (East)	1.70	3.00	35.0	16	2	3.600	2736	1324	2550	2591
Abutment 2 (West)	1.60	3.00	35.0	16	2	3.600	2455	1301	2529	2576
Pier 1 (27.4 x 46.8 x 2.4m thick)	2.50	3.90	23.0	10	5	4.850	6235	3069	4006	4082
Pier 2 (27.4 x 46.8 x 2.4m thick)	2.50	4.00	23.0	10	5	4.850	6300	3069	4163	4194
Pier 3 (22.5 x 46.8 x 2.4m thick)	2.50	3.90	26.0	10	5	4.850	6971	2525	4020	4085
Pier 4 (27.4 x 46.8 x 2.4 m thick)	2.50	4.00	26.0	10	5	4.850	7037	3069	4163	4197
Pier 5 (27.9 x 47.1 x 2.4 m thick)	3.25	4.20	29.0	10	5	4.800	10066	3145	4056	4147
						Totals	**41801**	**17501**		

OPTION 2 - STEEL PLATE GIRDER (SPREAD FOOTING FOUNDATIONS FOR PIERS)

Substructure Element	Length (m)	Width (m)	Thickness (m)	Concrete Volume (m3)
Pier 1	42.00	6.00	2.40	605
Pier 2	42.00	6.50	2.40	655
Pier 3	42.00	7.00	2.40	706
Pier 4	42.00	6.50	2.40	655
Pier 5	42.00	6.00	2.40	605
			Totals	**3226**

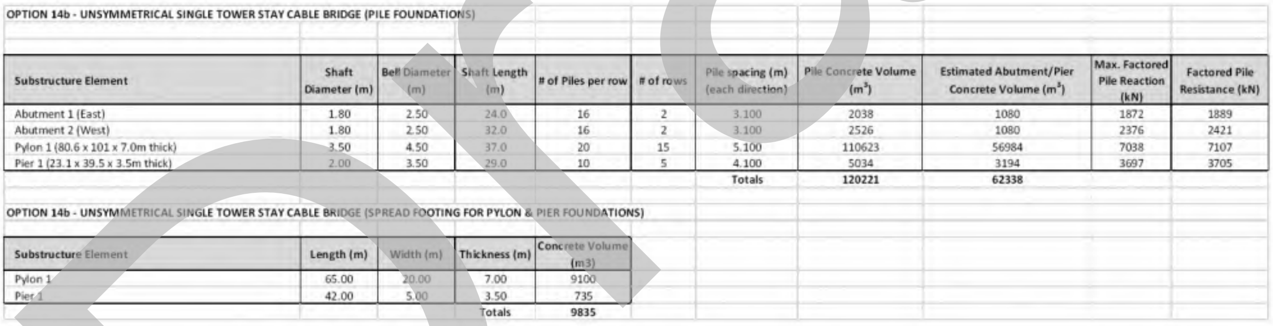


OPTION 10c - UNSYMMETRICAL STAY CABLE BRIDGE (PILE FOUNDATIONS)

Substructure Element	Shaft Diameter (m)	Bell Diameter (m)	Shaft Length (m)	# of Piles per row	# of rows	Pile spacing (m) (each direction)	Pile Concrete Volume (m^3)	Estimated Abutment/Pier Concrete Volume (m^3)	Max. Factored Pile Reaction (kN)	Factored Pile Resistance (kN)
Abutment 1 (East)	1.70	3.00	32.0	16	2	3.600	2519	1324	2393	2431
Abutment 2 (West)	1.60	3.00	30.0	16	2	3.600	2134	1301	2244	2275
Pylon 1 (44.4 x 75.0 x 3.5m thick)	3.00	4.50	34.0	15	8	5.100	30907	11655	6143	6218
Pylon 2 (31.8 x 60.5 x 3.5m thick)	2.50	3.50	37.0	15	7	4.100	19833	6734	4884	4952
						Totals	**55393**	**21014**		

OPTION 10c - UNSYMMETRICAL STAY CABLE BRIDGE (SPREAD FOOTING FOR PYLON FOUNDATIONS)

Substructure Element	Length (m)	Width (m)	Thickness (m)	Concrete Volume (m3)
Pylon 1	60.00	16.00	3.50	3360
Pylon 2	60.00	14.00	3.50	2940
			Totals	**6300**



OPTION 14b - UNSYMMETRICAL SINGLE TOWER STAY CABLE BRIDGE (PILE FOUNDATIONS)

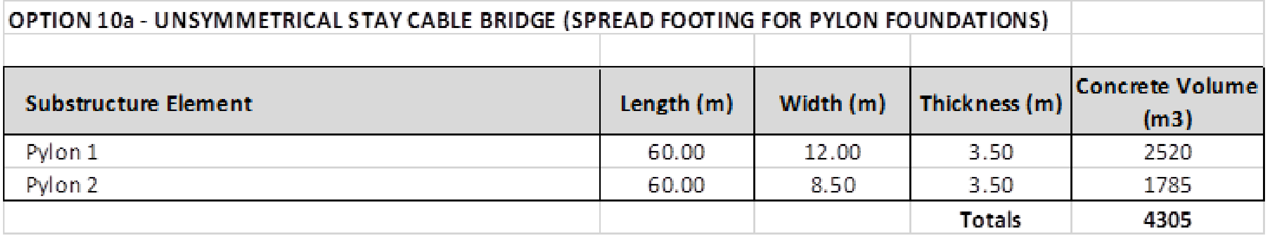
Substructure Element	Shaft Diameter (m)	Bell Diameter (m)	Shaft Length (m)	# of Piles per row	# of rows	Pile spacing (m) (each direction)	Pile Concrete Volume (m^3)	Estimated Abutment/Pier Concrete Volume (m^3)	Max. Factored Pile Reaction (kN)	Factored Pile Resistance (kN)
Abutment 1 (East)	1.80	2.50	24.0	16	2	3.100	2038	1080	1872	1889
Abutment 2 (West)	1.80	2.50	32.0	16	2	3.100	2526	1080	2376	2421
Pylon 1 (80.6 x 101 x 7.0m thick)	3.50	4.50	37.0	20	15	5.100	110623	56984	7038	7107
Pier 1 (23.1 x 39.5 x 3.5m thick)	2.00	3.50	29.0	10	5	4.100	5034	3194	3697	3705
						Totals	**120221**	**62338**		

OPTION 14b - UNSYMMETRICAL SINGLE TOWER STAY CABLE BRIDGE (SPREAD FOOTING FOR PYLON & PIER FOUNDATIONS)

Substructure Element	Length (m)	Width (m)	Thickness (m)	Concrete Volume (m3)
Pylon 1	65.00	20.00	7.00	9100
Pier 1	42.00	5.00	3.50	735
			Totals	**9835**

From the numbers above and the Canadian Unit priced received in the meantime it became apparent, that

- spread footings are much more economical than pile footings
- Option 10a will be more economical than 10 c, since the bending moments in the lower tower legs are considerably smaller (for 10b they are about the same as for 10c)



OPTION 10a - UNSYMMETRICAL STAY CABLE BRIDGE (SPREAD FOOTING FOR PYLON FOUNDATIONS)

Substructure Element	Length (m)	Width (m)	Thickness (m)	Concrete Volume (m3)
Pylon 1	60.00	12.00	3.50	2520
Pylon 2	60.00	8.50	3.50	1785
			Totals	**4305**

4 Cost Evaluation

4.1 Initial Estimate

We have performed an initial cost evaluation based on our quantity estimate and current European unit costs.

The BOQ estimate has been supported by some preliminary calculations, which we have needed for calculation of the support reactions anyway.

The unit prices need to be considered with care, they vary also in Europe quite a bit.

The construction cost for Foundation and Abutments are not yet included.

The table below shows pure construction cost with rather rough estimates in item 6.

Usually we do not consider temporary works in those structural costs, but here the differences may become rather high, so we have added estimated costs for

- the jetty or a dam in the river with 1 mill Euro – the price should be critically assessed with local experience
- temporary pier incl. foundation with 80 000€ ea. - ditto
- erection derrick at front of CSB with 200 000€ ea. whether one or two derricks are needed, depends on the construction time schedule and time constraints. It may also be possible to rent such a derrick. e.g. an so called “American Shear Leg Derrick S40”

Note that fixed cost for

- mobilization
- construction equipment (other than mentioned above),
- planning/engineering
- environmental assessment reports and other documentations

are not yet included below.

To confirm the tonnage of the stay cables at Option 10 a more refined analysis has been performed with teh following results (valid for all three Options 10 a to 10 c)

Option 10 Pylon 1

g composite deck , future MuP included	650	KN/m	total Bridge	
P UDL plus TL	176	KN/m	total Bridge	
Cable Distance Mainspan	13.0	m	Sidespan A	11.0
all'bl Load/Strand (ULS)	180	KN		

							ULS	ULS	n	G
	Tower		Beam				three Cable Plane		per Stay	per CPL
Stay No	X	Y	X	Y	Alpha	L	PL	Traffic	(3 Planes)	
Mainspan	m	m	m	m	grd	m	KN	KN		ton
1	1.75	59.00	15.00	24.00	69.265	38.08	9035	2446	22	0.97
2	1.75	61.50	28.00	24.00	55.008	46.80	10315	2793	25	1.36
3	1.75	64.00	41.00	24.00	45.542	57.28	11839	3206	28	1.91
4	1.75	66.50	54.00	24.00	39.125	68.72	13391	3626	32	2.58
5	1.75	69.00	67.00	24.00	34.592	80.71	14884	4030	35	3.37
6	1.75	71.50	80.00	24.00	31.259	93.04	16284	4409	39	4.25
7	1.75	74.00	93.00	24.00	28.720	105.59	17585	4761	42	5.20
8	1.75	76.50	106.00	24.00	26.730	118.29	18787	5087	45	6.22
9	1.75	79.00	119.00	24.00	25.130	131.10	19897	5388	47	7.30
10	1.75	81.50	132.00	24.00	23.819	143.98	20923	5665	50	8.42
										41.56

							ULS	ULS	n	G
South	Tower		Beam				per Cable Plane	per Cable Plane	per Stay	per CPL
Stay No	X	Y	X	Y	Alpha	L	PL	Traffic		
Backspan	m	m	m	m	grd	m	KN	KN		ton
1	1.75	59.00	15.00	23.00	69.794	41.00	9261	2063	21	1.03
2	1.75	61.50	26.00	23.00	57.794	48.46	11098	2288	25	1.44
3	1.75	64.00	37.00	23.00	49.313	57.23	12718	2553	29	1.93
4	1.75	66.50	48.00	23.00	43.245	66.78	14262	2826	32	2.52
5	1.75	69.00	59.00	23.00	38.782	76.81	15718	3091	35	3.19
6	1.75	71.50	70.00	23.00	35.398	87.16	17077	3342	38	3.92
7	1.75	74.00	81.00	23.00	32.763	97.72	18339	3578	41	4.72
8	1.75	76.50	92.00	23.00	30.659	108.42	19506	9864	55	7.00
9	1.75	79.00	103.00	23.00	28.946	119.24	20586	10393	58	8.12
10	1.75	81.50	114.00	23.00	27.527	130.13	21585	10884	60	9.29
										43.15

🟦 ass'd to act as Backstays

	MS	41.6
	BS	43.2
Pylon 1 (one plane)		84.7
Pylon 2 (one plane		32.7
Three Planes	Total Bridge	**352**
	take	**370**

			Option 02			Option 06			Option 10a			Option 10b			Option 10c			Option 14 a			Option 14 b		
			Multiple Plate Girder Bridge			Arch Bridge			unsymetrical CSB with two 3-Leg Steel Towers, integrated into superstructure			unsymetrical CSB with two 3-Leg Steel Towers, integrated into lower piers			unsymetrical CSB with two 3-Leg PC Concrete Towers			One Tower Stay Cable Bridge Steel Tower above deck			One Tower Stay Cable Bridge Concrete Tower		
	Descripcion	Unit	Unit Cost Estimate Individual [€]	Quantity	Cost [€]	Unit Cost Estimate Individual [€]	Quantity	Cost [€]	Unit Cost Estimate Individual [€]	Quantity	Cost [€]	Unit Cost Estimate Individual [€]	Quantity	Cost [€]	Unit Cost Estimate Individual [€]	Quantity	Cost [€]	Unit Cost Estimate Individual [€]	Quantity	Cost [€]	Unit Cost Estimate Individual [€]	Quantity	Cost [€]
A.	**Main Bridge L =**	m		**410**			**410**			**410**			**410**			**410**			**410**			**410**	
1.	**Main Foundations**	Numbers		7			4			4			4			4			4			4	
1.1	**Piles**																						
1.11	Pile Diameter	m			-			-			-			-			-			-			-
1.12	Number of Piles	Pc			-			-			-			-			-			-			-
1.13	Structural Steel Grade 350	ton	3000		-	3000		-	3000		-	3000		-	3000		-	3000		-	3000		-
1.14	Concrete Grade 35 - Piles	m3	400		-	400		-	400		-	400		-	400		-	400		-	400		-
1.15	Reinforcement Grade 420	ton	1300		-	1300		-	1300		-	1300		-	1300		-	1300		-	1300		-
											-												
1.2	**Pilecap**				-			-			-			-			-			-			-
1.21	Concrete Grade 35 - Pilecap	m3	500		-	500		-	500		-	500		-	500		-	500		-	500		-
1.22	Reinforcement Grade 420	ton	1300		-	1300		-	1300		-	1300		-	1300		-	1300		-	1300		-
	SUBTOTAL				-			-			-			-			-			-			-
2.	**Piers (excluding abutments)**																						
2.01	Number of Piers	Pc		5	-		-	-		-	-		-	-		-	-		1	-		1	-
2.02	Concrete Grade 40	m3	600	2'718	1'630'619	600	-	-	600	-	-	600	-	-	600	-	-	600	220	132'000	600	220	132'000
2.03	Reinforcement Grade 420	ton	1300	544	706'602	1300	-	-	1300	-	-	1300	-	-	1300	-	-	1300	55	71'500	1300	55	71'500
	SUBTOTAL				2'337'221			-			-			-			-			203'500			203'500
3.	**Towers / Arch (option 6)**						(Arch only)																
3.01	Number of Towers/arches	Pc		-	-		1	-		2	-		2	-		2	-		1	-		1	-
3.02	Concrete Grade 45	m3	600	-	-	600	-	-	600	1'350	810'000	600	1'540	924'000	1000	3'800	3'800'000	800	830	664'000	1000	2'300	2'300'000
3.03	Reinforcement Grade 420	ton	1300	-	-	1300	-	-	1300	338	438'750	1300	385	500'500	1300	1'140	1'482'000	1300	208	269'750	1300	575	747'500
3.04	PT Bars	ton	6000	-		8000	-	-	6000	-	-	6000	10		6000	30	180'000						
3.05	Structural Steel, Grade 350 AT, Cat 2	ton	4000	-	-	4000	3'000	12'000'000	4000	1'180	4'720'000	4000	1'250	5'000'000	240	230	55'200	4000	1'700	6'800'000	4000	200	800'000
	SUBTOTAL				-			12'000'000			5'968'750			6'424'500			5'517'200			7'733'750			3'847'500
4.	**Superstructure**																						
4.1	**Mainspan L =**	m					180.00			225.00			225.00			225.00			220.00			220.00	
4.10	Area (deck without MUP)						7'560			9'450	-		9'450			9'450			9'240			9'240	
4.11	Precast Concrete f'c=55 Mpa	m3	800		-	800	1'837	1'469'664	800	2'296	1'837'080	800	2'296	1'837'080	800	2'296	1'837'080	800	2'245	1'796'256	800	2'245	1'796'256
4.12	Cast in Place Concrete Grade 55	m3	600		-	600	204	122'472	600	255	153'090	600	255	153'090	600	255	153'090	600	249	149'688	600	249	149'688
4.13	Reinforcement Black steel Grade 400	ton	1300		-	1300	-	-	1300	-	-	1300	-	-	1300	-	-	1300	-	-	1300	-	-
4.14	Reinforcement Stainless steel Grade 520	ton	3000			3000	510	1'530'900	3000	638	1'913'625	3000	638	1'913'625	3000	638	1'913'625	3000	624	1'871'100	3000	624	1'871'100
4.15	Longitudinal Posttensioning Grade 1860 Mpa	ton	6000		-	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	500	3'000'000	6000	500	3'000'000
4.16	Transverse Posttensioning Grade 1860 Mpa	ton	6000		-	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-
4.17	Transverse Prestressing in PCP Grade 1860 Mp	ton	6000			6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-
4.18	Structural Steel, Grade 350 AT, Cat 2	ton	4500		-	4500	2'306	10'376'100	4500	2'800	12'600'000	4500	2'700	12'150'000	4500	2'700	12'150'000	4500	2'918	13'131'900	4500	2'818	12'681'900
	SUBTOTAL				-			13'499'136			16'503'795			16'053'795			16'053'795			19'948'944			19'498'944
4.2	**Backspans L =**	m		410.00			230.00			185.00			185.00			185.00			190.00			190.00	
4.20	Area (deck without MUP)			17'220	-		9'660	-		7'770	-		7'770			7'770			7'980			7'980	
4.21	Precast Concrete f'c=55 Mpa	m3	800	2'070	1'656'000	800	2'610	2'088'000	800	1'200	960'000	800	1'200	960'000	800	1'200	960'000	800	1'160	928'000	800	1'160	928'000
4.22	Cast in Place Concrete Grade 55	m3	600	4'000	2'400'000	600	-	-	600	2'430	1'458'000	600	2'430	1'458'000	600	2'430	1'458'000	600	2'350	1'410'000	600	2'350	1'410'000
4.23	Reinforcement Black steel Grade 400	ton	1300	850	1'104'740	1300	365	475'020	1300	-	-	1300	-	-	1300	-	-	1300	92	120'079	1300	129	168'111
4.24	Reinforcement Stainless steel Grade 520	ton	3000	607	1'821'000	3000	261	783'000	3000	726	2'178'000	3000	726	2'178'000	3000	726	2'178'000	3000	610	1'828'895	3000	610	1'828'895
4.25	Ballast Concrete	m3	300	-	-	300	-		300	3'100	930'000	300	3'100	930'000	300	3'100	930'000	300	2'000	600'000	300	2'000	600'000
4.26	Longitudinal Posttensioning Grade 1860 Mpa	ton	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-
4.27	Transverse Posttensioning Grade 1860 Mpa	ton	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-
4.28	Transverse Prestressing in PCP Grade 1860 Mp	ton	6000	79	473'460	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-	6000	-	-
4.29	Structural Steel, Grade 350 AT, Cat 2	ton	4500	5'650	25'425'000	5000	3'462	17'310'720	5000	2'280	11'400'000	5000	2'180	10'900'000	5000	2'180	10'900'000	5000	2'534	12'669'500	5000	2'434	12'169'500
	SUBTOTAL				32'880'200			20'656'740			16'926'000			16'426'000			16'426'000			17'556'474			17'104'505
5.	**Stay cables/Hangers**																						
5.01	Number of Stay Cables/ Hangers	Pc					24			96			96			96			52			52	
5.02	Strands , Grade 1860 Mpa, 150mm2 (0.60")	ton	7500		-	10000	20	240'000	7500	370	2'775'000	7500	370	2'775'000	7500	370	2'775'000	7500	455	3'412'500	7500	455	3'412'500
5.03	Dampers	Pc							5000	48	240'000	5000	48	240'000	5000	48	240'000	6000	52	312'000	6000	52	312'000
5.04	Ice removal system (not considered so far)																						
	SUBTOTAL				-			240'000			2'775'000			2'775'000			2'775'000			3'412'500			3'412'500
6.	**Ancillaries**																						
6.01	Barriers	ml	200	1'230	246'000	200	1'230	246'000	200	1'230	246'000	200	1'230	246'000	200	1'230	246'000	200	1'230	246'000	200	1'230	246'000
6.02	Wearing Surface t = 100mm	m2	100	17'056	1'705'600	100	17'056	1'705'600	100	17'056	1'705'600	100	17'056	1'705'600	100	17'056	1'705'600	100	17'056	1'705'600	100	17'056	1'705'600
6.03	Waterproof	m2	50	17'056	852'800	50	17'056	852'800	50	17'056	852'800	50	17'056	852'800	50	17'056	852'800	50	17'056	852'800	50	17'056	852'800
6.04	Expansion Joints	ml	2000	84	168'000	2000	84	168'000	2000	84	168'000	2000	84	168'000	2000	84	168'000	2000	84	168'000	2000	84	168'000
6.05	Elastomeric Bearings (Fixed and Sliding)	Pc	8000	49	392'000	8000	12	96'000	6000	6	36'000	6000	22	132'000	6000	22	132'000	8000	12	96'000	8000	14	112'000
6.05	Disk Bearings	Pc	0	-	-	0		-	47500	6	285'000	50000	-	-	50000	-	-	95000	2	190'000	0	-	-
	SUBTOTAL				3'364'400			3'068'400			3'293'400			3'104'400			3'104'400			3'258'400			3'084'400
7.	**Major Temporary Works - estimate**																						
7.01	Jetty	Pc	1000000	1	1'000'000	1000000	1	1'000'000	1000000	-	-	1000000	-	-	1000000	-	-	1000000	-	-	1000000	-	-
7.02	Temporary Piers incl Foundation	Pc	80000	6	480'000	80000	6	480'000	80000	1	80'000	80000	-	-	80000	-	-	80000	-	-	80000	-	-
7.03	Lifting Derricks	Pc	200000	-	-	200000	1	200'000	200000	2	400'000	200000	2	400'000	200000	2	400'000	200000	1	200'000	200000	1	200'000
	SUBTOTAL				1'480'000			1'680'000			480'000			400'000			400'000			200'000			3'284'400
TOTAL excluding Foundation and Abutment Cost					**40'100'000**			**51'100'000**			**45'900'000**			**45'200'000**			**44'300'000**			**52'300'000**			**50'400'000**
Cost in % related to least expensive Option				100%			127%			114%			113%			110%			130%			126%	
		ml = long. meter																					
Notes:	1) The total cost above does not include mobilisation, environmental penalties and construction cost for foundation, abutments, slope stabilisation																						
	2) Items in Pos 6 and 7 have been added with best guess prices																						

Comparison

			Option 02	Option 06	Option 10a	Option 10b	Option 10c	Option 14 a	Option 14 b
			Multiple Plate Girder Bridge	Arch Bridge	unsymetrical CSB with two 3-Leg Steel Towers, integrated into superstructure	unsymetrical CSB with two 3-Leg Steel Towers, integrated into lower piers	unsymetrical CSB with two 3-Leg PC Concrete Towers	One Tower Stay Cable Bridge Steel Tower above deck	One Tower Stay Cable Bridge Concrete Tower
	Descripcion	Unit	Cost [€]	Cost [€]	Cost [€]	Cost [€]	Cost [€]	Cost [€]	Cost [€]
TOTAL excluding Foundation and Abutment Cost			**40'100'000**	**51'100'000**	**45'900'000**	**45'200'000**	**44'300'000**	**52'300'000**	**50'400'000**
Cost in % related to least expensive Option			**100%**	**127%**	**114%**	**113%**	**110%**	**130%**	**126%**
Notes:	1) The total cost above does not include mobilisation, environmental penalties and construction cost for foundation, abutments, slope stabilisation								

4.2 Refined Estimate

In the Bridge Option Evaluation Workshop at 25th October it has been decided to evaluate only Option 02 and Option 10c further. With the first greensheet estimates and the results of the foundation study summarized above it became also clear that Option 10a, which was ruled out earlier, is likely more economical than 10 c. This was confirmed with the final results summarized below.

28. Nov 19 rev04			Option 02			Option 10a			Option 10c		
			Multiple Plate Girder Bridge w/ spread footings			Unsymetrical CSB with two 3-Leg Steel Towers, integrated into superstructure w/ spread footings			Unsymetrical CSB with two 3-Leg CIP Concrete Towers w/ spread footings		
	Descripicion	Unit	QTY check (RT)	Unit Cost [CAD]	Total Cost [CAD]	QTY check (RT)	Unit Cost [CAD]	Total Cost [CAD]	QTY check (RT)	Unit Cost [CAD]	Total Cost [CAD]
A.	**Main Bridge L =**	m									
1.	**Main Foundations**	Numbers									
1.1	**Piles**										
1.11	Pile Diameter	m									
1.12	Number of Piles	Pc									
1.13	Structural Steel Grade 350	ton									
1.14	Concrete Grade 35 - Piles	m3									
1.15	Reinforcement Grade 420	ton									
1.2	**Spread Foundation**										
1.21	Concrete Grade 35 - Spread footing	m3	3'826	$ 634.73	$ 2'428'231.29	4'665	$ 634.73	$ 2'961'025.45	6'660	$ 634.73	$ 4'227'316.07
1.22	Reinforcement Grade 420	ton	727	$ 2'691.00	$ 1'955'991.02	886	$ 2'691.00	$ 2'385'167.85	1'265	$ 2'691.00	$ 3'405'191.40
	SUBTOTAL				4'384'222			5'346'193			7'632'507
2.	**Piers (excluding abutments)**										
2.01	Number of Piers	Pc	5	$ -							
2.02	Concrete Grade 40	m3	2'718	$ 1'386.07	$ 3'766'920.75						
2.03	Reinforcement Grade 400	ton	544	$ 2'980.00	$ 1'619'748.60						
	SUBTOTAL				5'386'669			-			-
3.	**Towers / Arch (option 6)**										
3.01	Number of Towers/arches	Pc				2			2	$ -	
3.02	Concrete Grade 45	m3				1'350	$ 3'526.44	$ 4'760'700.69	3'815	$ 3'510.60	$ 13'394'506.26
3.03	Reinforcement Grade 400	ton				338	$ 2'940.00	$ 992'250.00	1'145	$ 3'031.22	$ 3'469'635.99
3.04	PT Bars	ton				-		$ -	-		$ -
3.05	Structural Steel Grade 350	ton				1'260	$ 9'224.12	$ 11'622'388.34	200	$ 11'313.00	$ 2'262'600.00
3.06	PT Tendons in Crossbeams	ton									
	SUBTOTAL				-			17'375'339			19'126'742
4.	**Superstructure**										
4.1	**Mainspan L =**	m									
4.10	Area (deck without MUP)					9'338	$ -		9'338	$ -	
4.11	Precast Concrete f'c=55 Mpa	m3				2'552	$ 6'881.48	$ 17'558'100.00	2'552	$ 6'881.48	$ 17'558'100.00
4.12	Cast in Place Concrete Grade 55	m3					incl.	incl.		incl.	incl.
4.13	Reinforcement Black steel Grade 400	ton					incl.	incl.		incl.	incl.
4.14	Reinforcement Stainless steel Grade 520	ton					incl.	incl.		incl.	incl.
4.15	Longitudinal Posttensioning Grade 1860 Mpa	ton									
4.16	Transverse Posttensioning Grade 1860 Mpa	ton									
4.17	Transverse Prestressing in PCP Grade 1860 Mpa	ton									
4.18	Structural Steel, Grade 350	ton				2'800	$ 6'277.68	$ 17'577'512.20	2'700	$ 6'277.68	$ 16'949'743.90
	SUBTOTAL				-			35'135'612			34'507'844
4.2	**Backspans L =**	m	410.00								
4.20	Area (deck without MUP)		17'220	$ -		7'678	$ -		7'678	$ -	
4.21	Precast Concrete f'c=55 Mpa	m3	2'070	$ 9'417.19	$ 19'493'578.13	3'630	$ 9'300.00	$ 33'759'000.00	3'630	$ 9'300.00	$ 33'759'000.00
4.22	Cast in Place Concrete Grade 55	m3	4'000	$ 1'038.88	$ 4'155'531.32		incl.	incl.		incl.	incl.
4.23	Reinforcement Black steel Grade 400	ton	850	$ 3'216.00	$ 2'732'956.80		incl.	incl.		incl.	incl.
4.24	Reinforcement Stainless steel Grade 520	ton	607	$ 8'250.00	$ 5'007'750.00		incl.	incl.		incl.	incl.
4.25	Ballast Concrete	m3	-	$ -	$ -	3'100	$ 785.07	$ 2'433'725.00	3'100	$ 785.07	$ 2'433'725.00
4.26	Longitudinal Posttensioning Grade 1860 Mpa	ton	-	$ -	$ -						
4.27	Transverse Posttensioning Grade 1860 Mpa	ton	-	$ -	$ -						
4.28	Transverse Prestressing in PCP Grade 1860 Mpa	ton	79	$ 12'412.53	$ 979'472.74						
4.29	Structural Steel, Grade 350	ton	5'650	$ 6'630.98	$ 37'465'012.20	2'280	$ 6'277.68	$ 14'313'117.07	2'180	$ 6'277.68	$ 13'685'348.78
	Schedule Delay (2 seasons/years)				see below			N/A			N/A
	SUBTOTAL				69'834'301			50'505'842			49'878'074
5.	**Stay cables/Hangers**										
5.01	Number of Stay Cables/ Hangers	Pc									
5.02	Strands , Grade 1860 Mpa, 150mm2 (0.62")	ton				370	$ 15'351.94	$ 5'680'217.86	370	$ 15'351.94	$ 5'680'217.86
	SUBTOTAL				-			5'680'218			5'680'218
6.	**Ancillaries**										
6.01	Barriers	ml	1'640	$ 1'350.00	$ 2'214'000.00	1'640	$ 1'350.00	$ 2'214'000.00	1'640	$ 1'350.00	$ 2'214'000.00
6.02	Wearing Surface t = 100mm	m2	17'056	$ 55.00	$ 938'080.00	17'056	$ 55.00	$ 938'080.00	17'056	$ 55.00	$ 938'080.00
6.03	Waterproof	m2	17'056	$ 75.00	$ 1'279'200.00	17'056	$ 75.00	$ 1'279'200.00	17'056	$ 75.00	$ 1'279'200.00
6.04	Expansion Joints	ml	84	$ 12'000.00	$ 1'008'000.00	84	$ 12'000.00	$ 1'008'000.00	84	$ 12'000.00	$ 1'008'000.00
6.05	Elastomeric Bearings	Pc	49	$ 15'000.00	$ 735'000.00	6	$ 15'000.00	$ 90'000.00	22	$ 15'000.00	$ 330'000.00
6.05	Disk Bearings	Pc				6	$ 71'155.50	$ 426'933.00			
	SUBTOTAL				6'174'280			5'956'213			5'769'280
7.	**Major Temporary Works - estimate**										
7.01	Jetty, accesses, soil stabilization (pile option) & cofferdams	Pc	1	$ 18'600'225.71	$ 18'600'225.71	1	$ 6'172'177.32	$ 6'172'177.32	1	$ 6'590'577.32	$ 6'590'577.32
7.02	Temporary Piers incl Foundation	Pc	6	$ 365'875.00	$ 2'195'250.00						
7.03	Lifting Derricks	Pc				4	$ 200'000.00	$ 800'000.00	4	$ 200'000.00	$ 800'000.00
7.04	Deck Erection Gantry					4	$ 150'000.00	$ 600'000.00	4	$ 150'000.00	$ 600'000.00
	SUBTOTAL				20'795'476			7'572'177			7'990'577
TOTAL	**excluding Foundation and Abutment Cost**				**$ 106'570'000**			**$ 127'570'000**			**$ 130'590'000**
Cost in % related to least expensive Option								3%			5%
		ml = long. meter		**Total Cost**	**$ 144'440'000**		**Total Cost**	**$ 148'070'000**		**Total Cost**	**$ 151'090'000**

Notes:

1) The total cost above does not include mobilisation, environmental penalties and construction cost for foundation, ab

2) Items in Pos 6 and 7 have been added with best guess prices

3) Barriers in Option 2 might be 3 only, but in that case the central one will be stronger

4) All unit rates are at cost i.e. not included: indirect, soft costs, engineering, escalation, contingency, risk, profit.

	Option 02		Option 10a		Option 10c	
		WAHR		WAHR		WAHR
	Area [m2]	cost per m2	Area [m2]	cost per m2	Area [m2]	cost per m2
	17'220	$ 8'388	17'220	$ 8'599	17'220	$ 8'774
				$ 3'630'000.00		$ 6'650'000.00

Additional costs:	Qty	Un	UP	Total	Qty	UP	Total	Un	UP	Total
Abutments				**$ 12'715'384.66**			**$ 11'898'457.06**			**$ 11'898'457.06**
Concrete for piles	5191	m3	$ 1'518.45	$ 7'882'288.48	4653	$ 1'518.45	$ 7'065'360.87	4653	$ 1'518.45	$ 7'065'360.87
Concrete for abutment pier	2625	m3	$ 1'841.18	$ 4'833'096.19	2625	$ 1'841.18	$ 4'833'096.19	2625	1'841.18	$ 4'833'096.19
Electrical & ITS	17220	m2	$ 280.00	**$ 4'821'600.00**	1	$ 280.00	**$ 4'821'600.00**	1	$ 280.00	**$ 4'821'600.00**
Health Monitoring System	17220	m2	$ 150.00	**$ 2'583'000.00**	1	$ 150.00	**$ 2'583'000.00**	1	$ 150.00	**$ 2'583'000.00**
Inspection trucks	20		$ 10'000.00	**$ 200'000.00**	1	$ 300'000.00	**$ 300'000.00**	1	$ 300'000.00	**$ 300'000.00**
Cradles & Hoists				n/a	6	$ 150'000.00	**$ 900'000.00**	6	$ 150'000.00	**$ 900'000.00**
			Sub-Total	**$ 20'319'984.66**		**Sub-Total**	**$ 20'503'057.06**		**Sub-Total**	**$ 20'503'057.06**
Environmental delays and work in the river							**N/A**			**N/A**
Construction schedule delay:	Salaries on average including fringes (no expats, bonus, etc)									
			$/month	$ 13'000						
say	30 staff office									
	60 site (control/planning/managers/engineering/etc)									
			staff	90						
			$/ month	$ 19'500						
			total / mo	$ 1'755'000						
			months	10						
			total schedule extension cost	**$ 17'550'000**			**N/A**			**N/A**

Total Direct		% on selling	**$**	**144'440'000**		% on selling	**$**	**148'070'000**		% on selling	**$**	**151'090'000**
1.0 Indirects		**25%**	**$**	**77'101'500**		**25%**	**$**	**77'371'000**		**25%**	**$**	**78'939'000**
Staff Salaries		7.0%	$	22'029'000		7.0%	$	22'106'000		7.0%	$	22'554'000
Indirect Expenses		7.0%	$	22'029'000		7.0%	$	22'106'000		7.0%	$	22'554'000
Engineering & Consulting Expeneses		8.0%	$	25'176'000		8.0%	$	25'264'000		8.0%	$	25'776'000
Indirect Labor and Equipment		1.0%	$	3'147'000		1.0%	$	3'158'000		1.0%	$	3'222'000
Non-productive days & Winter Conditions		1.5%	$	4'720'500		1.5%	$	4'737'000		1.5%	$	4'833'000
2.0 Soft Costs		**4.6%**	**$**	**14'476'200**		**3.6%**	**$**	**11'368'800**		**3.6%**	**$**	**11'599'200**
Bonds & Insurances		0.5%	$	1'573'500		0.5%	$	1'579'000		0.5%	$	1'611'000
Warranties & Follow-ups		0.1%	$	314'700		0.1%	$	315'800		0.1%	$	322'200
Escalation (2020 + construction years)	52 months	4.0%	$	12'588'000	42 months	3.0%	$	9'474'000	42 months	3.0%	$	9'666'000
Currency Risk			$	-			$	-			$	-
Financing			$	-			$	-			$	-
3.0 Risks, Contingencies and OH&Profits		**25.0%**	**$**	**78'675'000**		**25.0%**	**$**	**78'950'000**		**25.0%**	**$**	**80'550'000**
Risks		5.0%	$	15'735'000		5.0%	$	15'790'000		5.0%	$	16'110'000
Contingencies		5.0%	$	15'735'000		5.0%	$	15'790'000		5.0%	$	16'110'000
OH & Profit		15.0%	$	47'205'000		15.0%	$	47'370'000		15.0%	$	48'330'000
Total Indirect			**$**	**170'252'700**			**$**	**167'689'800**			**$**	**171'088'200**
Total Selling (+/- 15%)		Option 02	**$**	**314'700'000**		Option 10a	**$**	**315'800'000**		Option 10c	**$**	**322'200'000**
								0.3%				2.4%

5 Recommended Inspection Cycles

Item	frequency of Inspection		
	visual, from a distance (authority/client)	visual (specialist)	"hands on" inspection / non. destructive testing
structural weathering steel, superstructure	1 time / year	1 time / 3 years	1 time / 6 years
structural weathering steel, pylon / arch	1 time / year	1 time / 3 years	1 time / 6 years
steel coating systems (not considered so far)	1 time / year	1 time / 3 years	1 time / 3 years
concrete pylon	-	1 time / 3 years	-
concrete deck slab girder bridge	1 time / year	1 time / 3 years	-
concrete deck slab stay cable bridge	1 time / year	1 time / 3 years	
concrete pier	-	1 time / 3 years	-
concrete pile cap	-	-	-
concrete piles	-	-	-
elastomeric bearings	1 time / year	1 time / 3 years	1 time / 6 years
disc bearing bearings	1 time / year	1 time / 3 years	1 time / 6 years
expansion joint	1 time / year	1 time / 3 years	1 time / 6 years
wearing surface	1 time / year	1 time / 3 years	1 time / 3 years
drainage	1 time / year	1 time / 3 years	-
Joint seals, sliders and springs	1 time / year	1 time / 3 years	-
stay cables 1)	-	1 time / 3 years	1 time / 6 years
Sheaths for Stay cables 2)	1 time / year	1 time / 3 years	1 time / 6 years
Dampers for stay cables	1 time / year	1 time / 3 years	1 time / 6 years
Stay Cable Snow and Ice Removal System 3)	1 time / year	1 time / 3 years	1 time / 6 years
Hangers	1 time / year	1 time / 3 years	1 time / 6 years
Structural Health Monitoring Systems	1 time / year	1 time / 3 years	1 time / 6 years
galvanized steel barriers	1 time / year	1 time / 3 years	-
galvanized steel railing	1 time / year	1 time / 3 years	-
concrete barriers	1 time / year	1 time / 3 years	-
Sign support structures	1 time / year	1 time / 3 years	-
lamp post	1 time / year	1 time / 3 years	1 time / year (luminance test)

Durability/Replacement Periods assumed

Item	design service/lifetime [years]	replacement [times]	design service/lifetime [years]	replacement [times]	design service/lifetime [years]	replacement [times]	design service/lifetime [years]	replacement [times]
structural weathering steel, superstructure	100	-	100	-	100	-	100	-
structural weathering steel, pylon / arch	-	-	100	-	100	-	100	-
steel coating systems (not considered so far)	35	2	35	2	35	2	35	2
concrete pylon	-	-	-	-	100 (10c)	-	100 (14b)	-
concrete deck slab girder bridge	50	1 x 410m	50 (30% of total)	1 x 120m	-	-	50 (20% of Total)	1 x 80m
concrete deck slab cable suspended girder	100	-	100	-	100	-	100	-
concrete pier	100	-	100	-	100	-	100	-
concrete pile cap	100	-	100	-	100	-	100	-
concrete piles	100	-	100	-	100	-	100	-
elastomeric bearings	35	2 x 49	35	2 x 26	35	2 x 22	35	2 x 14
disc bearing bearings	-	-	-	-	50 (10a)	1 x 6	50 (14a)	1 x 2
expansion joint	35	2	35	2	35	2	35	2
wearing surface	25	3	25	3	25	3	25	3
drainage	35	2	35	2	35	2	35	2
Joint seals, sliders and springs	15	6	15	6	15	6	15	6
stay cables [1]	-	-	-	-	100	1 x 10%	100	1 x 10%
Sheaths for Stay cables [2]	-	-	-	-	100	1 x 10%	100	1 x 10%
Dampers for stay cables	-	-	-	-	50	1	50	1
Stay Cable Snow and Ice Removal System [3]	-	-	-	-	25	3	25	3
Hangers	-	-	50	1	-	-	-	-
Structural Health Monitoring Systems	25	3	25	3	25	3	25	3
galvanized steel barriers	40	2	40	2	40	2	40	2
galvanized steel railing	40	2	40	2	40	2	40	2
concrete barriers	40	2	40	2	40	2	40	2
Sign support structures	50	1	50	1	50	1	50	1
lamp post	50 /upon need	1	50 /upon need	1	50 /upon need	1	50 / upon need	1

Notes

1) Around 10% of the strands may need to be replaced along the structure lifetime

2) Using bright colours (white or nearly white) will increase the lifetime of the sheets considerably (getting close to 100y). We assume that 10 % of the sheets may need to be replaced within the 100y

3) If stay cables with small ducts are used (e.g. parallel wire systems or ropes) the risk of ice accumulation decrease considerably. Many suppliers are close to a solution to mitigate that problem completely

6 Further Comments

6.1 Inspection Gantry

The need of an inspection gantry is usually defined by the clients. Should he request one for the Saskatoon Freeway Project, some slight changes in the design could be done, so that **one** gantry is sufficient

1. Lower the Pylon crossbeam by about 1.20m. That creates a clear distance of 1.3 (to date) + 1.2 = of 2.5 m between crossbeam top and deck bottom so that the gantry can path the Pylon legs: turn it or shift it together (slide rule principle). Note that option 10a has no crossbeam below the deck at all and the gantry can pass easily.

2. At one of the abutments path over tracks would allow to shift it from upstream to downstream deck or vs)

6.2 Widening the Roadway

The design was so far developed according to the sketch on page 5 of this report

- Initial Layout: 4 Lanes with 3.70m each, 3 of them for Traffic, one for MuP, 2 Shoulders with 2.60m
- Future Layout: 4 Lanes with 3.70m each, 2 Shoulders with 2.60m. MuP on a light Cantilever with 3.60m width

Should it be required to add another lane to the Southbound, it has no structural consequence except that in a first approach the cost will rise proportionally to the deck area for Option 2 and 10.

By adding a forth traffic lane to the Southbound, two alternatives may be further developed

Alt 1 does not change the Southbound, it has 4 traffic lanes from the beginning and 4 in future
Initial Layout:

- Northbound: 4 Lanes with 3.70m each, 3 Lanes for Traffic, one for MuP, 2 Shoulders with 2.60m (as above)
- Southbound: 4 Lanes with 3.70m each plus 1 Lane 3.60m for MuP, 2 Shoulders with 2.60m

Future Layout:

- Northbound: 4 Lanes with 3.70m each, 2 Shoulders with 2.60m. MuP on a light Cantilever with 3.60m width
- Southbound: 4 Lanes with 3.70m each plus 1 Lane 3.60m for MuP, 2 Shoulders with 2.60m – same as initial

Alt 2 has 4 lanes at the beginning and 5 traffic lanes on Southbound in the future

Initial Layout:

- Northbound: 4 Lanes with 3.70m each, 3 Lanes for Traffic, one for MuP, 2 Shoulders with 2.60m (same as Alt1)
- Southbound: 4 Lanes with 3.70m each plus 1 Lane 3.60m for MuP, 2 Shoulders with 2.60m

Future Layout:

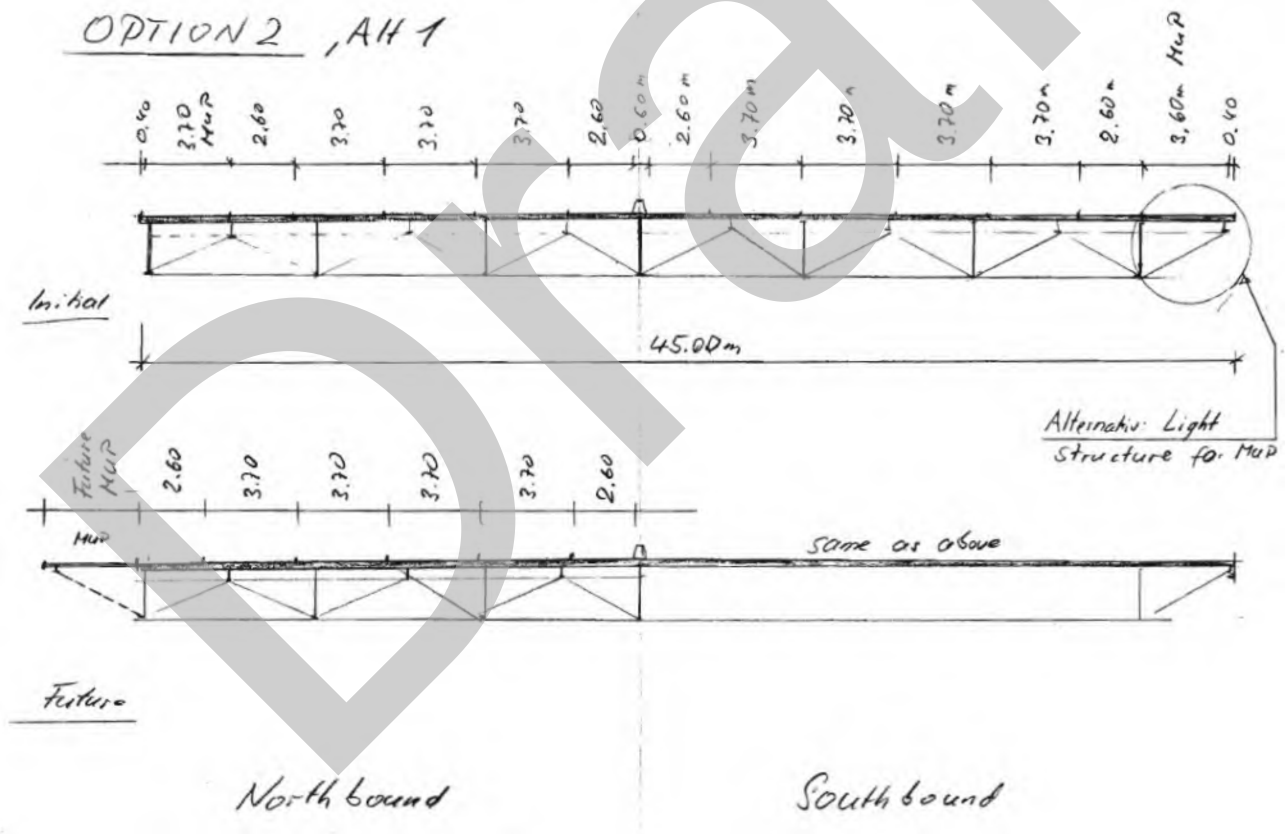
- Northbound 4 Lanes with 3.70m each, 2 Shoulders with 2.60m. MuP on a light Cantilever with 3.60m width (same as Alt 1)
- Southbound: 5 Lanes with 3.70m each, 2 Shoulders with 2.60m. MuP on a light Cantilever with 3.60m width

Consequences for the Options:

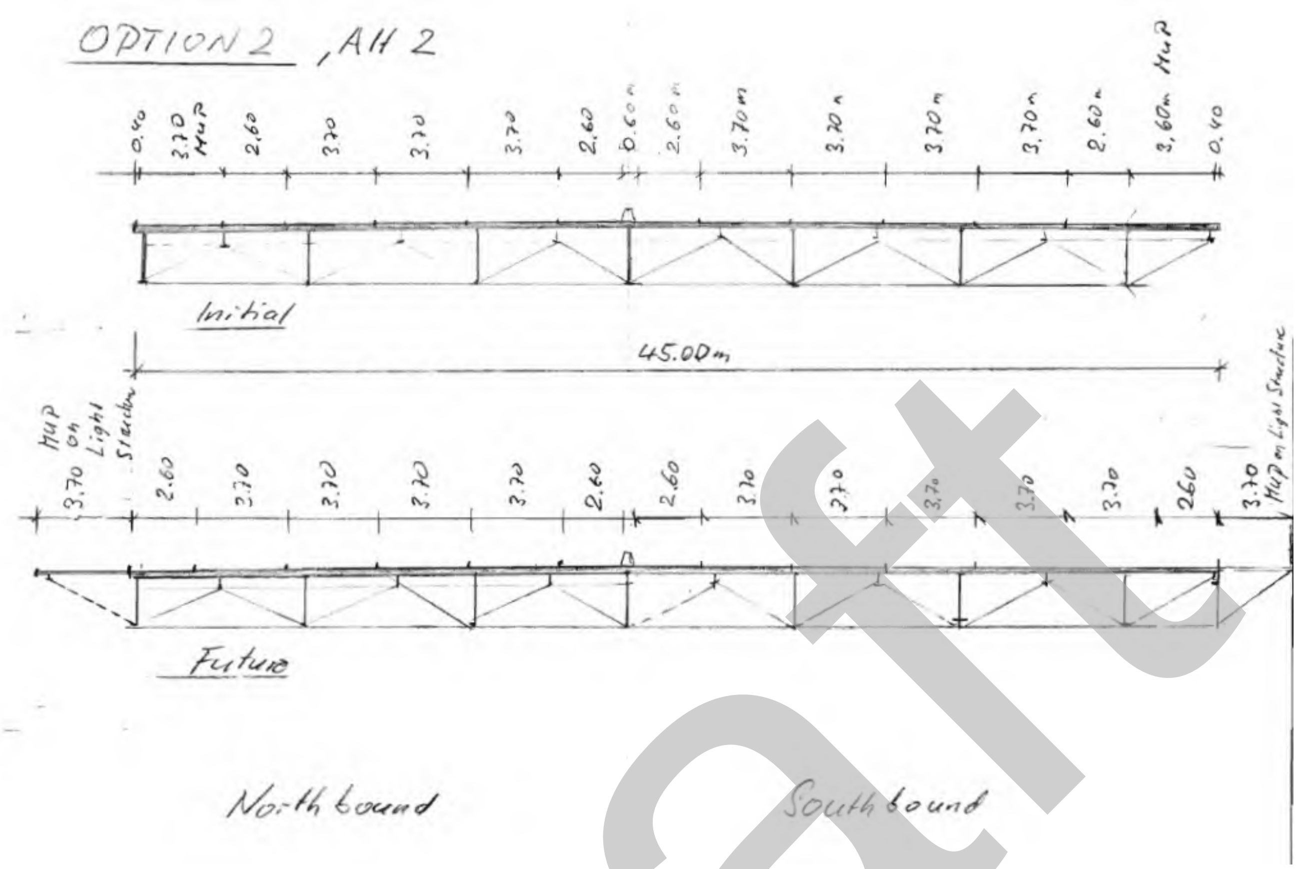
Option 2

For Option 2 this can be directly adopted

Alt 1



Additional remark: It may be possible to place the Southbound MuP from the very beginning on a light cantilever. This would avoid the very wide concrete slab

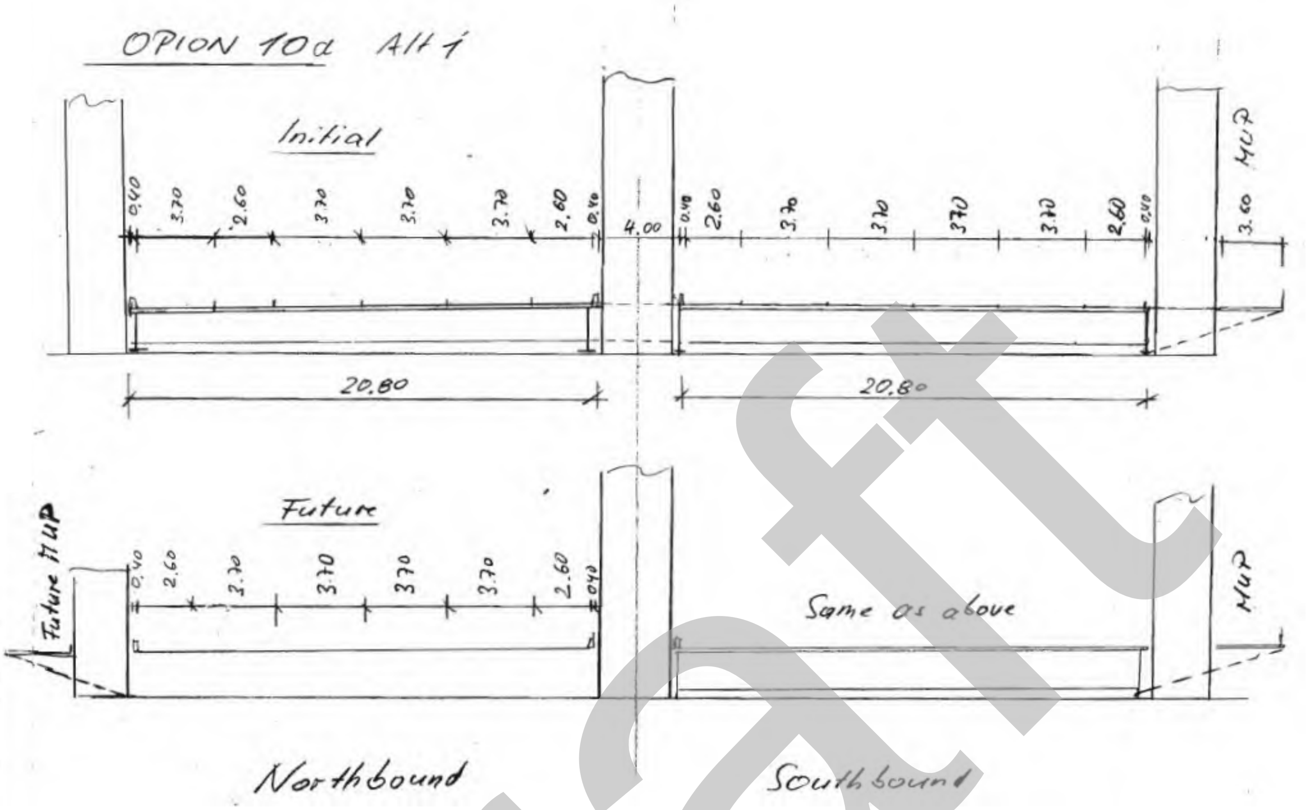


This alternative requires a really wide concrete deck. So, a twin deck with separated superstructures should really be taken into account, but the problems with adding an eccentric MuP Lane (torsion & deformations) needs to be addressed.

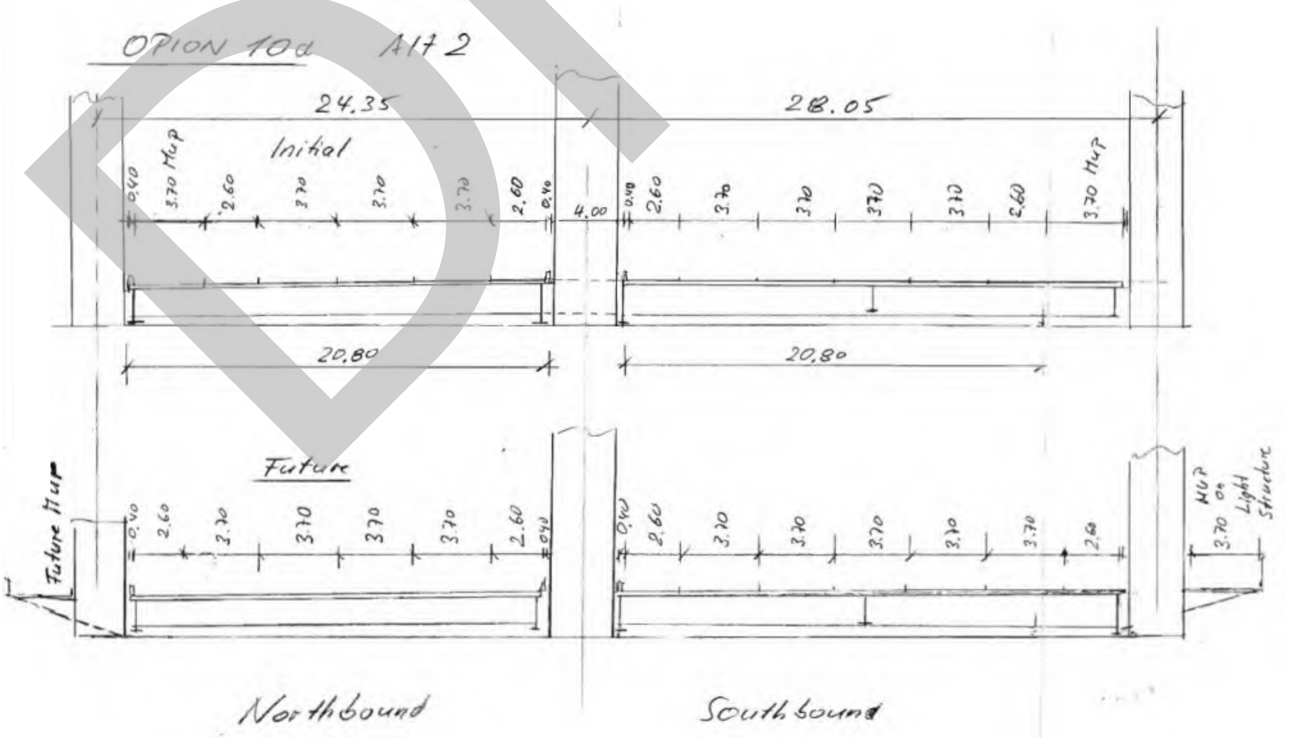
Option 10

For Option 10 the MuP should be placed from the beginning on a light structure in order to clear the outer pylon leg.

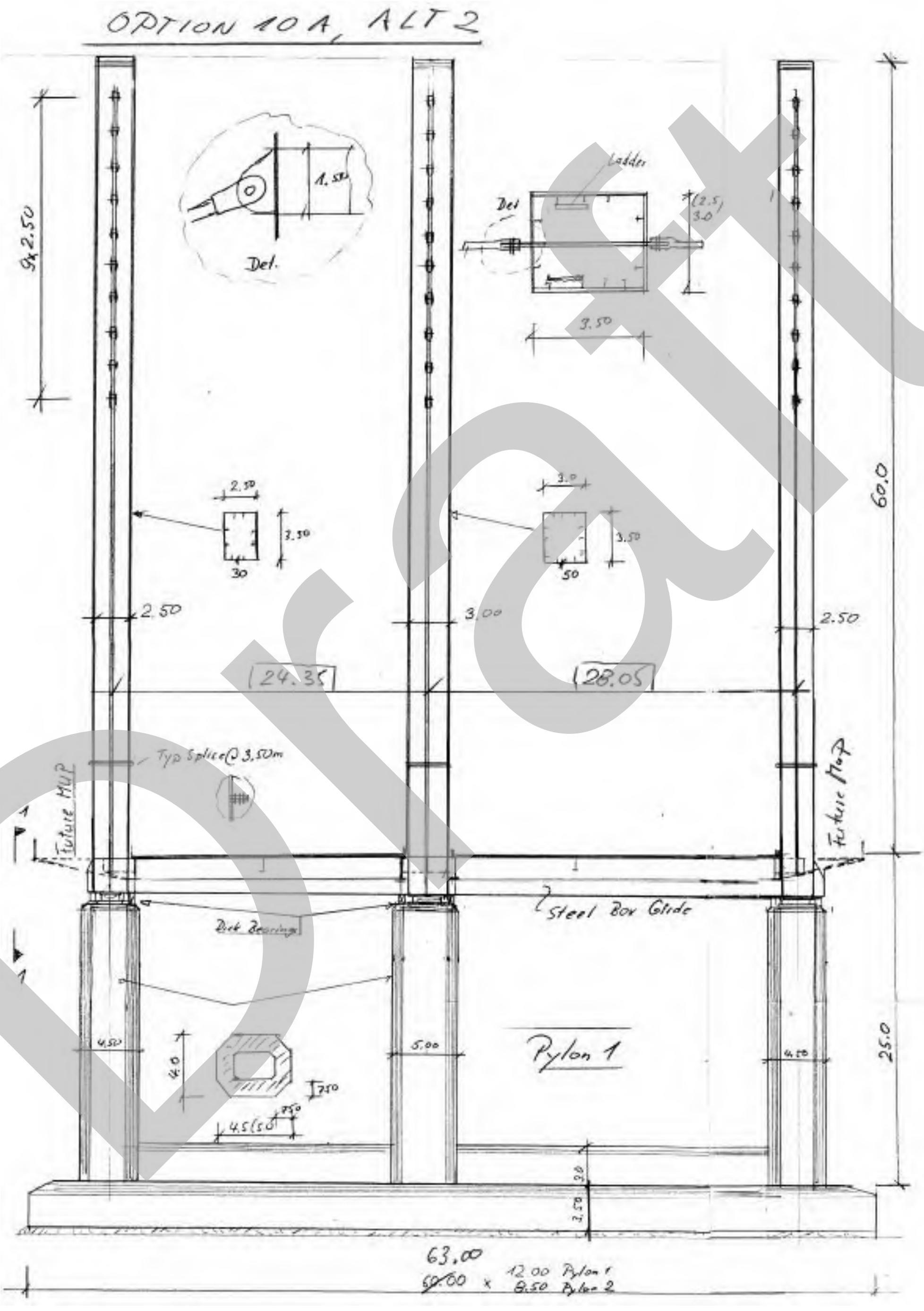
Alt 1


OPION 10a Alt 1
Initial
0.40
3.70
2.60
3.70
3.70
3.70
2.60
0.40
4.00
0.40
2.60
3.70
3.70
3.70
3.70
2.60
0.40
3.60
MUP
20.80
20.80
Future
Future MUP
0.40
2.60
3.70
3.70
3.70
3.70
2.60
0.40
Same as above
MUP
Northbound
Southbound

Alt 2


OPION 10a Alt 2
24.35
28.05
Initial
0.40
3.70 MUP
2.60
3.70
3.70
3.70
2.60
0.40
4.00
0.40
2.60
3.70
3.70
3.70
3.70
2.60
3.70 MUP
20.80
20.80
Future
Future MUP
0.40
2.60
3.70
3.70
3.70
3.70
2.60
0.40
0.40
2.60
3.70
3.70
3.70
3.70
3.70
2.60
3.70
MUP on Light Structure
Northbound
Southbound

In case a 5th Traffic Lanes is needed (Alt 2), the tower legs would have a different spacing: Northbound 24.35m, Southbound 28.05m. This is illustrated below and one can see that it does not harm the aesthetics much. Most of the public would not realize this at all or would believe it is done by purpose to bring more visual tension into the design.



Option 6 and 14 would get more problems due to the extremely long span of the crossbeams, but those options will not be considered further anyway.

APPENDIX H

Geohazard Assessment

Saskatoon Freeway Functional Planning Study

Preliminary Report – Geohazard Assessment of Proposed Main Bridge Site

Saskatchewan Ministry of Highways

June 8, 2023

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Notice to Reader / Sign-Off Sheet

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The findings, conclusions, and recommendations in this report (i) have been developed in a manner consistent with the level of skill normally exercised by professionals currently practicing under similar conditions in the area, and (ii) reflect SNC-Lavalin's best judgment based on information available at the time of preparation of this report. No other warranties, either expressed or implied, are made with respect to the professional services provided to the Client or the findings, conclusions, and recommendations contained in this report. The findings and conclusions contained in this report are valid only as of the date of this report and may be based, in part, upon information provided by others. If any of the information is inaccurate, new information is discovered, or project parameters change, modifications to this report may be necessary.

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Table of Contents

1 Introduction

The Saskatchewan Ministry of Highways (Ministry) has selected SNC-Lavalin Inc. (SNC-Lavalin) for the completion of the Saskatoon Freeway Functional Planning Study Project. The objective of the functional planning study is to finalize the route for approximately 55 km of freeway around the City of Saskatoon with Right of Way Plan. As part of the Project, SNC-Lavalin is providing this Preliminary Report which outlines the geotechnical desktop review and site inspection at the site of the proposed new bridge crossing the South Saskatchewan River.

This Preliminary Report outlines the following:

- The results of the desktop study, including site geology, and 3D geohazard mapping (digital air photo interpretation);
- A field review of the proposed river crossing;
- A discussion of the potential failure mechanisms; and,
- A scoping study, including a recommended geotechnical investigation.

1.1 Site Location

The Saskatoon Freeway Functional Planning Study (SFFPS) will consider the placement of a new bridge crossing the South Saskatchewan River. The alignment crosses the River to the southeast of the Highway 11 interchange. The proposed new bridge is located along the proposed alignment of the Saskatoon Freeway between the Northern and Eastern Segments. The bridge location is within the South Saskatchewan River Valley and within Section 26-37-05-W3M (SE, NE and NW quarter sections). The location plan is provided in **Figure I-1 (Appendix I)**.

2 Background

The wide corridor for the proposed river crossing sits within a generally level glaciated plain dissected by the South Saskatchewan River Valley and river terraces formed during dewatering of Lake Saskatchewan following the last glaciation in the Pleistocene. Topographic elevation varies between approximately 500 metres above sea level (masl) along the western side of the South Saskatchewan River, to approximately 485 masl along the eastern side of the South Saskatchewan River. The eastern side of the study area sits on a terrace formed during the last deglaciation and is approximately 15 m lower than the western side of the valley. It is understood that landslides have occurred along the western river embankment. Indications of slope movement along the eastern embankment are less evident. Both river embankments are covered with thin accumulations of slough and hill wash. The river channel is covered with a lag concentrate of boulders. The boulders likely originate from boulder pavements between till units and from intra-till boulders within the till units that were exposed as the river channel deepened from melt water erosion (MDH, 2004).

2.1 General Alignment and Terrain Analysis

The proposed alignment crosses the South Saskatchewan River to the southeast of the Highway 11 interchange with a profile that lowers from the west to the east at 1.755% grade. As shown in **Figure 2-1**, the profile requires a cut on the west bank in order to accommodate the grade lines. The cut will reduce the height of driving force on the west bank, but it is understood that disturbance to the slope is an imperative geotechnical consideration.

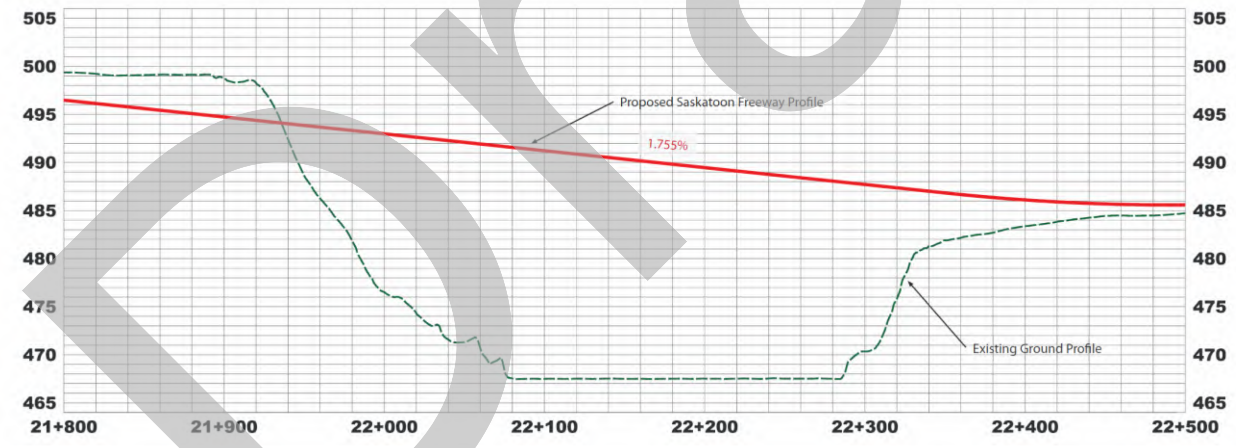


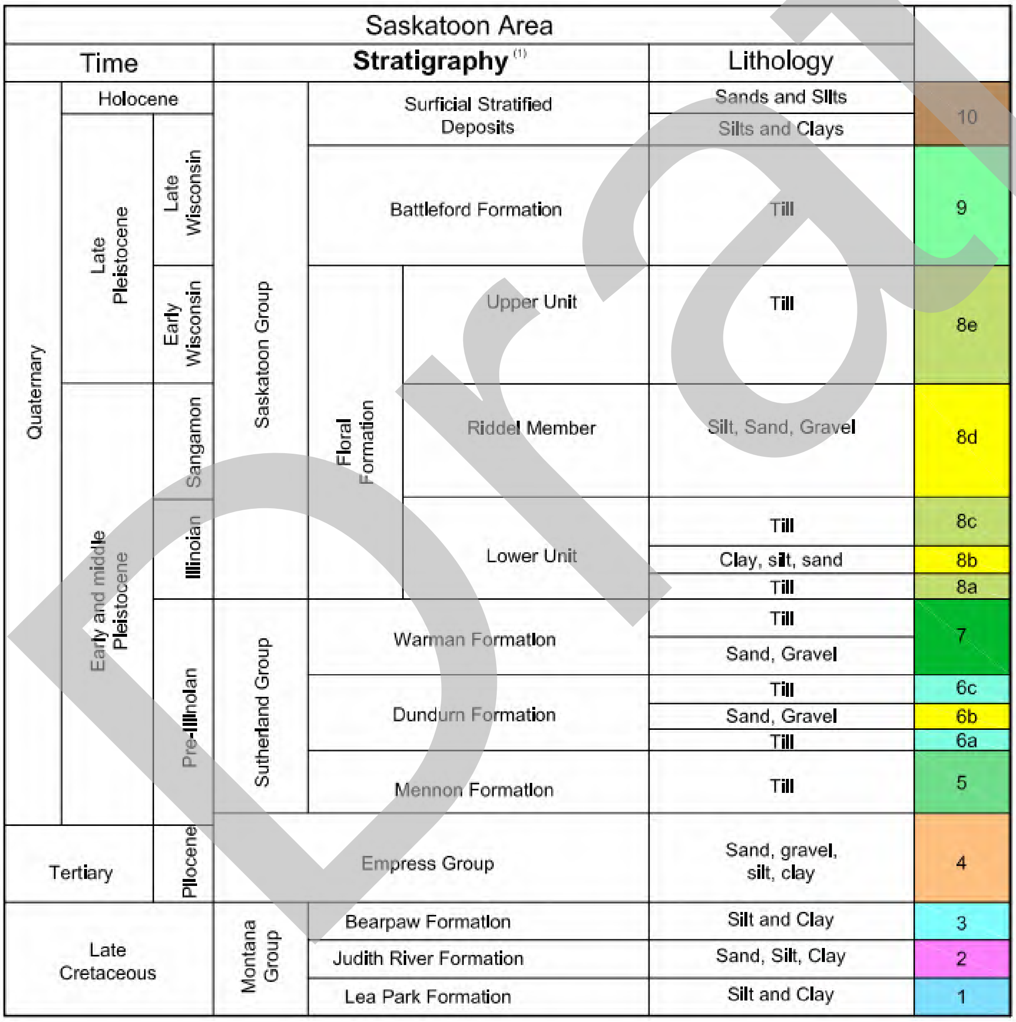
Figure 2-1: South Saskatchewan River Crossing – Gradeline profile.

A geohazard mapping program was carried out to determine if terrain or other geohazard concerns may affect construction on the slopes at the South Saskatchewan River Crossing. The geohazard assessment included historical aerial photograph review, terrain mapping, and site inspection.

3 Desktop Study

3.1 Geology

SNC-Lavalin has extensive experience with Saskatchewan landslides and therefore, used past experience as well as several in-house reports and available borehole databases to understand the geology at the proposed river crossing. SNC-Lavalin (formerly MDH Engineered Solutions Corp.) completed a preliminary geotechnical analysis project in 2004 at the proposed river crossing. The report entitled, *Preliminary Geotechnical Analysis Proposed Saskatoon Perimeter Road North Bridge Crossing*, is provided in **Appendix II**. The stratigraphic profile in the vicinity of the Saskatoon area, modified by Christiansen (1992), is provided in **Figure 3-1.**



Saskatoon Area

Time			Stratigraphy (1)			Lithology	
Quaternary	Holocene		Saskatoon Group	Surficial Stratified Deposits		Sands and Silts	10
						Silts and Clays	
	Late Pleistocene	Late Wisconsin		Battleford Formation		Till	9
		Early Wisconsin		Floral Formation	Upper Unit	Till	8e
	Early and middle Pleistocene	Sangamon			Riddel Member	Silt, Sand, Gravel	8d
		Illinoian			Lower Unit	Till	8c
						Clay, silt, sand	8b
						Till	8a
		Pre-Illinoian	Sutherland Group	Warman Formation		Till	7
						Sand, Gravel	
				Dundurn Formation		Till	6c
						Sand, Gravel	6b
						Till	6a
				Mennon Formation		Till	5
Tertiary		Pliocene	Empress Group			Sand, gravel, silt, clay	4
Late Cretaceous			Montana Group	Bearpaw Formation		Silt and Clay	3
				Judith River Formation		Sand, Silt, Clay	2
				Lea Park Formation		Silt and Clay	1

(1) modified after Christiansen, 1992

Figure 3-1: Quaternary stratigraphy and lithology in the Saskatoon area.

A stratigraphic cross-section, in the vicinity of the proposed river crossing, was developed by SNC-Lavalin as part of the above-mentioned project in 2004. The cross-section is provided within Appendix F of the historic report which is provided in **Appendix II**. The detailed geomorphology, geology and groundwater conditions can be found in the historic report (**Appendix II**), along with several borehole logs that are within close proximality to the proposed river crossing.

3.2 Geohazard Mapping

Digital aerial photograph stereo pairs for the years 1971, 1987, and 2003 and a 2D orthophoto from 2014 were ordered from ISC. The stereo pairs were georeferenced in 3D and were viewed in the heads-up 3D mapping software DAT/EM Summit Evolution®. Features were digitized on-screen using ESRI® ArcMap. LiDAR data from 2018 was processed as a Digital Elevation Model (DEM) and added into the ArcMap file. A hillshade derived raster image along with a 2D orthoimage of the study area were also incorporated into the ArcMap file.

Mapping was completed and used to guide fieldwork, then updated to reflect the findings of the field inspection prior to finalizing. The mapping boundaries extended outside the project area to account for any features that could potentially affect the project area. Fieldwork was completed by the geohazard specialist, Shirley McCuaig, Ph.D., P.Geo., and Geotechnical Engineer, Katherine Lockhart, P.Eng., on June 29 and June 30, 2020. The area was accessed on foot. The crest of each slope was walked first, followed by an investigation of the lower slopes. Important areas highlighted by the mapping were visited during the crest and slope walks. Field site locations are indicated in **Figure I-1** (**Appendix I**) and **Figure I-2** (**Appendix I**).

The geohazard assessment conducted as part of this study excluded the following items:

- Surficial geology mapping;
- Terrain classification and terrain stability assessment (as per Howes and Kenk,1997 and RIC, 1996); and,
- Deterministic slope stability assessment.

4 Field Inspection

SNC-Lavalin completed a field review of the proposed river crossing on 29 June 2020 and 30 June 2020. During the field review, SNC-Lavalin completed a Risk Management System for Landslides in Saskatchewan Site Inspection Form, which is provided in **Appendix III**. This is a standard form of the Ministry which is used to assess the failure and risk associated with a landslide and erosion. The landslide is rated based on the risk of catastrophic failure as well as the consequence factor upon failure. The scale in which the probability and consequence factors are measured, as well as the recommended response level is provided in **Appendix IV**. The following summarizes the overall landslide and erosion risk for the site:

- Landslide Risk: Proposed Saskatoon Freeway – South Saskatchewan River Crossing Location:
  - **Probability Factor**: 9+2 (Active landslide with moderate, steady or decreasing rate of movement in defined shear zone). The '+2' is added for uncertainty since this site has not been previously inspected and there is no instrumentation installed to ascertain rate of movement. Both sides of the river show evidence of small debris slides. There is also evidence of larger slides, specifically on the west slope; however, these appear not to have been active since 1971;
  - **Consequence Factor**: 1 (Since there is currently no infrastructure at this site there is no consequence); and,
  - **Risk Level**: 11 (Response level is inactive; therefore, there is no set instrumentation monitoring on inspection schedule at this time).
- Erosion Risk: Proposed Saskatoon Freeway – South Saskatchewan River Crossing Location:
  - **Probability Factor**: 9+2 (Active erosion with moderate, steady or decreasing rate of movement). The '+2' is added for uncertainty since this site has not been previously inspected and the rate of erosion is unknown. As discussed in Section 5.1, toe erosion on the west slope could occur which causing potential slope instability;
  - **Consequence Factor**: 1 (Since there is currently no infrastructure at this site there is no consequence); and,
  - **Risk Level**: 11 (Response level is inactive; therefore, there is no set instrumentation monitoring on inspection schedule at this time).

The following sections highlight observations regarding the general site conditions at the time of the field review, as well as observations made during the air photo interpretation which were then confirmed in the field. Additional information is presented in the Site Inspection Form provided in **Appendix III**.

The "Field Site" locations that are mentioned throughout the following sections can be found on **Figure I-2** (**Appendix I**) and **Figure I-3** (**Appendix I**).

4.1 Mapped Areas

The west and east slopes are quite different in terms of geohazards; however, both slopes have fluvial terrace deposits at their bases. The west slope has much higher relief and vegetation has grown in wetter areas, mainly in the depressions formed by old landslides. Dense brush and trees are located in the depressions. Other areas are drier and grassy, as can be expected for a south-facing slope. The slope is undulating and there are a few quad trails on the middle and upper slopes that have caused some vegetation loss. The east slope is much shorter and mostly tree-covered. The trees are more widely spaced with a much less dense understory compared to the west slope. The upper portion of the east slope is locally steep (85% gradient at Field Site 5 – the location of this is shown in **Figure I-2** (**Appendix I**) and **Figure I-3** (**Appendix I**) and transitions to a lower slope with gradients of 20%–30%. The lower portion of the slope varies between wet and dry zones and has a fairly consistent gradient.

4.2 Shoreline Erosion

The high-water mark, or best estimation of high-water mark, was mapped for each photograph and LiDAR year (**Figure I-2, Appendix I**). The largest amount of erosion appears to have occurred on the west fluvial terrace. This area is part of the outer bank, albeit a relatively straight stretch of it. Overall erosion rates range from 0.03 to 0.16 metres per year on the east shore and from 0.03 to 0.29 metres per year on the west shore, depending on location. The banks are eroding via small rotational failures in the fluvial sand (**Photograph 4-1**).

Photograph 4-1: South side of West Riverbank – Looking northeast at riverbank erosion (from Field Site 12 of 3D Mapping Figures).

4.3 Seepage

At the time of the inspection, there was no seepage evident within the project area on the west slope. However, a seepage zone is present outside of the project area (**Figure I-3, Appendix I**). Lower slopes and the fluvial terraces are treed, apart from a few grassy areas on the fluvial terraces. The lower bowl portion of the larger debris slides are densely vegetated with shrubs and trees.

The east slope exhibited several observed seepage areas (**Figure I-3, Appendix I** and **Photograph 4-2**) during the inspection. Equisetum is the most common vegetation type within these areas, and the ground is moist to saturated with some standing water. Although the seepage areas change shape and size with time, they remain in the same general locations. There is no discernible trend of increase or decrease in size over time, based on the historical aerial photograph review.

Photograph 4-2: North side of East Riverbank - Looking at seepage spring at base of slope (from Field Site 6 of 3D Mapping Figures).

4.4 Landslides

Large landslides, interpreted to be rotational debris slides, occurred sometime prior to 1971 on the west slope (derived from historic photographs, principally aerial photographs). These landslides appear to have not reactivated since, based on the historical aerial photograph review (**Figure I-2, Appendix I**). The landslide bowls are moderately steep in the upper portions and transition to gentle slopes in the lower portions (**Photograph 4-3**). There is an upper slide block present at the site. A few small debris slides occurred between 2014 and 2018 (**Figure I-2, Appendix I**) including one that may have been caused by localized increased water infiltration via a hand-dug test-pit at Field Site 13. The test pit was not backfilled and is located approximately 3 m uphill of the small slide.

A number of small debris slides have occurred on the upper portion of the east slope. One of these shows evidence of being a rotational slide (earth slump), with the upper slide blocks down-dropped less than a metre from the surface (Field Site 3 shown in **Photograph 4-4**). Another (Field Site 4) is located where a tension crack was identified in 1971. By 1987, the slide had formed, with the head scarp immediately behind the location of the former tension crack (shown in **Figure I-2, Appendix I**). An adjacent tension crack mapped from the 1987 aerial photographs was not evident in the field. Soil creep is also evident along the entire east slope, as evidenced by pistol grip and tilted trees.

A few tension cracks are visible on the LiDAR image and orthoimage from 2018 (shown in **Figure I-2**, **Appendix I**). Another possible tension crack was identified in the field at Field Site 9 (west slope). Here, a change in grass colour and a few holes, approximately 20 to 30 cm wide and 30 cm deep, are the only indication that a tension crack is present. This location is adjacent to two small debris slide head scarps that are visible on the 2018 LiDAR images (**Figure I-2, Appendix I**). No other new tension cracks were identified near the crest of either slope.

Photograph 4-3: North side of West Riverbank - Looking down slope at lower slopes of a rotational debris slide (from Field Site 9 of 3D Mapping Figures), looking south.

Photograph 4-4: Middle of East Riverbank – Looking northeast at older debris slide head scarp (at Field Site 3 of 3D Mapping Figures).

4.5 Gullies

Gullies are present locally on both slopes (**Figure I-2, Appendix I**). A number of quad trails cross the west slope at various locations, but none of these has yet developed into gullies. There is no apparent trend in gully activity over the years.

The east slope has three gullies that are anthropogenic. These were excavated sometime between 1971 and 1987, and one was created for the construction of a road to the water (Field Sites 1 and 2 and shown in **Photograph 4-5**). This road is no longer in use, and the gullies are not currently eroding due to vegetation growth. Piling of boulders (removed from the agricultural land) along the edge of the east slope crest is common, including in these three gully areas. The boulder piles do not appear to have caused any slope instability to date. The surficial soil of the agricultural land and in the gullies comprises of glacial till with a sandy silt matrix. Other gullies are visible in the 1987 aerial photographs (**Figure I-2, Appendix I**). These have not changed with time.

Photograph 4-5: South of East Riverbank – Looking north at central anthropogenic gully, smaller sub-gully in front of person standing within larger gully (at Field Site 1 of 3D Mapping Figures).

5 Failure Mechanisms

The landslides observed along the west and east riverbank of the South Saskatchewan River can only be assessed in general terms, based on review of existing available data and the field visit. Generally, slope failures in relatively homogeneous materials, as seen on the riverbank, slide upon a spherical slip surface (e.g. earth slumps). The presence of a layer of relatively low shearing resistance (Warman Formation), will modify the simple circular slip surface into a composite form. The presence of clayey till between two relatively competent tills, forces a composite form for the potential slip surface. In this case, based on existing information, the most critical failure surface on both sides of the river would likely be a composite slip into clayey till of the Warman Formation (further discussed in the historic report provided in **Appendix II**). This expected slip surface, based on the previous drilling investigation in this area (**Appendix II**), is at an elevation of approximately 470 masl (30 m below ground from the top of the valley) and 472 masl (10 m below ground from the top of the valley) for the western and eastern river embankments, respectively.

5.1 Findings and Conclusions

Shoreline erosion is not expected to affect construction on the slope. It predominately affects the fluvial terraces at the base of the slopes and continues at a consistent rate over the period examined. Shoreline erosion may have the potential to impact the slopes above the fluvial terrace deposits depending upon the conditions within the South Saskatchewan River (i.e., river levels). Based upon review of the historical air photos and field inspection, shoreline erosion was observed only at the base of the slopes. Shoreline erosion and the subsequent loss of material at the base of the slopes may have the potential to trigger slope instability at higher elevations if left unchecked. Erosion should be monitored, especially after large floods, as this situation could change in the future as climate continues to change and flooding severity increases as a consequence. If the fluvial terraces are completely eroded through, toe erosion of the slopes (most likely the west slope) could occur, causing potential slope instability.

Seepage was observed along areas of the east slope during the field inspection, however, periodic episodes of seepage owing to elevated groundwater, precipitation events and/or surface runoff may have the potential to occur along the west slope . Here, drainage should be carefully controlled to avoid potential saturation of the slope, which could lead to instability. The northern portion of the east slope should be monitored to check for changes in slope drainage during and after construction, as well as long-term.

The west slope exhibits numerous large rotational debris slides. These slides occurred prior to 1971 and have not reactivated since 1971. However, a few small debris slides have occurred within these slide areas in recent years. One appears to have been caused by water infiltration. Tension cracks are uncommon, but where present signify potential future movement. Loading of the top of the slope, or removal of the slope toe by erosion or other means, could cause reactivation of the larger slides. Geotechnical investigation and analysis of slope stability are recommended prior to construction, as well as periodic monitoring of the slope for development of new tension cracks and/or new slide activity during and following construction.

The east slope, by contrast, displays only a few small debris slides. One of these now has a headscarp where a tension crack was formerly present. Development of a headscarp suggests the occurrence of progressive or episodic movement between 1971 and 1987 which has subsequently remained dormant or suspended (as evidenced during the field inspection) in the years following. However, ongoing indications of creep movement along the entire east slope are suggestive of an active state condition. It is anticipated that creep movement would be in the order of less than 16 mm/year (Cruden and Varnes, 1996). Again, geotechnical investigation and analysis of slope stability is recommended to determine the risk of slope instability related to construction activities and long term. It is also recommended that the slope be monitored for the presence of new tension cracks or renewed slide activity.

Gullies are present on both slopes, including those created by human activity. These do not appear to be increasing or decreasing in size, but periodic monitoring, especially after large storms, is recommended.

6 Recommendations for Further Investigation

As a result of the geohazard assessment, it was recommended further investigation be considered to assess riverbank stability, as well as targeted to provide factual data of encountered geological units, including index and strength properties for design. SNC-Lavalin proposed to complete deep stratigraphic boreholes at the proposed location of the South Saskatchewan River Crossing by means of mud rotary drilling. The investigation was intended to target the location of proposed bridge abutments and pier locations. The borehole investigation was completed in November 2021 and included two boreholes completed on land, at the location of the proposed east and west bridge abutments, drilled to approximately 100 m (330 ft) (SNC-Lavalin, 2023). Site conditions at the time of the investigation did not allow for drilling at the pier locations. SNC-Lavalin recommends completing drilling at the pier locations in the future.

The recommended stratigraphic drilling was completed subsequent to this geohazard study and before this report was finalized. The drilling methodology and data collected during the stratigraphic investigation is detailed in the Phase 2 Factual Geotechnical Data Report (SNC-Lavalin, 2023).

7 References

Christensen, E.A.,1992, Pleistocene stratigraphy of the Saskatoon area, Saskatchewan, Canada: an update. Canadian Journal of Earth Sciences, v.29, p. 1767-1778.

Cruden, D.M., and Varnes, D.J., 1996, Landslide types and process. Special Report, Transportation Research Board, National Academy of Sciences, 247:36-75.

Howes, D.E. and Kenk, E., 1997, Terrain classification system for British Columbia; British Columbia Ministry of Environment, Lands and Parks, Victoria, Version 2.

MDH (MDH Engineered Solutions Corp.), 2004, Preliminary Geotechnical Analysis Proposed Saskatoon Perimeter Road North Bridge Crossing. M442-350003.

RIC (Resources Inventory Committee), 1996, Terrain Stability Mapping in British Columbia: a review and suggested method for landslides hazard and risk mapping; Slope Stability Task Group, Earth Sciences Task Force.

SNC-Lavalin Inc., 2023, Phase 2 Factual Geotechnical Data Report. 659183.

Appendix I

Figures

LEGEND

●	PROPOSED FOUNDATION HOLE
🟦	PHASE I
🟪	PHASE II
🟩	PHASE III
⬚	PROPOSED FREEWAY CORRIDOR

NAME	NAD 1983 UTM Zone 13N		ELEVATION
	EASTING	NORTHING	
F-12	390,404.0	5,785,156.8	482.7
F-13	390,313.8	5,785,240.5	467.2
F-14	390,243.8	5,785,294.2	467.2
F-15	390,158.8	5,785,374.0	471.5
F-17	390,037.8	5,785,482.3	499.1

NOTES

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SCALE: 1:2,000

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
LOCATION PLAN - PROPOSED BOREHOLES

DATE	2020 11 04	**DWG No.**	659183-0000-4EDD-0042	**FIG No.**	1	**REV**	00

SIZE 11x17

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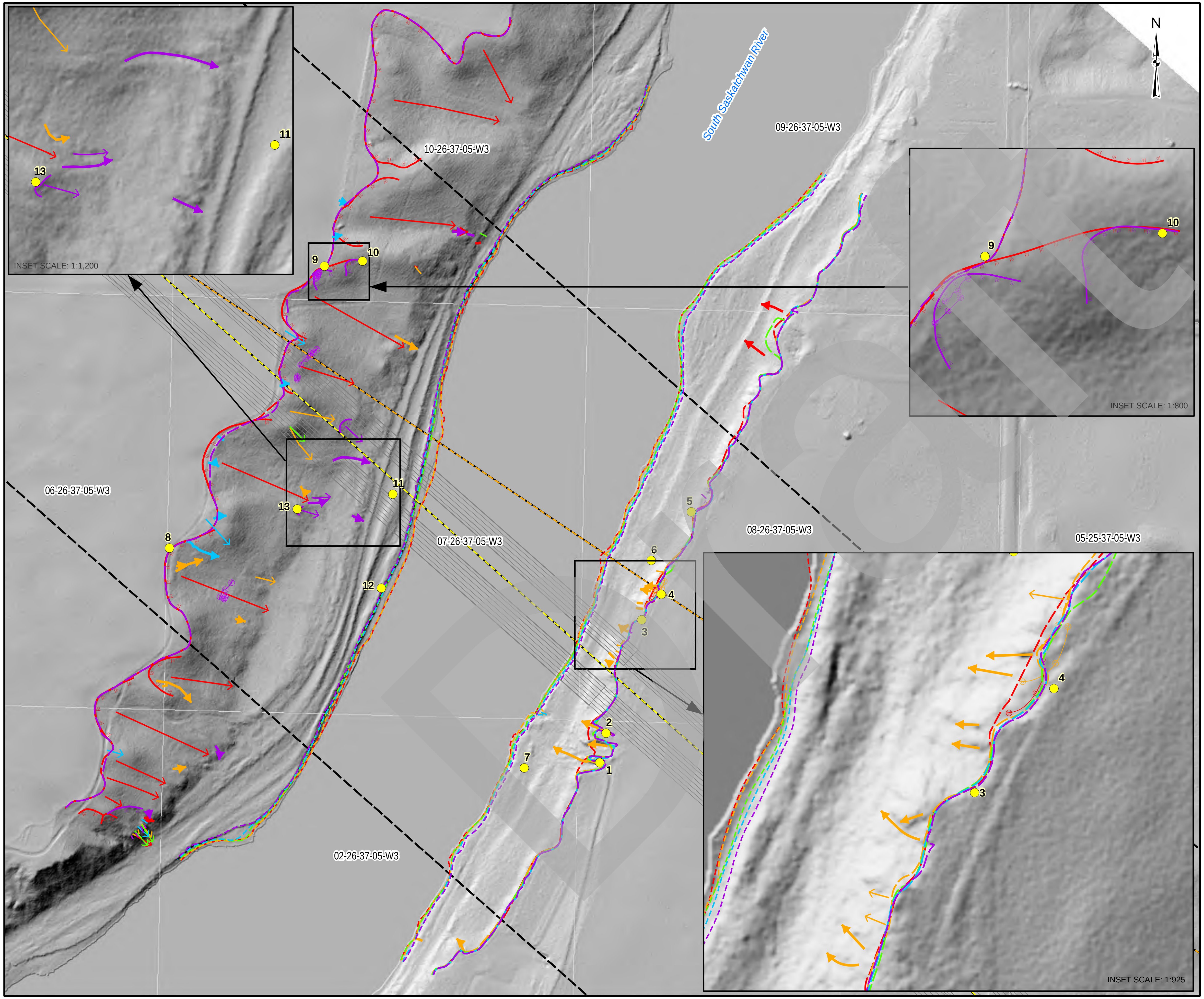

LEGEND

- FIELD SITE

LIDAR YEAR - 2018

- CLIFF CREST
- DEBRIS SLIDE
- GULLY
- HEADSCARP
- SHORELINE - HIGH WATER MARK
- TENSION CRACK

AIR PHOTO YEAR - 2014

- CLIFF CREST
- DEBRIS SLIDE
- GULLY
- SHORELINE - HIGH WATER MARK

AIR PHOTO YEAR - 2003

- CLIFF CREST
- DEBRIS SLIDE
- SHORELINE- HIGH WATER MARK

AIR PHOTO YEAR - 1987

- CLIFF CREST
- DEBRIS SLIDE
- GULLY
- HEADSCARP
- SHORELINE - HIGH WATER MARK
- TENSION CRACK

AIR PHOTO YEAR - 1971

- CLIFF CREST
- DEBRIS SLIDE
- GULLY
- HEADSCARP
- SHORELINE - HIGH WATER MARK
- TENSION CRACK
- ALIGNMENT
- MODIFIED ALIGNMENT
- OTHER LINEAR DESIGN ELEMENTS
- PROPOSED FREEWAY CORRIDOR
- LEGAL SUB-DIVISION

NOTES

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SCALE: 1:3,750

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CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS AND INFRASTRUCTURE

PROJECT LOCATION
SOUTH SASKATCHEWAN RIVER CROSSING

TITLE
LINEAR GEOHAZARDS

DATE 2020 12 01 **DWG No.** 659183-0000-4EDD-0037 **FIG No.** 2 **REV** 00

SIZE 11x17

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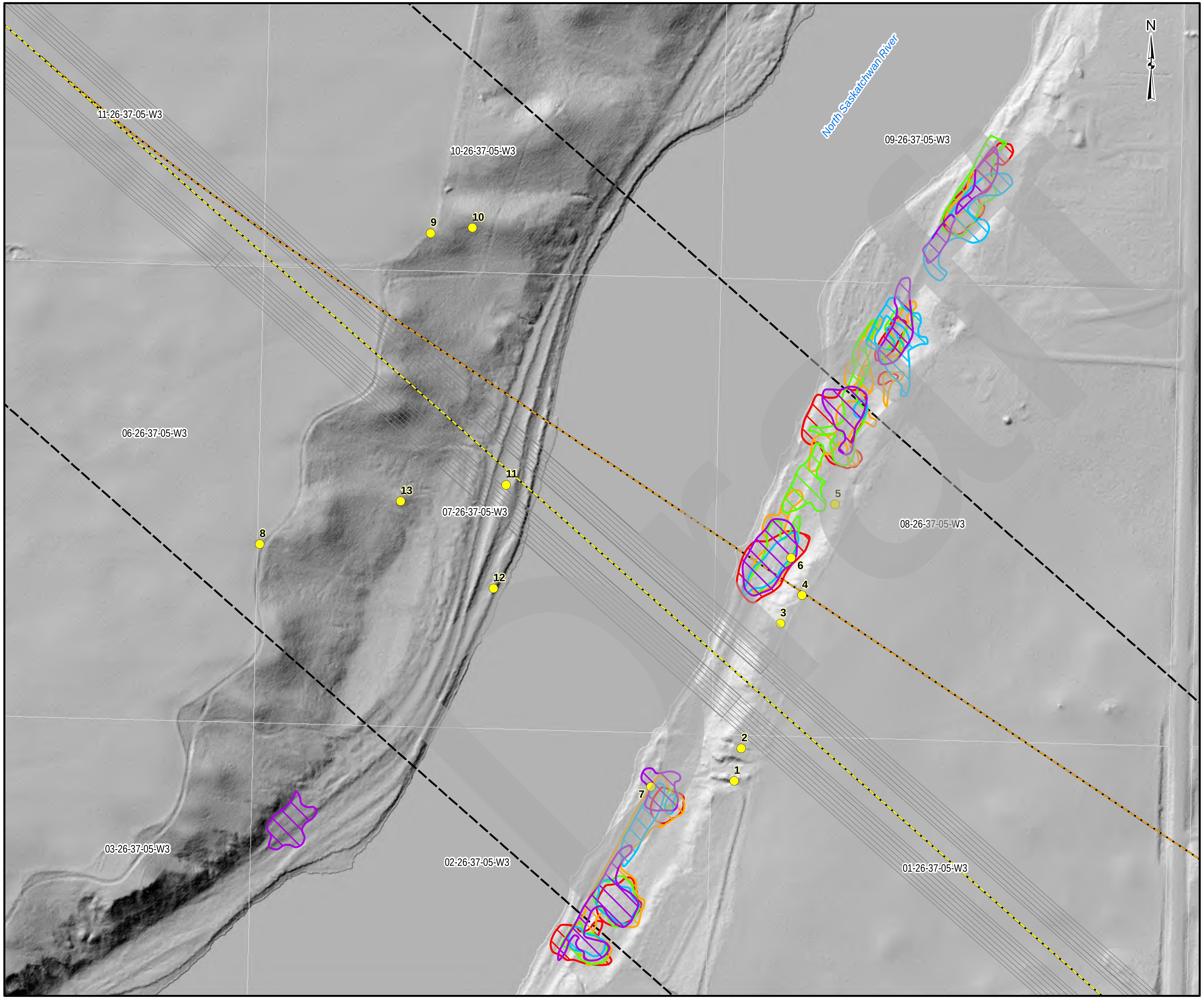

SIZE 11x17

LEGEND

- ● FIELD SITE
- **LIDAR YEAR - 2018**
- ▨ SEEPAGE
- **AIR PHOTO YEAR - 2014**
- ▨ SEEPAGE
- **AIR PHOTO YEAR - 2003**
- ▨ SEEPAGE
- **AIR PHOTO YEAR - 1987**
- ▨ SEEPAGE
- **AIR PHOTO YEAR - 1971**
- ▨ SEEPAGE
- ALIGNMENT
- MODIFIED ALIGNMENT
- OTHER LINEAR DESIGN ELEMENTS
- PROPOSED FREEWAY CORRIDOR
- LEGAL SUB-DIVISION

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SCALE: 1:3,400

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PROJECT LOCATION
SOUTH SASKATCHEWAN RIVER CROSSING

TITLE
SEEPAGE AREAS

DATE	2020 12 01	DWG No.	674253-0000-4EDD-0038	FIG No.	3	REV	00

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Appendix II

Historic MDH Report – River Crossing

MDH
ENGINEERED SOLUTIONS

Preliminary Geotechnical Analysis
Proposed Saskatoon Perimeter Road
North Bridge Crossing

Prepared For

uma

City of Saskatoon

August 2004
M442-350003

Executive Summary

MDH Engineered Solutions Corp. (MDH) of Saskatoon, Saskatchewan was commissioned by UMA Engineering Ltd. (UMA) on behalf of the City of Saskatoon to complete a preliminary geotechnical analysis of the proposed City of Saskatoon's perimeter road north river crossing. The primary objective of the project was to determine if site stratigraphy or geotechnical considerations prohibited building a bridge within the proposed wide corridor for the perimeter road in Section 26, Township 37, Range 5, West of the 3rd Meridian.

The work was completed in two phases. Phase I consisted of a preliminary assessment using available information and site reconnaissance. Phase II consisted of a limited scale drilling, instrumentation, and laboratory testing investigation. This Phase also involve the development of a preliminary stratigraphic framework for the site, creation of preliminary slope stability models for each embankment, as well as determining the preliminary geotechnical considerations for the proposed crossing. Two boreholes and six vibrating wire piezometers were installed as part of the investigation (one borehole and three vibrating wire piezometers on each side of the river along the preferred bridge alignment).

In general, the stratigraphy and groundwater hydraulics within the wide corridor are conducive to the construction of a new bridge. Based on the information acquired during the preliminary investigation, there are no geotechnical issues that would prevent the construction of a bridge at the proposed site. However, there are a number of geotechnical considerations which need to be addressed for the proposed alignment. These issues can be addressed during the detailed geotechnical investigation.

Geological data acquired during this investigation indicate that two highly artesian preglacial aquifers exist at depth beneath the site. In addition, a shallow flowing artesian aquifer unit may be present beneath the river. Although the pore pressure within the preglacial sediments is high, thick accumulations of till beneath the site should be sufficient to limit uplift pressures and hydraulic gradients during construction of the pier foundations. However, the intersection of a highly artesian aquifer unit during future drilling could result in uncontrollable influx of water, potential piping of sediments, and loss of the borehole. Adequate mud densities will be required to control the strong artesian heads present beneath the site during any future investigation. A shallow, flowing artesian sand unit may be present beneath the river valley. If the shallow sand unit is present beneath the river channel, high pore pressures will be a consideration during the design and installation of the pier foundations.

Preliminary slope stability modelling indicates the present slope configurations are stable (with a minimum calculated factor of safety above 1.5 for both the eastern and western embankments). The pier foundations will be located on overconsolidated till with a relatively good bearing capacity. Because of the elevation differences between the west and east river embankments, a deep cut will likely be required along the western embankment to achieve an appropriate approach grade for the

bridge. This excavation will mostly likely cut into the Floral Formation sands and produce enough water to create difficult working conditions during construction. Seepage control and long-term drainage filters will likely be required for the approach excavation along the western river embankment to control seepage from the Floral Formation sands.

The eastern approach foundation will be placed on silts, sands and gravels present along the river terrace. A more thorough investigation will be required along the eastern river terrace to determine the terrace stratigraphy and accumulations of compressible sediments (normally consolidated fines and organics). The presence of coarse lithologies within this unit should help control any excess porewater pressure development and will form a natural drain (reducing porewater pressures) during construction of the approach.

A lag concentrate of large boulders (boulder pavement) is likely present along the bottom of the river channel. The boulders will create an obstacle to future geotechnical investigations, excavations for pier footings, and construction of cofferdams.

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1.0 Introduction

MDH Engineered Solutions Corp. (MDH) of Saskatoon, Saskatchewan was commissioned by UMA Engineering Ltd. (UMA) on behalf of the City of Saskatoon to complete a preliminary geotechnical analysis of the proposed City of Saskatoon's perimeter road north river crossing. The primary objective of the project was to determine if site stratigraphy or geotechnical considerations prohibited building a bridge within the proposed wide corridor for the perimeter road in Section 26, Township 37, Range 5, West of the 3rd Meridian. The detailed scope of the project was to:

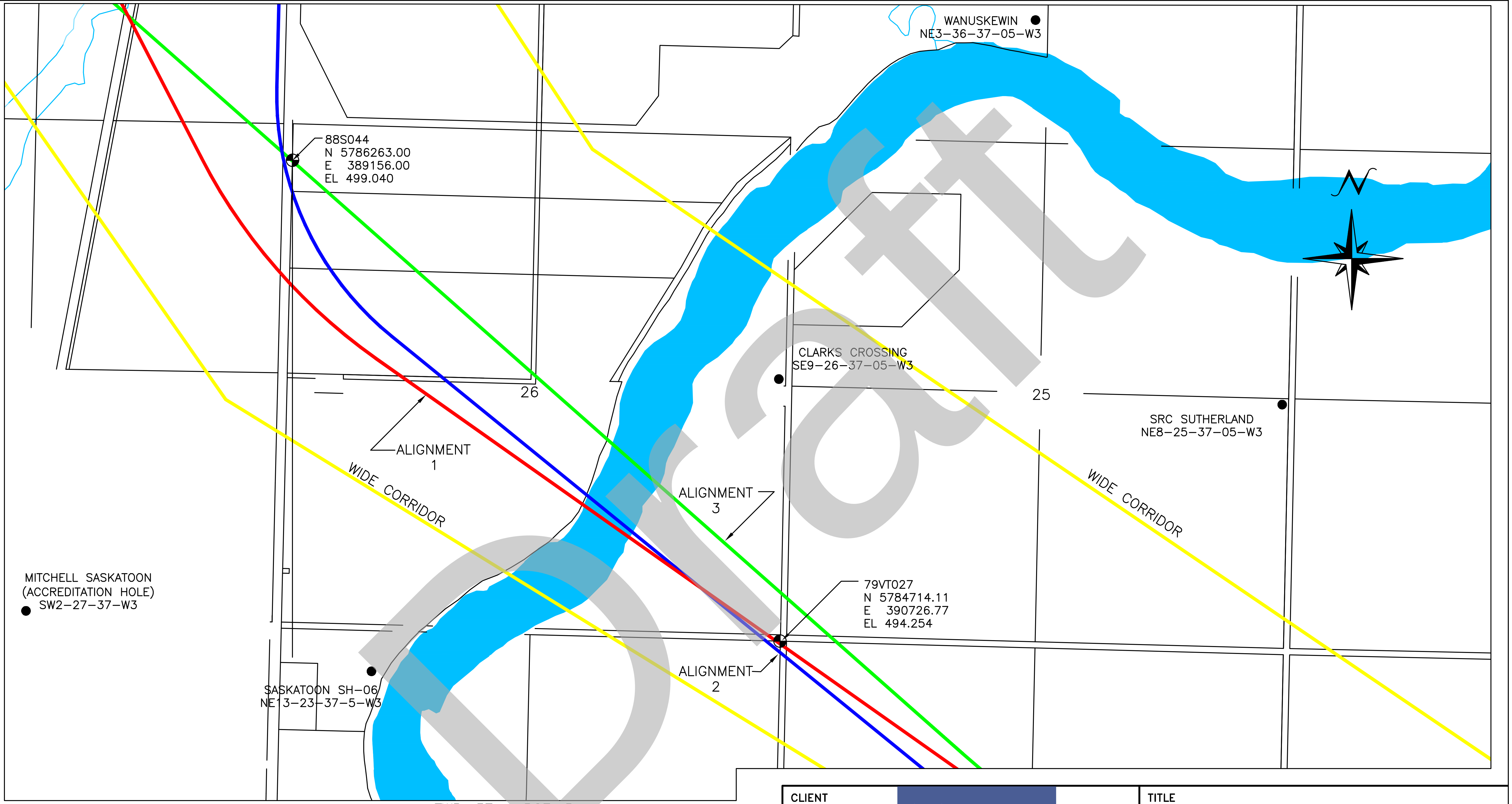
1. Complete a preliminary assessment of the proposed wide corridor of the Saskatoon perimeter road north bridge crossing. This preliminary analysis was to include:
    a. Gathering of readily available public information for the area;
    b. Completion of a detailed air photo interpretation for the wide corridor crossing; and,
    c. Completion of a preliminary stratigraphic mapping exercise along the river embankment.
2. Complete a limited scale stratigraphic drilling, instrumentation, and laboratory testing program to develop a preliminary stratigraphic and geotechnical model along the preferred bridge alignment;
3. Complete a survey of the instruments installed as part of this investigation and develop a topographic profile of the river bank in the vicinity of the preferred bridge alignment;
4. Complete a preliminary slope stability modelling investigation to determine the current calculated factor of safety of the existing slope configuration on both the western and eastern river embankments of the proposed bridge alignment; and,
5. Provide a report detailing the field and laboratory investigation programs. This report was to provide the preliminary site stratigraphic framework, the results of the preliminary slope stability modelling, and a discussion of the preliminary geotechnical considerations for the proposed north bridge crossing.

Figure 1.1 provides the limits of proposed Saskatoon perimeter road wide corridor and the three potential bridge crossing alignments. A panoramic view of the proposed river crossing is provided in Appendix A.

2.0 Background

On 27 May 2003, UMA issued a RFP to MDH to provide the preliminary geotechnical engineering components for the City of Saskatoon north river crossing of the proposed Saskatoon perimeter road. On the 10 June 2003, MDH submitted a proposal entitled "*Preliminary Geotechnical Investigation for the Saskatoon Perimeter Highway North Bridge Functional Planning Study*" (MDH, 2003). The project was awarded to MDH in July 2003. Shortly after initiation of the project, MDH was instructed to delay the work until the summer of 2004.

In the spring of 2004, MDH issued Saskatchewan Highways and Transportation "Form A - Notice of Intention to Enter Upon Land" letters and forms to land owners that would be affected by the preliminary geotechnical investigation. In May 2004, Form A letters were delivered to L&L Gravel and Ranching Co. Ltd., ERCO Worldwide, 619220 Saskatchewan Ltd., and Ralph and Maryanne McKitrick. Immediately upon receiving the Form A letter of intent, ERCO Woldwide objected to the bridge crossing investigation due to concerns regarding the proposed river crossings in relation to their operations. Although the Form A letter allowed entering upon the land without permission from the site owner, the City of Saskatoon decided to meet with ERCO representatives prior to any work being completed. Subsequent meetings between the City of Saskatoon and ERCO Worldwide resulted in focusing the preliminary field investigation along the northern bridge alignment (Alignment 3; Figure 1.1). This bridge alignment would not significantly disrupt the ERCO operations. Subsequent discussions between UMA and MDH personnel resulted in minor modifications to the original proposal. This report documents the work as completed.



NOTE: TESTHOLE LOCATIONS ARE APPROXIMATE.

TWP. 37 – RGE. 5
WEST OF THIRD MERIDIAN

REV NO	REVISION

SCALE: 1:12000 DATE:

SUPERVISED BY:	A. KARVONEN, P.Eng., P.Geo.	04-AUG-04
DRAWN BY:	P. BIRNIE	04-AUG-04
APPROVED BY:	A. KARVONEN, P.Eng., P.Geo.	04-AUG-04

CLIENT uma

PRODUCED BY MDH ENGINEERED SOLUTIONS

TITLE
WIDE CORRIDOR AND PRELIMINARY
BRIDGE CROSSING LOCATIONS

PROJECT No. M442-350003 FIG. No. 1.1

DRAWING No. M442-61-1 REV.

3.0 Site Investigation

3.1 Phase I - Preliminary Assessment

Prior to completion of the field components of the investigation, a preliminary assessment was completed using air photos, governmental maps, publicly available borehole data, and readily available publications. This preliminary investigation was completed to develop a general understanding of the site and to identify whether the site was satisfactory prior to initiation of more costly field investigations. The preliminary investigation established:

1. Expected depth to bedrock;
2. Expected geologic formations that exist in the area;
3. Probable elevation of the geologic formations;
4. Type, texture and material properties of the soils in the area;
5. Regional topography and natural features;
6. The existence of groundwater seeps and existing instabilities;
7. Location of utilities, geodetic benchmarks, roads, and drill access; and,
8. Potential geotechnical considerations and concerns for the site.

A review of in-house MDH reports and available borehole databases established that several boreholes existed in the general vicinity of the proposed bridge site. A summary of the selected borehole data is provided in Table 3.1. Figure 1.1 provides the approximate location of the selected existing boreholes. Copies of selected borehole logs are provided in Appendix B.

As part of the preliminary assessment, MDH personnel completed a field reconnaissance study to determine the existing landforms at the site, to log the geology of the outcroppings along the river in the vicinity of the proposed crossing, and to determine if any existing instabilities exist along the proposed wide corridor.

Table 3.1 - Summary of Existing Boreholes

Borehole Name	LSD Location	Borehole Depth (m)	Approximate Ground Elevation (masl)
Mitchell Saskatoon	SW2-27-37-5-W3	97.5	463
SRC Clarks Crossing	SE9-26-37-5-W3	62.2	480
SRC Sutherland	NE8-25-37-5-W3	93.0	491
Sutherland	1-24-37-5-W3	77.7	497
SRC Wanuskewin	NE-3-36-37-5-W3	158.5	495.3
Saskatoon SH-06	NE-13-23-37-05-W3	69.6	499.5

3.1.1 Field Mapping and Reconnaissance

Dr. Malcolm Reeves (P.Eng., P.Geo) and Andrew Karvonen (P.Eng., P.Geo.) completed a field reconnaissance and stratigraphic mapping investigation on 31 May 2004. Stratigraphic mapping was completed on both sides of the river along the majority of the wide corridor of the north bridge crossing. The field mapping focused along the southern limits of the wide corridor where geologic outcroppings enabled detailed examination of the shallow stratigraphic units. The results of the field mapping and reconnaissance is provided in Section 5.2.

3.2 Phase II – Stratigraphic Drilling and Instrumentation

Discussions were held between UMA and MDH personnel following the field mapping and reconnaissance investigation to discuss the results of the preliminary assessment. The results of Phase I warranted additional work at the proposed bridge crossing location and MDH recommended implementation of the proposed preliminary stratigraphic drilling and instrumentation investigation on both sides of the river. The drilling was to include one stratigraphic borehole (to bedrock) on either side of the river to establish stratigraphic control for the site. Stacks of vibrating wire piezometers were to be installed to determine porewater pressures with depth. Discussions with the City of Saskatoon resulted in the focus of the investigation to be along the preferred alignment (Alignment 3; Figure 3.1).

Stauber Drilling Ltd. (Stauber) of Regina, SK mobilized their Failing 1250 hydraulic rotary drill rig, water truck, and a service vehicle to the site on 08 June 2004. The drill rig utilized in the investigation is provided in Photograph 3.1. Between the dates of 08 June 2004 and 11 June 2004, two boreholes were drilled to depths of 79.3 m (M442-01) and 85.3 m (M442-02). Both boreholes were drilled to a minimum diameter of 130 mm ($5^{1/8}$ inches). Boreholes were subsequently reamed to 159 mm (6¼ inches) to allow room to install the instrumentation assemblies.

Cutting samples were obtained during drilling at 1.5 m (5 ft) intervals and selected shelby tube samples were collected to facilitate laboratory testing (Photographs 3.2 and 3.3). The stony nature of the tills present at the site made it difficult to collect undisturbed Shelby tube samples of the till units. As a result, many of the shelby tubes collapsed during attempts at core collection (Photograph 3.4) and only a few of the acquired samples were intact. All cuttings were dried on site using a propane oven and logged for a description of the lithology encountered. Soil colors were determined using a Munsell Soil Color Chart (2000 edition). The location of the boreholes drilled as part of this investigation are provided in Figure 3.1.

Prior to installation of downhole instrumentation, single point resistance (SPR) and spontaneous potential (self potential; SP) logs were obtained for each borehole. The stratigraphic and geophysical logs for each borehole are provided in Appendix C. The Terms, Symbols, and Abbreviations utilized on the logs are also appended.

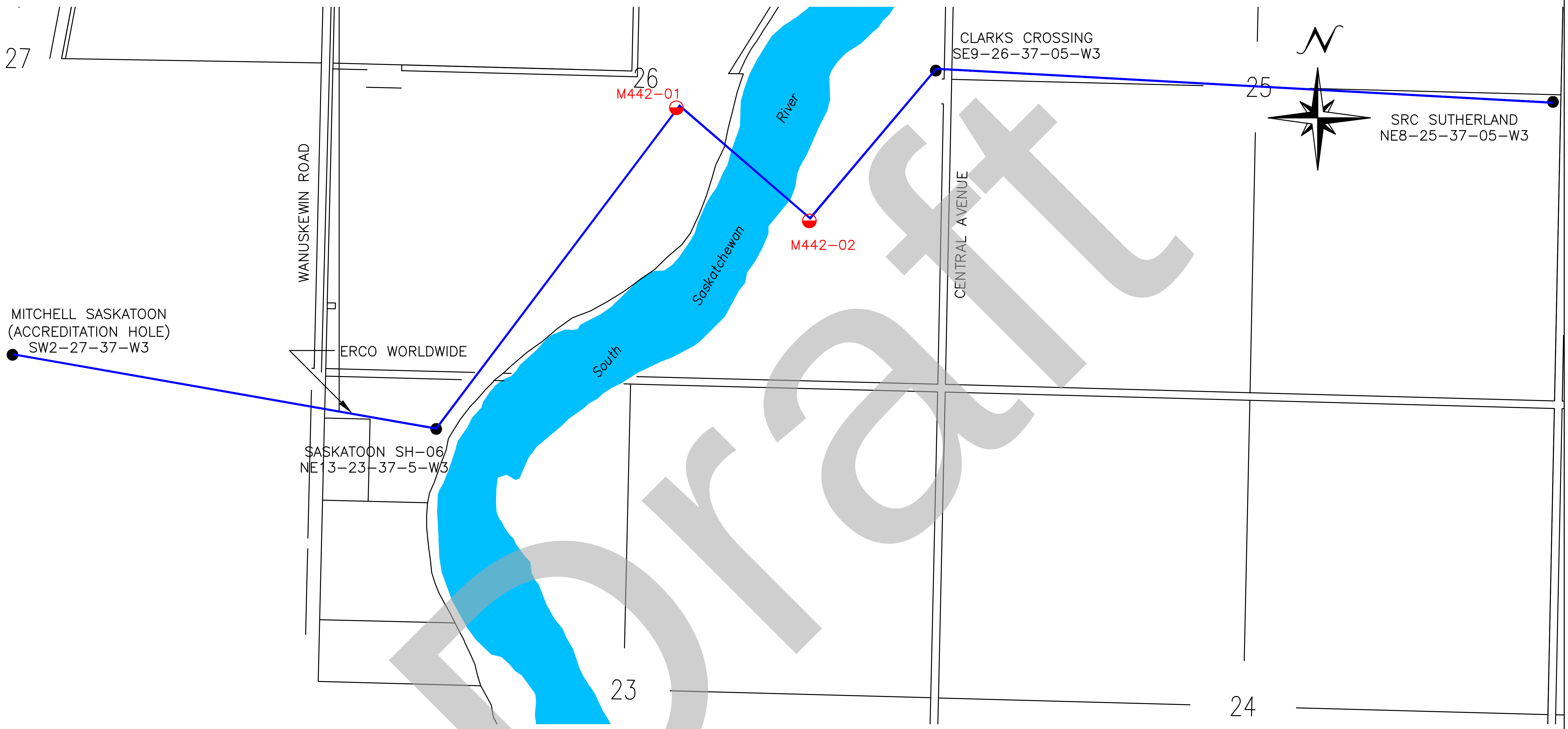
Stacks of vibrating wire piezometers were installed in each of the boreholes once the required depth was reached. Each piezometer stack consisted of three Geokon 4500-S vibrating wire piezometers. Both Geokon (1 MPa) range and Geokon 700 kPa range vibrating wire piezometers were utilized. The vibrating wire piezometer tips were surrounded with a filter pack of 12/20 Unimin industrial quartz, placed in protective canvas bags, attached to a one inch Schedule 40 PVC pipe and inserted into the borehole (Photograph 3.5 and Photograph 3.6). The PVC pipe supplied the rigidity necessary to ensure the correct piezometer placement depth and was utilized as a tremmie pipe during grouting. The piezometer wires were cut to form three different lengths at the surface. Each length represents the installation depth (with the shortest length belonging to the deepest piezometer and the longest wire length the belonging to the shallowest piezometer). This convention was maintained for both boreholes.

Photograph 3.1 – Failing 1250 hydraulic rotary drill rig utilized for subsurface investigation.

Photograph 3.2 - Disturbed cuttings samples.

Photograph 3.3 - Shelby tube sample.

Photograph 3.4 - Collapsed shelby tubes.



TOWNSHIP 37 RANGE 5 WEST OF THIRD

LEGEND

● PRE–EXISTING TESTHOLES APPROXIMATE LOCATIONS)

◓ M442 VIBRATING WIRE PIEZOMETERS INSTALLED
AS PART OF THIS INVESTIGATION

REV NO	REVISION	SCALE: 1:10000		DATE:
		SUPERVISED BY:	A. KARVONEN, P.Eng., P.Geo.	04–AUG–04
		DRAWN BY:	P. BIRNIE	04–AUG–04
		APPROVED BY:	A. KARVONEN, P.Eng., P.Geo.	04–AUG–04

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MDH
ENGINEERED SOLUTIONS

TITLE
BOREHOLE LOCATIONS
AND
LOCATION OF CROSS–SECTION A–A'

PROJECT No. M442–350003
FIG. No. 3.1
DRAWING No. M442–61–1
REV. △

Photograph 3.5 - Vibrating wire piezometers prior to installation.

Photograph 3.6 - Installation of vibration wire piezometers.

One vibrating wire piezometer was installed at the approximate elevation of the river, one near the approximate elevation of the river thalweg, and one at the base of exploration (within the preglacial sediments). Prior to mobilization to the field, the base of exploration was anticipated to be the Judith River Formation (the first bedrock horizon). However, thick accumulations of Empress Group sediments were encountered in borehole M442-02. As a result of budgetary constraints, the borehole was terminated prior to reaching the bedrock stratigraphic marker. A piezometer was installed at the top of the Empress Group sediments instead of the Judith River Formation at this location. Although the bedrock surface was not reached in borehole M442-02, an adequate depth was obtained to complete the preliminary geotechnical investigation. However, a deep stratigraphic borehole should be drilled along the eastern river embankment during future investigations to establish stratigraphic control.

Both boreholes were grouted to surface to reduce drilling induced preferential flow paths. The one-inch PVC pipe acted as a tremmie pipe for grout application. The grout utilized was Aquaguard brand bentonite grout mixed to a consistency of approximately 30% active solids. Following installation, a locking steel casing protector was installed over each piezometer cluster to deter vandalism to the instrumentation. Keys for the locks can be obtained from MDH should they be required by the City of Saskatoon.

Vibrating wire piezometers were installed instead of standard Casagrande style standpipe piezometers because they do not require decommissioning. Future decommissioning of the piezometers will simply involve cutting the piezometer wire at the surface. It should be noted that man-made seals do not provide a hydraulic barrier as effective as the naturally occurring intact glacial till. Although the borehole has been grouted, it may still be a preferential conduit for the downward migration of contaminants.

Initial potentiometric readings were downloaded from each piezometer after installation. Additional sets of potentiometric measurements were acquired on 24 June 2004 and 29 July 2004. No dedicated logging devices were installed. However, dedicated logging instrumentation can be installed for continuous porewater pressure measurements.

A borehole and piezometer summary is provided in Table 3.2. The piezometer completion details are provided in Appendix C. The vibrating wire calibration reports and acquired potentiometric data is provided in Appendix D. The terms, symbols, and abbreviations used on the borehole logs are also appended

Photograph 3.7 - Final piezometer completion.

Table 3.2 - Borehole and piezometer summary.

Borehole Number	Date Drilled	Borehole Depth (m)	Piezometer Number	Serial Number	Installation Type	Completion Horizon	UTM Location (NAD 83)		Tip Depth (m)	Elevation (masl)	
							Easting	Northing		Ground	Tip
M442-01	8-Jun-04	79.25	M442-01A	04-5828	4500S (700 kPa)	Judith River Fm.	390041.40	5785460.51	74.68	499.56	424.88
			M442-01B	04-5533	4500S (700 kPa)	Floral Fm. till	390041.40	5785460.51	35.05	499.56	464.51
			M442-01C	04-5535	4500S (700 kPa)	Dundurn Fm. Till	390041.40	5785460.51	26.21	499.56	473.35
M442-02	10-Jun-04	85.34	M442-02A	04-5331	4500S (1 MPa)	Empress Group	390390.73	5785163.33	68.88	482.60	413.72
			M442-02B	04-5332	4500S (700 kPa)	Floral Fm till	390390.73	5785163.33	16.15	482.60	466.45
			M442-02C	04-5334	4500S (700 kPa)	Dundurn Fm. Till	390390.73	5785163.33	8.84	482.60	473.76

3.3 *Phase III – Filed Survey and Potentiometric Measurements*

A detailed survey was completed on 11 June 2004 to establish river embankment profiles for use in the preliminary stability modelling and to acquire UTM and elevation data for the boreholes and installed piezometers. Geodetic benchmarks 88S044 and 79VTO27 were used to establish control for the survey. It should be noted that the co-ordinates for 88S044 provided by the Saskatchewan Information Services Corporation were incorrect. As such, the co-ordinates utilized were N5786263.0 E389156.0. These co-ordinates were established by using the 79VT027 benchmark co-ordinate and the detailed description for 88S044 to accurately locate the correct UTM coordinates for the benchmark.

The topographic survey was completed by shooting three lines on both embankments starting at the valley shoulder and ending at the edge of the Saskatchewan River. One survey line was acquired down the approximate centerline of the proposed bridge crossing. The other two lines were acquired on either side of the proposed alignment. Thick bushes made it difficult to complete a more thorough survey without establishing cut lines. The acquired topographic map of the South Saskatchewan River embankment is provided along with the slope stability models (Appendix G).

4.0 Laboratory Testing

Representative cutting samples were recovered for laboratory analysis. To aid in interpretation of the till stratigraphy, selected samples from four boreholes were sent to the Saskatchewan Research Council's Geoanalytical Laboratory for carbonate testing. The results of the carbonate testing are provided in Appendix E (as provided by SRC) and are summarized in Table 4.1. The total carbonate content with depth is graphically represented on each of the borehole logs provided.

Grainsize distributions, Atterberg limits and water content values were acquired for selected core samples. The laboratory testing focused on the horizon where the carbonate testing indicated the existence of the Warman Formation. The results of the geotechnical laboratory testing are provided in Appendix E and are summarized in Table 4.2. The results of the laboratory testing are annotated on the borehole logs provided in Appendix C.

Table 4.1 - Total Carbonate Content

BOREHOLE M442-01				BOREHOLE M442-02			
Sample Number	Depth (ft)	Depth (m)	Total CO2 (ml)	Sample Number	Depth (ft)	Depth (m)	Total CO2 (ml)
ADK 01	5	1.5	36.02	ADK 62	5	1.5	33.83
ADK 02	10	3.0	33.81	ADK 63	10	3.0	35.31
ADK 03	15	4.6	28.43	ADK 65	20	6.1	38.22
ADK 04	20	6.1	23.95	ADK 66	25	7.6	37.62
ADK 11	55	16.8	35.5	ADK 67	30	9.1	21.39
ADK 12	60	18.3	34.12	ADK 68	35	10.7	28.4
ADK 13	65	19.8	32.56	ADK 69	40	12.2	26.69
ADK 17	80	24.4	34.71	ADK 70	45	13.7	27.69
ADK 19	85	25.9	34.87	ADK 71	50	15.2	31.46
ADK 21	90	27.4	21.72	ADK 72	55	16.8	29.67
ADK 23	95	29.0	28.22	ADK 73	60	18.3	29.11
ADK 25	100	30.5	27.44	ADK 76	75	22.9	23.39
ADK 27	105	32.0	26.54	ADK 77	80	24.4	28.93
ADK 30	110	33.5	28.51	ADK 78	85	25.9	26.09
ADK 31	115	35.1	37.32	ADK 79	90	27.4	25.46
ADK 32	120	36.6	27.36	ADK 80	95	29.0	26.05
ADK 33	125	38.1	28.92	ADK 81	100	30.5	26.5
ADK 34	130	39.6	30.05	ADK 82	105	32.0	24.25
ADK 35	135	41.1	23.77	ADK 83	110	33.5	22.99
ADK 36	140	42.7	28	ADK 84	115	35.1	22.28
ADK 37	145	44.2	26.57	ADK 85	120	36.6	23.02
ADK 38	150	45.7	22.1	ADK 86	125	38.1	22.29
ADK 39	155	47.2	22.95	ADK 87	130	39.6	20.68
ADK 40	160	48.8	23.14	ADK 88	135	41.1	21.8
ADK 41	165	50.3	24.82	ADK 89	140	42.7	20.72
ADK 42	170	51.8	20.53	ADK 91	150	45.7	19.48
ADK 43	175	53.3	21.51	ADK 92	155	47.2	21.91
ADK 44	180	54.9	21.53	ADK 93	160	48.8	21.24
ADK 45	185	56.4	20.6	ADK 94	165	50.3	25.27
ADK 46	190	57.9	27.36	ADK 95	170	51.8	27.28
ADK 47	195	59.4	25.01	ADK 96	175	53.3	34.9
ADK 48	200	61.0	25.45	ADK 97	180	54.9	33.04
ADK 49	205	62.5	27.29	ADK 98	185	56.4	32.29
ADK 50	210	64.0	26.27	ADK 99	190	57.9	32.98
ADK 51	215	65.5	25.5	ADK 100	195	59.4	30.23
ADK 52	220	67.1	25.54	ADK 101	200	61.0	27.13
ADK 53	225	68.6	27.51	ADK 102	205	62.5	22.65
ADK 54	230	70.1	23.63	ADK 103	210	64.0	28.13
				ADK 104	215	65.5	27.44
				ADK 105	220	67.1	28.6

Table 4.2 - Summary of geotechnical laboratory testing.

Borehole	Sample No.	Depth	Atterberg Limits			Classification	Dry Density	Grainsize Distribution (%)			
		(m)	PL%	WC %	LL%		(kg/m^3)	Gravel	Sand	Silt	Clay
M442-01	ADK 16	22.9	14.90	12.91	32.00	CL	1938	1	33	46	20
M442-01	ADK18	24.4	14.50	19.96	30.60	CL	1962	2	33	46	19
M442-01	ADK20	25.9	13.40	13.50	30.00	CL	1910	2	31	47	20
M442-01	ADK22	27.4	13.90	13.53	37.60	CL	1945	3	31	43	23
M442-01	ADK24	29.0	15.40	13.36	33.70	CL	1888	1	32	47	20

Borehole	Sample No.	Depth	Peak Shear Strength		Residual Shear Strength	
		(m)	ϕ' (deg)	c' (kPa)	ϕ' (deg)	c' (kPa)
M442-01	ADK20	25.9	27	0	24	0

5.0 Geology

5.1 General

The stratigraphic profile in the vicinity of the Saskatoon area is provided in Figure 5.1. All material between the ground surface and the bedrock surface are collectively referred to as drift. Bedrock refers to pre-Quaternary materials that constitute the base of the geotechnical investigation. A stratigraphic cross-section in the vicinity of the proposed bridge location is provided in Appendix F.

5.2 Geomorphology

The surface materials and geomorphology were determined from air-photo interpretation and analysis of topographic and soil survey maps. A detailed analysis of the site geomorphology was completed during the field reconnaissance. Figure 5.2 provides an annotated map of the site.

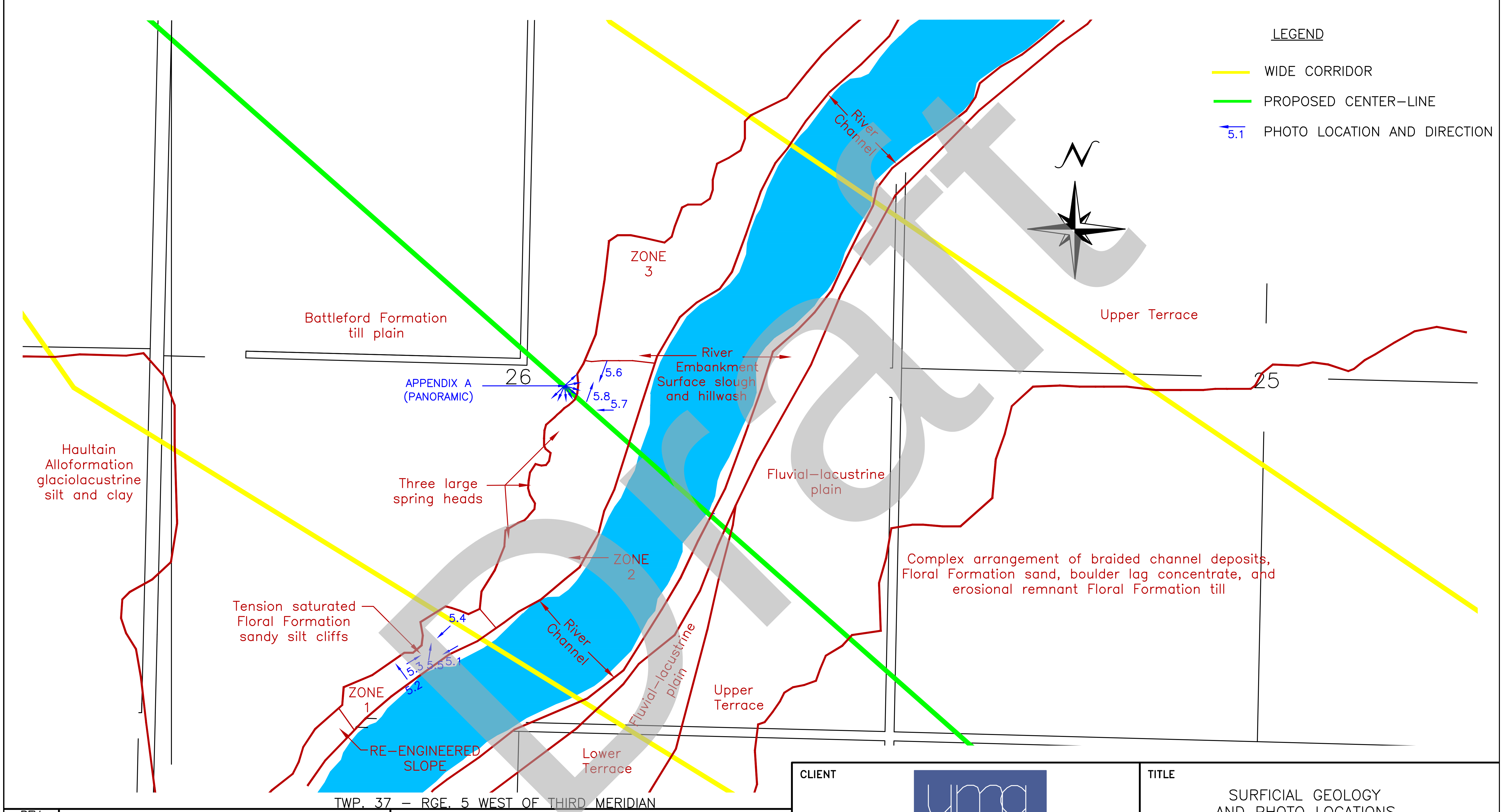
The wide corridor for the proposed Saskatoon North Bridge sits within a generally level glaciated plain dissected by the South Saskatchewan River Valley and river terraces formed during dewatering of Lake Saskatchewan following the last glaciation in the Pleistocene. Topographic elevation varies between approximately 500 masl (along the western shoulder of the South Saskatchewan River) to approximately 485 masl (along the eastern shoulder of the South Saskatchewan River). The eastern shoulder of the study area sits on a terrace formed during the last deglaciation and is approximately 15 m lower than the western shoulder of the valley. Landslides have occurred along the western river embankment. Indications of slope movement along the eastern embankment are less evident. Both river embankments are covered with thin accumulations of slough and hill wash. The river channel is covered with a lag concentrate of boulders. The boulders likely originate from boulder pavements between till units and from intra-till boulders within the till units that were exposed as the river channel deepened from melt water erosion.

The following sections provide a brief summary of the stratigraphic mapping of the river outcrops and the airphoto interpretation completed for the site. Figure 5.2 provides reference locations for all photographs and an interpretation of the surficial geology.

Saskatoon Area							
Time			Stratigraphy (1)			Lithology	
Quaternary	Holocene		Saskatoon Group	Surficial Stratified Deposits		Sands and Silts	10
						Silts and Clays	
	Late Pleistocene	Late Wisconsin		Battleford Formation		Till	9
		Early Wisconsin		Floral Formation	Upper Unit	Till	8e
	Early and middle Pleistocene	Sangamon			Riddel Member	Silt, Sand, Gravel	8d
		Illinoian			Lower Unit	Till	8c
						Clay, silt, sand	8b
						Till	8a
		Pre-Illinoian	Sutherland Group	Warman Formation		Till	7
						Sand, Gravel	
				Dundurn Formation		Till	6c
						Sand, Gravel	6b
						Till	6a
				Mennon Formation		Till	5
Tertiary		Pliocene	Empress Group			Sand, gravel, silt, clay	4
Late Cretaceous			Montana Group	Bearpaw Formation		Silt and Clay	3
				Judith River Formation		Sand, Silt, Clay	2
				Lea Park Formation		Silt and Clay	1

(1) modified after Christiansen, 1992

Figure 5.1: Quaternary stratigraphy and lithology in the Saskatoon area.



REV NO	REVISION	SCALE:	1:8000	DATE:
		SUPERVISED BY:	A. KARVONEN, P.Eng., P.Geo.	04–AUG–04
		DRAWN BY:	P. BIRNIE	04–AUG–04
		APPROVED BY:	A. KARVONEN, P.Eng., P.Geo.	04–AUG–04

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PRODUCED BY
MDH
ENGINEERED SOLUTIONS

TITLE
SURFICIAL GEOLOGY
AND PHOTO LOCATIONS

PROJECT No. M442–350003
FIG. No. 5.2
DRAWING No. M442–61–1
REV.

Western Embankment

In the vicinity of the proposed river crossing, the western shoulder of the South Saskatchewan River Valley is characterized by a broad, generally flat till plain with thin accumulations of post-glacial stratified silts and clays of the Haultain Alloformation (Grasswood Allomember) silt and clay. The proposed bridge crossing lies within the transition zone between the area covered by glaciolacustrine deposits (to the south) and the area where the Battleford Formation till comprises the surficial stratigraphic unit. The river embankment is characterized by both active and inactive landslides which occur relatively continuously along the river embankment. Within the study area, three primary zones have been delineated: 1) Zone 1 consists of steeply dipping cliffs where the sandy silts of the Riddell Member of the Floral Formation outcrop; 2) Zone 2 consists of gradually sloping valley walls characterized by thick vegetative stand resulting from groundwater discharge; 3) Zone 3 consists of gradually sloping valley walls with less vegetative growth. The three zones are highlighted in Figure 5.2.

The river embankment along the southern edge of the wide corridor (Zone 1) is characterized by steeply dipping cliffs formed by the sandy silts of the Riddell Member of the Floral Formation (Photograph 5.1, Photograph 5.2 and Photograph 5.3; Figure 5.2). The most dramatic examples of the cliffs are found just outside the southern limits of the north bridge wide corridor. Although they are outside of the wide corridor, these cliffs were examined in detail as they represented the best outcropping of the stratigraphy in the study area. The cliffs are comprised of highly stratified silty sand with beds of coarser grained horizons. Sporadic wood chips and drop stones are evident in exposed sections. Zone 1 is characterized by alternating steep tension saturated cliffs and less steeply dipping zones where spring discharge occurs (Photograph 5.1 and Photograph 5.2).

The base of the cliffs are marked by a thin layer of oxidized, firm, strongly calcareous, silty clay till with a sharp unconformable contact with the overlying aquifer (Photograph 5.4). Thin accumulations of talus, surface slump debris, and hill wash cover the intact lithologies from the base of the cliffs to the valley bottom except where exposed by recent sloughing. A second sand horizon lies beneath the Floral till and is only evident upon removal of the overburden debris, surficial sediments and organics (Photograph 5.5). This sand unit was generally comprised of clean uniform sand where observed.

Photograph 5.1 - Tension saturated Floral Formation sandy silt cliffs.

Photograph 5.2 - Tension saturated sandy silt Floral Formation cliffs.

Photograph 5.3 - Tension saturated Floral Formation (Riddell Member) sandy silt cliffs.

Photograph 5.4 - Contact between Floral Formation sand and till.

Photograph 5.5 - Lower sand unit within the Floral Formation.

The western river embankment grade becomes more gradual northward towards the proposed river crossing location (Photograph 5.6; Zone 2-Figure 5.2) in comparison with the steep tension saturated silty sand cliffs in Zone 1. The proposed north bridge crossing is present within northern portion of Zone 2. The overburden was removed at several locations along the embankment in Zone 2 to reveal similar lithologic features as found along the southern limits of the investigation area, indicating the shallow stratigraphy is generally flat across the study area. In general, the Floral Formation sand units within Zone 2 were coarser in lithology than in Zone 1 and ranged from uniform fine to coarse grained sand with some silt and gravel horizons and limited finer lithologies (Photograph 5.7). The till units encountered generally consisted of calcareous firm, sandy silt till with trace amounts of clay. The coarser lithologies within the Floral Formation sands (compared to those encountered in the southern limits of the investigation area) likely account for the inability of the sediments to form steep tension saturated cliffs. The Floral Formation sands mapped within the study area were unsaturated where encountered. It is likely that only a thin saturated zone occurs at the contact between the sand and the underlying till units. Three relatively large springheads were found within this region of the study area and result in a significant increase in vegetative stand. Any excavations below the base of the Floral Formation sands within this area can expect to produce a significant amount of water.

North of the proposed bridge location, the river embankment is similarly characterized by a gently undulating topography with a shallow grade (Photograph 5.8). The shallow slope angle of the river embankment may indicate that the dormant and active landslides may be mobilizing residual angles of internal friction along the slip surfaces. Shallow excavations completed within Zone 3 indicated similar lithologies as in the immediate vicinity of the preferred bridge crossing.

Photograph 5.6 - Gradual embankment grades in vicinity of proposed bridge crossing.

Photograph 5.7 - Floral Formation sands and gravels in the vicinity of the bridge crossing.

Photograph 5.8 - Northern region of the western embankment wide corridor.

Eastern Embankment

The eastern shoulder of the South Saskatchewan River valley extends into two broad, flat terraces formed as part of a high level braided drainage system from Lake Saskatchewan during the retreat of the last glaciation around 11,500 years ago (Christiansen and Sauer, 1994). The river terrace can be subdivided into three main zones in the immediate vicinity of the proposed bridge crossing: 1) A lower fluvial-lacustrine terrace; 2) an upper fluvial-lacustrine terrace; and, 3) a complex arrangement of braided channel deposits, outcrops of Floral Formation sand, boulder lag concentrate, and erosional remnants of Saskatoon Group till. The river embankment along the southern edge of the wide corridor is characterized by a generally consistent slope grade with limited undulation. Groundwater seepage along the edge of the terrace is evident by the thick vegetative stand along the majority of the eastern river embankment. Thick vegetation prevented manual excavation to expose mapping surfaces.

5.3 *Upper Cretaceous Stratigraphy*

The Upper Cretaceous Judith River Formation forms the bedrock surface subcroping beneath the western embankment of the proposed bridge site. The Judith River Formation in the Saskatoon area consists of marine and non-marine deltaic silts and sands containing concretionary and carbonaceous horizons. The thickness of the Judith River Formation is highly variable due to large amounts of post-depositional erosion and reaches accumulations of approximately 50 m within the Saskatoon area. The overlying Bearpaw Formation was not encountered during the investigation indicating erosion of the unit during the formation of the preglacial Tyner Valley and/or through subsequent glacial erosion.

The Judith River Formation was encountered at a depth of approximately 70 m in borehole M422-01 and is unconformable to the overlying Sutherland Group tills. The thickness of the Judith River Formation immediately beneath the proposed bridge crossing is unknown as it was not encountered during this investigation. However, borehole M442-01 indicates its thickness in excess of 9 m. The Judith River Formation encountered in borehole M442-01 generally consisted of poorly graded, unoxidized, noncalcareous, fine grained silty sand. Bentonitic and carbonaceous horizons were encountered within the unit.

The underlying Lea Park Formation was not encountered as a result of the depth of investigation. However, the Lea Park Formation was encountered in existing boreholes (SRC Clarks Crossing and SRC Sutherland). The estimated depth of the Lea Park Formation provided in cross-section A-A’ was inferred from existing data. The depth of the Lea Park Formation beneath the site is unknown but is not a geotechnical consideration for the development of a bridge at the proposed location.

5.4 *Tertiary-Quaternary Stratigraphy*

The Empress Group (Whitaker and Christensen, 1972) in the Saskatoon area is composed of pre-glacial and pro-glacial stratified sediments between the bedrock surface and the oldest till unit. The Empress Group includes a wide variety of lithologies that were lain down as fluvial, lacustrine, and colluvial deposits on the bedrock surface prior to and during glaciation. The thickest accumulations of Empress Group sediments are associated with the Tyner Valley infill.

Prior to the periods of glaciation in the Pleistocene, the Western Glaciated Plains were mature and well integrated with valleys incised into the Upper Cretaceous bedrock sediments. The Tyner Valley is a pre-glacial valley that was subsequently modified by proglacial waters and during interglacial periods. The alluvial and colluvial Empress Group infill within the Tyner Valley was subsequently covered by thick accumulations of till during glaciation in the Pleistocene. The Empress Group sediment associated with the Tyner Valley Aquifer is found in accumulations in excess of 80 m north of the site (SRC Wanuskewin; Figure 3.1; Appendix A).

Empress Group sediments were encountered in borehole M442-02 at a depth of approximately 68 m. The Empress Group consisted of three primary horizons: 1) an organic rich, poorly graded, calcareous, fine to medium grained sand; 2) an organic rich interbedded fine sand and silt; and, 3) a sandy, rounded to subrounded, fine gravel comprised of igneous, metamorphic, and carbonate lithology clasts. The lithologic characteristics (shield and carbonate gravel clasts) of the Empress group sediments encountered indicate that the deposit was likely proglacial in origin. The bedrock depression beneath the South Saskatchewan River is likely a tributary of the main Tyner Valley channel located north of the site.

As a result of budgetary constraints, the base of the Empress Group was not encountered during the investigation. However, accumulations in excess of 17 m were encountered. It should be noted that this unit has been mapped as Empress Group. Since the bedrock surface was not encountered, it is not possible to confirm this interpretation and it is possible that the sediments are interglacial. However, the organic rich nature of the deposit indicates the unit is likely pre-glacial in origin.

5.5 Quaternary Stratigraphy

The Quaternary deposits in the Saskatoon area have been investigated intermittently, and a number of papers have been published on the deposits (e.g. Christensen 1968a, Christensen 1968b, Christensen 1970, Christensen 1992, Christensen and Sauer 1994, etc.). The Quaternary deposits represent glacial and post-glacial sediments and are separated into the Saskatoon Group and the Sutherland Group. The Sutherland Group and Saskatoon Group are differentiated based on the carbonate content of the tills, the stratigraphic relationship between the till and inter-till deposits, the presence of oxidized zones, and their geophysical signatures.

The divisions of the Quaternary stratigraphy on cross-section A-A' is preliminary. A more thorough assessment of the stratigraphy in the immediate vicinity of the bridge crossing should be undertaken in association with the detailed geotechnical investigation once a more thorough database of laboratory testing results has been acquired.

5.5.1 Sutherland Group

The Sutherland Group is defined as the glacial drift that occurs between the Empress Group and the Saskatoon Group (Christensen,1968a). In the Saskatoon area, the Sutherland Group consists of glacial till and intertill and intra till stratified deposits. The Sutherland Group is subdivided into the Mennon, Dundurn, and Warman Formations. These divisions are primarily based on carbonate content, clay content, Atterberg limits and the presence of weathered zones.

The Sutherland Group was encountered in thicknesses of approximately 44 m (M442-01) and 60 m (M442-02). Both the tills of the Warman Formation and Dundurn Formation were encountered during the investigation. No till of the Mennon Formation has been identified in the investigation area.

The Dundurn Formation was encountered in thicknesses of approximately 41 m (M444-01) and 57.5 m (M444-02). The Dundurn Formation till encountered generally consisted of massive, grey to dark grey, stiff to hard, unoxidized, silt till with some sand and clay and trace coarser fractions. The lower unit of Dundurn Formation till in borehole M444-02 had larger accumulations of cobbles. The base of the Dundurn Formation sits unconformably to the underlying preglacial sediments. Although there may be up to three separate till units of the Dundurn Formation. Only two units within the Dundurn have been subdivided (upper unit and lower unit; Appendix B and Appendix F). The division is based on lithologic characteristics, electric log signature and carbonate content values. Carbonate contents and geophysical signatures indicate an additional till unit may be present at the base of the Sutherland Group.

Approximately 3 m of gravel were encountered between the upper and lower unit of the Dundurn Formation in borehole M444-02. Although the continuity of this unit is regionally limited (it has not been encountered in any other holes), its continuity beneath the river is presently unknown. It is likely that the sand unit is a reflection of the Empress Group sediments at depth. During glaciation, subglacial drainage of melt water released at the base of the ice generally follows pre-existing channels on the ground surface, forming stacked channels. As a result, it is possible that the sand unit follows the preglacial Empress Group channel (which is south to north in orientation). Porewater pressures in the vicinity of the sand are high indicating is does not exist under the river channel. If it was present beneath the river channel, high flowing artesian pressures within the unit would have likely resulted in piping and reduction in pore fluid pressure. The lateral continuity of this unit will require further investigation during the detailed geotechnical analysis.

The Warman Formation was encountered in accumulations less than 3.0 m thick in both borehole drilled as part of this investigation. The Warman Formation consisted of clayey silt till to silty clay till with varying accumulations of coarser lithologies. The till encountered was generally massive, grey, unoxidized, stiff, and weakly calcareous. The base of the Warman Formation in borehole M444-02 was marked by approximately 30 cm of sand and gravel. Detailed laboratory testing from samples acquired from borehole M442-01 indicate no significant change in measured geotechnical properties within this unit from those in the overlying Floral Formation till. It is possible that no Warman Formation exists at the proposed river crossing site. The preliminary differentiation provided in this document is based on carbonate content and geophysical signatures. The presence of the Warman Formation is important to the stability of the slopes at the proposed crossing. Historical work on the till of the Warman Formation indicates it has low shear strength relative to other till horizons. Further work will be required to determine if the Warman Formation exists at the site. The presence of a thin layer of Warman Formation till at the site is a conservative assumption for slope stability because of its relatively low shear strength.

5.5.2 Saskatoon Group

The Saskatoon Group was first proposed by Christensen (1968a) as the portion of drift lying between the Sutherland Group and the topographic surface. The Saskatoon Group is subdivided into the Floral Formation, the Battleford Formation, and the Surficial Stratified Deposits. The Saskatoon Group is differentiated from the underlying Sutherland Group on the basis of electric log signatures, lithologic characteristics and carbonate content. The Saskatoon Group tills have higher carbonate and electric log signatures and are generally coarser in lithology with respect to the underlying Sutherland Group tills. Both the Battleford Formation and the upper and lower units of the Floral Formation were encountered during the stratigraphic drilling completed during this investigation.

The Floral Formation was encountered in thicknesses of approximately 23 m (M442-01) and 10 m (M442-02). Less accumulation of Floral Formation till was encountered in borehole M442-02 than in borehole M442-01. Post-depositional erosion of the upper sequences during draining of Lake Saskatchewan during the last deglaciation removed part of the formation on the eastern side of the river.

The Floral Formation is composed of both upper and lower till units and both intertill and intratill stratified horizons. The Floral Formation sits unconformably on the Sutherland Group tills. The lower unit is composed of two tills and a separating sand unit (Cross-Section A-A'; Appendix F). The lower unit of the Floral Formation is overlain by the silts, sands and gravel of the Riddell Member of Sangamon age (SkwaraWoolf, 1981).

The lower unit of the Floral Formation was encountered in a thickness of approximately 10 m in both boreholes M442-01 and M442-02. The Lower till unit was generally comprised of grey, unoxidized, firm-stiff, sandy, silt till with some clay and gravel accumulations. Less than 3 m of stratified deposits was encountered within the lower unit in both holes. Thin accumulations (less than 3 m) of oxidized till was found in both boreholes at the top of the lower unit of the Floral Formation.

The Riddell Member of the Floral Formation was encountered in borehole M444-01. No sediments of the Riddell Member were encountered in borehole M444-02 as a result of post depositional erosion. The Riddell Member was comprised of two distinct stratigraphic horizons totaling approximately 9.5 m of stratified deposits. The lower unit consisted of oxidized fine silty sand. Layers of iron stained clay and frequent drop stones were encountered. The upper unit consisted of oxidized, poorly graded, stratified, fine to medium sand with trace to some silt. Iron stained wood fragments were encountered within the Riddell Member. Geophysical signatures obtained during the drilling indicate the majority of the Riddell Member is unsaturated in the vicinity of borehole M444-01.

The upper unit of the Floral Formation was encountered in a thickness of approximately 3.0 m in borehole M444-01. No upper till unit was encountered in borehole M444-02 as a result of post-depositional erosion. The till encountered consisted of oxidized, firm, calcareous, light yellow brown to olive brown silt and sand till with patchy iron staining. The base of the unit contained inclusions of mottled sand and silt indicating incorporation of underlying Riddell Member sediments.

The Battleford Formation was encountered in a thickness of approximately 3 m in borehole M444-01. No Battleford Formation was encountered in borehole M444-02 as a result of post-depositional erosion. The Battleford Formation till consisted of light olive brown sandy silt till with trace gravel and clay. The till was calcareous and soft to very soft in consistency. A boulder pavement in the vicinity of site marks the base of the Battleford Formation. Visual assessment of outcropping boulders indicates they have been soled and striated. The Battleford Formation till lies unconformably over the Floral Formation till and was differentiated based on consistency and the presence of the boulder pavement.

Thin accumulations of Surficial Stratified Sediments (less than 1.0 m) were encountered in both holes. It should be noted that the surficial stratified sediments in SRC Clarks Crossing borehole (east of the site) have been mapped as Holiday Park Alloformation. This unit is associated with sediments deposited on the river terrace during drainage of Lake Saskatchewan. It is possible that these accumulations belong to the Floral Formation, however, the interpretation provided on Section A-A' is consistent with previous interpretations (Christensen and Sauer, 1994).

6.0 Preliminary Geotechnical Analysis

6.1 Preliminary Porewater Pressure Analysis

Potentiometric measurements obtained from the vibrating wire piezometers are provided in Figure 6.1 and Figure 6.2 for the piezometer clusters installed in boreholes M444-01 and M444-02, respectively. Detailed piezometer output and calibration reports for each of the vibrating wire piezometers are provided in Appendix D for each of the piezometers installed as part of this investigation.

Potentiometric data from the piezometers installed within the till units of the Saskatoon Group and the Sutherland Group indicate essentially hydrostatic conditions, with only a small difference in hydraulic head vertically.

As expected, potentiometric data indicates the South Saskatchewan River Valley is a groundwater sink for the area and all measured head values are above river elevation (approximately 467 masl), indicating groundwater flow towards the river. Potentiometric data indicates the hydraulic head within the Empress Group and Judith River Formation in the vicinity of the site is strongly artesian in the vicinity of the site (flowing artesian heads over 20 m at river level).

No piezometers were installed within the Floral Formation aquifer units. Based on the geophysical information obtained during the field investigation, the units are primarily unsaturated. A thin saturated horizon is likely present at the base of each of the Floral Formation sands. This condition is typical for aquifers that are exposed along river embankments. The presence of springheads along the western embankment provides evidence of groundwater discharge from the Floral Formation sands. The thick vegetative stand in the vicinity of the proposed bridge crossing is also indicative of groundwater discharge (Figure 5.2).

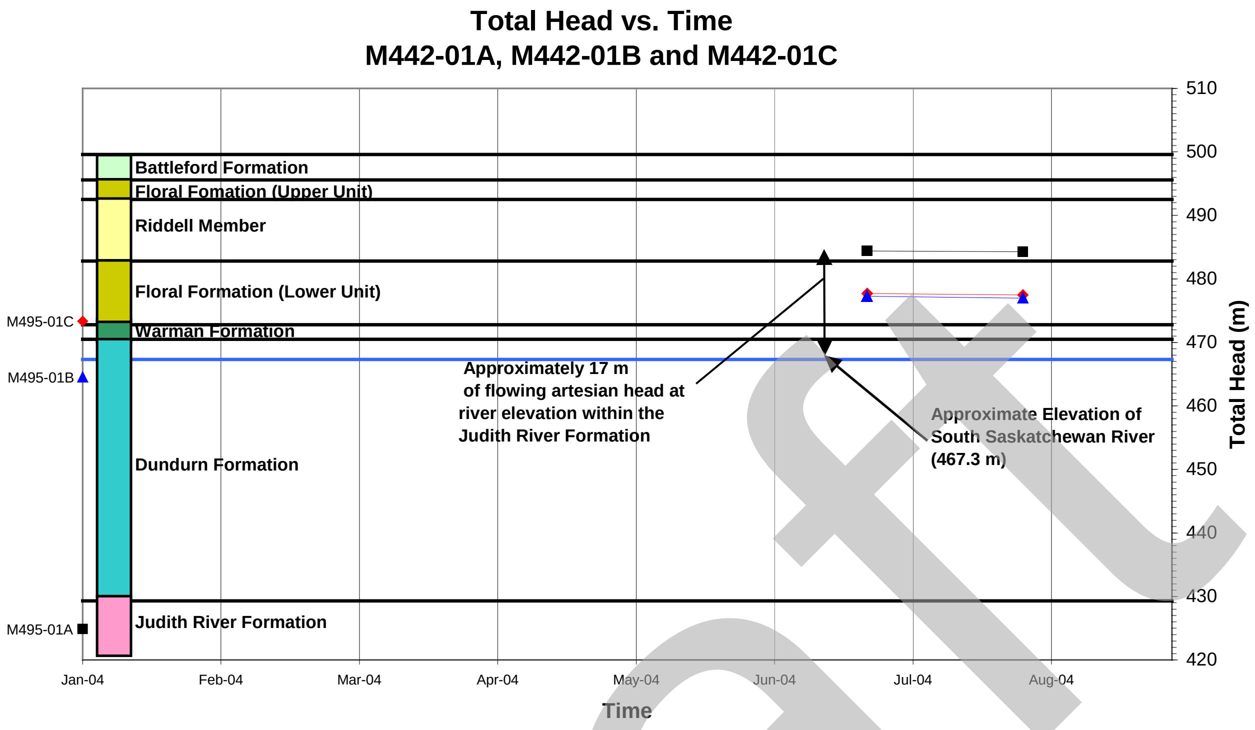

Figure 6.1 - Potentiometric head with depth in borehole M442-01.

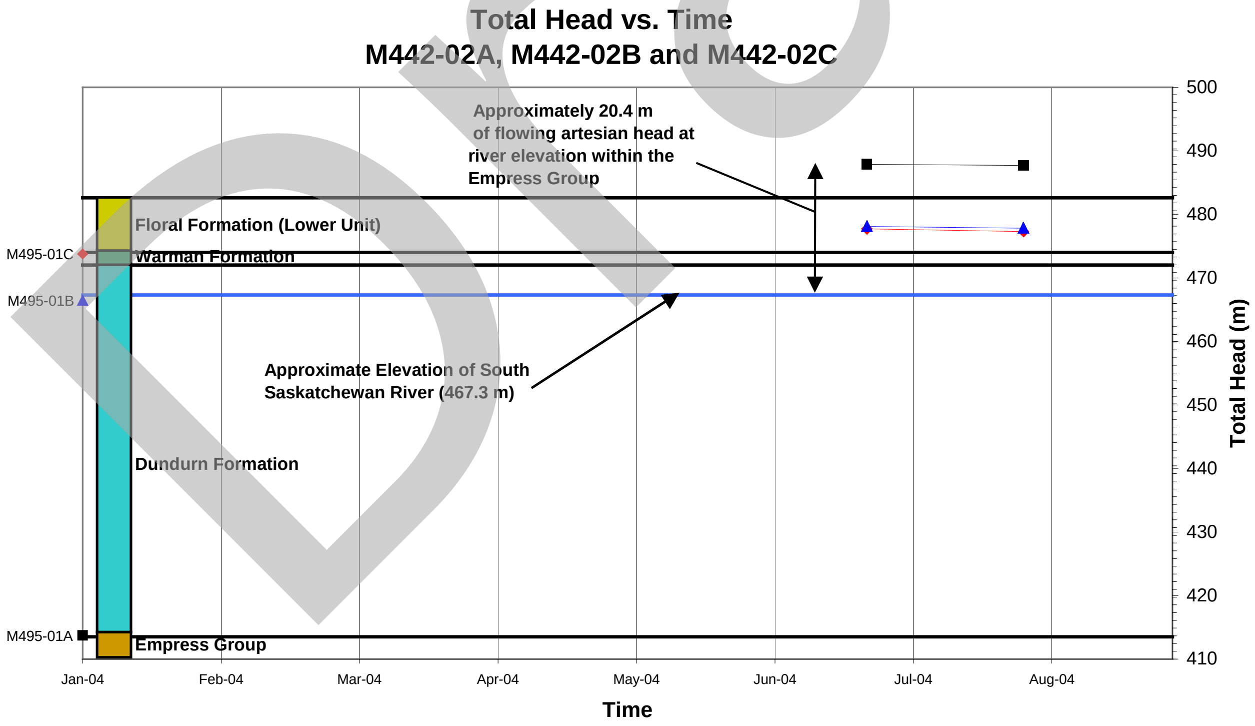

Figure 6.2 - Potentiometric head with depth in borehole M442-02.

6.2 *Preliminary Slope Stability Modelling*

6.2.1 General

Slope stability is assessed by a limit equilibrium analysis that calculates a factor of safety (Fs) against failure. Fs can generally be expressed as:

Fs = Resisting Forces / Mobilizing Forces

Therefore, a factor of safety of unity (Fs = 1) identifies a failure condition according to limit equilibrium theory. The following criteria may be used in evaluating the results of the analysis.

- Calculated factor of safety, Fs, equal to 1.00 is a condition of almost certain failure
- Calculated Fs between 1.00 and 1.50 is a high risk zone
- Calculated Fs greater than 1.50 is a relatively moderate risk condition where the probability of failure is low.

The computer program SLOPE/W v.5.17 produced by GeoSlope was used for the assessment of factor of safety during this investigation. Slope stability modelling output is provided in Appendix F. An example of the slope stability models produced by SLOPE/W for both the western and eastern embankments are provided in Appendix G. The input data for the computer analysis was obtained from site investigation information and from published references on slope stability analyses in similar geological environments.

6.2.2 Requirements for the stability analysis

There are six elements required for a stability analysis. These are:

1. Topography and surface geometry;
2. Stratigraphy or layers of different materials;
3. Mechanical properties of materials for each layer;
4. Hydraulic heads in the layers (porewater pressure);

5. Failure mechanism, or geometry of potential slip surfaces; and,

6. Method of analysis (theoretical).

6.2.3 Topography and surface geometry

The riverbank slopes were determined from contours produced during the survey of the river embankment. Two cross sections X-X', and Y-Y' were created that represent the approximate critical slopes based on the topographic survey. The average slope angles for X-X' and Y-Y' are approximately 11.3° and 9.6°, respectfully. The location and profiles of the cross sections are shown in Appendix G. The details from these cross sections were then used to determine the slopes for input into the slope stability models.

6.2.4 Stratigraphy or layers of different materials

Stratigraphy for the slope stability models was generally based upon the interpretation of boreholes M442-01 and M442-02 (Appendix B and Appendix F). The similarity between the stratigraphy at M442-01 and Saskatoon SH-06 suggests there is little stratigraphic variation across the area of interest and the geology utilized in the model is likely representative of the geology across the north bridge wide corridor. The original borehole log for SH-06 is provided in Appendix A. A summary of both the western and eastern embankment stratigraphy used in the model is provided below.

The upper till of the Dundurn Formation forms the base of the stability investigation on both sides of the river. Plastic till of the Warman Formation overlies the upper till of the Dundurn Formation. The clayey texture of the till of the Warman Formation and Dundurn Formation shows clearly in the electrical resistance logs. Sandy till of the Floral Formation overlies the Warman Formation till. Lithologic and geophysical evidence indicates that this lower till may contain a layer of clay rich till similar to that of the Warman Formation. A layer of sand and gravel lies between the two till units of the Lower unit of the Floral Formation. Fine sand of the Riddell Member lies between the lower till and the upper till of the Floral Formation. A thin layer of sandy till of the Battleford Formation lies between the upper till of the Floral Formation and the ground surface. The stratigraphy on both sides of the river is generally consistent. However, on the eastern embankment, the upper unit of the Floral Formation and the Battleford Formation have been removed as a result of post-depositional erosion.

6.2.5 Mechanical properties of materials for each layer

Shear strength parameters, effective angle of internal friction (ϕ'), effective cohesion (c'), and unit weight γ for each layer of soil are the properties required for slope stability calculations. The water table is fairly low at this site and as a result, much of the soil that would be involved in the potentially unstable zone is unsaturated. Thus, an additional component of shear strength is present which is calculated from the parameter ϕ^b (Fredlund and Rahardjo, 1993).

The shear strength parameters used for this investigation were those acquired from laboratory testing and estimated from geotechnical index properties provided in Sauer *et al* (1993). The published values were considered to be realistic because they were based on field experience with materials of similar index properties in the Saskatoon area. The shear strength parameters utilized for the Warman Formation in the slope stability models were more conservative than those measured during the investigation.

There is little published data on the parameter required for calculating the contribution of negative pore-water pressures (suction) to the shearing resistance of the unsaturated soils at the site. Consequently, the selection of values of ϕ^b for the different layers of soils was made through judgment based on rather limited laboratory experiments. A summary of the shear strength parameters used for this analysis is provided in Table 6.1.

Table 6.1- Shear strength parameters used for stability analysis.

Stratigraphic Layer	**Parameter**			
	ϕ' (°)	**c' (kPa)**	**γ (kN/m^2)**	**ϕ^b (°)**
Battleford Formation Till	25	20	20	-
Upper Floral Formation Till	25	20	20	-
Riddell Member Sand & Gravel	35	0	22	15
Lower Floral Formation Till	28	20	20	20
Intertill Sand & Gravel	35	0	22	10
Warman Formation Till	24	5	20	15

The properties of silts and sands of the Judith River Formation, and the tills of the Dundurn Formation do not likely influence the stability of the slope. Instability is most likely to be seated in the till of the Warman Formation that has higher clay content than the underlying till of the Dundurn Formation and the overlying Floral Formation tills. . As a result, the Dundurn Formation is modelled as a competent layer in which the slip surface will not propagate.

The parameter ϕ^b is assumed to be zero for the Battleford Formation and upper unit of the Floral Formations in anticipation of prolonged periods of rainfall during which the upper layers could become saturated. This assumption yields results that tend to be on the conservative side during dry weather conditions as a result of soil suction.

6.2.6 Hydraulic heads in the layers (porewater pressures).

The groundwater regime at this site appears to be relatively stable. A review of the data from piezometers M442-01A, B, C and M442-01A, B, C indicates that the groundwater elevation within the embankment profile does not vary significantly (although only two measurements have been obtained). Thus, a piezometric elevation of 478 masl was used to represent hydrostatic conditions throughout the strata up to the crest of the slope on the western and eastern slope stability models, respectively.

6.2.7 Failure mechanism, or geometry of potential slip surfaces.

Slope failures in relatively homogeneous materials generally slide upon a spherical slip surface that is characterized as a circular line in a two-dimensional analysis. The presence of a layer of relatively low shearing resistance (Warman Formation), however, will modify the simple circular slip into a composite form. The presence the clayey till between two relatively competent tills, forces a composite form for the potential slip surface. In this case, the most critical failure modes on both sides of the river will likely be a composite slip into clayey till of the Warman Formation at an elevation of approximately 470 masl and 472 masl for the western and eastern river embankments, respectively.

6.2.8 Method of analysis (theoretical)

The Morgenstern and Price method of slices was used for the slope stability analysis. This method satisfies both force and moment equilibrium. The computer program SLOPE/W was used for the slope stability calculations. A total of 121 slip surface grid points and 11 slip surface radiuses were specified for the analysis, combining for the evaluation of 1331 possible slip surfaces.

6.2.9 Preliminary Slope Stability Modelling Results

Results of Deterministic Analysis

Several slope models were created based upon the input parameters presented in the preceding sections. The slope profiles selected for analysis were the critical slope configurations in the vicinity of the preferred bridge alignment. The critical slope profiles were determined from the preliminary survey data acquired during the field program (Appendix G). The two cross sections selected were X-X' and Y-Y' (Appendix G).

The calculated Fs for cross section X-X' and Y-Y' was 2.024 and 2.310, respectively. The resultant slope stability models for these two sections are shown in Appendix G. Since groundwater elevations and geology at both cross sections is essentially identical, the difference in Fs can be contributed to difference in slope angle and slope height. The Fs for X-X' is lower as a result of a slightly steeper average slope than Y-Y' (11.3° as compared to 9.6°). The groundwater elevation for both cross sections is located at an elevation of 478 masl, within the Floral Formation intratill sand and gravel unit, as indicated by vibrating piezometers installed on each side of the river.

The failure surface for the minimum calculated Fs in both cases is a circular composite failure that is based in the Warman Formation till. The calculations suggest that evidence of slope movement would be expected to appear on the bottom half of the slope. However, in both cases the slopes are in a low risk of failure category.

Results of Probabilistic Analysis

The calculated Fs of a slope is controlled entirely by the input parameters. For this investigation, topography, stratigraphy and hydraulic conditions are relatively well known. The results, however, are largely dependent on the shear strength properties that were used. The shear strength parameters used were estimated based upon published values for similar soils in the Saskatoon area and engineering judgment. Any deviation from the actual insitu soil properties will result in Fs that may be higher or lower than the actual insitu condition. Furthermore, laboratory results on natural soils taken from the same stratigraphic unit indicate that most soil properties can be considered as random variables conforming to the normal distribution function. The software package used for the stability analysis, SLOPE/W, considers the variability of input parameters by allowing the analyst to specify the standard deviation of the material properties.

A probabilistic slope stability assessment was conducted for both cross sections X-X' and Y-Y'. A total of 1000 Monte Carlo trials were conducted with standard deviations specified for all of the shear strength parameters (ϕ', c', γ, and ϕ^b) and groundwater elevation. The standard deviation used for soil properties during this investigation was a value equal to 10% of the input parameter (for instance, ϕ' for the Battleford Formation till was estimated to be 25° with a standard deviation of 2.5°). The standard deviation used for the groundwater elevation was equal to 1 m.

Results of the analysis are presented in Table 6.2. Probabilistic data including minimum, maximum, and statistical values (mean and standard deviation) of the results are presented. The probability density functions for each of the cases are presented in Figure 6.3 and Figure 6.4.

Table 6.2 - Results of probabilistic analysis.

Model I.D.	Groundwater Elevation	Probability Data *			
		Mean Fs	Standard Deviation	Minimum Fs	Maximum Fs
X-X'	478.0 masl	2.04	0.154	1.57	2.53
Y-Y'	478.0 masl	2.49	0.357	1.67	4.15

* Calculated Results of 1000 Monte Carlo Trials

The results of the probabilistic analysis indicate that the present slope configuration is stable with a minimum factor of safety greater than 1.5 for both slopes, indicating the probability of instability is low.

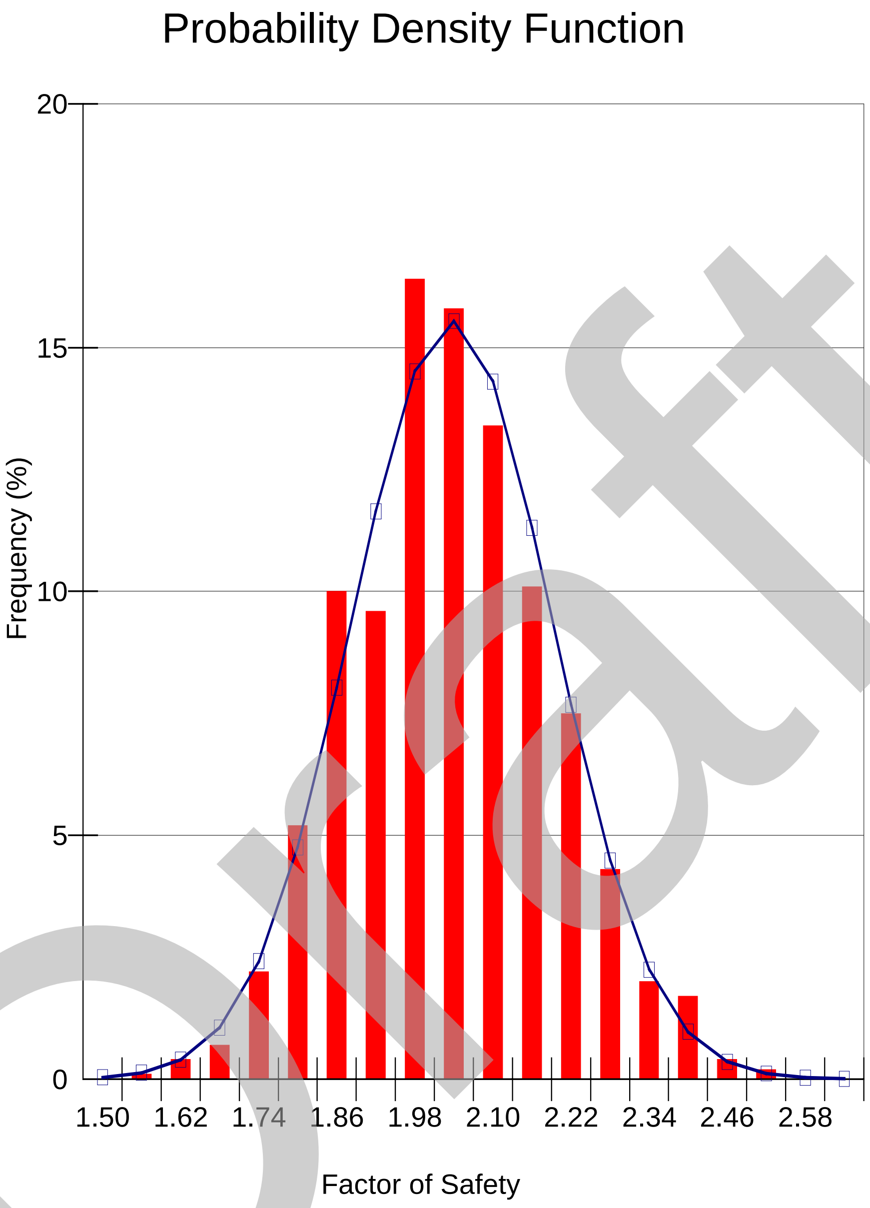

Figure 6.3 - Probability density function for cross-section X-X'

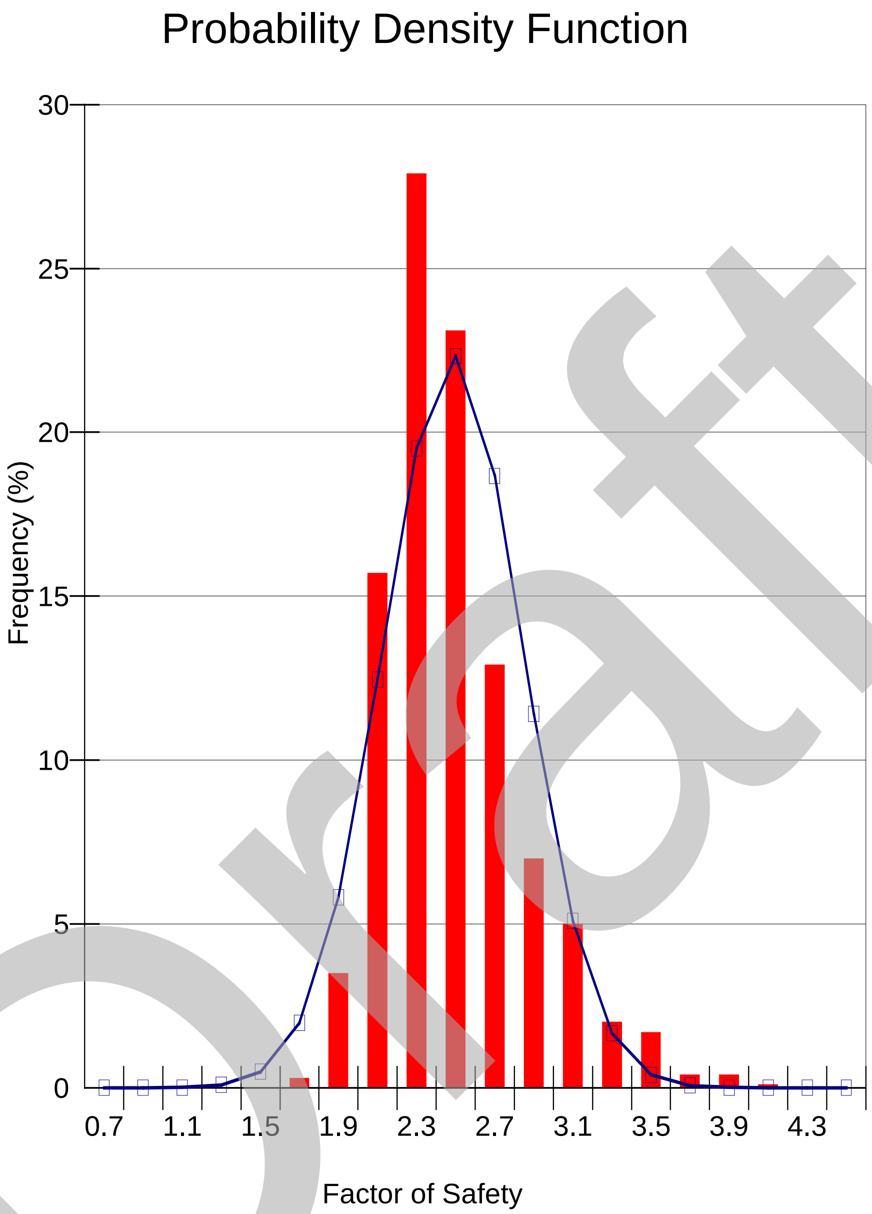

Figure 6.4 - Probability density function for cross-section Y-Y'

Limitations of Analysis

Limit equilibrium analysis is the current 'state-of-the-practice' method to solve the slope stability of natural or man-made embankments in rock and soil. The advancement of computing technology has made it possible to better understand the limit equilibrium method and more importantly recognize its limitations. Limit equilibrium methods of analyses were initially developed to analyze slopes where the normal stress along the slip surface was primarily influenced by gravity. Herein lies a major limitation of this method; the stress conditions calculated from a limit equilibrium analysis may be different from the actual stress conditions in the ground.

There are a number of limitations of the limit equilibrium method of analyses that arise because of material properties and the geometry of slopes including:

1. The heterogeneous nature of soils and/or existence of thin soil layers that may dominate the stability condition of the slope;
2. The stresses calculated from a limit equilibrium analysis near the toe of the slope can be different from actual stress conditions;
3. The stress distribution calculated using the limit equilibrium method of analysis ignores the complex stress-strain properties of some soils; and,
4. The effects of a dynamic groundwater flow system are not incorporated into the analysis.

Despite these limitations, limit equilibrium methods allow a relative factor of a slope to be calculated. It also helps to identify and quantify the key parameters controlling slope stability. Furthermore, the assumptions used to complete a limit equilibrium method of analysis generally tend to provide results that are slightly conservative.

7.0 Engineering Significance

In general, the stratigraphy and groundwater hydraulics within the north bridge wide corridor are conducive to the construction of a new bridge. Based on the existing preliminary investigation, there are no evident geotechnical factors that would prevent a bridge at the proposed site. However, it should be noted that the scope of the investigation was preliminary. Site investigations completed as part of the detailed geotechnical analysis will likely result in additional geotechnical considerations. Sections 7.1 through 7.5 highlight the key geotechnical considerations for the site based on the information obtained during this investigation.

7.1 Bridge Foundation Stability

It is assumed that the foundations for the bridge piers will be spread footings. Based on stratigraphy encountered during this investigation, the bridge foundations will be seated on Dundurn Formation till. As a result of the scope of the investigation, limited material testing was completed on this unit. No preconsolidation pressures have been measured in the immediate vicinity of the site, however the preconsolidation pressures can be expected to fall within the range (1800 kPa ± 200 kPa) reported by Sauer *et al.* (1993) for the older tills throughout Saskatchewan. In general, the Dundurn Formation till will be overconsolidated and the bearing capacity of the units will be fairly high. However, additional testing will be required during the detailed geotechnical investigation associated with the bridge crossing.

In general, the Dundurn Formation till will be a good material in which to seat bridge pier footings. Geological data acquired during this investigation indicates a shallow sand unit may be present beneath the site. This unit may be highly artesian and will be a consideration during the design and installation of the pier foundations if present beneath the river.

7.2 Groundwater Hydraulics

The potentiometric data indicates that the head within both the Empress Group and the Judith River Formation is strongly artesian in the vicinity of the proposed North Bridge crossing. Measured hydraulic head within the Empress Group is approximately 488 m in piezometer M444-02A. Similarly, the measured hydraulic head within the Judith River

Formation is over 484 m. At river elevation (approximately 467 m), this amounts to over 20 m of flowing artesian head within the sediments at depth beneath the river valley. Because of the strong flowing artesian conditions at depth, drilling into these units must be done carefully. Intersection of a highly artesian aquifer unit could result in uncontrollable influx of water, potential piping of sediments and loss of the borehole. Adequate mud densities will be required to control the strong artesian heads present beneath the site.

Although the pore pressure within the Empress Group is high. The thick accumulations of till should be sufficient enough to limit uplift pressures and hydraulic gradients to allow construction of the pier foundations. The hydraulic gradient through the till beneath the river valley can be calculated based on the following formula: Gradient through till i = Δh/thickness of till. During construction of the piers, the base of the excavation would not likely be any lower than 462 masl (assuming pier foundation excavations of approximately 3 m and river depth of approximately 2 m). Potentiometric elevation in the Empress Group is about 488 masl. Based on these values, there could be as much as 26 m of flowing artesian pressures within the Empress Group during construction of the pier. Although the pore pressure is large, the thick accumulation of Dundurn Formation till beneath the site results in a hydraulic gradient of approximately 0.54 m/m. This below the critical gradient (1.0) and represents a factor of safety of around 2.0. This should be sufficient enough to ensure the effective stress within the Dundurn Formation remains sufficient to allow safe working conditions.

A thin sand unit was encountered at the intersection between the upper and lower units of the Dundurn Formation. The lateral extent and pore pressure within this unit are presently unknown. Potentiometric data acquired immediately above the unit along the eastern embankment (Piezometer M442-02) indicate heads within this sand are likely around 477 masl. If present beneath the river valley, this unit will be flowing artesian at river elevation by approximately 10 m. Because the unit is relatively shallow (approximately 460 masl), if this unit is present beneath the river channel, artesian pressures and water inflow from this unit will need to be controlled during pier foundation excavations. The continuity and hydraulic properties of this unit will need to be investigated during the detailed geotechnical investigation to determine its continuity and what hydraulic relief measures will be required during the pier installations (if any). Should the intertill sand unit be encountered beneath the river channel, there are many available methods to hydraulically control the flowing artesian conditions and ensure safe working conditions. It should be noted that during any future site investigations, sufficient weight material (barite, magnetite, etc.) should be utilized to ensure hydraulic control of borehole during the investigation.

Because of the elevation difference between the west and east river embankments, it is likely that the western side of the river embankment will require a large cut to achieve an appropriate approach grade. Excavation into the Floral Formation sands will likely produce significant quantities of water to create difficult working conditions during construction. Seepage control and long-term drainage filters will likely be required for the approach excavation along the western river embankment to control seepage from the Floral Formation sands.

7.3 Slope Stability and Foundation Stability

Dormant and active slope instabilities are present along the entire river embankment (particularly the western river embankment). These slope instabilities have resulted in ERCO Worldwide to reduce the slope of the river valley immediately south of the north bridge wide corridor (Figure 5.2). The majority of the instabilities are likely seated within the high plastic till of the Warman Formation. However, numerical modelling completed as part of this investigation indicates the slope configurations at the preferred bridge alignment location (Alignment 3) should be stable with minimum Fs of over 1.5.

7.4 Stability of Embankment and Approach Foundation Material

The foundation stability under the western embankment will not likely be a major geotechnical consideration. The till of the Battleford Formation and overlying thin accumulations of surficial stratified materials will likely be removed during excavation of the western embankment approach road. As a result, the western embankment foundation materials will consist of till of the Sutherland Group and Floral Formation and intertill stratified deposits. These tills are heavily overconsolidated; so induced porewater pressures will not likely be a problem in these materials. The accumulations of stratified deposits will also aid in stabilizing the embankments by providing drainage.

The eastern embankment foundation and approach will be placed on silts, sand and gravel present along the river terrace. A more thorough investigation will be required along the eastern river terrace to determine the terrace stratigraphy and accumulations of compressible sediments (normally consolidated fines and organics). The presence of coarse lithologies within this unit should help control any excess porewater pressure development and will form a natural drain (to reduce porewater pressure development) during embankment and approach construction.

7.5 Boulder Lag Concentrate at the Bottom of the River Channel

A lag concentrate of large boulders (boulder pavement) is likely present along the bottom of the river channel. The boulders will create an obstacle to future geotechnical investigations, excavations for pier footings, and construction of cofferdams.

8.0 Closure

MDH Engineered Solutions Corp., hereinafter collectively referred to as “MDH”, has exercised reasonable skill, care and diligence in preparing this report. MDH will not be liable under any circumstances for the direct or indirect damages incurred by any individual or entity due to the contents of this report, omissions and/or errors within, or use thereof, including damages resulting from loss of data, loss of profits, loss of use, interruption of business, indirect, special, incidental or consequential damages, even if advised of the possibility of such damage. This limitation of liability will apply regardless of the form of action, whether in contract or tort, including negligence.

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Should you have any questions or comments please contact us.

Regards,

MDH Engineered Solutions Corp.

Association of Professional Engineers
And Geoscientists of Saskatchewan
Certificate of Authorization Number 662

Andrew Karvonen, M.Sc., P.Eng., P.Geo.

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TERMS, SYMBOLS AND ABBREVIATIONS

Terms, Symbols and Abbreviations

Field geological description of a soil is achieved through a brief description of the following points. All points should be included to accurately describe a soil for geoenvironmental applications:

1) Lithology/texture (size, proportion, and shape);
2) Colour and oxidation;
3) Consistency and plasticity (cohesive soils);
4) Condition (non-cohesive soils);
5) Moisture; and
6) Other miscellaneous descriptors.

1) Lithology / Texture

The texture of a soil is a combination of the size and shape of the particles and the relative proportions of each of the constituents (eg. subrounded to subangular gravel, sandy, some silt, trace cobble).

Particle Size (ASTM D2487-85)

Boulder	300mm plus
Cobble	75 – 300 mm
Gravel	4.75 – 75 mm
Sand	0.075 – 4.75mm
Fine:	0.075 – 0.425 mm
Medium:	0.425 – 2 mm
Coarse:	2 – 4.75 mm

Relative Proportions (by weight)

Parent Material	>35% and main fraction
Modifier	20 – 35%
eg: gravely, sandy, silty, clayey, etc.	
Some	10 – 20%
Trace	0 – 10%

Particle Shape (coarse grained soils)

Rounded	No edges and smoothly curved sides
Subrounded	Well-rounded corners and edges, nearly plane sides
Subangular	Similar to angular but have rounded edges
Angular	Sharp edges and relatively plane sides with unpolished surfaces

Gradation (coarse grained soils)

Well Graded	Having a wide range of grain sizes and substantial amount of all intermediate sizes
Uniform (Poorly Graded)	Possessing particles of predominantly one size
Gap Graded	Possessing particles of several distinct sizes

2) Colour and Oxidation

A soils colour may be described either qualitatively in the field at the soils natural moisture content using common colours (eg. light grey, light brown, dark grey, etc.) or quantitatively by comparison with a colour chart. Soils colour is typically quantified using a Munsell Book of Colour. The soil colour description is characterized by a combination of hue, value and chroma. The hue notation of a colour indicates its relation to red, yellow, green, blue and purple; the value notation indicates its lightness; and the chroma notation indicates its strength (or departure from a neutral of the same lightness (eg 2.5Y 4/2). Quantitative determination of colour using a Munsell Book of Colours is completed after the soil has been allowed to dry at a low temperature.

When a soil is exposed to an oxygen rich environment it oxidizes and the soils colour departs from neutral (eg from dark grey-5Y 4/1 to dark reddish brown-5Y4/2). The colour change is generally a result of iron oxidation and staining (red) or manganese staining (purple to black). The oxidation may occur throughout the entire soil mass or commonly as fracture and joint coatings and haloes.

3) Consistency and Plasticity (Cohesive Soils)

The consistency of a soil is a qualitative description of a cohesive soils ability to resist deformation and may be correlated to the undrained shear strength. Consistency and undrained shear strength (Su) of a soil may be field-tested using the thumb and thumbnail or more accurately with a pocket penetrometer.

The plasticity of a soil is a measure of the soils ability to deform without rupture. The plasticity of a cohesive soil should be estimated as low (LL <30), medium (30<LL<50), or high (LL>50) plasticity. The plasticity can be verified in the laboratory through Atterberg Limit testing.

Consistency	Undrained Shear Strength - Su (kPa) (CFEM, 2nd edition, 1985)	Field Identification (ASTM D 2488-84)
Very Soft	<12	Thumb will penetrate soil more than 25mm
Soft	12 – 25	Thumb will penetrate soil about 25mm
Firm	25 – 50	Thumb will indent soil about 6 mm
Stiff	50 – 100	Thumb will indent but penetrate only with great effort (CFEM)
Very Stiff	100 – 200	Readily indented by thumbnail (CFEM)
Hard	>200	Thumb will not indent but readily indented with thumbnail
Very Hard	N/A	Thumbnail will not indent soil

Note: - Pocket penetrometer readings can be used to measure Su directly where Su is equal to approximately ½ of the pocket penetrometer reading (ie. The pocket penetrometer measures unconfined compressive strength (approx 2Su)

4) Compactness Condition (Non-Cohesive Soils)

A Standard Penetration Test (STP) is used to estimate the compactness condition of a soil.

Compactness Condition	SPT N-Index (Blows / 300mm)
Very Loose	0 – 4
Loose	4 – 10
Compact	10 – 30
Dense	30 – 50
Very Dense	>50

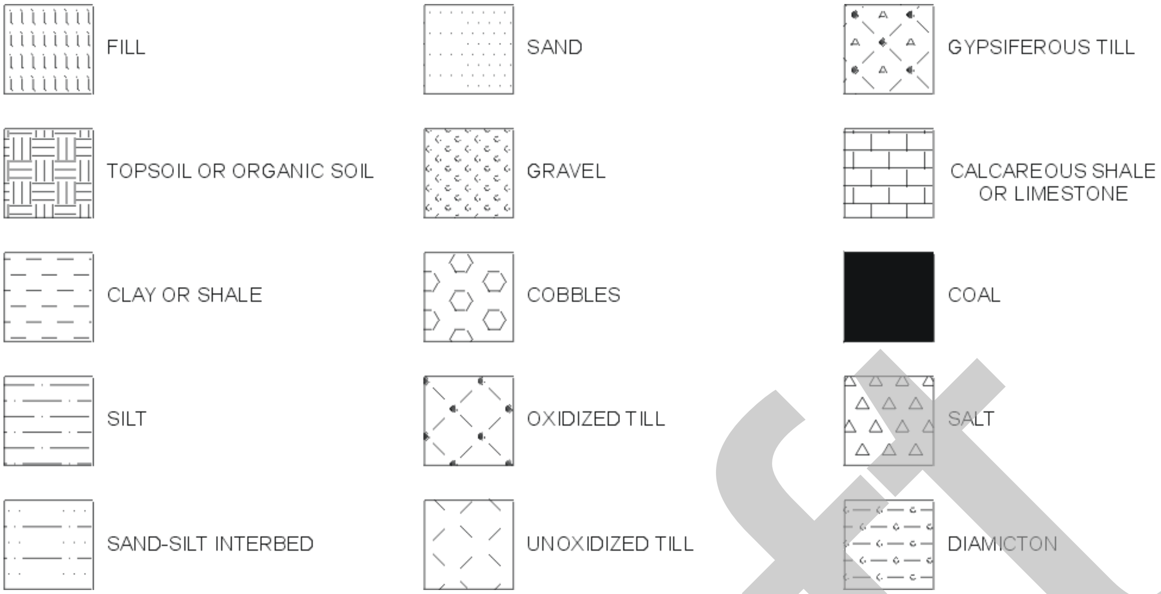
5) Moisture Conditions (ASTM D2488-84)

- Dry - No moisture, dusty, dry to touch
- Moist - Damp but contains no visible water
- Wet - Visible, free water, indicating soil is below water table

6) Other Descriptors

- Primary structure - structure formed during soil deposition (eg. stratified, laminated, lensed, bedded, massive, cross-bedded, etc.)
- Secondary structure - structure formed following original deposition (eg. cementation, salt crystallization, jointing, fissuring, fracturing, slickensides, blocky, brecciated, mottled, etc.)
- Carbonate content - weakly, moderately, or strongly calcareous (based on effervescence in dilute (10%) HCl acid)
- Organics (spongy feel, fibrous texture)
- Sensitivity (sands)
- Odour

7) **Soil Type Symbols**



8) **Sampling Symbols** ***(left hand side of testhole log)***

■ CORE (any type) ◫ SPLIT TUBE ☒ BAGGED CUTTINGS □ NO RECOVERY ⊟ SHELBY TUBE

9) **Oxidized Zones** ***(right hand side of testhole log)***

■ OXIDIZED ZONES □ UNOXIDIZED ZONES

10) **Field and Laboratory Test Symbols**

W_P PLASTIC LIMIT
W_N NATURAL MOISTURE CONTENT
W_L LIQUID LIMIT

▲ POCKET PENETROMETER

× SIEVE ANALYSIS

11) **Piezometer and Inclinometer Symbols**

STATIC WATER LEVEL ▼

Common Abbreviations

Pale = pl.
Olive = ol.
Light = lt.
Yellow = ylw.
Brown = br
Grey = gr.
Green =grn.
Pink = Pk.
Dark = dk.
Very = v.
Large = lg.
Strongly = st.
Weakly = wkly.
Subrounded = sbrnd.
Subangular = sbang.
Rounded = rnd.
Angular = ang.
Medium = m.
Fine = f.
Coarse = c.

Calcareous = calc.
Non-Calcareous = noncalc.
Laminated = lam.
Predominantly = predom.
Carbonate = carb.
Quartz = qz.
Ablation = abl.
Weathered = wthrd.
Material = mat.
Mottled (Mottling) = mot.
Fracture = frac.
Iron = Fe
Manganese = Mn

Examples

1) Sand, silty, some subrounded to subangular gravel, light brownish grey (2.5Y6/2), oxidized, well graded, loose, wet, stratified, weakly calcareous
2) Silt, clayey, trace fine sand, grey (5Y5/1), unoxidized, soft-very soft, moist, thinly laminated, strongly calcareous, Fe and Mn staining
3) Clay till, sandy, some subangular-angular gravel, trace subrounded cobble, greyish brown (2.5Y5/2), oxidized, moderate plasticity, stiff, moist, moderately calcareous, Fe stained fractures, Glauber's salts
4) Gravel (sbrnd-rnd) predominantly shield and carbonate lithos, sandy (f.-c.), well sorted, unoxidized, compact, wet, wood chips

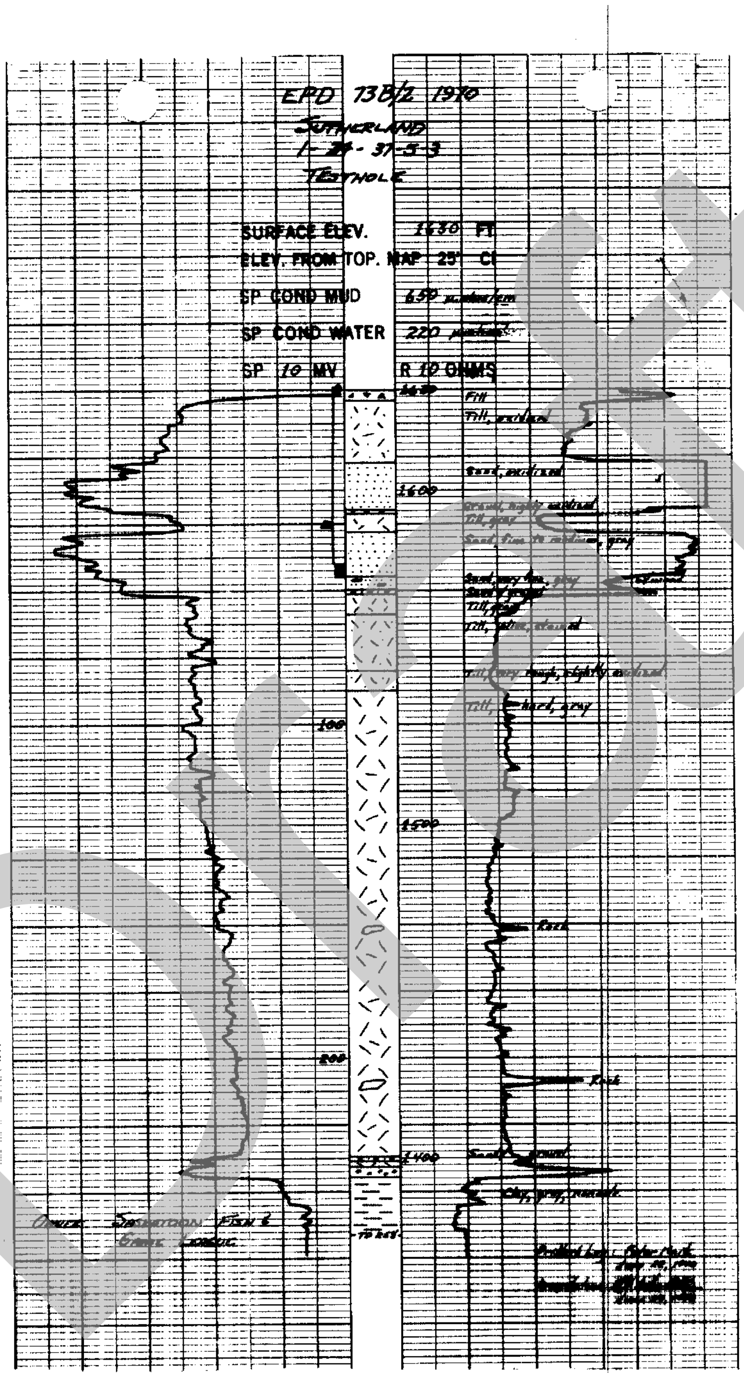
Appendix A

Panoramic View of Proposed River Crossing


Proposed Bridge Location
31/05/2004
31/05/2004
31/05/2004

APPENDIX B

Selected Available Borehole Logs

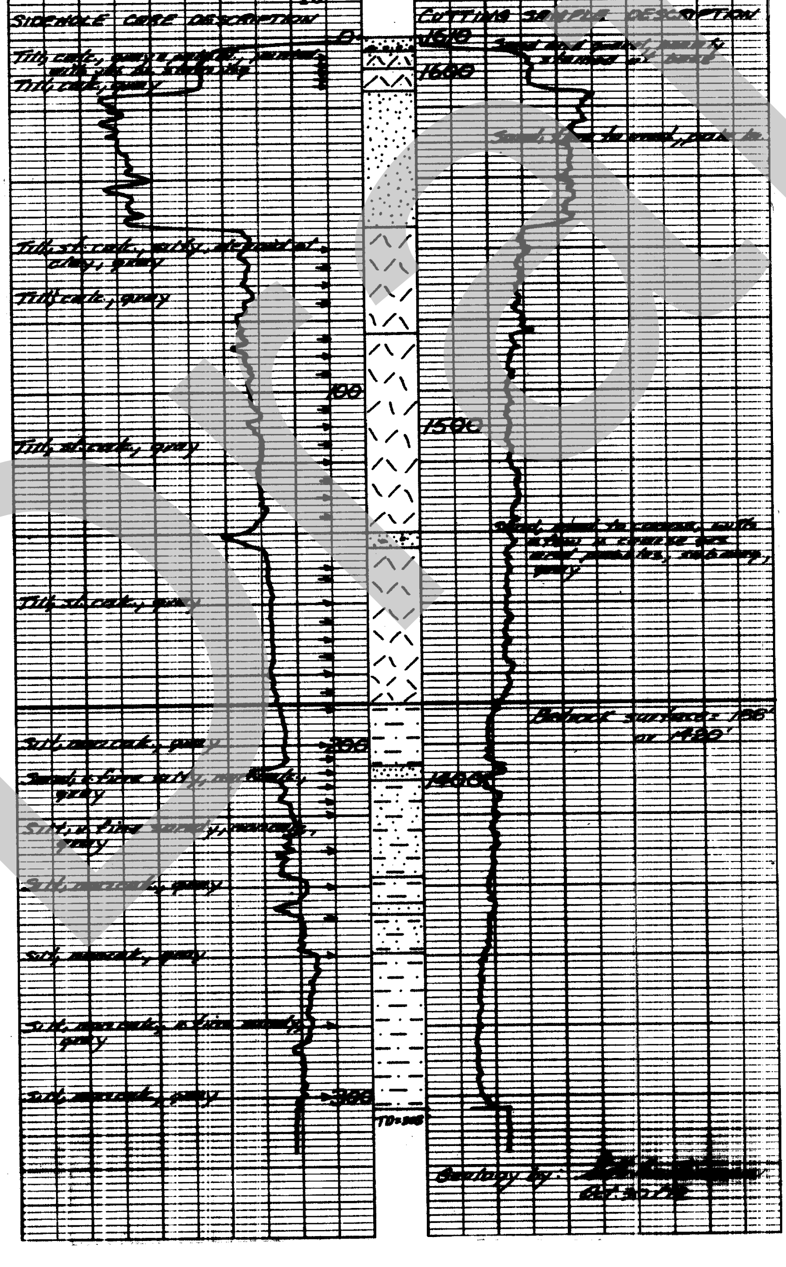

EPD 73B/2 1970
SUTHERLAND
1-34-37-5-3
TESTHOLE
SURFACE ELEV. 1630 FT
ELEV. FROM TOP. MAP 25' CI
SP COND MUD 650 μmhos/cm
SP COND WATER 220 μmhos/cm
SP 10 MV
R 10 OHMS
1630
Fill
Till, oxidized
Sand, oxidized
1600
Gravel, highly oxidized
Till, gray
Sand, fine to medium, gray
Sand, very fine, gray
Sand & gravel
Till, gray
Till, silty, stained
Till, very tough, slightly oxidized
Till, hard, gray
100
1500
Rock
200
Rock
1400
Sand, gravel
Clay, gray, massive
TD 245
OWNER: SASKATOON FISH & GAME LEAGUE
Drilled by: Peter Koch
Aug. 20, 1970

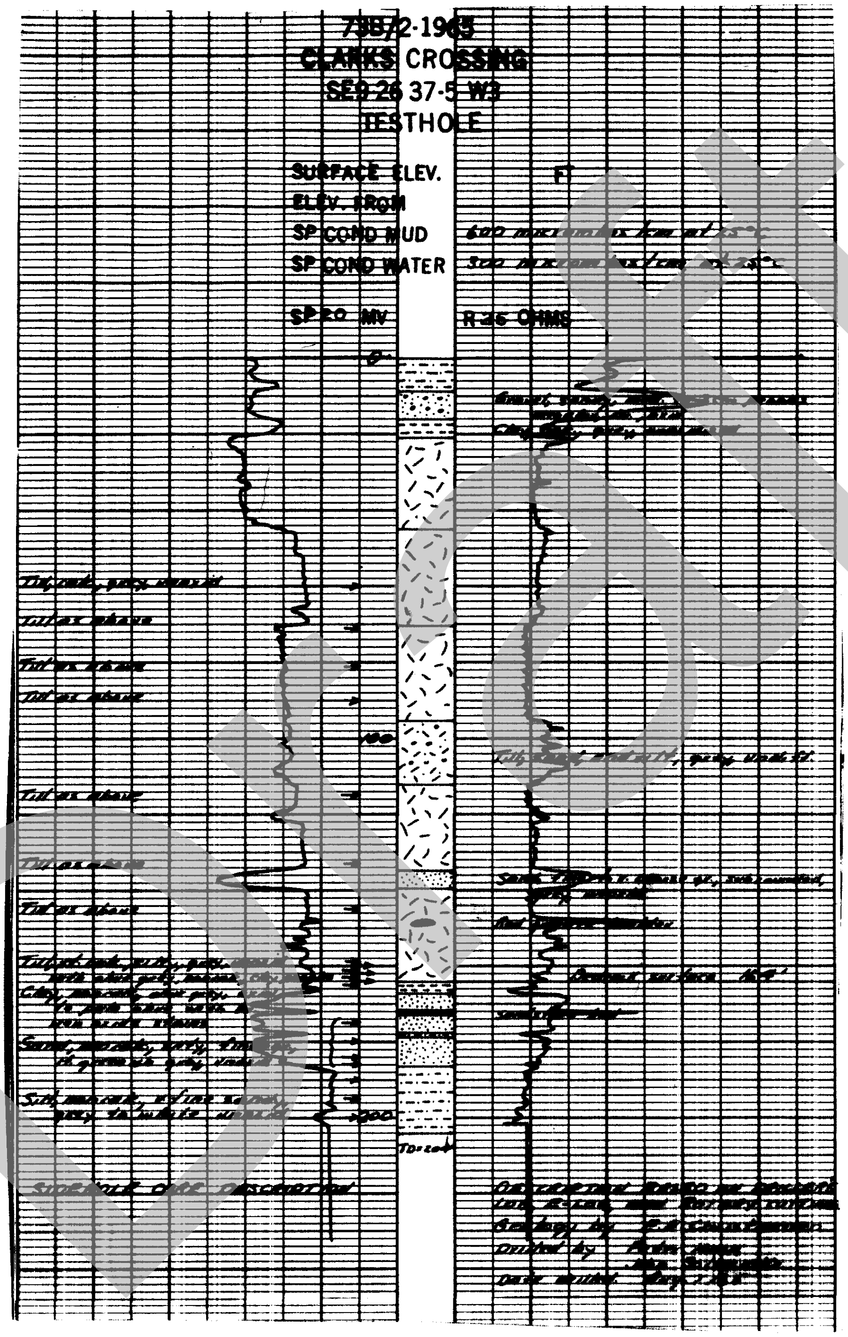
SRC 73B/2 1972
SUTHERLAND
NE8-25-37-5-W3
TESTHOLE

ELK POINT DRILLING LTD
EDMONTON, ALTA.
NORTH BATTLEFORD, SASK.

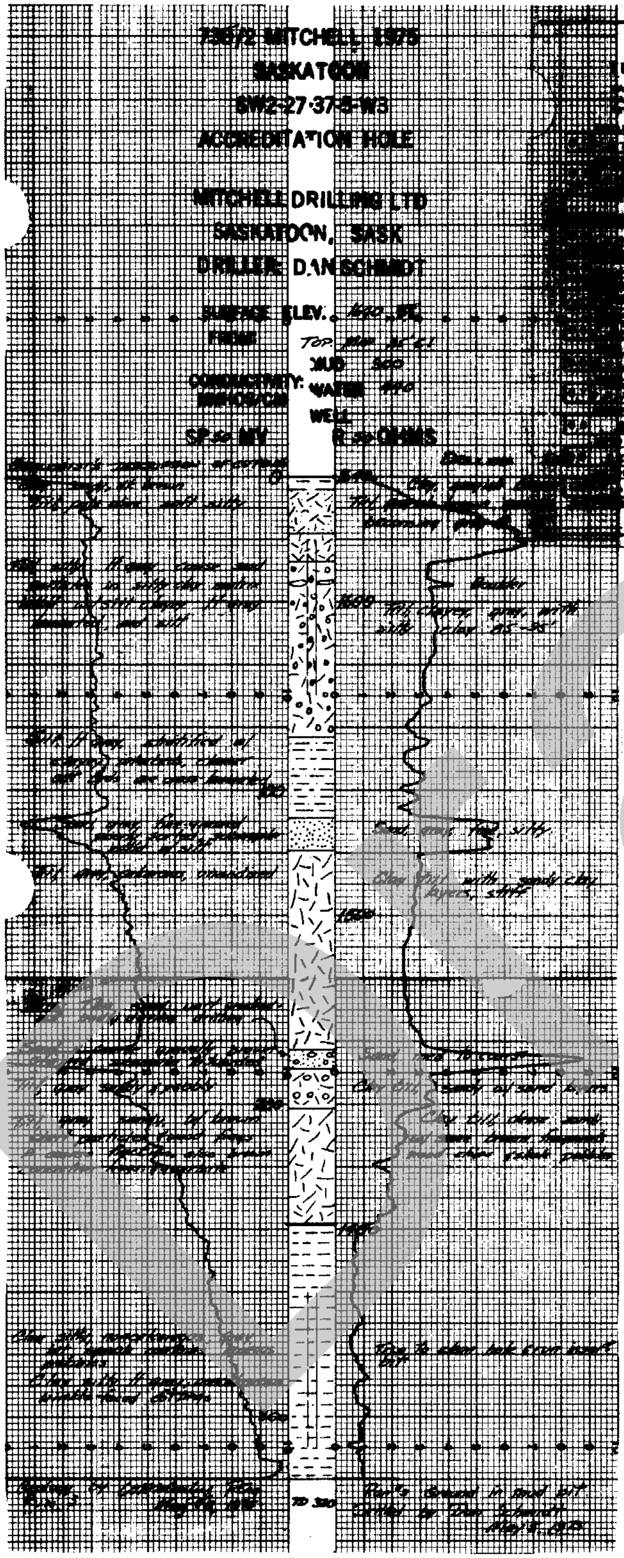
DRILLERS: PETER MAIK
JOHN SOLONINKO

SURFACE ELEV. 1610 FT
ELEV. FROM Top. map 10' C.I.
SP COND MUD 1150 micromhos/cm
SP COND WATER 450
SP 10 MV R 10 OHMS




73B/2-1965
CLARKS CROSSING
SE9-26-37-5-W3
TESTHOLE
SURFACE ELEV.
FT
ELEV. FROM
SP COND MUD
600 micromhos/cm at 25°C
SP COND WATER
300 micromhos/cm at 25°C
SP 20 MV
R 25 OHMS
0
100
200
TD=206
Till, as above
Till as above
Till as above
Till as above
Till as above
Till as above
Sidehole core description
Drilled by
Date drilled

1519



ELECTRIC LOG

EST DRILLING ASSISTANCE PROGRAM

MILY FARM IMPROVEMENT BRANCH
SKATCHEWAN DEPARTMENT OF AGRICULTURE
18 WINNIPEG STREET, REGINA. PH. 527-0656

ACQUISITION NO.
GROUP NO. 0000

ING CONTRACTOR : COMPANY NAME: TCHELL DRILLING LTD
ACTOR'S TELEPHONE NUMBER: DIAL NO. 242-9964 OR RURAL NO. R
CONTRACTOR'S ADDRESS: 206 BIRKS BLDG
CONTRACTOR'S ADDRESS: SASKATOON SASK
CONTRACTOR OR REPRESENTATIVE: DAY MONTH YEAR
ILY FARM IMPROVEMENT BRANCH
DIAL NO. 527-0656 OR RURAL NO. R
OWNER'S ADDRESS: 1318 WINNIPEG ST
OWNER'S ADDRESS: REGINA SASK
DAY 5 MONTH 5 YEAR 75
OLE MUNICIPAL LAND LOCATION: SEC 27 - TP 37 - RGE 5 - MER W3
RURAL MUNICIPALITY (RM) OR LOCAL IMPROVEMENT DISTRICT (LID) OR INDIAN RESERVATION (IR)? CHECK ONE: RM ☑ OR LID ☐ OR IR ☐ NO. 344
ER'S NAME: NAME LAST NAME SCHMIDT
DATE TESTHOLE COMPLETED: DAY 5 / MONTH 5 / YEAR 75
ER OPERATOR'S NAME: NAME LAST NAME SCHMIDT
DATE TESTHOLE LOGGED: DAY 5 / MONTH 5 / YEAR 75

Number For Each Month

01 JAN	05 MAY	09 SEP
02 FEB	06 JUN	10 OCT
03 MAR	07 JUL	11 NOV
04 APR	08 AUG	12 DEC

CTIVITY: DRILLING FLUID: 00 µmhos/cm at 25°C
CONDUCTIVITY: DRILLING WATER: 440 µmhos/cm at 25°C
TRADE NAME OF LOGGER: NELTRONIC
DRILLED: 0. feet
DEPTH LOGGED: 320. feet
TYPE OR MODEL OF LOGGER: KPD0899
IAMETER: inches
SERIAL NO. OF LOGGER: AS0101
ACCREDITATION DATE: DAY 5 / MONTH 5 / YEAR 75

LOG SCALES
ONTANEOUS POTENTIAL: 50 millivolts/inch
SINGLE-POINT RESISTANCE: 50 ohms/inch

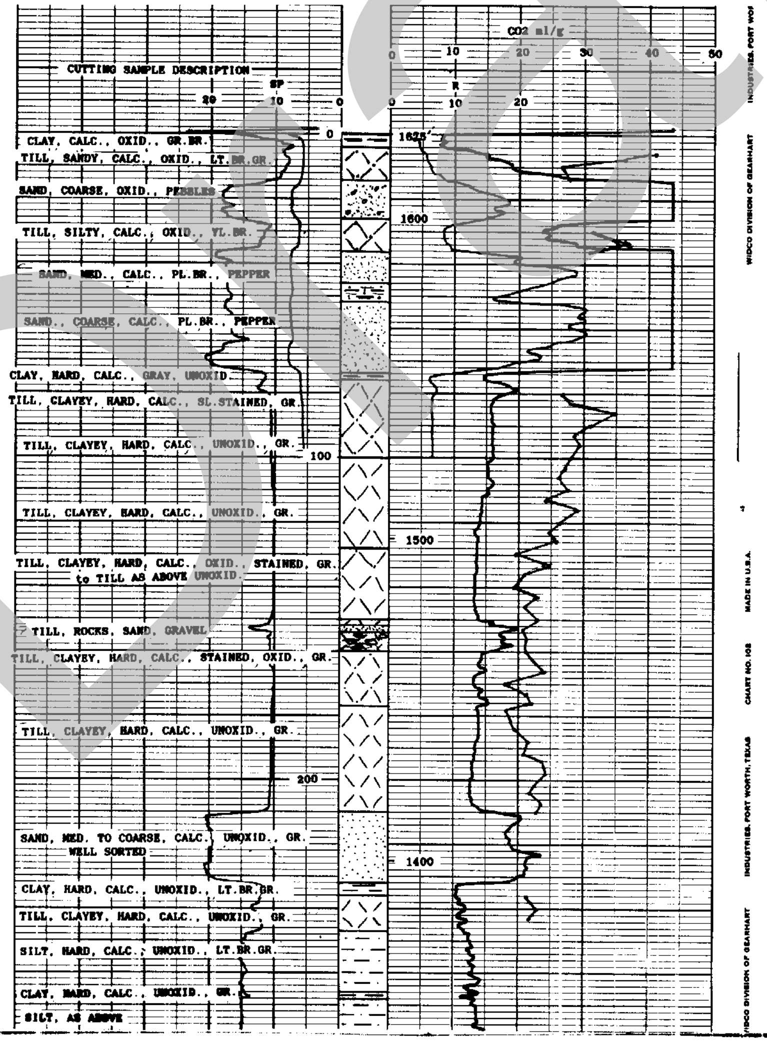
Saskatchewan Research Council 73-B/2 1987
Wanuskewin
NE-3-36-37-5-W3
13:3913250E/57862500N
TESTHOLE - Plastic Cased

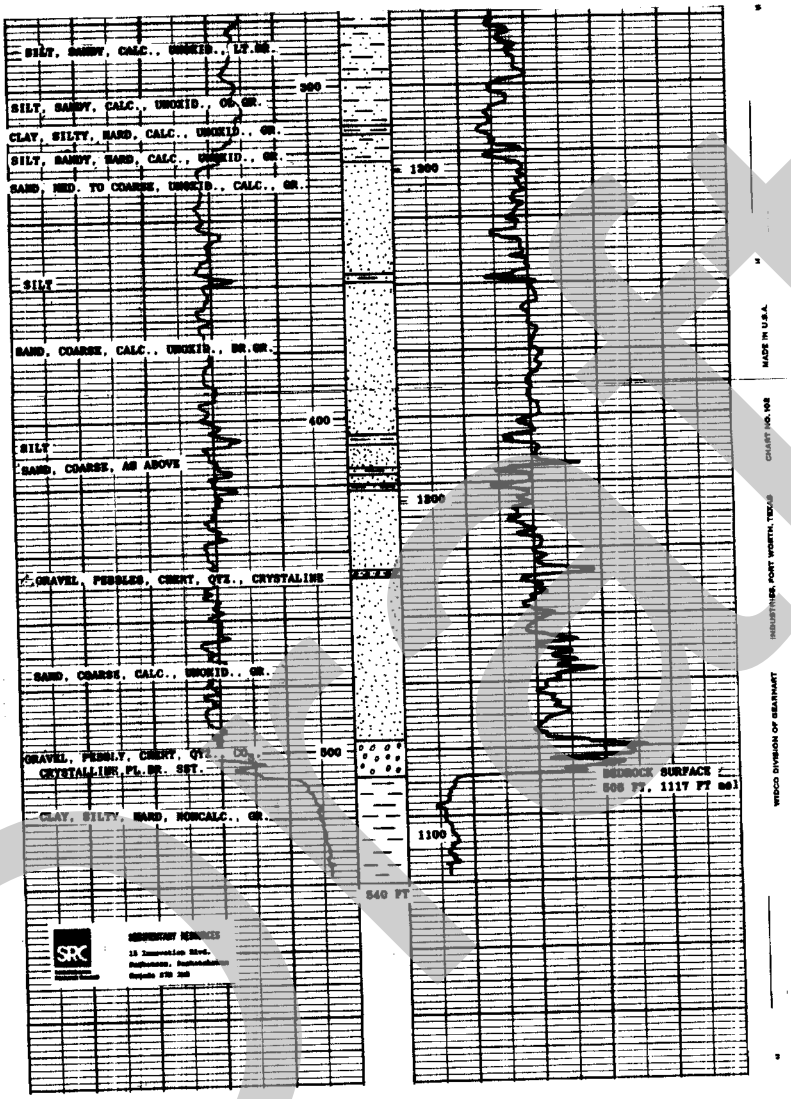
BOREHOLE NO. Wanuskewin NTS 73B/2
LAND LOCATION NE-3-36-37-5-W3
UTM COORD. 13:391625E/5786675N
GRD. ELEV. 1625 DEPTH 520 ft.
DATE DRILLED 25/09 TO 26/09, 1987
COND. WATER 900 MICROSIEMENS/CM AT 25° C
COND. MUD 675 MICROSIEMENS/CM AT 25° C
SPECIFIC GRAVITY MUD
SUPERVISOR B. Schreiner
ASS'T SUPERVISOR M. Millard
LOGGED BY B. Schreiner
INSTRUMENT WIDCO 2000
PROBE ELECTRIC
PROBE GAMMA
PROBE CALIPER
DATE LOGGED 26/09, 1987
TIME OF LOGGING 4:00 p.m. TO 5:00 p.m.
DRILL OPERATOR John Renault
CONTRACTOR Elk Point Drilling Corp.
REMARKS

PROJECT Wanuskewin Site
CUTTING SAMPLE INTERVAL 3 ft.
CORE SAMPLE INTERVAL
FROM
CASING DEPTH 540' 3' above ground
CASING WALL THICKNESS 2" PVC
WATER OR MUD LEVEL
ABANDONMENT Cased hole - backfilled
BIT SIZE 4 7/8 in. INTERVAL
BIT SIZE INTERVAL
BIT SIZE INTERVAL
TYPE OF DRILL RIG

	DEPTH	SCALE	SPEED
SP.	535 ft.	10	
RES.	535 ft.	10	
GAMMA			
CAL.			

GAMMA TIME CONSTANT (T.C.) SECONDS
GEOLOGY BY B.T. Schreiner 18/03/88

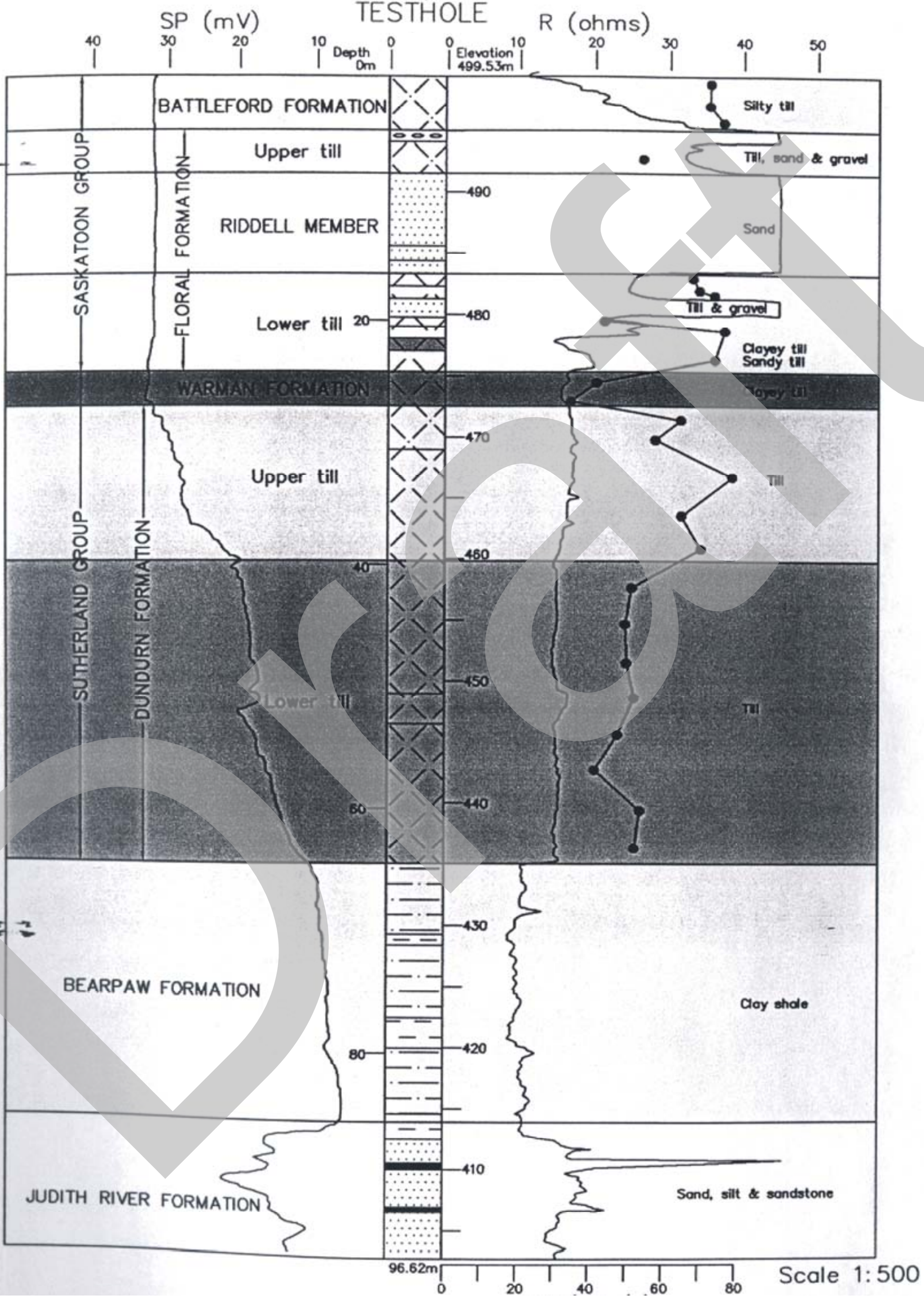




SRC Wanuskewin

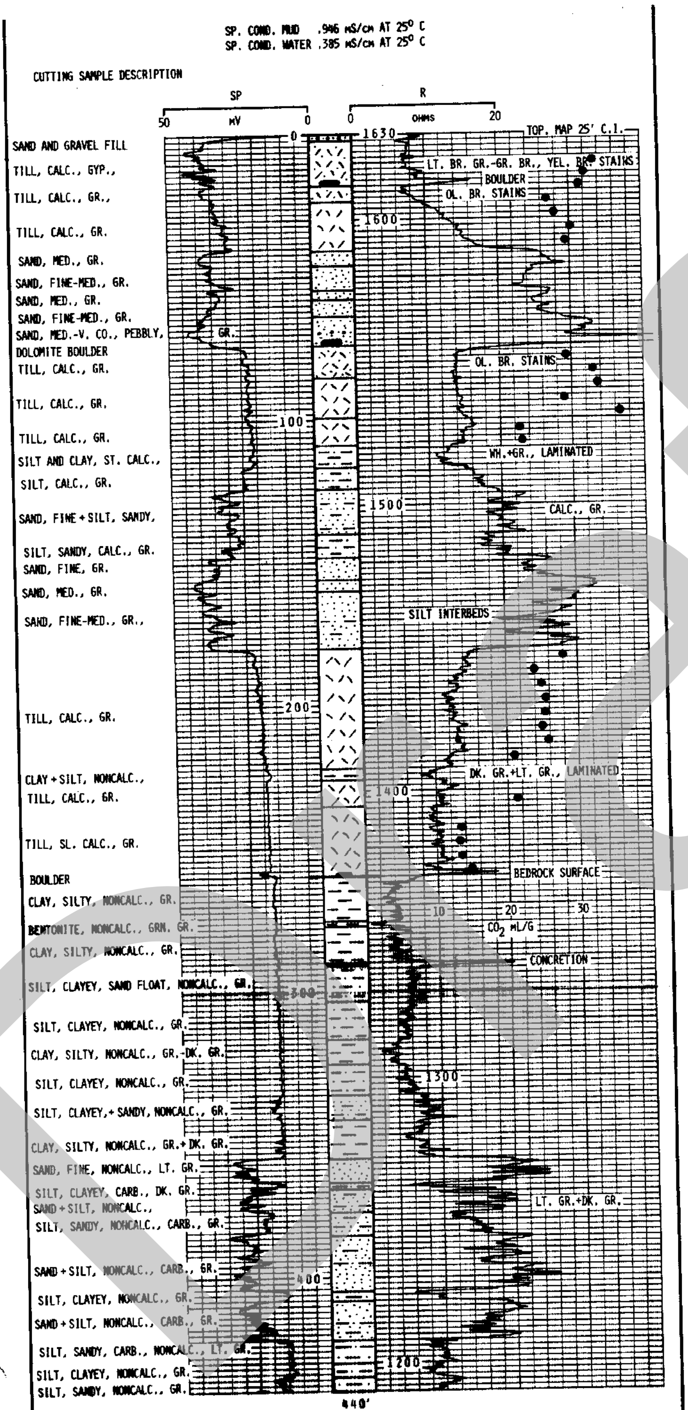
NE 3-36-37-SW3

SPC 73B/02 1997
Saskatoon SH-06
NE-13-23-37-05-W3
13: 389431E/5784397N
TESTHOLE



2919

SWC 73-B/02 1991
SASK PLACE NO.01
SE-02-20-37-05-W3
13:385250E/5783050N
TESTHOLE



ELECTRIC LOG BY
RAY JUROSKA
MINERAL LOGGING SYSTEMS INC.
JUNE 3, 1991

DRILLED BY
[illegible] HAWTER
HAWTER DRILLING LTD.
JUNE 3, 1991

GEOLOGY BY
E.A. CHRISTIANSEN
E.A. CHRISTIANSEN CONSULTING LTD.
JUNE 4, 1991

APPENDIX C

Borehole Logs and Piezometer Completion Details

TESTHOLE M442-01
CITY OF SASKATOON/UMA
2004

5785460.51 N 390041.40 E
NAD 83 ZONE 13
NW7-26-37-5-W3
73 B/2

TOPSOIL: silty, organic rich, br–blk, soft, roots

SILT TILL: sandy, trace gravel, trace clay, light ol. br. (2.5Y5/3), ox., soft–v.soft, low plast., calc., salts, roots
– at 3.0m limestone boulder, sand and gravel seam

SILT TILL: sandy, some gravel, trace clay, lt. yllw. br. (2.5Y6/3), ox., firm, low plast., calc., patchy Fe staining, salts

SAND TILL: silty, trace gravel, trace clay, lt. ol. br. (2.5Y5/3), ox., firm, low plast., calc., mottled sand and silt laminations, salts, transitional to below

SAND(f–m): trace silt–some silt, ox., poorly graded, wood chips and fragments (Fe stained), sporadic gravel clasts (ang.–subang.), silty bedding, stratified, occ. bone? or shell fragments

SAND(F): silty, trace gravel, (ang., predom. carb lithos), ox., gap graded, dropstones, Fe stained clayey bedding

SAND TILL: gravelly, some silt, lt. yllw. br. (2.5Y6/4), ox., firm, low plast., calc., patchy Fe staining, transitional to below

SILT TILL: sandy, some gravel, trace clay, lt. ol. br. (2.5Y5/4), ox., med. plast., firm, calc., st. Fe & Mn staining

SILT TILL: sandy, some clay, trace gravel, gr. (5Y5/1). unox., med. plast., calc., minor patchy Fe stains

SAND(F–C): some gravel (carbonate and igneous lithos, subang.), ox., well graded

GRAVEL: (ang.–subang., shield and carb lithos), sandy (m–c), well graded, unox., till clasts

SILT TILL: clayey, sandy, trace gravel, gr. (5Y5/1), unox., firm–stiff, med. plast., weakly calc., massive
– at 27.4m stiff, weakly calc.

GRAVEL: (sbrnd.–subang., shield and carb lithos), some sand (coarse), unox., poorly graded

SILT TILL: clayey, some sand, trace gravel, gr. (5Y5/1), unox., stiff, med. plast., calc., massive
– at 30.5m sporadic cobbles
– at 32.0m v.stiff
– at 35.7m gravel layer (as per driller)

SILT TILL: clayey, some sand, trace gravel, drk. gr. (5Y4/1) to gr. (5Y5/1), unox., stiff–v.stiff, massive
– at 62.2m to 62.5m limestone boulder
– at 62.5m to 67.1m sporadic shale nodules

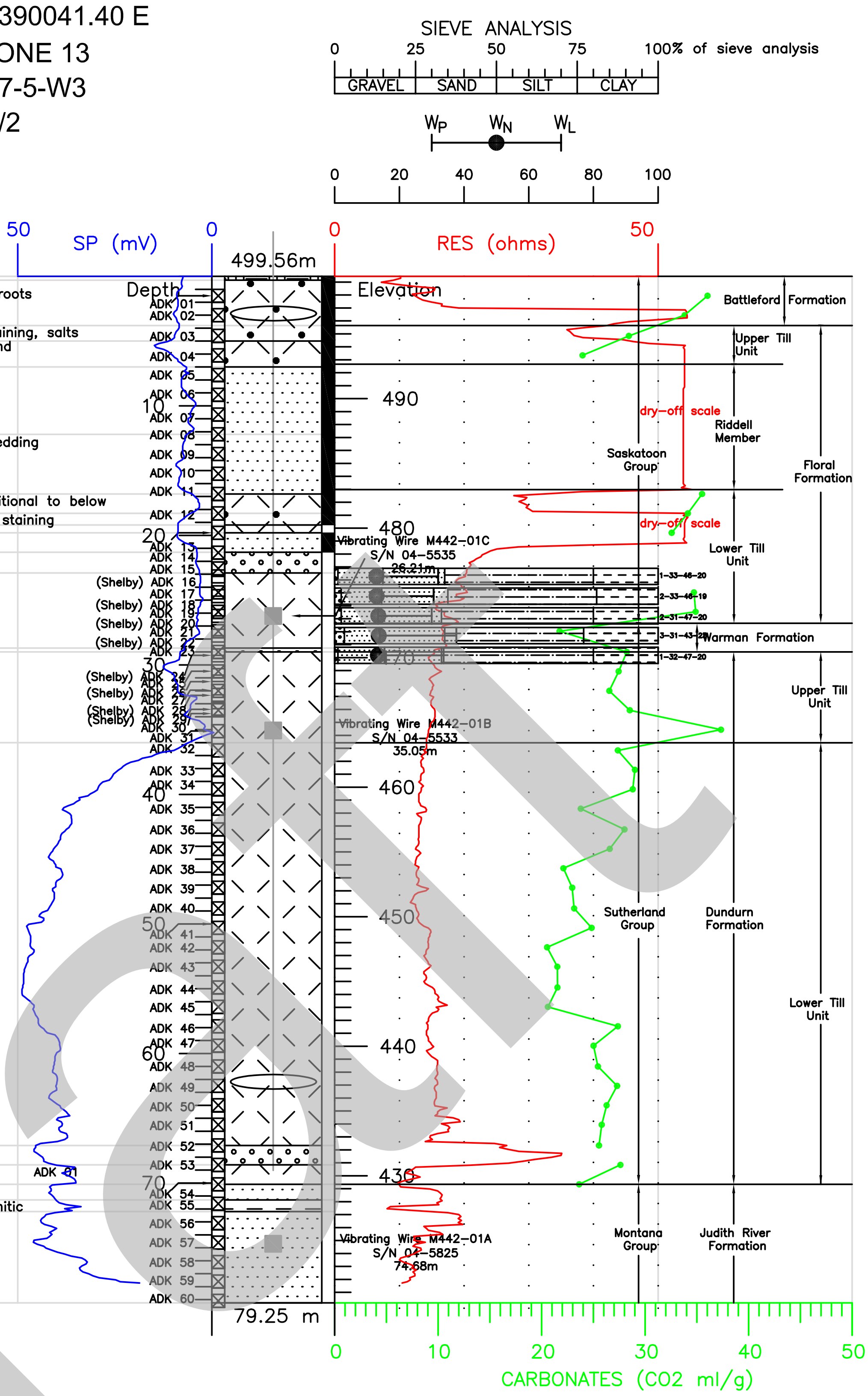
GRAVEL: (subang.–ang, shield and carb lithos), sandy (m–c), unox., well graded

SILT TILL: clayey, trace–some sand, gr (5Y5/1), unox., v.stiff, med. plast., clac., massive

SAND(F): silty, or (5Y5/1), unox., poorly graded, non–calc.

CLAY SHALE: some silt, grey (5Y6/1), unox., firm–soft, high plast., non. calc., mottled appearance, bentonitic

SAND(F): silty, trace clay, grey (5Y6/1), poorly graded, non. calc., carbonaceous, clayey beds



NOTE: For Vibrating Wire Completion Details see Drawings VW–M442–01A_01B_01C

LIMITATION

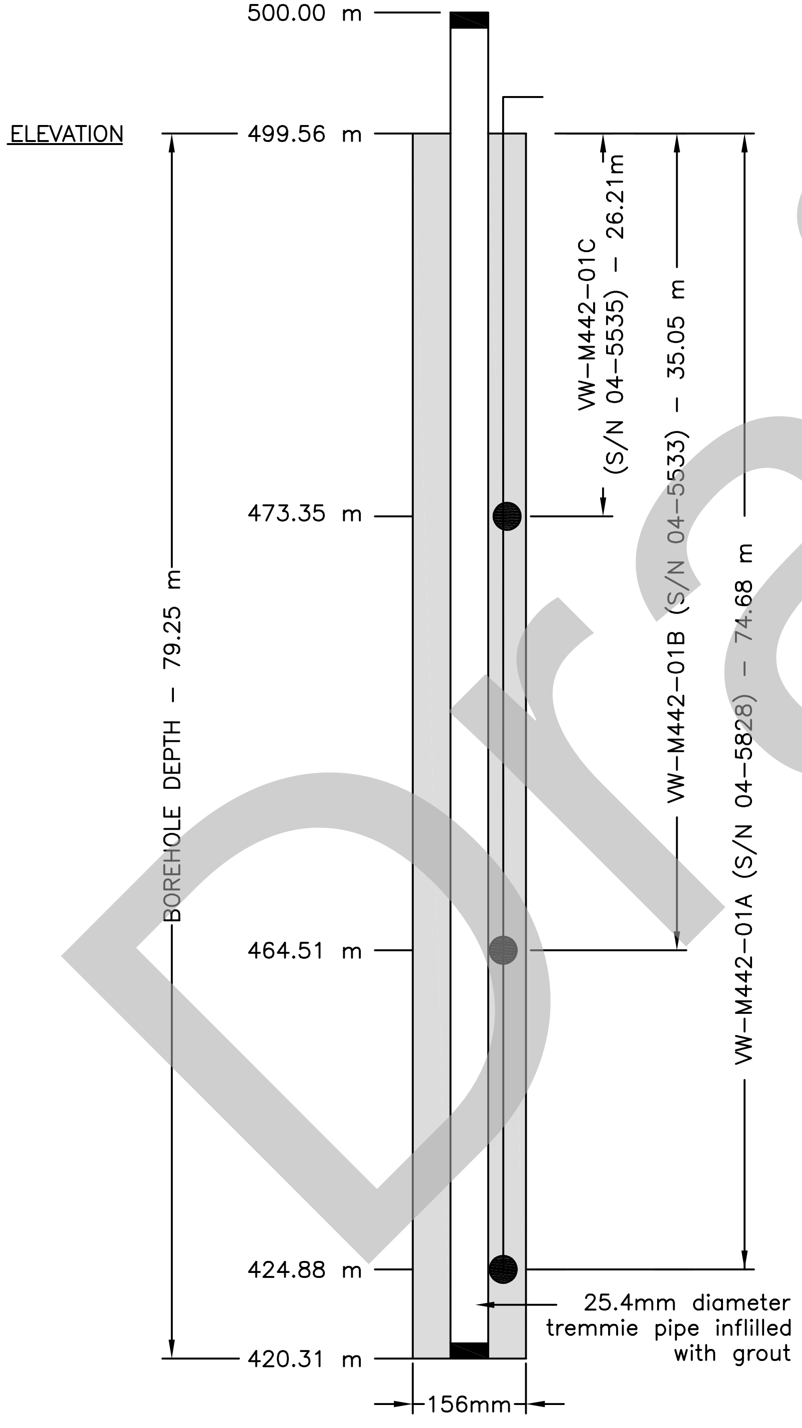
This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

SUPERVISOR: A. KARVONEN, P.Eng., P.Geo.	**COND. WATER:** 650 µsiemens/cm	**CUTTING SAMPLE INTERVAL:** 1.5m	**CLIENT:** uma
DATE DRILLED: 08 JUN 04	**COND. MUD:** 990	**TYPE OF DRILL RIG:** FAILING 1250	MDH ENGINEERED SOLUTIONS
DRILL OPERATOR: L. GLASS	**DENSITY:**	**TYPE OF LOGGER:** WIDCO	**APPROVED BY:** A. KARVONEN, P.Eng., P.Geo.
CONTRACTOR: STAUBER DRILLING	**ABANDONMENT:** AQUAGUARD	**GAMMA** T.C.N/ASECONDS	**DRAWN BY:** S. DESAUTELS
LOGGED BY: A. KARVONEN, P.Eng., P.Geo.	**BIT SIZE:** 158.7mm **INTERVAL:** 0m–44.2m	**LOGGING SPEED:** GAMMA: N/A	**PROJECT No.** M442–350003
GEOLOGY BY: A. KARVONEN, P.Eng., P.Geo.	**BIT SIZE:** 130.2mm **INTERVAL:** 44.2m–79.2m	RES: 4.6m/min	**DATE:** 18–JUN–04 **SCALE:** 1:500

ACADDWG:\\Projects\UMA\M442\Testholes\TH–M442–01.dwg

VIBRATING WIRES VW-M442-01A, 01B, 01C
CITY OF SASKATOON/UMA

5784560.51 N 390041.40 E
NAD 83 ZONE 13
NW 7-26-37-5-W3
73B/2



PIEZOMETER
– Geokon vibrating wires

GROUT SPECIFICATIONS:
– Aquaguard
– 22.7kg of Aquaguard into 53 liters of water–30% active solids slurry

NOTES:
- bag of 12/20 Unimin filter sand surrounding each vibrating wire piezometer
- vibrating wire piezometers were attached to a 1" diameter PVC casing to ensure proper installation depth
- 1" PVC casing was utilized at a tremmie pipe for the Aquaguard
- grount return obtained at surface

VW–M442–01A:
- short length wire
- piezometer type 4500S–1MPa

VW–M442–01B:
- medium length wire
- piezometer type 4500S–700kPa

VW–M442–01C:
- long length wire
- piezometer type 4500S–750kPa

NOTES: All depths are expressed in metres above or below natural ground surface, unless otherwise indicated. All elevations are expressed in metres above sea level.

CLIENT	uma				
PRODUCED BY:	MDH ENGINEERED SOLUTIONS				
DRILL OPERATOR:	L. GLASS				
CONTRACTOR:	STAUBER DRILLING	**APPROVED BY:**	A. KARVONEN, P.Eng, P.Geo.		
TYPE OF DRILL RIG:	FAILING 1250	**DRAWN BY:**	L. BELL		
SUPERVISOR:	A. KARVONEN, P.Eng, P.Geo.	**PROJECT No.**	M442–350003		
DATE INSTALLED:	09–JUN–04	**DATE:**	30–JUN–04	**SCALE:**	NTS

ACADDWG:\\Ultimatewarrior\Projects\UMA\M442\Testholes\VW–M442–01A_01B_01C

TESTHOLE M442-02
CITY OF SASKATOON/UMA
2004

5785163.33 N 390390.73 E
NAD 83 ZONE 13
SW 8- 26-37-5-W3
73B/2

TOPSOIL: sandy, organic rich, black–dark grey, v.soft, calc., roots
– at 0.9m limestone boulder (0.3m in diameter)

SILT TILL: sandy, some clay, trace gravel, lt. ol. br., (2.5Y5/3), ox., firm, med. plast., calc., Fe staining, fractured?

SAND (F–c): some gravel (subrounded, shield and carb. lithos), ox., well graded, Fe stained

SILT TILL: some sand, some clay, trace gravel, gr. (5Y5/1), unox., firm, med. plast., calc., massive

CLAY TILL: silty, trace sand, gr., (5Y5/1), unox., stiff, med. plast. to high plasticity, weakly calc., massive

CLAY TILL: silty, trace sand, trace gravel, gr. (5Y5/1), unox., stiff, med. plast., weakly calc., salts (gypsum)
–at 13.7m stiff
–from 15.2m–19.2m infrequent cobbles
–at 19.2m limestone boulder

GRAVEL: (ang–subang., shield and carb lithos.), some sand (m–c), unox., well graded

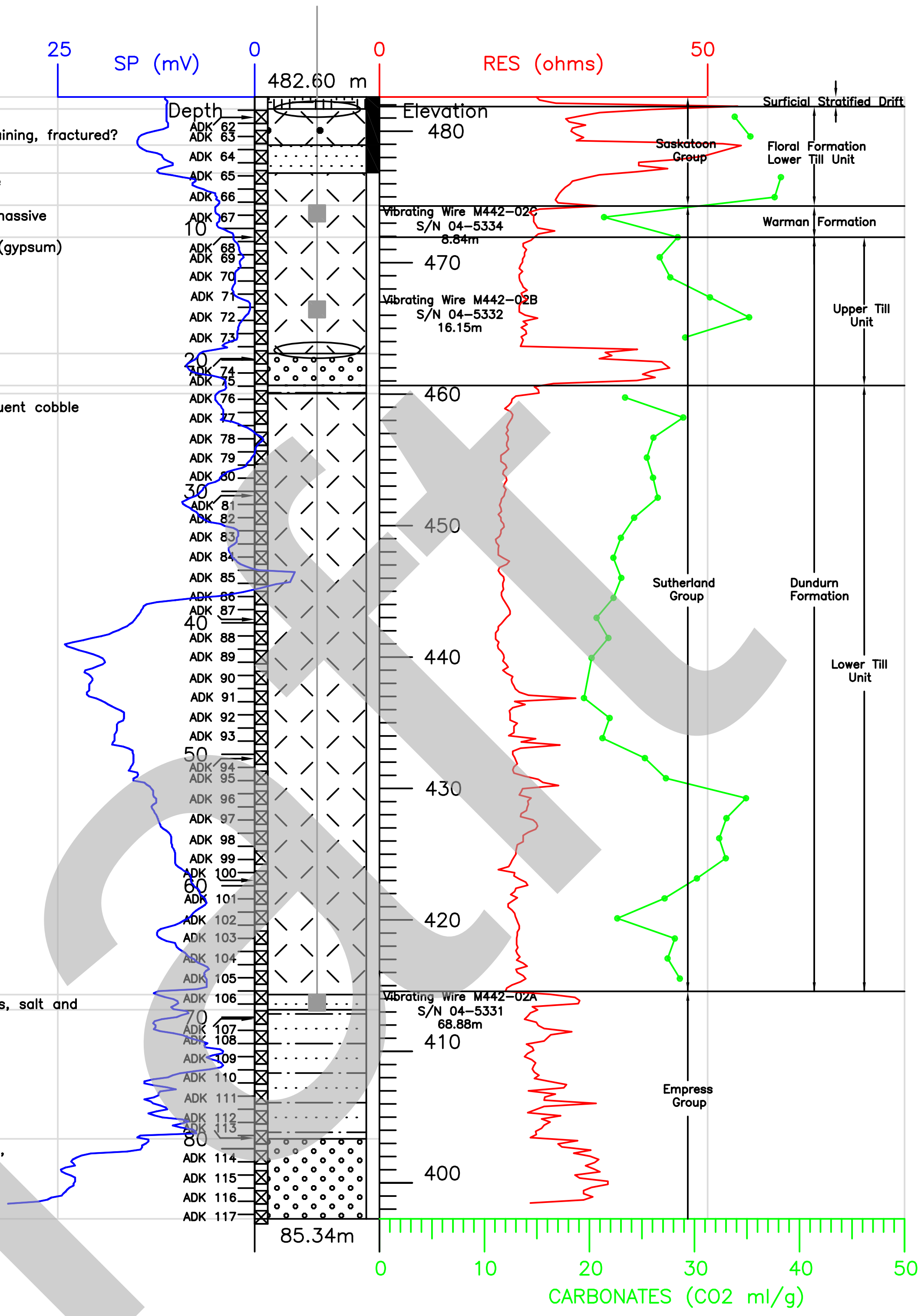
SILT: some fine sand, gr (5y5/1), unox., calc.

CLAY TILL: silty, some–trace sand, gr. (5Y5/1), unox., stiff, med–high plast., calc., massive, infrequent cobble and gravel clasts, infrequent shale clasts
–at 45.7m stiff–hard, cobbly and bouldery

SAND (F–m): silty, unox., bedded, coarse sand and rounded gravel clasts, poorly graded, calcareous, salt and pepper appearance, organic rich

FINE SAND AND SILT (INTERBEDDED): unox., poorly graded, organic rich

GRAVEL: fine, (rounded–subrounded shield and carbonate lithos), sandy (m–c), unox., poorly graded, strongly calcareous



NOTE: –Did not reach bedrock marker as a result of budgetory constraints
–For Vibrating Wire Completion Details see Drawings VW–M442–02A_02B_02C

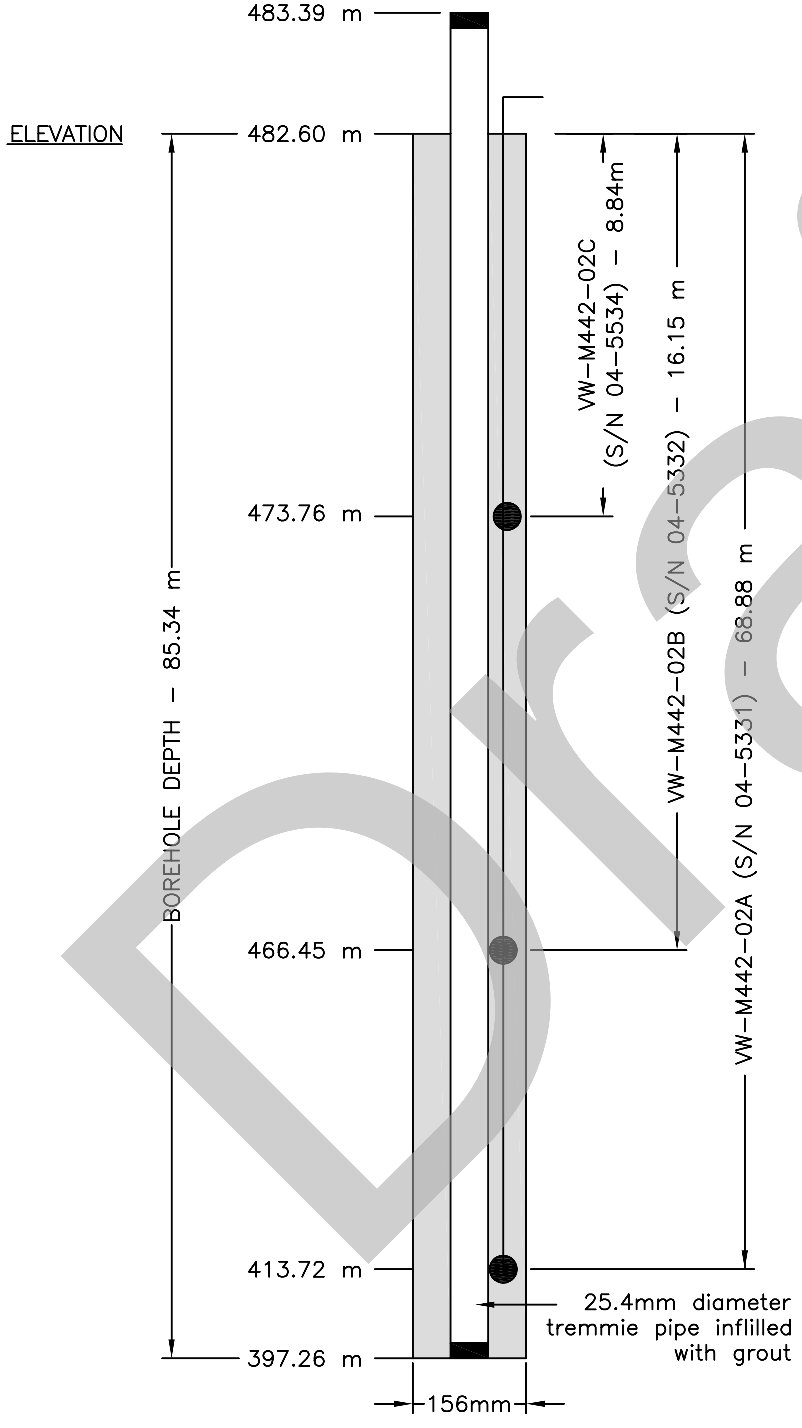
This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

SUPERVISOR: A. KARVONEN, P.Eng., P.Geo.	COND. WATER: 403 µsiemens/cm	CUTTING SAMPLE INTERVAL: 1.5m	CLIENT:
DATE DRILLED: 10–JUN–04	COND. MUD: 968	TYPE OF DRILL RIG: FAILING 1250	
DRILL OPERATOR: L. GLASS	DENSITY:	TYPE OF LOGGER: WIDCO	APPROVED BY: A. KARVONEN, P. Eng., P. Geo.
CONTRACTOR: STAUBER DRILLING	ABANDONMENT: AQUAGUARD	GAMMA T.C.N/ASECONDS	DRAWN BY: S. DESAUTELS
LOGGED BY: A. KARVONEN, P.Eng., P.Geo.	BIT SIZE: 158.7mm INTERVAL: 0m–24.4m	LOGGING SPEED: GAMMA: N/A	PROJECT No. M442–350003
GEOLOGY BY: A. KARVONEN, P.Eng., P.Geo.	BIT SIZE: 130.2mm INTERVAL: 24.4m–85.3m	RES: 4.6m/min	DATE: 18–JUN–04 SCALE: 1:500

ACADDWG:\\Projects\UMA\M442\Testholes\TH–M442–02.dwg

VIBRATING WIRES VW-M442-02A, 02B, 02C
CITY OF SASKATOON/UMA

5785163.33 N 390390.73 E
NAD 83 ZONE 13
SW 8-26-37-5-W3
73B/2



PIEZOMETER
- Geokon vibrating wires

GROUT SPECIFICATIONS:
- Aquaguard
- 22.7 kg of Aquaguard into 53 liters of water–30% active solids slurry

NOTES:
- bag of 12/20 Unimin filter sand surrounding each vibrating wire piezometer
- vibrating wire piezometers were attached to a 1" diameter PVC casing to ensure proper installation depth
- 1" PVC casing was utilized at a tremmie pipe for the Aquaguard
- grount return obtained at surface

VW–M442–02A:
- short length wire
- piezometer type 4500S–700kPa

VW–M442–02B:
- medium length wire
- piezometer type 4500S–700kPa

VW–M442–02C:
- long length wire
- piezometer type 4500S–700kPa

NOTES: All depths are expressed in metres above or below natural ground surface, unless otherwise indicated. All elevations are expressed in metres above sea level.

DRILL OPERATOR:	L. GLASS
CONTRACTOR:	STAUBER DRILLING
TYPE OF DRILL RIG:	FAILING 1250
SUPERVISOR:	A. KARVONEN, P.Eng, P.Geo.
DATE INSTALLED:	11–JUN–04

CLIENT	uma		
PRODUCED BY:	MDH ENGINEERED SOLUTIONS		
APPROVED BY:	A. KARVONEN, P.Eng, P.Geo.		
DRAWN BY:	L. BELL		
PROJECT No.	M442–350003		
DATE:	30–JUN–04	**SCALE:**	NTS

ACADDWG:\\Ultimatewarrior\Projects\UMA\M442\Testholes\VW–M442–02A_02B_02C

APPENDIX D

Vibrating Wire Calibration Reports and Piezometer Readings

Borehole Number	Date Drilled	Borehole Depth (m)	Piezometer Number	Serial Number	Installation Type	Completion Horizon	UTM Location (NAD 83)		Tip Depth (m)	Elevation (masl)		Status
							Easting	Northing		Ground	Tip	
M442-01	8-Jun-04	79.25	M442-01A	04-5828	4500S (700 kPa)	Judith River Fm.	390041.40	5785460.51	74.68	499.56	424.88	Active
			M442-01B	04-5533	4500S (700 kPa)	Floral Fm. till	390041.40	5785460.51	35.05	499.56	464.51	Active
			M442-01C	04-5535	4500S (700 kPa)	Dundurn Fm. Till	390041.40	5785460.51	26.21	499.56	473.35	Active
M442-02	10-Jun-04	85.34	M442-02A	04-5331	4500S (1 MPa)	Empress Group	390390.73	5785163.33	68.88	482.60	413.72	Active
			M442-02B	04-5332	4500S (700 kPa)	Floral Fm till	390390.73	5785163.33	16.15	482.60	466.45	Active
			M442-02C	04-5334	4500S (700 kPa)	Dundurn Fm. Till	390390.73	5785163.33	8.84	482.60	473.76	Active

Vibrating Wire Pressure Transducer Data

Project Number (installation project number):	**M442**
Location:	**Proposed Saskatoon North Bridge Crossing**
Installation Identification:	**M442-01A**
Serial Number:	04-5828
Surface Elevation:	499.56 m
Installation Depth:	74.68 m
Installation Depth:	245.0 ft
Tip (Installation) Elevation:	424.88 m
Factory Elevation	**177.0** masl
Elev. Diff. From Factory Zero	813.0 ft
Elevation Correction Factor (E)	0.407 psi
Linear Calibration Factor (G):	**0.036** psi / B unit
Temperature Calibration Factor (K):	**0.02233** psi / °C rise
Factory Zero Reading (Ro):	**8624**
Factory Temperature (To):	**26.3** °C
Factory Pressure (So):	**992.8** mbar
Factory Pressure (So):	99.28 kPa
Polynomial Gage Factor (A):	**-1.38E-07**
Polynomial Gage Factor (B):	**-0.03418**
Polynomial Gage Factor (C):	**304.7**

Vibrating Wire Data					Linear Calibration			
Date	**Geokon Data**	**Reading (Hz^2)**	**Temp. (°C)**	**Barom. P (kPa)**	**Pressure (psi)**	**Pressure (kPa)**	**h_p (m)**	**Total Head (m)**
24-Jun-2004	2508.55	6292.81	5.63	101	83.62	584.00	59.53	484.41
24-Jun-2004	2508.50	6292.56	5.60	101	83.63	584.05	59.54	484.42
24-Jun-2004	2508.49	6292.53	5.68	101	83.63	584.07	59.54	484.42
24-Jun-2004	2508.49	6292.50	5.57	101	83.63	584.07	59.54	484.42
24-Jun-2004	2508.49	6292.53	5.57	101	83.63	584.06	59.54	484.42
24-Jun-2004	2508.48	6292.47	5.60	101	83.63	584.08	59.54	484.42
24-Jun-2004	2508.49	6292.50	5.65	101	83.63	584.08	59.54	484.42
29-Jul-2004	2509.68	6298.50	5.64	101	83.41	582.57	59.39	484.27
29-Jul-2004	2509.68	6298.50	5.60	101	83.41	582.56	59.38	484.26
29-Jul-2004	2509.68	6298.47	5.62	101	83.42	582.57	59.39	484.27
29-Jul-2004	2509.70	6298.59	5.60	101	83.41	582.54	59.38	484.26
29-Jul-2004	2509.69	6298.53	5.59	101	83.41	582.55	59.38	484.26
29-Jul-2004	2509.68	6298.50	5.59	101	83.41	582.56	59.38	484.26
29-Jul-2004	2509.68	6298.47	5.66	101	83.42	582.58	59.39	484.27
29-Jul-2004	2509.69	6298.53	5.62	101	83.41	582.56	59.38	484.26
29-Jul-2004	2509.69	6298.56	5.64	101	83.41	582.55	59.38	484.26

Vibrating Wire Pressure Transducer Data

Project Number (installation project number):	**M442**	
Location:	**Proposed Saskatoon North Bridge Crossing**	
Installation Identification:	**M442-01B**	
Serial Number:	04-5533	
Surface Elevation:	499.56	m
Installation Depth:	35.05	m
Installation Depth:	115.0	ft
Tip (Installation) Elevation:	464.51	m
Factory Elevation	**177.0**	masl
Elev. Diff. From Factory Zero	943.0	ft
Elevation Correction Factor (E)	0.472	psi
Linear Calibration Factor (G):	**0.02158**	psi / B unit
Temperature Calibration Factor (K):	**-0.00837**	psi / °C rise
Factory Zero Reading (Ro):	**8662**	
Factory Temperature (To):	**25.8**	°C
Factory Pressure (So):	**992.8**	mbar
Factory Pressure (So):	99.28	kPa
Polynomial Gage Factor (A):	**-5.12E-08**	
Polynomial Gage Factor (B):	**-0.02094**	
Polynomial Gage Factor (C):	**185.28**	

Vibrating Wire Data				
Date	**Geokon Data**	**Reading (Hz^2)**	**Temp. (°C)**	**Barom. P (kPa)**
24-Jun-2004	2796.80	7822.11	5.48	101
24-Jun-2004	2796.80	7822.07	5.33	101
24-Jun-2004	2796.80	7822.07	5.41	101
24-Jun-2004	2796.88	7822.55	5.31	101
24-Jun-2004	2796.80	7822.07	5.36	101
24-Jun-2004	2796.80	7822.11	5.38	101
24-Jun-2004	2796.79	7822.02	5.37	101
24-Jun-2004	2796.80	7822.11	5.39	101
24-Jun-2004	2796.79	7822.02	5.41	101
24-Jun-2004	2796.82	7822.20	5.40	101
24-Jun-2004	2796.80	7822.11	5.38	101
24-Jun-2004	2796.80	7822.11	5.42	101
29-Jul-2004	2799.57	7837.58	5.33	101
29-Jul-2004	2799.56	7837.54	5.30	101
29-Jul-2004	2799.57	7837.58	5.36	101
29-Jul-2004	2799.57	7837.58	5.32	101
29-Jul-2004	2799.65	7838.02	5.31	101
29-Jul-2004	2799.30	7836.09	5.30	101
29-Jul-2004	2799.57	7837.58	5.30	101
29-Jul-2004	2799.58	7837.63	5.29	101

Linear Calibration			
Pressure (psi)	**Pressure (kPa)**	**h_p (m)**	**Total Head (m)**
18.52	129.33	13.18	477.69
18.52	129.34	13.18	477.69
18.52	129.34	13.18	477.69
18.51	129.27	13.18	477.69
18.52	129.34	13.18	477.69
18.52	129.33	13.18	477.69
18.52	129.35	13.19	477.70
18.52	129.33	13.18	477.69
18.52	129.35	13.19	477.70
18.52	129.32	13.18	477.69
18.52	129.33	13.18	477.69
18.52	129.33	13.18	477.69
18.19	127.01	12.95	477.46
18.19	127.01	12.95	477.46
18.18	127.00	12.95	477.46
18.19	127.01	12.95	477.46
18.18	126.94	12.94	477.45
18.22	127.23	12.97	477.48
18.19	127.01	12.95	477.46
18.18	127.00	12.95	477.46

Vibrating Wire Pressure Transducer Data

Project Number (installation project number):	**M442**	
Location:	**Proposed Saskatoon North Bridge Crossing**	
Installation Identification:	**M442-01C**	
Serial Number:	04-5535	
Surface Elevation:	499.56	m
Installation Depth:	26.21	m
Installation Depth:	86.0	ft
Tip (Installation) Elevation:	473.35	m
Factory Elevation	**177.0**	masl
Elev. Diff. From Factory Zero	972.0	ft
Elevation Correction Factor (E)	0.486	psi
Linear Calibration Factor (G):	**0.02394**	psi / B unit
Temperature Calibration Factor (K):	**-0.00696**	psi / °C rise
Factory Zero Reading (Ro):	**8760**	
Factory Temperature (To):	**25.1**	°C
Factory Pressure (So):	**992.8**	mbar
Factory Pressure (So):	99.28	kPa
Polynomial Gage Factor (A):	**-9.22E-08**	
Polynomial Gage Factor (B):	**-0.02272**	
Polynomial Gage Factor (C):	**206.09**	

Vibrating Wire Data					Linear Calibration			
Date	Geokon Data	Reading (Hz^2)	Temp. (°C)	Barom. P (kPa)	Pressure (psi)	Pressure (kPa)	h_p (m)	Total Head (m)
24-Jun-2004	2923.36	8546.04	5.50	101	5.50	38.38	3.91	477.26
24-Jun-2004	2923.40	8546.29	5.44	101	5.49	38.35	3.91	477.26
24-Jun-2004	2923.39	8546.19	5.44	101	5.49	38.36	3.91	477.26
24-Jun-2004	2923.37	8546.09	5.44	101	5.50	38.38	3.91	477.26
24-Jun-2004	2923.37	8546.09	5.49	101	5.49	38.38	3.91	477.26
24-Jun-2004	2923.37	8546.09	5.46	101	5.50	38.38	3.91	477.26
24-Jun-2004	2923.34	8545.89	5.43	101	5.50	38.41	3.92	477.27
24-Jun-2004	2923.36	8546.04	5.45	101	5.50	38.39	3.91	477.26
24-Jun-2004	2923.39	8546.19	5.41	101	5.49	38.36	3.91	477.26
24-Jun-2004	2923.38	8546.14	5.39	101	5.49	38.37	3.91	477.26
24-Jun-2004	2923.36	8546.04	5.48	101	5.50	38.39	3.91	477.26
24-Jun-2004	2923.45	8546.54	5.51	101	5.48	38.30	3.90	477.25
24-Jun-2004	2923.36	8546.04	5.48	101	5.50	38.39	3.91	477.26
24-Jun-2004	2923.38	8546.14	5.48	101	5.49	38.37	3.91	477.26
24-Jun-2004	2923.37	8546.09	5.50	101	5.49	38.38	3.91	477.26
24-Jun-2004	2923.37	8546.09	5.49	101	5.49	38.38	3.91	477.26
24-Jun-2004	2923.39	8546.19	5.46	101	5.49	38.36	3.91	477.26
24-Jun-2004	2923.38	8546.14	5.49	101	5.49	38.37	3.91	477.26
24-Jun-2004	2923.39	8546.19	5.37	101	5.49	38.37	3.91	477.26
24-Jun-2004	2923.36	8546.04	5.45	101	5.50	38.39	3.91	477.26
24-Jun-2004	2923.38	8546.14	5.43	101	5.49	38.37	3.91	477.26
24-Jun-2004	2923.37	8546.09	5.49	101	5.49	38.38	3.91	477.26
24-Jun-2004	2923.33	8545.84	5.43	101	5.50	38.42	3.92	477.27
24-Jun-2004	2923.40	8546.24	5.41	101	5.49	38.36	3.91	477.26
29-Jul-2004	2926.40	8563.81	5.38	101	5.07	35.42	3.61	476.96
29-Jul-2004	2926.36	8563.61	5.36	101	5.08	35.45	3.61	476.96
29-Jul-2004	2926.36	8563.61	5.40	101	5.08	35.45	3.61	476.96

Vibrating Wire Pressure Transducer Data

Project Number (installation project number):	**M442**	
Location:	**Proposed Saskatoon North Bridge Crossing**	
Installation Identification:	**M442-02A**	
Serial Number:	04-5331	
Surface Elevation:	482.6	m
Installation Depth:	68.88	m
Installation Depth:	226.0	ft
Tip (Installation) Elevation:	413.72	m
Factory Elevation	**177.0**	masl
Elev. Diff. From Factory Zero	776.4	ft
Elevation Correction Factor (E)	0.388	psi
Linear Calibration Factor (G):	**0.02392**	psi / B unit
Temperature Calibration Factor (K):	**0.00535**	psi / °C rise
Factory Zero Reading (Ro):	**9029**	
Factory Temperature (To):	**25.4**	°C
Factory Pressure (So):	**992.8**	mbar
Factory Pressure (So):	99.28	kPa
Polynomial Gage Factor (A):	**-8.50E-08**	
Polynomial Gage Factor (B):	**-0.02274**	
Polynomial Gage Factor (C):	**212.29**	

Vibrating Wire Data				
Date	**Geokon Data**	**Reading (Hz^2)**	**Temp. (°C)**	**Barom. P (kPa)**
24-Jun-2004	2162.34	4675.69	5.56	101
24-Jun-2004	2162.34	4675.69	5.58	101
24-Jun-2004	2162.34	4675.69	5.54	101
24-Jun-2004	2162.33	4675.68	5.63	101
24-Jun-2004	2162.33	4675.68	5.65	101
24-Jun-2004	2162.34	4675.69	5.53	101
24-Jun-2004	2162.34	4675.69	5.57	101
24-Jun-2004	2162.34	4675.69	5.55	101
29-Jul-2004	2164.44	4684.80	5.58	101
29-Jul-2004	2164.43	4684.77	5.57	101
29-Jul-2004	2164.44	4684.79	5.57	101
29-Jul-2004	2164.44	4684.80	5.55	101
29-Jul-2004	2164.44	4684.79	5.60	101
29-Jul-2004	2164.44	4684.79	5.55	101
29-Jul-2004	2164.44	4684.79	5.61	101
29-Jul-2004	2164.44	4684.79	5.57	101
29-Jul-2004	2164.44	4684.79	5.62	101
29-Jul-2004	2164.44	4684.80	5.56	101
29-Jul-2004	2164.44	4684.79	5.61	101

Linear Calibration			
Pressure (psi)	**Pressure (kPa)**	**h_p (m)**	**Total Head (m)**
104.16	727.49	74.16	487.88
104.16	727.49	74.16	487.88
104.16	727.48	74.16	487.88
104.17	727.49	74.16	487.88
104.17	727.49	74.16	487.88
104.16	727.48	74.16	487.88
104.16	727.49	74.16	487.88
104.16	727.49	74.16	487.88
103.95	725.96	74.00	487.72
103.95	725.97	74.00	487.72
103.95	725.97	74.00	487.72
103.95	725.96	74.00	487.72
103.95	725.97	74.00	487.72
103.95	725.97	74.00	487.72
103.95	725.97	74.00	487.72
103.95	725.97	74.00	487.72
103.95	725.97	74.00	487.72
103.95	725.96	74.00	487.72
103.95	725.97	74.00	487.72

Vibrating Wire Pressure Transducer Data

Project Number (installation project number):	**M442**	
Location:	**Proposed Saskatoon North Bridge Crossing**	
Installation Identification:	**M442-02B**	
Serial Number:	04-5332	
Surface Elevation:	482.6	m
Installation Depth:	16.15	m
Installation Depth:	53.0	ft
Tip (Installation) Elevation:	466.45	m
Factory Elevation	**177.0**	masl
Elev. Diff. From Factory Zero	949.4	ft
Elevation Correction Factor (E)	0.475	psi
Linear Calibration Factor (G):	**0.02418**	psi / B unit
Temperature Calibration Factor (K):	**0.00297**	psi / °C rise
Factory Zero Reading (Ro):	**8773**	
Factory Temperature (To):	**25.4**	°C
Factory Pressure (So):	**992.8**	mbar
Factory Pressure (So):	99.28	kPa
Polynomial Gage Factor (A):	**-8.55E-08**	
Polynomial Gage Factor (B):	**-0.02304**	
Polynomial Gage Factor (C):	**208.62**	

Vibrating Wire Data					Linear Calibration			
Date	**Geokon Data**	**Reading (Hz^2)**	**Temp. (°C)**	**Barom. P (kPa)**	**Pressure (psi)**	**Pressure (kPa)**	**h_p (m)**	**Total Head (m)**
24-Jun-2004	2850.44	8125.01	5.15	101	15.83	110.59	11.27	477.72
24-Jun-2004	2850.44	8125.01	5.07	101	15.83	110.59	11.27	477.72
24-Jun-2004	2850.42	8124.92	5.14	101	15.84	110.60	11.27	477.72
24-Jun-2004	2850.44	8125.01	5.06	101	15.83	110.59	11.27	477.72
24-Jun-2004	2850.42	8124.92	5.11	101	15.84	110.60	11.27	477.72
24-Jun-2004	2850.43	8124.96	5.12	101	15.84	110.59	11.27	477.72
24-Jun-2004	2850.42	8124.92	5.07	101	15.84	110.60	11.27	477.72
29-Jul-2004	2854.93	8150.64	5.08	101	15.21	106.26	10.83	477.28
29-Jul-2004	2854.92	8150.59	5.05	101	15.22	106.27	10.83	477.28
29-Jul-2004	2854.93	8150.64	5.10	101	15.21	106.26	10.83	477.28
29-Jul-2004	2854.94	8150.68	5.11	101	15.21	106.25	10.83	477.28
29-Jul-2004	2854.93	8150.64	5.03	101	15.21	106.26	10.83	477.28
29-Jul-2004	2854.92	8150.59	5.03	101	15.22	106.26	10.83	477.28

Vibrating Wire Pressure Transducer Data

Project Number (installation project number):	**M442**	
Location:	**Proposed Saskatoon North Bridge Crossing**	
Installation Identification:	**M442-02C**	
Serial Number:	04-5334	
Surface Elevation:	482.6	m
Installation Depth:	8.84	m
Installation Depth:	29.0	ft
Tip (Installation) Elevation:	473.76	m
Factory Elevation	**177.0**	masl
Elev. Diff. From Factory Zero	973.4	ft
Elevation Correction Factor (E)	0.487	psi
Linear Calibration Factor (G):	**0.02418**	psi / B unit
Temperature Calibration Factor (K):	**0.00297**	psi / °C rise
Factory Zero Reading (Ro):	**8773**	
Factory Temperature (To):	**25.4**	°C
Factory Pressure (So):	**992.8**	mbar
Factory Pressure (So):	99.28	kPa
Polynomial Gage Factor (A):	**-8.55E-08**	
Polynomial Gage Factor (B):	**-0.02304**	
Polynomial Gage Factor (C):	**208.62**	

Vibrating Wire Data					Linear Calibration			
Date	Geokon Data	Reading (Hz^2)	Temp. (°C)	Barom. P (kPa)	Pressure (psi)	Pressure (kPa)	h_p (m)	Total Head (m)
24-Jun-2004	2920.44	8528.98	4.79	101	6.08	42.44	4.33	478.09
24-Jun-2004	2920.43	8528.93	4.68	101	6.08	42.45	4.33	478.09
24-Jun-2004	2920.43	8528.93	4.76	101	6.08	42.45	4.33	478.09
24-Jun-2004	2920.43	8528.88	4.74	101	6.08	42.46	4.33	478.09
24-Jun-2004	2920.43	8528.93	4.79	101	6.08	42.45	4.33	478.09
24-Jun-2004	2920.43	8528.88	4.78	101	6.08	42.46	4.33	478.09
24-Jun-2004	2920.43	8528.88	4.82	101	6.08	42.46	4.33	478.09
24-Jun-2004	2920.45	8529.03	4.77	101	6.08	42.44	4.33	478.09
24-Jun-2004	2920.43	8528.88	4.76	101	6.08	42.46	4.33	478.09
29-Jul-2004	2923.17	8544.94	4.52	101	5.69	39.74	4.05	477.81
29-Jul-2004	2923.18	8544.99	4.60	101	5.69	39.74	4.05	477.81
29-Jul-2004	2923.19	8545.04	4.53	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.19	8545.04	4.56	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.20	8545.09	4.54	101	5.69	39.72	4.05	477.81
29-Jul-2004	2923.21	8545.14	4.48	101	5.69	39.71	4.05	477.81
29-Jul-2004	2923.18	8544.99	4.52	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.18	8544.99	4.55	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.19	8545.04	4.55	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.19	8545.04	4.52	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.19	8545.04	4.50	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.19	8545.04	4.54	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.19	8545.04	4.51	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.19	8545.04	4.54	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.18	8544.99	4.49	101	5.69	39.73	4.05	477.81
29-Jul-2004	2923.19	8545.04	4.58	101	5.69	39.73	4.05	477.81

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Type: S

Date of Calibration: May 26, 2004

Serial Number: 04-5531

Temperature: 22.1 °C

Pressure Range: 700 kPa

†Barometric Pressure: 989.2 mbar

Cal. Std. Cntrl. #(s): W9-182, 511, 506, 216, 468, 403, 018

Technician: gwo

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9030	9030	9030	1.382	0.20	-0.019	0.00
140.0	8190	8191	8191	139.8	-0.03	140.2	0.02
280.0	7348	7348	7348	278.7	-0.18	279.9	-0.02
420.0	6498	6498	6498	418.9	-0.16	420.0	0.01
560.0	5644	5644	5644	559.7	-0.04	560.0	0.00
700.0	4784	4786	4785	701.4	0.20	700.1	0.02

(kPa) Linear Gage Factor (G): 0.1649 **(kPa/ digit)**

Regression Zero: 9038

Polynomial Gage Factors: **A:** -5.862E-07 **B:** -0.1568 **C:** 1463.7

Thermal Factor (K): 0.0369 **(kPa/ °C)**

(psi) Linear Gage Factor (G): 0.02392 **(psi/ digit)**

Polynomial Gage Factors: **A:** -8.50265E-08 **B:** -0.02274 **C:** 212.29

Thermal Factor (K): 0.00535 **(psi/ °C)**

Calculated Pressures: **Linear, $P = G(R_0 - R_1)+K(T_1 - T_0)-(S_1 - S_0)$****

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0)-(S_1 - S_0)$**

†Barometric pressures are absolute. Barometric compensation is <u>not</u> required with vented and differential pressure transducers.

Factory Zero Reading:

GK-401 Pos. B or F(R_0): 9029

Temp(T_0): 25.4 °C

†Baro(S_0): 992.8 mbar

Date: June 03, 2004

***Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used the field value of C must be calculated by plugging the initial zero reading into the polynomial equation with the value of P set to zero.**

The above instrument was found to be in tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Type: S

Date of Calibration: May 26, 2004

Serial Number: 04-5532

Temperature: 22.1 °C

Pressure Range: 700 kPa

†Barometric Pressure: 989.2 mbar

Cal. Std. Cntrl. #(s): W9-182, 511, 506, 216, 468, 403, 018

Technician: gwo

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8768	8768	8768	1.370	0.20	-0.008	0.00
140.0	7938	7938	7938	139.8	-0.03	140.0	0.01
280.0	7104	7104	7104	278.8	-0.17	279.9	-0.01
420.0	6264	6264	6264	418.9	-0.16	420.0	0.00
560.0	5419	5420	5420	559.7	-0.04	560.1	0.01
700.0	4570	4570	4570	701.4	0.20	700.0	0.00

(kPa) Linear Gage Factor (G): 0.1667 (kPa/ digit)

Regression Zero: 8776

Polynomial Gage Factors: A: -5.893E-07 B: -0.1589 C: 1438.4

Thermal Factor (K): 0.0204 (kPa/ °C)

(psi) Linear Gage Factor (G): 0.02418 (psi/ digit)

Polynomial Gage Factors: A: -8.54651E-08 B: -0.02304 C: 208.62

Thermal Factor (K): 0.00297 (psi/ °C)

Calculated Pressures: **Linear, $P = G(R_0 - R_1)+K(T_1 - T_0)-(S_1 - S_0)$****

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0)-(S_1 - S_0)$**

†Barometric pressures are absolute. Barometric compensation is <u>not</u> required with vented and differential pressure transducers.

Factory Zero Reading:

GK-401 Pos. B or F(R_0): 8773 Temp(T_0): 25.4 °C †Baro(S_0): 992.8 mbar Date: June 03, 2004

*Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used the field value of C must be calculated by plugging the initial zero reading into the polynomial equation with the value of P set to zero.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Type: S

Date of Calibration: May 26, 2004

Serial Number: 04-5533

Temperature: 22.1 °C

Pressure Range: 700 kPa

†Barometric Pressure: 989.2 mbar

Cal. Std. Cntrl. #(s): W9-182, 511, 506, 216, 468, 403, 018

Technician: gwo

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8665	8666	8666	1.081	0.15	0.120	0.02
140.0	7734	7733	7734	139.8	-0.03	139.9	-0.01
280.0	6797	6798	6798	279.1	-0.13	280.0	0.00
420.0	5856	5856	5856	419.2	-0.12	420.0	0.00
560.0	4910	4910	4910	559.9	-0.01	560.2	0.02
700.0	3962	3963	3963	700.9	0.14	700.0	0.00

(kPa) Linear Gage Factor (G): 0.1488 **(kPa/ digit)**

Regression Zero: 8673

Polynomial Gage Factors: **A:** -3.528E-07 **B:** -0.1444 **C:** 1277.5

Thermal Factor (K): -0.0577 **(kPa/ °C)**

(psi) Linear Gage Factor (G): 0.02158 **(psi/ digit)**

Polynomial Gage Factors: **A:** -5.11716E-08 **B:** -0.02094 **C:** 185.28

Thermal Factor (K): -0.00837 **(psi/ °C)**

Calculated Pressures:

Linear, $P = G(R_0 - R_1)+K(T_1 - T_0)-(S_1 - S_0)^{**}$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0)-(S_1 - S_0)^{**}$

†Barometric pressures are absolute. Barometric compensation is <u>not</u> required with vented and differential pressure transducers.

Factory Zero Reading:

GK-401 Pos. B or F(R_0): 8662 Temp(T_0): 25.8 °C †Baro(S_0): 992.8 mbar Date: June 03, 2004

*Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used the field value of C must be calculated by plugging the initial zero reading into the polynomial equation with the value of P set to zero.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Type:	S	Date of Calibration:	May 26, 2004
Serial Number:	04-5534	Temperature:	22.1 °C
Pressure Range:	700 kPa	†Barometric Pressure:	989.2 mbar
Cal. Std. Cntrl. #(s):	W9-182, 511, 506, 216, 468, 403, 018	Technician:	gwo

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8757	8757	8757	1.318	0.19	0.023	0.00
140.0	7864	7865	7865	139.7	-0.05	140.0	0.00
280.0	6965	6966	6966	279.0	-0.14	280.2	0.02
420.0	6063	6063	6063	418.9	-0.15	420.0	0.00
560.0	5155	5155	5155	559.7	-0.04	560.0	0.00
700.0	4241	4242	4242	701.3	0.19	700.1	0.01

(kPa) Linear Gage Factor (G): 0.1550 **(kPa/ digit)** **Regression Zero:** 8766

Polynomial Gage Factors: **A:** -4.786E-07 **B:** -0.1488 **C:** 1339.7

Thermal Factor (K): -0.0285 **(kPa/ °C)**

(psi) Linear Gage Factor (G): 0.02248 **(psi/ digit)**

Polynomial Gage Factors: **A:** -6.94095E-08 **B:** -0.02158 **C:** 194.32

Thermal Factor (K): -0.00413 **(psi/ °C)**

Calculated Pressures: **Linear, $P = G(R_0 - R_1)+K(T_1 - T_0)-(S_1 - S_0)$****

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0)-(S_1 - S_0)$**

†Barometric pressures are absolute. Barometric compensation is not required with vented and differential pressure transducers.

Factory Zero Reading:

GK-401 Pos. B or F(R_0): 8759 Temp(T_0): 25.7 °C †Baro(S_0): 992.8 mbar Date: June 03, 2004

*Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used the field value of C must be calculated by plugging the initial zero reading into the polynomial equation with the value of P set to zero.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Type: S

Date of Calibration: May 17, 2004

Serial Number: 04-5828

Temperature: 21.7 °C

Pressure Range: 1 MPa

†Barometric Pressure: 1009.2 mbar

Cal. Std. Cntrl. #(s): W9-182, 511, 506, 216, 468, 402, 428

Technician: BT

Applied Pressure (MPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8616	8616	8616	0.002	0.21	0.000	0.00
0.2	7821	7821	7821	0.200	-0.05	0.200	-0.01
0.4	7020	7020	7020	0.398	-0.15	0.400	0.01
0.6	6215	6215	6215	0.598	-0.16	0.600	0.01
0.8	5406	5406	5406	0.799	-0.06	0.800	-0.02
1.0	4590	4590	4590	1.002	0.21	1.000	0.01

(MPa) Linear Gage Factor (G): 0.0002484 (MPa/ digit)

Regression Zero: 8624

Polynomial Gage Factors: A: -9.512E-10 B: -0.0002358 C: 2.1024

Thermal Factor (K): 0.0001541 (MPa/ °C)

(psi) Linear Gage Factor (G): 0.03600 (psi/ digit)

Polynomial Gage Factors: A: -1.37856E-07 B: -0.03418 C: 304.70

Thermal Factor (K): 0.02233 (psi/ °C)

Calculated Pressures: **Linear, $P = G(R_0 - R_1)+K(T_1 - T_0)-(S_1 - S_0)$****

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0)-(S_1 - S_0)$**

†Barometric pressures are absolute. Barometric compensation is <u>not</u> required with vented and differential pressure transducers.

Factory Zero Reading:

GK-401 Pos. B or F(R_0): 8624 Temp(T_0): 26.3 °C †Baro(S_0): 992.8 mbar Date: June 3, 2004

*Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used the field value of C must be calculated by plugging the initial zero reading into the polynomial equation with the value of P set to zero.

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON 48 Spencer St. Lebanon, N.H. 03766 USA

Vibrating Wire Pressure Transducer Calibration Report

Type: S

Date of Calibration: May 26, 2004

Serial Number: 04-5535

Temperature: 22.1 °C

Pressure Range: 700 kPa

†Barometric Pressure: 989.2 mbar

Cal. Std. Cntrl. #(s): W9-182, 511, 506, 216, 468, 403, 018

Technician: gwo

Applied Pressure (kPa)	Gage Reading 1st Cycle	Gage Reading 2nd Cycle	Average Gage Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8759	8760	8760	1.458	0.21	0.027	0.00
140.0	7922	7921	7922	139.8	-0.03	140.0	0.00
280.0	7080	7079	7080	278.8	-0.17	279.9	-0.01
420.0	6232	6233	6233	418.6	-0.19	420.0	-0.01
560.0	5378	5378	5378	559.7	-0.04	560.0	0.01
700.0	4519	4519	4519	701.5	0.22	700.0	0.00

(kPa) Linear Gage Factor (G): 0.1651 (kPa/ digit)

Regression Zero: 8768

Polynomial Gage Factors: A: -6.354E-07 B: -0.1567 C: 1420.9

Thermal Factor (K): -0.0480 (kPa/ °C)

(psi) Linear Gage Factor (G): 0.02394 (psi/ digit)

Polynomial Gage Factors: A: -9.2161E-08 B: -0.02272 C: 206.09

Thermal Factor (K): -0.00696 (psi/ °C)

Calculated Pressures: **Linear, $P = G(R_0 - R_1)+K(T_1 - T_0)-(S_1 - S_0)$****

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0)-(S_1 - S_0)$**

†Barometric pressures are absolute. Barometric compensation is <u>not</u> required with vented and differential pressure transducers.

Factory Zero Reading:

GK-401 Pos. B or F(R_0): 8760

Temp(T_0): 25.1 °C

†Baro(S_0): 992.8 mbar

Date: June 03, 2004

***Initial zero readings must be established in the field following the procedures described in the Instruction Manual. If the Polynomial equation is used the field value of C must be calculated by plugging the initial zero reading into the polynomial equation with the value of P set to zero.**

The above instrument was found to be in tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

Appendix E

Laboratory Testing Results

SRC Geoanalytical Laboratories
125 - 15 Innovation Blvd., Saskatoon, Saskatchewan, S7N 2X8
Tel: (306) 933-8118 Fax: (306) 933-5656 Email: geochem@src.sk.ca

MDH Engineered Solutions
Attention: Julian Gan
PO #/Project: M442
Samples: 86

Report No: 04-453
Date: July 20, 2004

Calcium Magnesium

Column Header Details

Calcium by ICP in % (Ca)
Magnesium by ICP in % (Mg)
Dolomite by Calculation in wt% (Dol)
Calcite by Calculation in wt% (Cal)
Total Carbonate by Calculation in Total wt% (CO3)

Dolomite/Calcite Ratio (Dol/Cal)
Carbon Dioxide from Calcite in ml (CO2Cal)
Carbon Dioxide from Dolomite in ml (CO2Dol)
Total Cabon Dioxide in ml (CO2Tot)

Sample Number	Ca %	Mg %	Dol wt%	Cal wt%	CO3 Total wt%	Dol/Cal	CO2Cal ml	CO2Dol ml	CO2Tot ml
BR2	5.14	1.56	11.83	6.41	18.24	1.85	14.35	28.74	43.09
ADK-01 5	3.66	1.69	12.82	2.18	15.00	5.88	4.88	31.14	36.02
ADK-02 10	3.46	1.57	11.91	2.18	14.09	5.46	4.88	28.93	33.81
ADK-03 15	3.04	1.24	9.41	2.49	11.90	3.78	5.57	22.86	28.43
ADK-04 20	2.52	1.07	8.12	1.89	10.01	4.30	4.23	19.72	23.95
ADK-11 55	4.11	1.36	10.32	4.66	14.98	2.21	10.43	25.07	35.50
ADK-12 60	3.98	1.29	9.78	4.63	14.41	2.11	10.36	23.76	34.12
ADK-13 65	3.90	1.17	8.87	4.92	13.79	1.80	11.01	21.55	32.56
ADK-17 80	4.07	1.30	9.86	4.81	14.67	2.05	10.76	23.95	34.71
ADK-19 85	4.13	1.28	9.71	5.04	14.75	1.93	11.28	23.59	34.87
ADK-21 90	2.60	0.78	5.92	3.28	9.20	1.80	7.34	14.38	21.72
ADK-23 95	3.52	0.93	7.05	4.96	12.01	1.42	11.10	17.12	28.22
ADK-25 100	3.31	0.97	7.36	4.27	11.63	1.72	9.56	17.88	27.44
ADK-27 105	3.25	0.91	6.90	4.37	11.27	1.58	9.78	16.76	26.54
ADK-30 110	3.50	0.97	7.36	4.75	12.11	1.55	10.63	17.88	28.51
ADK-31 115	4.70	1.20	9.10	6.80	15.90	1.34	15.22	22.10	37.32
ADK-32 120	3.38	0.92	6.98	4.65	11.63	1.50	10.41	16.95	27.36
ADK-33 125	3.49	1.02	7.74	4.52	12.26	1.71	10.12	18.80	28.92
ADK-34 130	3.88	0.91	6.90	5.94	12.84	1.16	13.29	16.76	30.05
ADK-35 135	2.90	0.82	6.22	3.87	10.09	1.61	8.66	15.11	23.77
BR2	4.88	1.51	11.45	5.97	17.42	1.92	13.36	27.81	41.17
ADK-36 140	3.41	0.97	7.36	4.52	11.88	1.63	10.12	17.88	28.00
ADK-37 145	3.27	0.90	6.83	4.46	11.29	1.53	9.98	16.59	26.57
ADK-38 150	2.72	0.75	5.69	3.70	9.39	1.54	8.28	13.82	22.10
ADK-39 155	2.82	0.78	5.92	3.83	9.75	1.55	8.57	14.38	22.95
ADK-40 160	2.87	0.77	5.84	4.00	9.84	1.46	8.95	14.19	23.14
ADK-41 165	3.14	0.79	5.99	4.59	10.58	1.31	10.27	14.55	24.82
ADK-42 170	2.52	0.70	5.31	3.41	8.72	1.56	7.63	12.90	20.53

MDH Engineered Solutions
Attention: Julian Gan
PO #/Project: M442
Samples: 86

Report No: 04-453
Date: July 20, 2004

Calcium Magnesium

Sample Number	Ca %	Mg %	Dol wt%	Cal wt%	CO3 Total wt%	Dol/Cal	CO2Cal ml	CO2Dol ml	CO2Tot ml
ADK-43 175	2.58	0.77	5.84	3.27	9.11	1.79	7.32	14.19	21.51
ADK-44	2.55	0.79	5.99	3.12	9.11	1.92	6.98	14.55	21.53
ADK-45 185	2.45	0.75	5.69	3.03	8.72	1.88	6.78	13.82	20.60
ADK-46 190	3.28	0.98	7.43	4.16	11.59	1.79	9.31	18.05	27.36
ADK-47 195	2.96	0.92	6.98	3.60	10.58	1.94	8.06	16.95	25.01
ADK-48 200	3.20	0.82	6.22	4.62	10.84	1.35	10.34	15.11	25.45
ADK-49 205	3.27	0.98	7.43	4.13	11.56	1.80	9.24	18.05	27.29
ADK-50 210	3.10	0.97	7.36	3.75	11.11	1.96	8.39	17.88	26.27
ADK-51 215	2.95	0.98	7.43	3.33	10.76	2.23	7.45	18.05	25.50
ADK-52 220	2.99	0.96	7.28	3.51	10.79	2.07	7.86	17.68	25.54
ADK-53 225	3.29	0.99	7.51	4.14	11.65	1.81	9.27	18.24	27.51
ADK-50 210 R	3.04	0.94	7.13	3.72	10.85	1.92	8.33	17.32	25.65
BR2	4.89	1.52	11.53	5.95	17.48	1.94	13.32	28.01	41.33
ADK-54 230	2.73	0.91	6.90	3.07	9.97	2.25	6.87	16.76	23.63
ADK-62 5	3.93	1.29	9.78	4.50	14.28	2.17	10.07	23.76	33.83
ADK-63 10	4.44	1.14	8.65	6.39	15.04	1.35	14.30	21.01	35.31
ADK-65 20	4.40	1.48	11.23	4.89	16.12	2.30	10.94	27.28	38.22
ADK-66 25	4.59	1.30	9.86	6.11	15.97	1.61	13.67	23.95	37.62
ADK-67 30	2.51	0.80	6.07	2.97	9.04	2.04	6.65	14.74	21.39
ADK-68 35	3.53	0.94	7.13	4.95	12.08	1.44	11.08	17.32	28.40
ADK-69 40	3.36	0.86	6.52	4.85	11.37	1.34	10.85	15.84	26.69
ADK-70 45	3.44	0.92	6.98	4.80	11.78	1.45	10.74	16.95	27.69
ADK-71 50	3.85	1.08	8.19	5.17	13.36	1.58	11.57	19.89	31.46
ADK-72 55	3.66	1.00	7.59	5.02	12.61	1.51	11.23	18.44	29.67
ADK-73 60	3.61	0.97	7.36	5.02	12.38	1.47	11.23	17.88	29.11
ADK-76 75	2.75	0.87	6.60	3.29	9.89	2.01	7.36	16.03	23.39
ADK-77 80	3.51	1.01	7.66	4.61	12.27	1.66	10.32	18.61	28.93
ADK-78 85	3.17	0.91	6.90	4.17	11.07	1.65	9.33	16.76	26.09
ADK-79 90	3.09	0.89	6.75	4.05	10.80	1.67	9.06	16.40	25.46
ADK-80 95	3.06	0.97	7.36	3.65	11.01	2.02	8.17	17.88	26.05
ADK-81 100	3.21	0.93	7.05	4.19	11.24	1.68	9.38	17.12	26.50
ADK-82 105	3.02	0.80	6.07	4.25	10.32	1.43	9.51	14.74	24.25
BR2	4.83	1.52	11.53	5.80	17.33	1.99	12.98	28.01	40.99
ADK-83 110	2.91	0.73	5.54	4.26	9.80	1.30	9.53	13.46	22.99
ADK-84 115	2.75	0.75	5.69	3.78	9.47	1.51	8.46	13.82	22.28
ADK-85 120	2.80	0.80	6.07	3.70	9.77	1.64	8.28	14.74	23.02
ADK-86 125	2.74	0.76	5.76	3.71	9.47	1.55	8.30	13.99	22.29
ADK-87 130	2.45	0.76	5.76	2.99	8.75	1.93	6.69	13.99	20.68
ADK-88 135	2.50	0.85	6.45	2.74	9.19	2.35	6.13	15.67	21.80
ADK-89 140	2.44	0.77	5.84	2.92	8.76	2.00	6.53	14.19	20.72

SRC Geoanalytical Laboratories
125 - 15 Innovation Blvd., Saskatoon, Saskatchewan, S7N 2X8
Tel: (306) 933-8118 Fax: (306) 933-5656 Email: geochem@src.sk.ca

MDH Engineered Solutions
Attention: Julian Gan
PO #/Project: M442
Samples: 86

Report No: 04-453
Date: July 20, 2004

Calcium Magnesium

Sample Number	Ca %	Mg %	Dol wt%	Cal wt%	CO3 Total wt%	Dol/Cal	CO2Cal ml	CO2Dol ml	CO2Tot ml
ADK-91 150	2.28	0.73	5.54	2.69	8.23	2.06	6.02	13.46	19.48
ADK-92 155	2.52	0.85	6.45	2.79	9.24	2.31	6.24	15.67	21.91
ADK-93 160	2.53	0.77	5.84	3.15	8.99	1.85	7.05	14.19	21.24
ADK-94 165	3.09	0.87	6.60	4.13	10.73	1.60	9.24	16.03	25.27
ADK-95 170	3.28	0.97	7.36	4.20	11.56	1.75	9.40	17.88	27.28
ADK-96 175	4.33	1.16	8.80	6.04	14.84	1.46	13.52	21.38	34.90
ADK-97 180	4.05	1.13	8.57	5.46	14.03	1.57	12.22	20.82	33.04
ADK-98 185	3.93	1.12	8.50	5.20	13.70	1.63	11.64	20.65	32.29
ADK-99 190	4.02	1.14	8.65	5.35	14.00	1.62	11.97	21.01	32.98
ADK-100 195	3.56	1.12	8.50	4.28	12.78	1.99	9.58	20.65	30.23
ADK-101 200	3.34	0.92	6.98	4.55	11.53	1.53	10.18	16.95	27.13
ADK-54 230 R	2.86	0.96	7.28	3.19	10.47	2.28	7.14	17.68	24.82
BR2	5.08	1.59	12.06	6.14	18.20	1.96	13.74	29.29	43.03
ADK-102 205	2.75	0.79	5.99	3.62	9.61	1.65	8.10	14.55	22.65
ADK-103 210	3.32	1.04	7.89	4.01	11.90	1.97	8.97	19.16	28.13
ADK-104 215	3.26	1.00	7.59	4.02	11.61	1.89	9.00	18.44	27.44
ADK-105 220	3.39	1.05	7.96	4.14	12.10	1.92	9.27	19.33	28.60
ADK-104 215 R	3.33	1.06	8.04	3.95	11.99	2.04	8.84	19.53	28.37

Calcium Magnesium: A 0.5g pulp is digested with 2 ml of HCl overnight at room temperature.
Dolomite wt% = column 2*7.5852 .
Calcite wt% = (column 1 -(column 2*1.6486))*2.4973 .
CO3 Total wt% = (column 3 + column 4) .
Dol/Cal = (column 3/column 4) .
CO2 from Calcite = Column 4*2.238 .
CO2 from Dolomite = Column 3*2.429 .
Total CO2 = Column 7 + Column 8 .

ATTERBERG LIMITS

Project: M442-01

Location: North Bridge Crossing

Technician:

Date: Aug 12 / 04

Sample: M442-01 ADK 16

Plastic Limit

Tare #	A-5	A-16					
Tare Wt, g	13.53	13.58					
Wet + Tare, g	17.07	18.43					
Dry + Tare, g	16.61	17.80					
M%	14.9%	14.9%		Average:	14.9%		

Liquid Limit

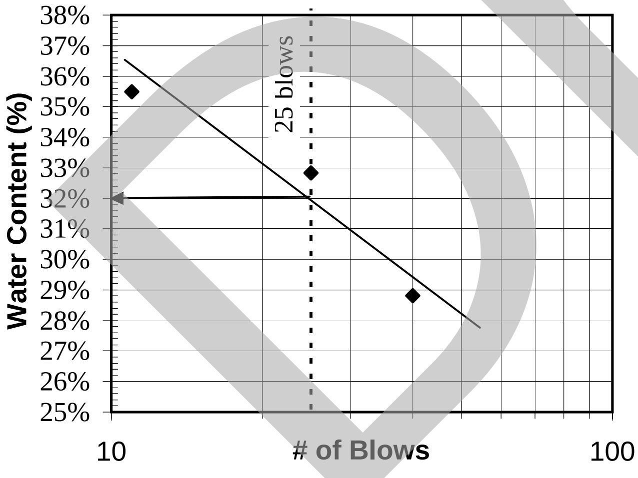
# of Blows	11	25	40				
Tare #	A-25	A-27	A-46				
Tare Wt, g	13.63	13.31	13.33				
Wet + tare, g	31.42	25.49	23.97				
Dry + tare, g	26.76	22.48	21.59				
M%	35.5%	32.8%	28.8%				

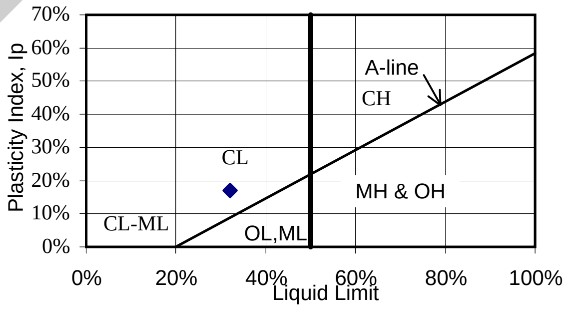
Plastic Limit: 14.9%

Liquid Limit: 32.0%

Plasticity Index: 17.1%

Classification: CL





Comments:

MDH ENGINEERED SOLUTIONS

ATTERBERG LIMITS

Project: M442-01
Location: North Bridge Crossing
Technician:
Date: Aug 12 / 04

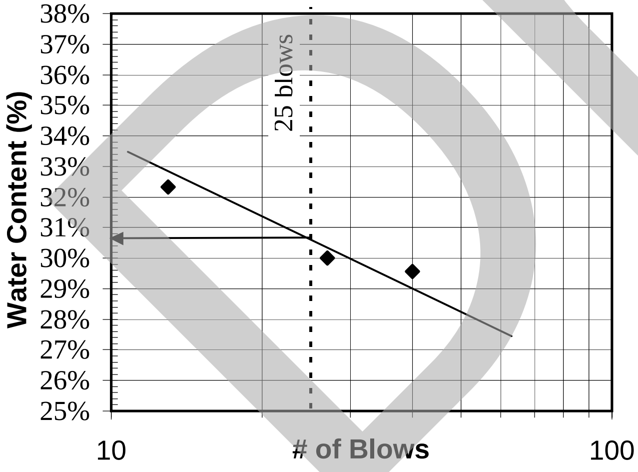
Sample: M442-01 ADK 18

Plastic Limit

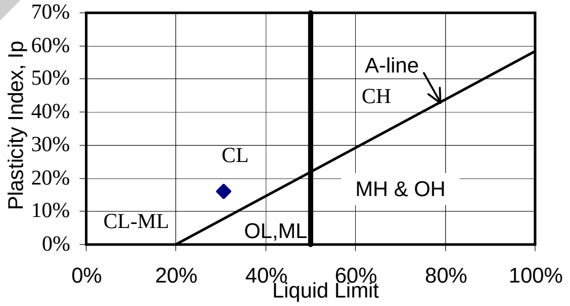
Tare #	A-11	A-21					
Tare Wt, g	13.52	13.51					
Wet + Tare, g	16.82	16.68					
Dry + Tare, g	16.40	16.28					
M%	14.6%	14.4%		Average:	14.5%		

Liquid Limit

# of Blows	13	27	40				
Tare #	A-34	A-43	A-9				
Tare Wt, g	13.30	13.50	13.53				
Wet + tare, g	29.43	33.09	28.96				
Dry + tare, g	25.49	28.57	25.44				
M%	32.3%	30.0%	29.6%				



Plastic Limit: 14.5%
Liquid Limit: 30.6%
Plasticity Index: 16.1%
Classification: CL



Comments:

ATTERBERG LIMITS

Project: M442-01

Location: North Bridge Crossing

Technician:

Date: Aug 10 / 04

Sample: M442-01 ADK 20

Plastic Limit

Tare #	A-5	A-11					
Tare Wt, g	13.52	13.53					
Wet + Tare, g	16.45	16.17					
Dry + Tare, g	16.10	15.86					
M%	13.6%	13.3%		Average:	13.4%		

Liquid Limit

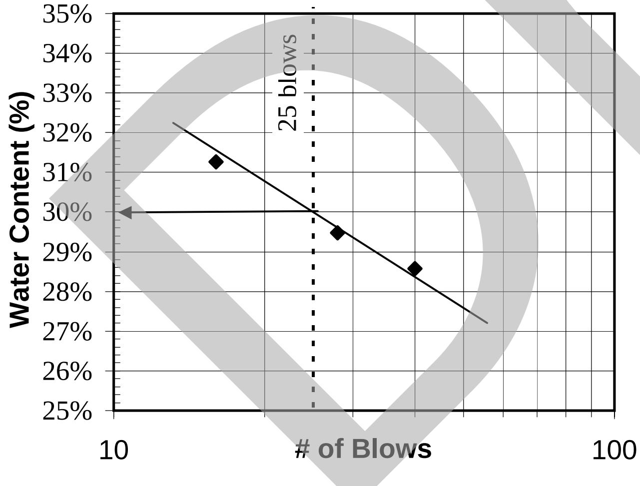
# of Blows	16	28	40				
Tare #	A-21	A-27	A-43				
Tare Wt, g	13.50	13.31	13.48				
Wet + tare, g	30.25	27.85	26.26				
Dry + tare, g	26.26	24.54	23.42				
M%	31.3%	29.5%	28.6%				

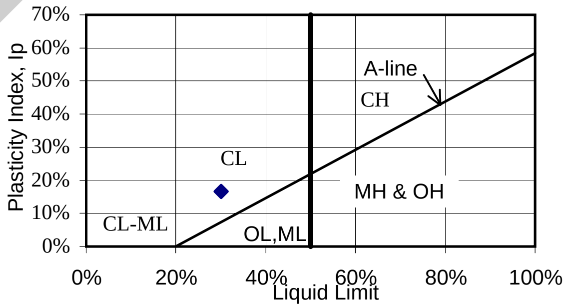
Plastic Limit: 13.4%

Liquid Limit: 30.0%

Plasticity Index: 16.6%

Classification: CL





Comments:

MDH
ENGINEERED SOLUTIONS

ATTERBERG LIMITS

Project: M442
Location: North Bridge

Technician:
Date: Aug 10/04

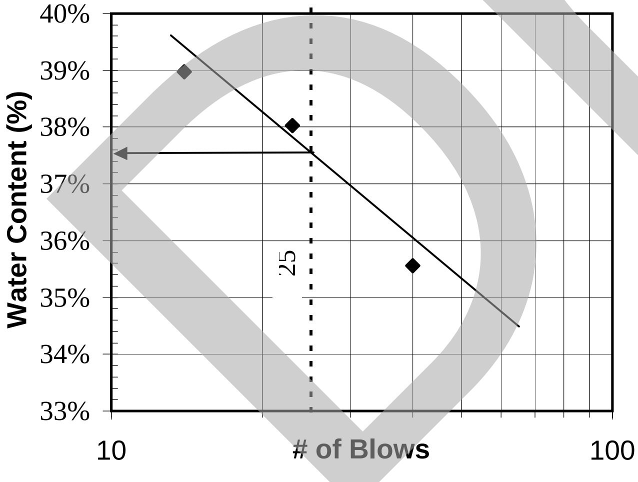
Sample: ADK-22

Plastic Limit

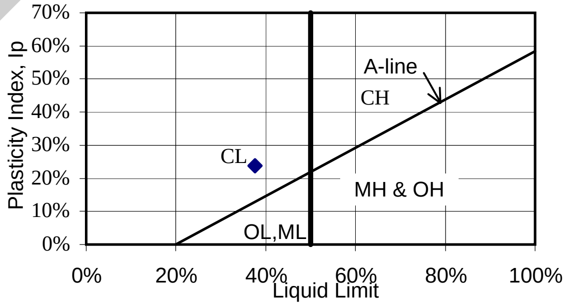
Tare #	A5	A11					
Tare Wt, g	13.52	13.52					
Wet + Tare, g	16.17	16.28					
Dry + Tare, g	15.84	15.95					
M%	14.2%	13.6%		Average:	13.9%		

Liquid Limit

# of Blows	14	23	40				
Tare #	A21	A34	A43				
Tare Wt, g	13.47	13.33	13.51				
Wet + tare, g	28.41	23.82	25.29				
Dry + tare, g	24.22	20.93	22.20				
M%	39.0%	38.0%	35.6%				



Plastic Limit: 13.9%
Liquid Limit: 37.6%
Plasticity Index: 23.7%
Classification: CL



Comments:

MDH ENGINEERED SOLUTIONS

ATTERBERG LIMITS

Project: M442

Location: North Bridge

Technician:

Date: Aug 10/04

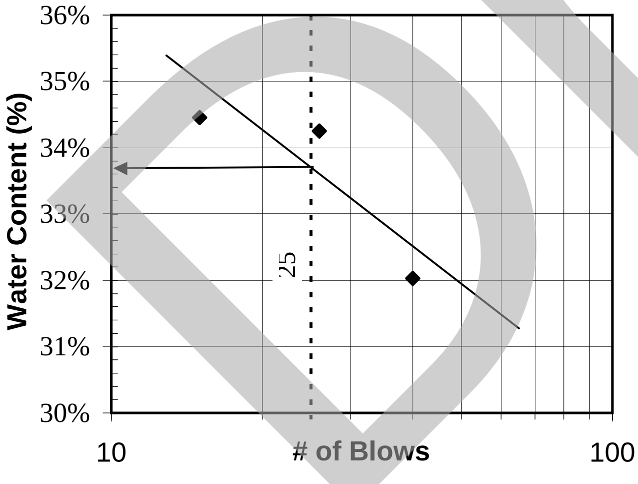
Sample: ADK-24

Plastic Limit

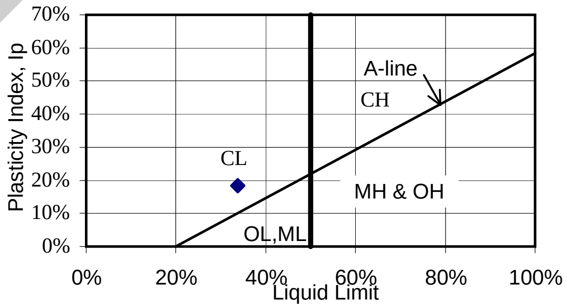
Tare #	A9	A16					
Tare Wt, g	13.54	13.57					
Wet + Tare, g	16.03	16.78					
Dry + Tare, g	15.70	16.35					
M%	15.3%	15.5%		Average:	15.4%		

Liquid Limit

# of Blows	15	26	40				
Tare #	A25	A27	A46				
Tare Wt, g	13.67	13.32	13.32				
Wet + tare, g	26.82	27.90	27.83				
Dry + tare, g	23.45	24.18	24.31				
M%	34.5%	34.3%	32.0%				



Plastic Limit:	15.4%
Liquid Limit:	33.7%
Plasticity Index:	18.3%
Classification:	CL



Comments:

MDH
ENGINEERED SOLUTIONS

WATER CONTENTS & BULK DENSITIES

Project: M442-01

Location: North Bridge Crossing

Date: Aug 9/04

Sample #	ADK-16	ADK-18	ADK-20	ADK-22	ADK-24	
Tare #	Z-3	AH	D1	G4	F3	
Tare Mass (g)	11.55	11.56	13.51	18.46	13.55	
Wet sample + tare (g)	94.21	253.87	148.87	173.49	123.21	
Dry sample + tare (g)	84.76	226.07	132.77	155.02	110.29	
Wt. Dry sample (g)	73.21	214.51	119.26	136.56	96.74	
Water Content (%)	12.91	12.96	13.50	13.53	13.36	
Bulk Density						
Weight of Sample (g)	324.02	242.42	108.39	472.77	356.03	
Sample Height (Avg) (mm)	37.47	26.58	Direct shear specimen	53.38	42.48	
Sample Diameter (Avg) (mm)	70.94	72.39		71.46	70.61	
Volume of Sample (m^3)	0.148100	0.109396	0.050000	0.214089	0.166344	
Bulk Wet Density (kg/m^3)	2188	2216	2168	2208	2140	
Bulk Dry Density (kg/m^3)	1938	1962	1910	1945	1888	
Sample #						
Tare #						
Tare Mass (g)						
Wet sample + tare (g)						
Dry sample + tare (g)						
Wt. Dry sample (g)						
Water Content (%)						
Bulk Density						
Weight of Sample (g)						
Sample Height (Avg) (mm)						
Sample Diameter (Avg) (mm)						
Volume of Sample (m^3)						
Bulk Wet Density (kg/m^3)						
Bulk Dry Density (kg/m^3)						

Comments: ADK-24 Sample's shape after extrution was quite oval. Therefore Bulk Density for this sample may be inaccurate.

GRAIN SIZE DISTRIBUTION

MDH
ENGINEERED SOLUTIONS

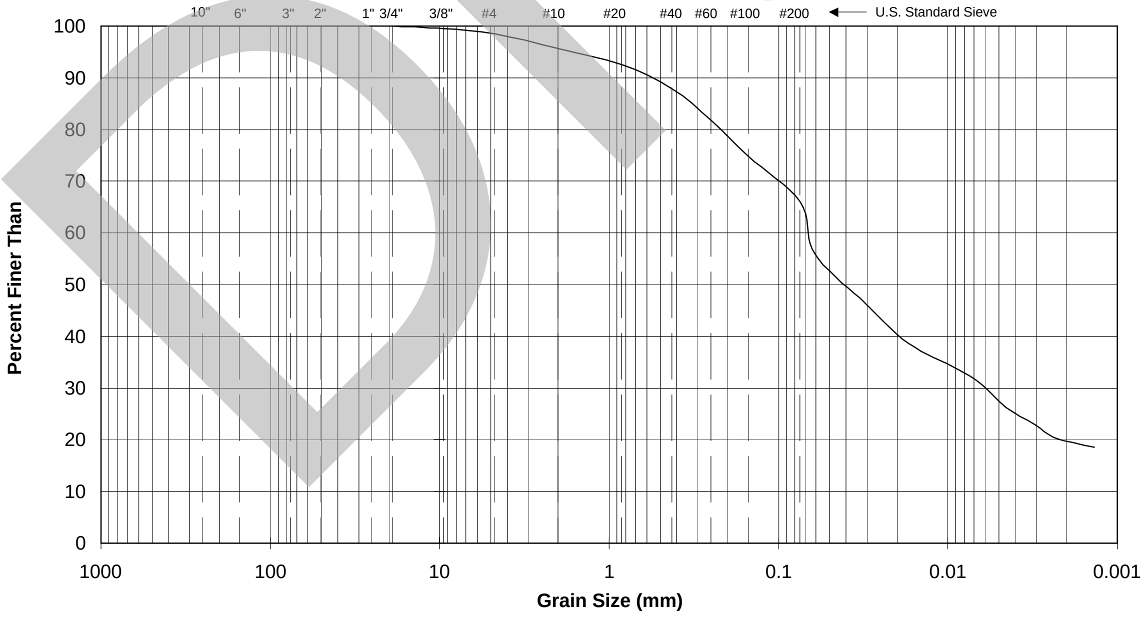
PROJECT: M442-01
North Bridge

SAMPLE: M442-01 ADK 16
DATE: Aug-16-04
COMMENTS:

	Sieve	Diameter (mm)	% Finer
Mechanical:	15"	381.0	100
	14"	355.6	100
	13"	330.2	100
	12"	304.8	100
	11"	279.4	100
	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	99
	# 4	4.75	99
	# 10	2.00	96
	# 20	0.850	93
	# 40	0.425	88
	# 60	0.250	82
	# 100	0.150	75
	# 200	0.075	66
Hydrometer:		0.0634	57.0
		0.0458	51.5
		0.0329	47.4
		0.0237	42.7
		0.0170	38.6
		0.0121	35.9
		0.0086	33.5
		0.0064	30.6
		0.0045	26.2
		0.0031	23.1
		0.0023	20.3
		0.0014	18.6

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	1
% SAND	33
% FINES (SILT, CLAY)	66



BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System

GRAIN SIZE DISTRIBUTION

	Sieve	Diameter (mm)	% Finer
Mechanical:	15"	381.0	100
	14"	355.6	100
	13"	330.2	100
	12"	304.8	100
	11"	279.4	100
	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	99
	# 4	4.75	98
	# 10	2.00	95
	# 20	0.850	92
	# 40	0.425	87
	# 60	0.250	81
	# 100	0.150	74
	# 200	0.075	65
Hydrometer:		0.0629	57.7
		0.0460	49.3
		0.0330	45.2
		0.0237	41.5
		0.0171	36.3
		0.0122	33.4
		0.0090	29.5
		0.0064	26.2
		0.0045	22.9
		0.0033	20.6
		0.0024	19.9
		0.0014	16.9

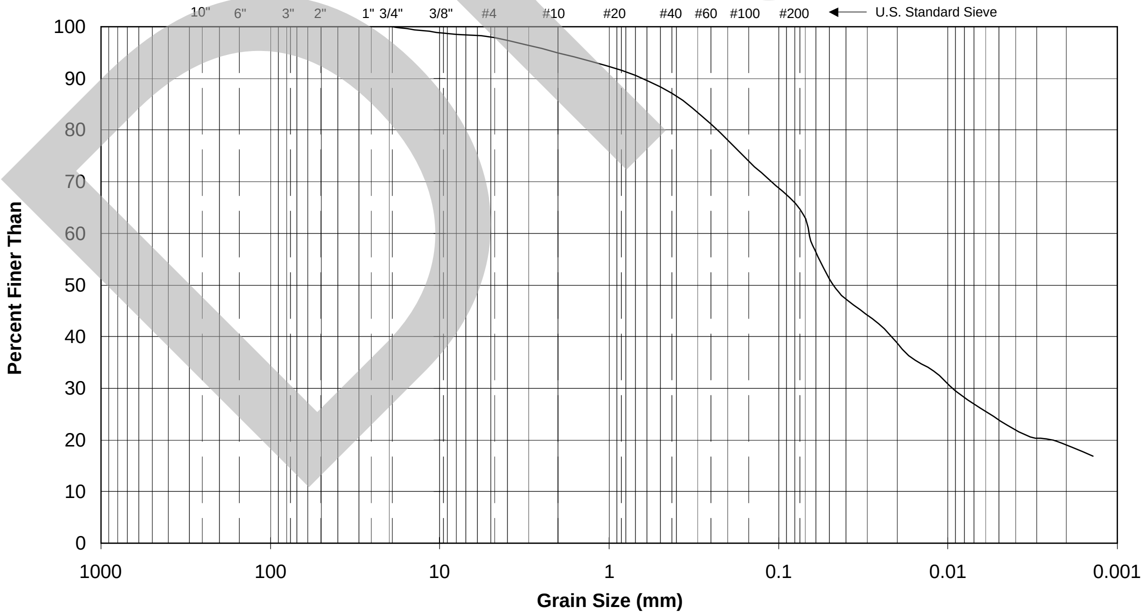
MDH
ENGINEERED SOLUTIONS

PROJECT: M442-01
North Bridge

SAMPLE: M442-01 ADK 18
DATE: Aug-16-04
COMMENTS:

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	2
% SAND	33
% FINES (SILT, CLAY)	65



BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System

GRAIN SIZE DISTRIBUTION

	Sieve	Diameter (mm)	% Finer
Mechanical:	15"	381.0	100
	14"	355.6	100
	13"	330.2	100
	12"	304.8	100
	11"	279.4	100
	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	100
	# 4	4.75	98
	# 10	2.00	97
	# 20	0.850	93
	# 40	0.425	88
	# 60	0.250	83
	# 100	0.150	76
	# 200	0.075	67
Hydrometer:		0.0629	55.9
		0.0457	49.0
		0.0327	45.2
		0.0234	42.6
		0.0169	37.3
		0.0125	33.7
		0.0087	31.5
		0.0060	28.0
		0.0045	26.4
		0.0032	23.2
		0.0023	20.5
		0.0014	18.3

MDH ENGINEERED SOLUTIONS

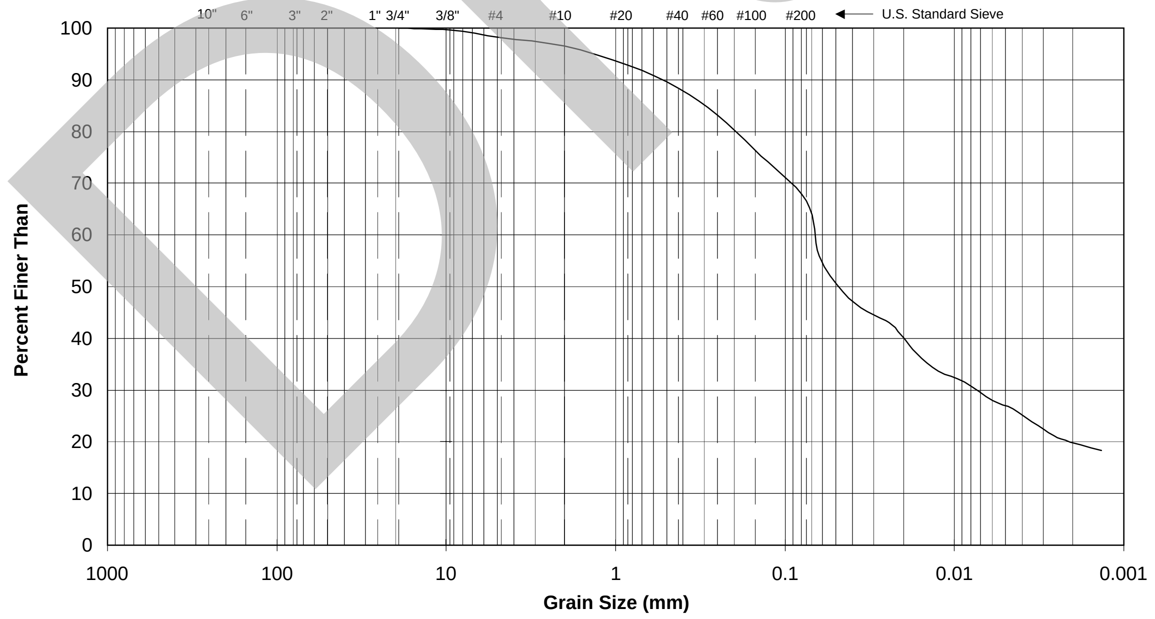
PROJECT: M442-01
North Bridge

SAMPLE: M442-01 ADK 20
DATE: Aug-09-04

COMMENTS:

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	2
% SAND	31
% FINES (SILT, CLAY)	67



BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System

GRAIN SIZE DISTRIBUTION

MDH ENGINEERED SOLUTIONS

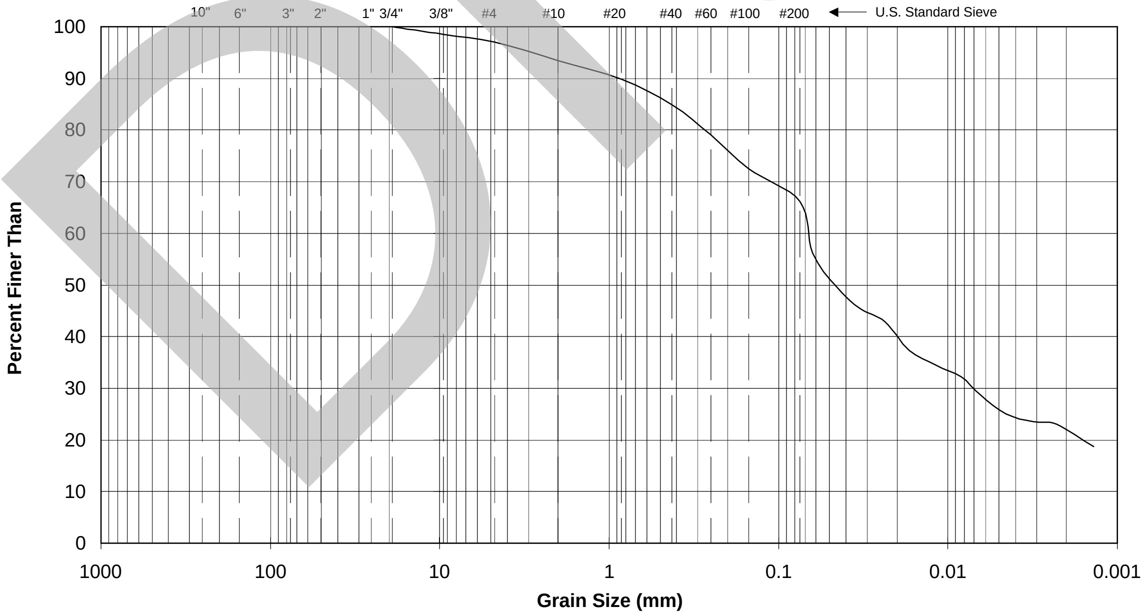
PROJECT: M442-01
North Bridge

SAMPLE: M442-01 ADK 22
DATE: Aug-16-04
COMMENTS:

	Sieve	Diameter (mm)	% Finer
Mechanical:	15"	381.0	100
	14"	355.6	100
	13"	330.2	100
	12"	304.8	100
	11"	279.4	100
	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	98
	# 4	4.75	97
	# 10	2.00	93
	# 20	0.850	90
	# 40	0.425	85
	# 60	0.250	79
	# 100	0.150	73
	# 200	0.075	66
Hydrometer:		0.0629	56.1
		0.0457	49.7
		0.0329	45.3
		0.0235	42.8
		0.0169	37.3
		0.0117	34.5
		0.0084	32.2
		0.0064	28.6
		0.0045	25.0
		0.0032	23.5
		0.0023	23.1
		0.0014	18.8

PARTICLE SIZE DISTRIBUTION SUMMARY

% BOULDERS	
% COBBLES	
% GRAVEL	3
% SAND	31
% FINES (SILT, CLAY)	66



BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System

GRAIN SIZE DISTRIBUTION

	Sieve	Diameter (mm)	% Finer
Mechanical:	15"	381.0	100
	14"	355.6	100
	13"	330.2	100
	12"	304.8	100
	11"	279.4	100
	10"	254.0	100
	9"	228.6	100
	8"	203.2	100
	7"	177.8	100
	6"	152.4	100
	5"	127.0	100
	4"	101.6	100
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	100
	# 4	4.75	99
	# 10	2.00	96
	# 20	0.850	92
	# 40	0.425	87
	# 60	0.250	81
	# 100	0.150	75
	# 200	0.075	67
Hydrometer:		0.0627	58.6
		0.0454	52.9
		0.0328	47.5
		0.0235	43.6
		0.0170	37.4
		0.0115	33.9
		0.0086	31.8
		0.0058	27.0
		0.0046	24.3
		0.0033	21.9
		0.0023	20.3
		0.0014	17.5

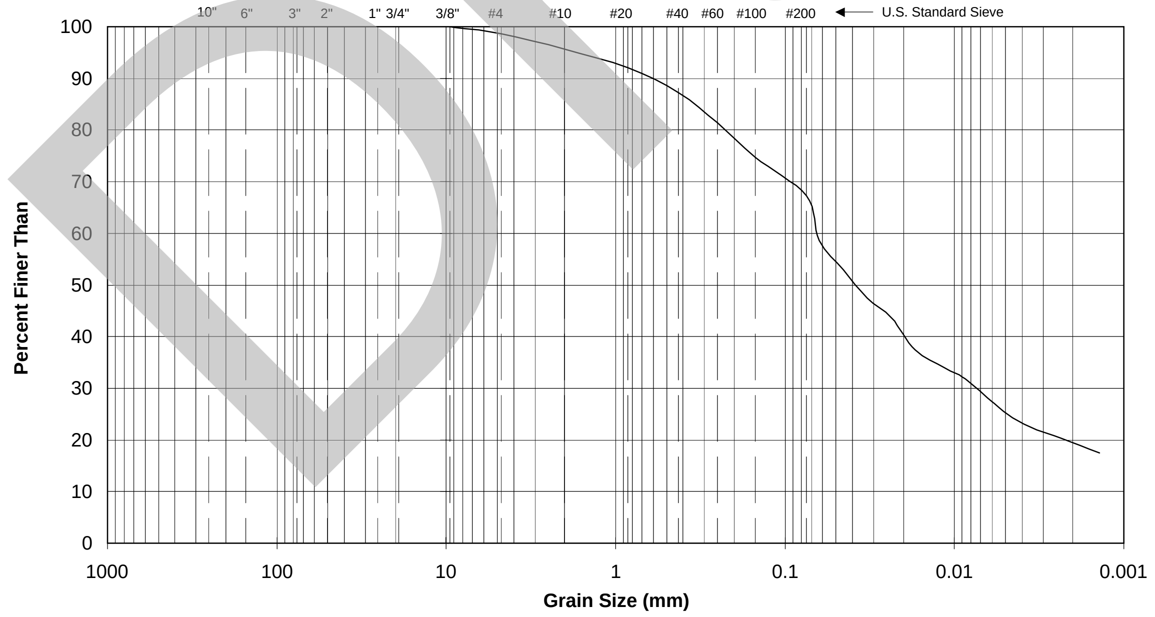
MDH ENGINEERED SOLUTIONS

PROJECT: M442-01
North Bridge

SAMPLE: M442-01 ADK 24
DATE: Aug-16-04
COMMENTS:

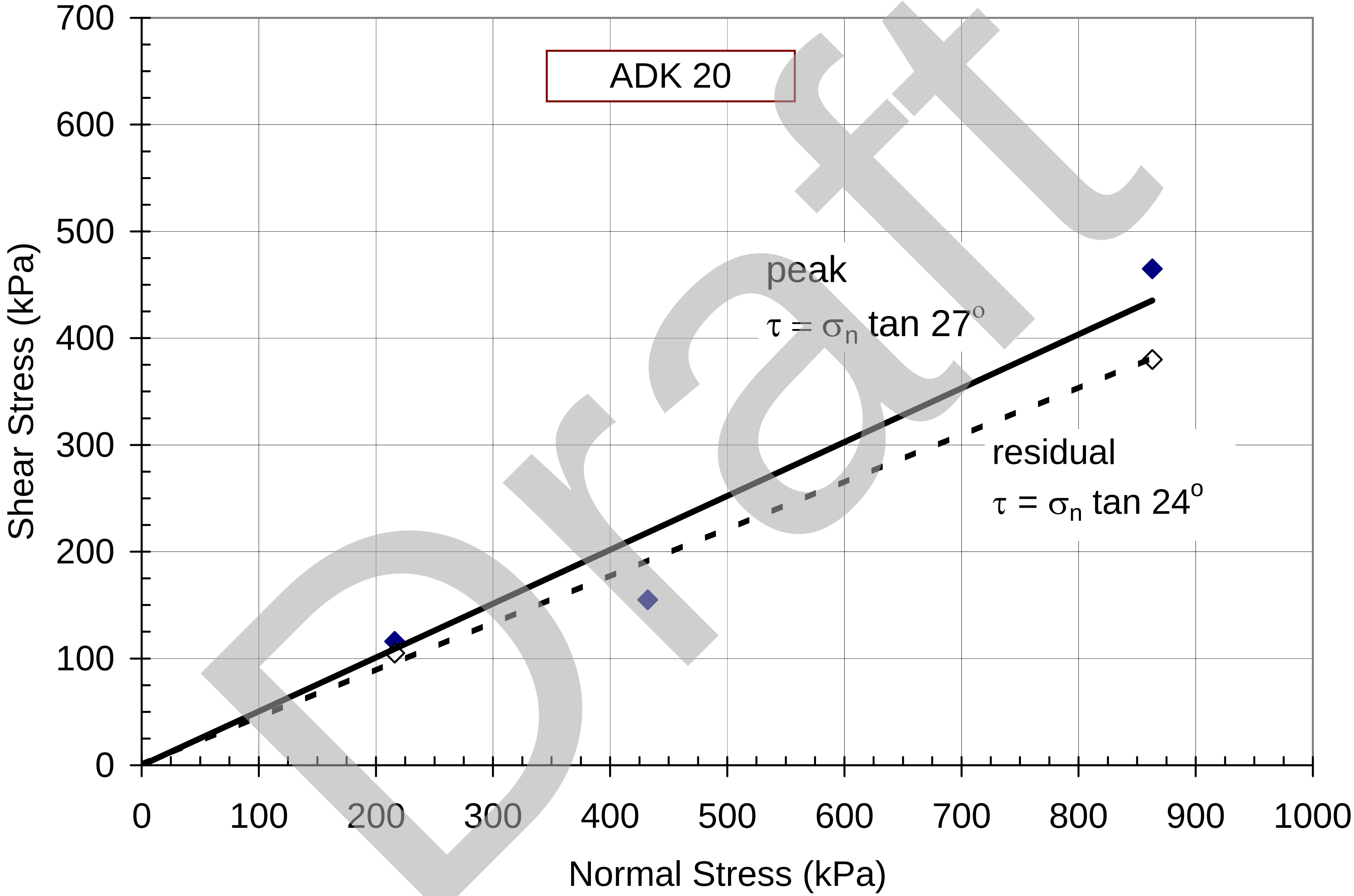
PARTICLE SIZE DISTRIBUTION SUMMARY

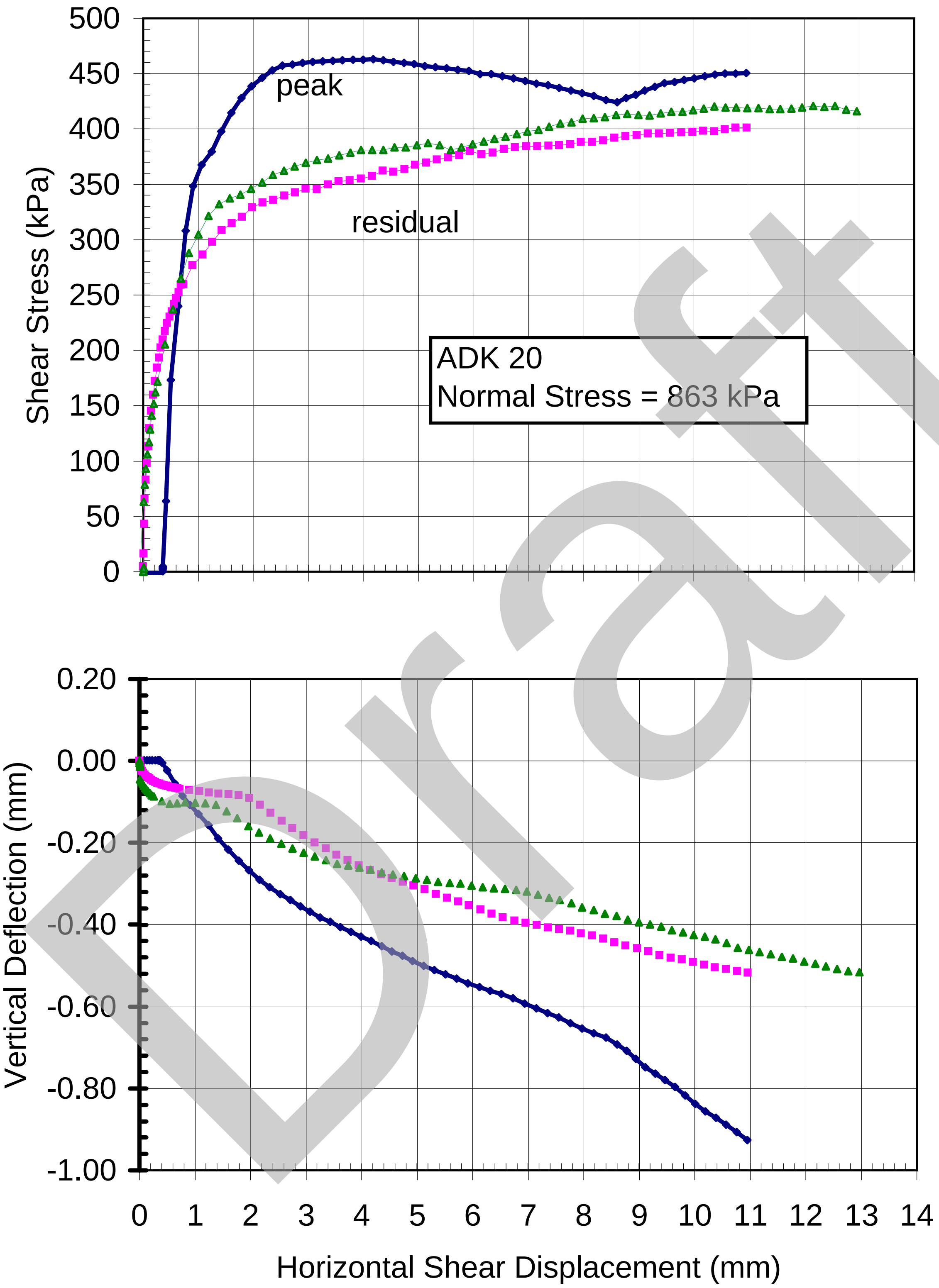
% BOULDERS	
% COBBLES	
% GRAVEL	1
% SAND	32
% FINES (SILT, CLAY)	67

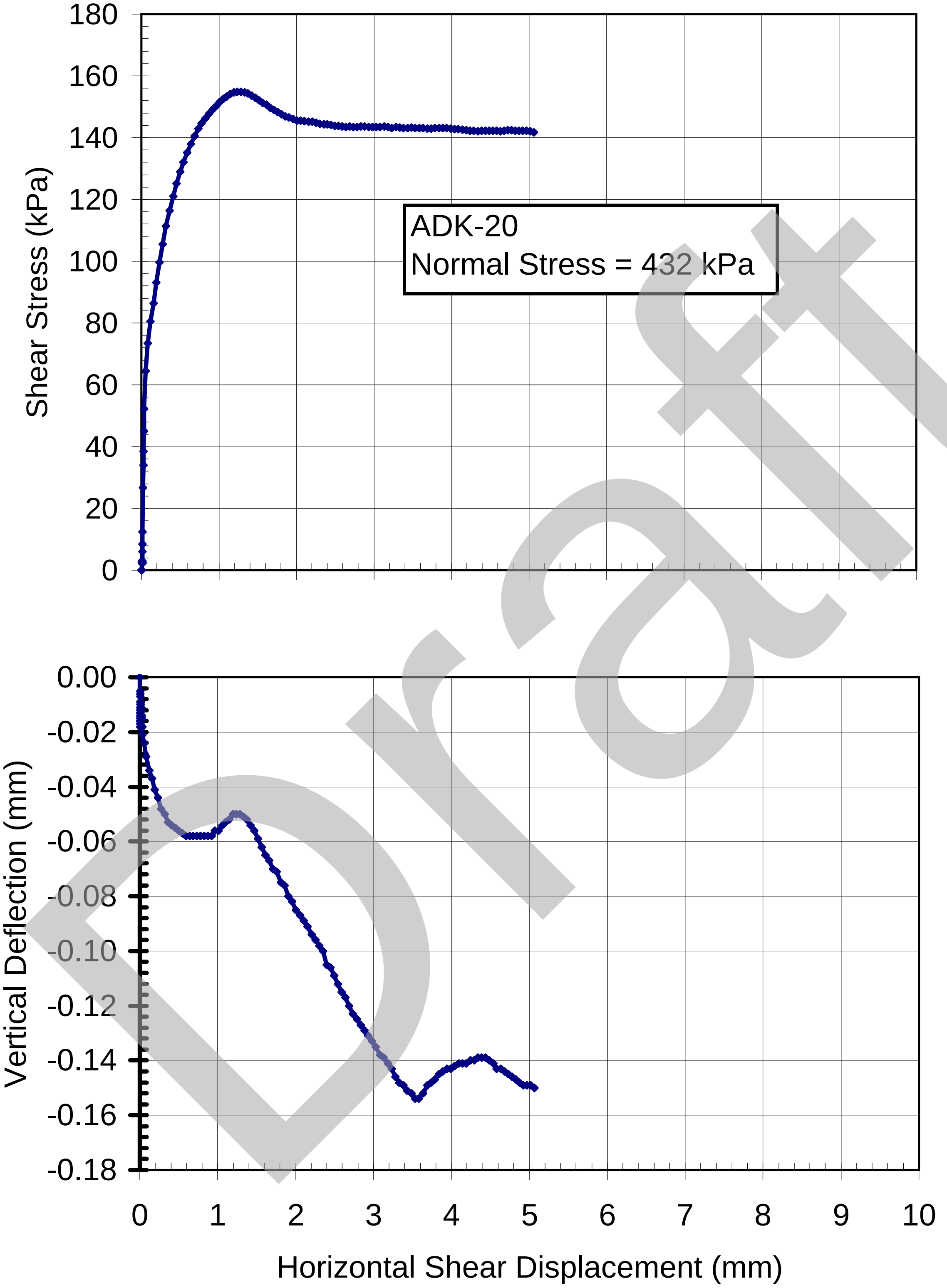


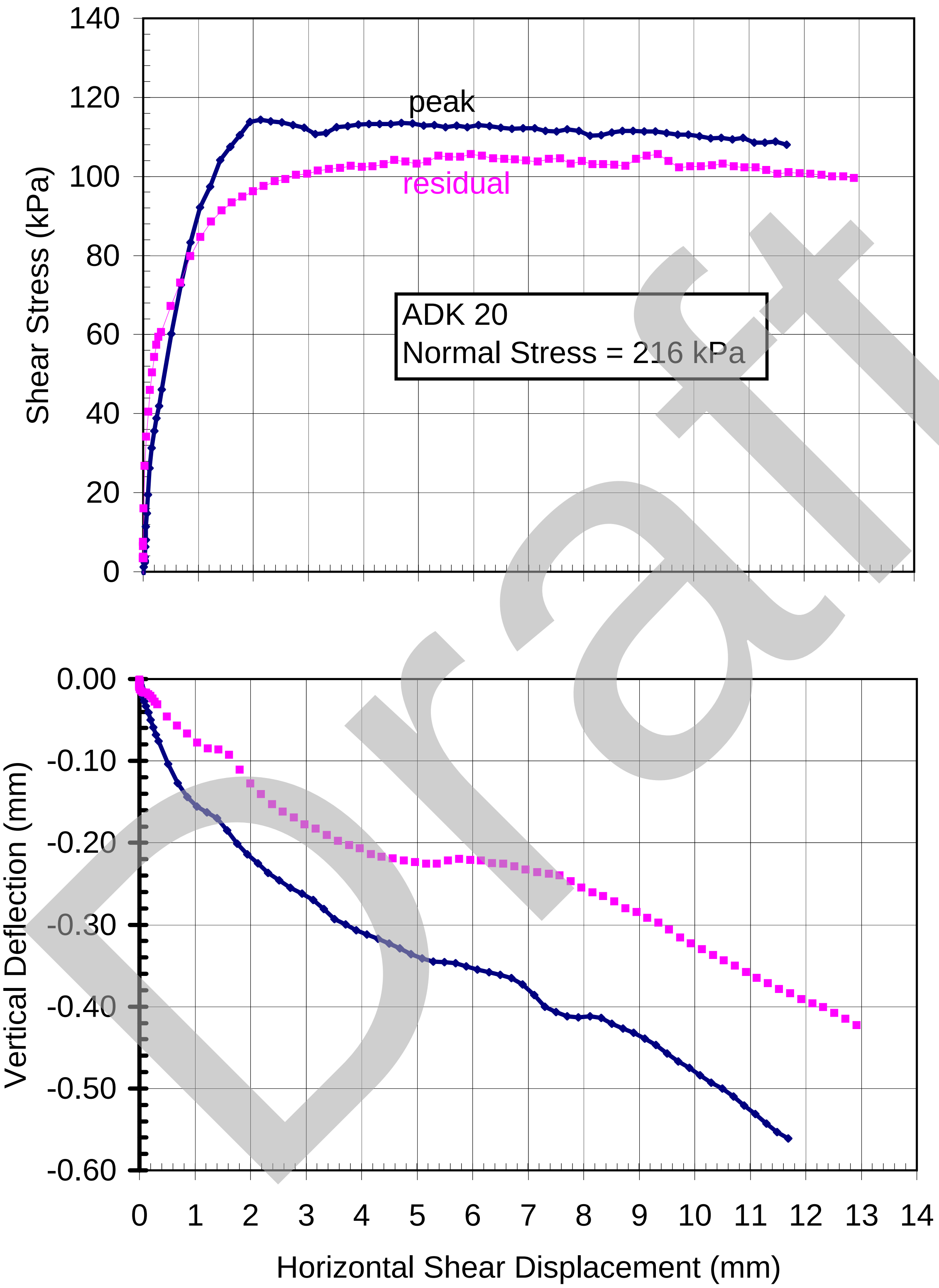
BOULDERS	COBBLES	GRAVEL		SAND			FINES (SILT, CLAY)
		Coarse	Fine	Coarse	Medium	Fine	

Unified Soil Classification System


ADK 20
peak
$\tau = \sigma_n \tan 27^o$
residual
$\tau = \sigma_n \tan 24^o$
Shear Stress (kPa)
0
100
200
300
400
500
600
700
Normal Stress (kPa)
0
100
200
300
400
500
600
700
800
900
1000


500
450
400
350
300
250
200
150
100
50
0
Shear Stress (kPa)
peak
residual
ADK 20
Normal Stress = 863 kPa
0.20
0.00
-0.20
-0.40
-0.60
-0.80
-1.00
Vertical Deflection (mm)
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Horizontal Shear Displacement (mm)


Shear Stress (kPa)
180
160
140
120
100
80
60
40
20
0
ADK-20
Normal Stress = 432 kPa
Vertical Deflection (mm)
0.00
-0.02
-0.04
-0.06
-0.08
-0.10
-0.12
-0.14
-0.16
-0.18
0
1
2
3
4
5
6
7
8
9
10
Horizontal Shear Displacement (mm)



Shear Stress (kPa)
140
120
100
80
60
40
20
0
peak
residual
ADK 20
Normal Stress = 216 kPa
Vertical Deflection (mm)
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
-0.60
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Horizontal Shear Displacement (mm)

APPENDIX F

Stratigraphic Cross Section A-A’

Time			Stratigraphy[1]			Lithology	
Quaternary	Holocene		Saskatoon Group	Surficial Stratified Deposits		Sands and Silts	10
						Silts and Clays	
	Late Pleistocene	Late Wisconsin		Battleford Formation		Till	9
		Early Wisconsin		Floral Formation	Upper Unit	Till	8e
	Early and middle Pleistocene	Sangamon			Riddel Member	Silt, Sand, Gravel	8d
		Illinoian			Lower Unit	Till	8c
						Clay, silt, sand	8b
						Till	8a
		Pre-Illinoian	Sutherland Group	Warman Formation		Till	7
						Sand, Gravel	
				Dundurn Formation		Till	6c
						Sand, Gravel	6b
						Till	6a
				Mennon Formation		Till	5
Tertiary		Pliocene	Empress Group			Sand, gravel, silt, clay	4
Late Cretaceous			Montana Group	Bearpaw Formation		Silt and Clay	3
				Judith River Formation		Sand, Silt, Clay	2
				Lea Park Formation		Silt and Clay	1

Saskatoon Area

(1) modified after Christiansen, 1992

LIMITATION

EXCEPT AT TESTHOLE SITES WHERE GEOLOGIC LOGS ARE AVAILABLE, GEOLOGIC CONTACTS ARE INFERRED AND REPRESENT GEOLOGIC MODELS THAT ARE BELIEVED TO BEST FIT THE INFORMATION.

REVISIONS

No.	DATE	DESCRIPTION	DRN.	DES.	CHK.	APP.

DRAWING STATUS | DATE:
PRELIMINARY
DESIGN REPORT △
APPROVED FOR TENDER REV. △
APPROVED FOR CONSTRUCTION REV. △
AS-BUILT

SCALE:	H 1:2500 V 1:750	DATE:
GEOLOGY BY:	A. KARVONEN, P.Eng., P.Geo.	05-AUG-04
DRAWN BY:	P. BIRNIE	05-AUG-04
CHECKED BY:	A. KARVONEN, P.Eng., P.Geo.	05-AUG-04
APPROVED BY:	A. KARVONEN, P.Eng., P.Geo.	05-AUG-04

CLIENT
uma

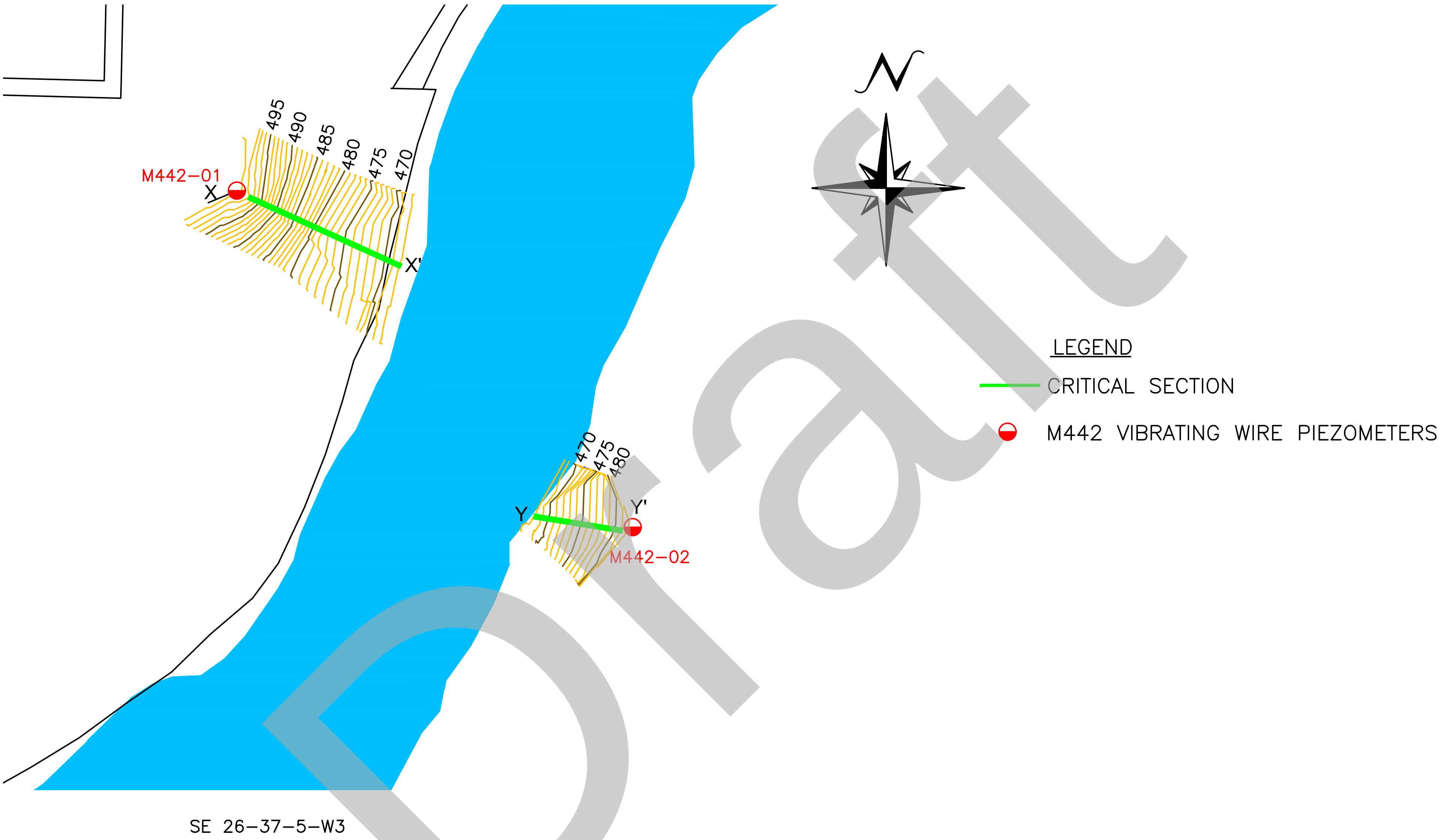
PRODUCED BY
MDH
ENGINEERED SOLUTIONS

TITLE
SECTION A-A'

PROJECT No. M442-350003 APPENDIX: F
DRAWING No. M442-62-1 REV. △

APPENDIX G

Slope Stability Modelling



CLIENT

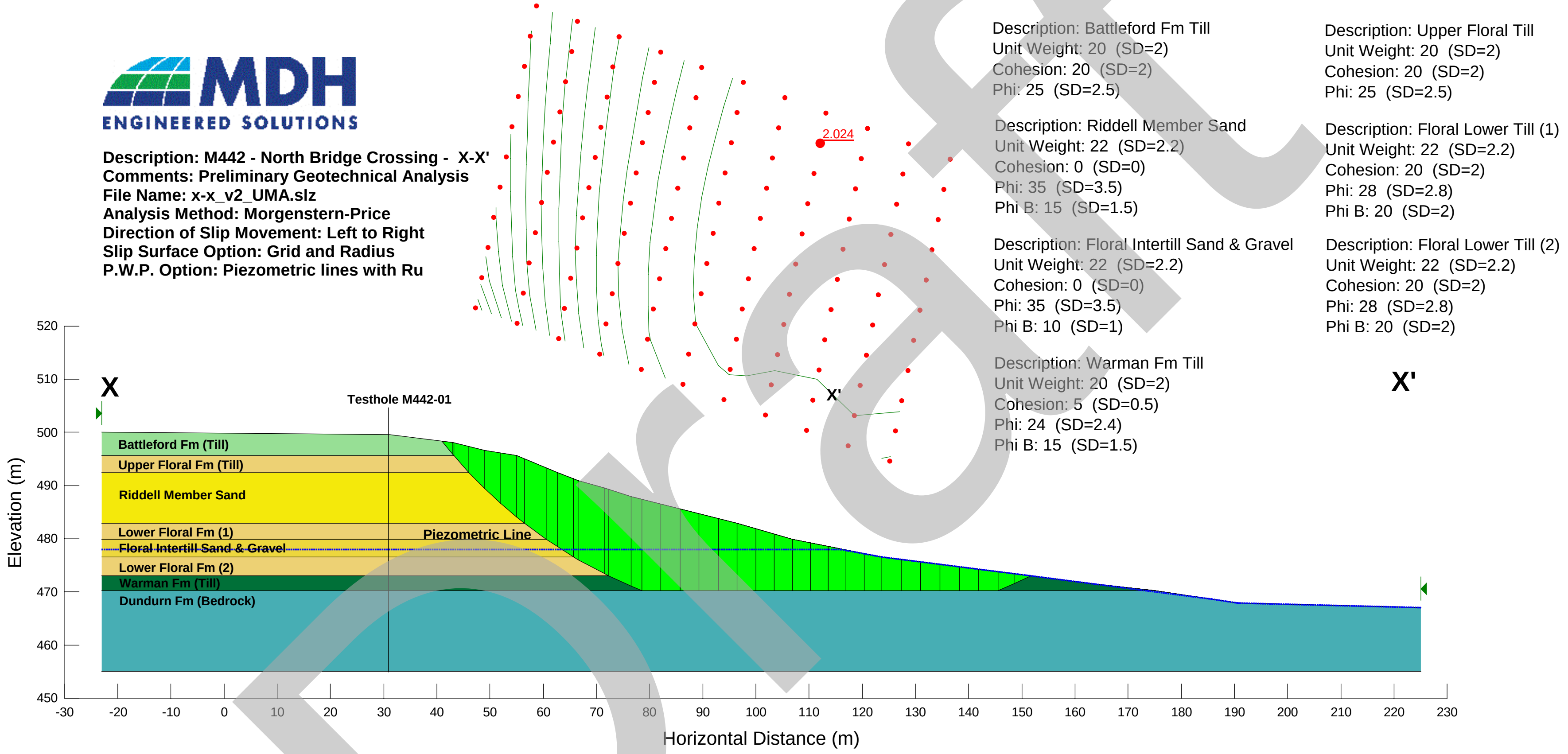
TITLE
APPROXIMATE TOPOGRAPHY IN
VICINITY OF PROPOSED
NORTH BRIDGE

SCALE: 1:5000

		DATE
DESIGN BY:	A. KARVONEN, P.Eng., P.Geo.	05–AUG–04
DRAWN BY:	P. BIRNIE	05–AUG–04
APPROVED BY:	A. KARVONEN, P.Eng., P.Geo.	05–AUG–04

PRODUCED BY
MDH
ENGINEERED SOLUTIONS

PROJECT No. M442–35–03
APPENDIX: G
DRAWING No. M442–61–1



Description: M442 - North Bridge Crossing - X-X'
Comments: Preliminary Geotechnical Analysis
File Name: x-x_v2_UMA.slz
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Left to Right
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru

Description: Battleford Fm Till
Unit Weight: 20 (SD=2)
Cohesion: 20 (SD=2)
Phi: 25 (SD=2.5)

Description: Riddell Member Sand
Unit Weight: 22 (SD=2.2)
Cohesion: 0 (SD=0)
Phi: 35 (SD=3.5)
Phi B: 15 (SD=1.5)

Description: Floral Intertill Sand & Gravel
Unit Weight: 22 (SD=2.2)
Cohesion: 0 (SD=0)
Phi: 35 (SD=3.5)
Phi B: 10 (SD=1)

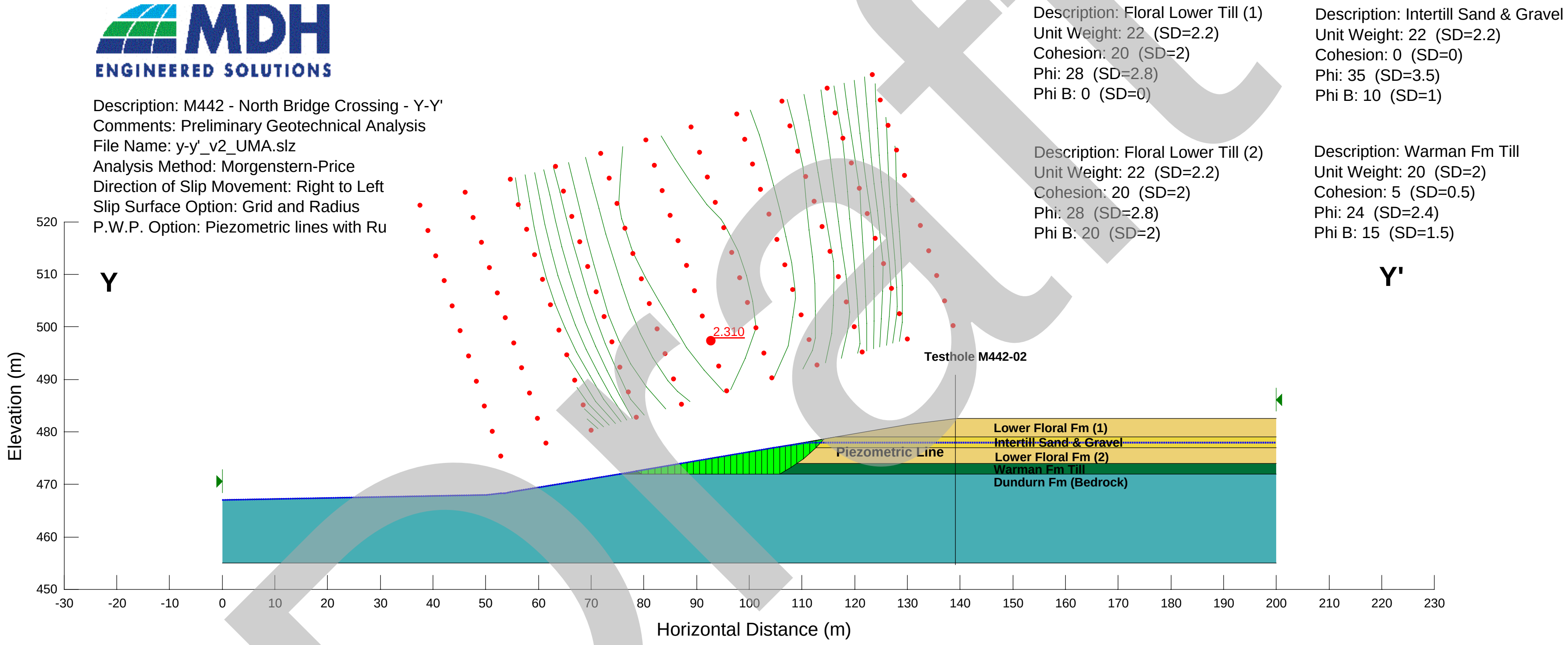
Description: Warman Fm Till
Unit Weight: 20 (SD=2)
Cohesion: 5 (SD=0.5)
Phi: 24 (SD=2.4)
Phi B: 15 (SD=1.5)

Description: Upper Floral Till
Unit Weight: 20 (SD=2)
Cohesion: 20 (SD=2)
Phi: 25 (SD=2.5)

Description: Floral Lower Till (1)
Unit Weight: 22 (SD=2.2)
Cohesion: 20 (SD=2)
Phi: 28 (SD=2.8)
Phi B: 20 (SD=2)

Description: Floral Lower Till (2)
Unit Weight: 22 (SD=2.2)
Cohesion: 20 (SD=2)
Phi: 28 (SD=2.8)
Phi B: 20 (SD=2)

Results of deterministic analysis for cross-section X-X' (Groundwater elevation = 478 masl)



Description: M442 - North Bridge Crossing - Y-Y'
Comments: Preliminary Geotechnical Analysis
File Name: y-y'_v2_UMA.slz
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru

Description: Floral Lower Till (1)
Unit Weight: 22 (SD=2.2)
Cohesion: 20 (SD=2)
Phi: 28 (SD=2.8)
Phi B: 0 (SD=0)

Description: Intertill Sand & Gravel
Unit Weight: 22 (SD=2.2)
Cohesion: 0 (SD=0)
Phi: 35 (SD=3.5)
Phi B: 10 (SD=1)

Description: Floral Lower Till (2)
Unit Weight: 22 (SD=2.2)
Cohesion: 20 (SD=2)
Phi: 28 (SD=2.8)
Phi B: 20 (SD=2)

Description: Warman Fm Till
Unit Weight: 20 (SD=2)
Cohesion: 5 (SD=0.5)
Phi: 24 (SD=2.4)
Phi B: 15 (SD=1.5)

Results of deterministic analysis for cross-section Y-Y' (Groundwater elevation = 478 masl)

Appendix III

Site Inspection Form

Government of Saskatchewan

RISK MANAGEMENT SYSTEM FOR LANDSLIDES IN SASKATCHEWAN

SITE INSPECTION FORM

CONTROL SECTION AND LOCATION CS xx-xx - Proposed Saskatoon Freeway - South Saskatchewan River Crossing	PREVIOUS INSPECTION DATE: none	INSPECTION DATE AND TIME DATE: 29 June 2020 FROM: 2:00 TO: 6:00 DATE: 30 June 2020 FROM: 9:30 TO: 1:30

LEGAL DESCRIPTION SE-26-37-05-W3M NE-26-37-05-W3M SW-26-37-05-W3M	NAD 83 COORDINATES Zone 13 U North Side N 5,785,392 E 390,132 South Side N 5,785,205 E 390,347	RISK ASSESSMENT Landslide: PF: 9+2 CF: 1 TOTAL: 11 Erosion: PF: 9+2 CF: 1 TOTAL: 11	WEATHER Sunny (29th) and Cloudy (30th), 20 degrees Celsius

SUMMARY OF SITE INSTRUMENTATION: Historical VW piezometers data available from instruments installed by MDH 2004	INSPECTED BY: Shirley McCuaig (SNC) Katherine Lockhart (SNC)

PRIMARY SITE ISSUE: The Saskatoon Freeway Functional Planning Study (SFFPS) will consider the placement of a new bridge crossing the South Saskatchewan River. The alignment crosses the River to the southeast of the Highway 11 interchange. This inspection is a baseline to determine if terrain or other geohazard concerns may affect construction on the slopes at the South Saskatchewan River Crossing.

The surficial geology on the western side of river valley is characterized by a broad, generally flat till plain with thin accumulations of post-glacial stratified silts and clays. The proposed bridge crossing lies within the transition zone between the area covered by glaciolacustrine deposits (to the south) and the area where the Battleford Formation till comprises the surficial stratigraphic unit.
The surficial geology eastern side of the river extends into two broad, flat terraces. The river terrace can be subdivided into three main zones in the immediate vicinity of the proposed bridge crossing: 1) A lower fluvial-lacustrine terrace; 2) an upper fluvial-lacustrine terrace; and, 3) a complex arrangement of channel deposits, outcrops of Floral Formation sand, boulder lag concentrate, and erosional remnants of Saskatoon Group till.

At surface, within the Saskatoon Group there is the Surficial Stratified Deposits, the Battleford Formation and the Floral Formation. Very small amounts of stratified deposits are expected at the bridge location. The Battleford Formation (which is a sandy silt till with trace gravel and clay), is expected at surface on the west side of the river. A boulder pavement may also be present beneath the Battleford Formation which marks the start of the Floral Formation Till. The Floral Formation till (with a very thin layer of stratified deposits) are expected close to surface on the east side of the river.

The Sutherland Group underlies the Saskatoon Group at the bridge location and consists of glacial till and intertill and intra till stratified deposits. The Empress Group underlies the Sutherland Group and consists of fine to medium grained sand; interbedded fine sand and silt; and/or a sandy, fine gravel. The Empress group is expected to be present on the east side of the river at approximately 68 m below ground (the exact depth to bedrock is unknown on the south side). The Upper Cretaceous Judith River Formation forms the bedrock surface which consists of marine and non-marine deltaic silts and sands. The thickness of the Judith River Formation is highly variable due to large amounts of post-depositional erosion and reaches accumulations of approximately 50 m within the Saskatoon area.
The overlying Bearpaw Formation was not encountered during past investigations of the bridge site which indicates erosion of the unit during the formation of the preglacial Tyner Valley and/or through subsequent glacial erosion. The Judith River Formation is expected on the west side of the river at a depth of approximately 70 m. The thickness of the Judith River Formation immediately beneath the proposed bridge crossing is unknown.

Previous investigations / data indicate that two highly artesian preglacial aquifers exist at depth beneath the proposed bridge site. Although the pore pressure within the preglacial sediments is high, thick accumulations of till beneath the site should be sufficient to limit uplift pressures and hydraulic gradients during construction of the pier foundations. A shallow, flowing artesian sand unit may be present beneath the river valley. If the shallow sand unit is present beneath the river channel, high pore pressures will be a consideration during the design and installation of the pier foundations.

The north river embankment is characterized by both active and inactive landslides which occur relatively continuously along the river embankment. Indications of slope movement along the southern embankment are less evident.

APPROXIMATE DIMENSIONS: The new bridge will be somewhere within the proposed corridor, which is approximately 500 m wide. The riverbank on both the north and south sides of the South Saskatchewan River was inspected as part of this baseline inspection. The area of inspection was about 500 m in length on the north side and 500 m in length on the south side.

ITEM	CONDITION EXISTS		DESCRIPTION AND LOCATION	NOTICABLE CHANGE FROM LAST INSPECTION	
	YES	NO		YES	NO
Pavement Distress		X	No pavement		
Slope Movement	X		Photo 1, Photo 11, Photo 12, Photo 13, Photo 14, Photo 15, Photo 16, Photo 17, Photo 19, Photo 20, Photo 21, Photo 22, Photo 23		
Erosion	X		Photo 4, Photo 5		
Seepage	X		Photo 6, Photo 7, Photo 8, Photo 9, Photo 10		
Culvert Distress		X	No culverts		

OBSERVATIONS AND COMMENTS

West Side of River:

- General: West slope has much higher relief and vegetation has grown in wetter areas, mainly in the depressions formed by old landslides (Photo 1). Dense brush and trees are located in the depressions. Other areas are drier and grassy, as can be expected for a south-facing slope.
- Erosion: relatively small amounts of erosion. The banks are eroding via small rotational failures in the fluvial sand (Photo 4 and Photo 5).
- Seepage: no evidence of seepage within proposed bridge corridor. Lower slopes and the fluvial terraces are heavily vegetated with trees and shrubs, apart from a few grassy areas on the fluvial terraces (Photo 6 and Photo 7).
- Landslides: An upper slide block of large landslide is present (Photo 11). A few recent small debris slides were present (Photo 12, Photo 13 and Photo 14). One recent small debris slide may have been caused by localized increased water infiltration via a hand-dug testpit. The testpit was not backfilled and is located approximately 3 m uphill of the small slide (Photo 15, Photo 16, and Photo 17).
- Tension cracks: one tension crack was identified in the field based on a change in grass colour and a few holes (Photo 22 and Photo 23). This location is adjacent to two small debris slide head scarps. No other new tension cracks were identified on the crest of the slope.
- Gullies: some local gullies are present. Also, a number of quad trails are present but they have not yet turned into gullies.

East Side of River:

- General: The East slope is much shorter than the west slope and mostly tree-covered. The trees are more widely spaced with a much less dense understory compared to the west slope. The upper portion of the east slope is locally steep (85% gradient: Photo 2 and Photo 3) and transitions to a lower slope with gradients of 20-30%. The lower portion of the slope varies between wet and dry zones and has a fairly consistent gradient.
- Erosion: relatively small amounts of erosion – nothing significant.
- Seepage: several seepage areas were visible (Photo 8, Photo 9 and Photo 10). Equisetum is the most common vegetation type within these areas, and the ground is moist to saturated with some standing water.

- Landslides: A number of small debris slides were visible on the upper portion of the east slope. One of these shows evidence of being a rotational slide, with the upper slide blocks down-dropped less than a metre from the surface (Photo 18 and Photo 19). A small debris slide was present at the location of a past tension crack (Photo 20 and Photo 21).
- Tension cracks: No new tension cracks were identified on the crest of the slope.
- Soil Creep: Soil creep is evident along the entire east slope, as evidenced by pistol grip and tilted trees.
- Gullies: east slope has three gullies that are anthropogenic (human-made). The gullies are not currently eroding due to vegetation growth (Photo 24, Photo 25, Photo 26, and Photo 27). The surficial soil of the agricultural land and in the gullies comprises glacial till with a sandy silt matrix (Photo 28).

RECOMMENDATIONS

- There is currently no infrastructure at this site. Slopes are currently inactive and have low probability of landslide occurrence. This will change based on future construction of the proposed bridge; therefore, the following is recommended prior to changing the natural slopes of the river:
  - A geotechnical investigation including instrumentation installation is required prior to design of the proposed bridge.
  - Geotechnical slope stability analysis and modelling is required for design and construction scenarios.

Site Location: West Side: 5,785,392 m N, 390,132 m E, East Side: 5,757,205 m N, 390,347 E (North American Datum 83 Zone 13)

Photo 1 – North side of West Riverbank - Looking down slope at lower slopes of a rotational debris slide (from Field Site 9 of 3D Mapping Figures), looking south.

Photo 2 – North side of East Riverbank - Looking at lower slope – fairly steep (from Field Site 5 of 3D Mapping Figures).

Photo 3 – North side of East Riverbank - Looking at upper slope – quite steep (from Field Site 5 of 3D Mapping Figures).

Photo 4 - South side of West Riverbank – Looking southwest at riverbank erosion (from Field Site 12 of 3D Mapping Figures).

Photo 5- South side of West Riverbank – Looking northeast at riverbank erosion (from Field Site 12 of 3D Mapping Figures).

Photo 6 – Middle part of West Riverbank – Looking northeast at grassy fluvial terrace consisting of sand (from Field Site 11 of 3D Mapping Figures).

Photo 7– Middle part of West Riverbank – Looking northwest at grassy fluvial terrace consisting of sand, with forested fluvial terrace above (from Field Site 11 of 3D Mapping Figures).

Photo 8 – North side of East Riverbank - Looking at seepage on the terrace (from Field Site 6 of 3D Mapping Figures).

Photo 9 – North side of East Riverbank - Looking at seepage spring at base of slope (from Field Site 6 of 3D Mapping Figures).

Photo 10 – South side of East Riverbank - Looking at part of a large seepage area (at Field Site 7 of 3D Mapping Figures).

Photo 11 – South side of West Riverbank - Looking southwest at headscarp of large slide area (an upper rotational slide block appears to be preserved at this location) - (at Field Site 8 of 3D Mapping Figures).

Photo 12 – South side of West Riverbank - Looking southeast at head scarp of small recent debris slide (at Field Site 13 of 3D Mapping Figures).

Photo 13 – North side of West Riverbank – Looking north at Thistles growing on recently exposed soil of head scarp - (at Field Site 10 of 3D Mapping Figures).

Photo 14 – North side of West Riverbank – Looking north at Thistles growing on recently exposed soil of head scarp - There is a badger den within the exposed soils just below the photograph location (at Field Site 10 of 3D Mapping Figures).

Photo 15 – South side of West Riverbank - Looking at exposed soil between newer vegetation, head scarp of small, recent debris slide (at Field Site 13 of 3D Mapping Figures).

Photo 16 – South side of West Riverbank - Looking at newer vegetation, small recent debris slide (at Field Site 13 of 3D Mapping Figures).

Photo 17– South side of West Riverbank - Looking at Testpit 1 x 1 x 0.5 m, located 3 m uphill of recent debris slide (at Field Site 13 of 3D Mapping Figures).

Photo 18 – Middle of East Riverbank – Looking northeast at older debris slide head scarp (at Field Site 3 of 3D Mapping Figures).

Photo 19– Middle of East Riverbank – Looking northwest at older debris slide head scarp (at Field Site 3 of 3D Mapping Figures).

Photo 20 – Middle of East Riverbank – Looking northeast at small debris slide (at Field Site 4 of 3D Mapping Figures).

Photo 21 – Middle of East Riverbank – Looking northwest at small debris slide head scarp (at Field Site 4 of 3D Mapping Figures).

Photo 22 – North side of West Riverbank – Tension crack indicated by change in grass colour (at Field Site 9 of 3D Mapping Figures).

Photo 23 – North side of West Riverbank – Tension crack indicated by small holes - one visible near shovel tip (at Field Site 9 of 3D Mapping Figures).

Photo 24 – South of East Riverbank – Looking at south anthropogenic gully with bushes growing in the bottom and exposed soil on the north side (at Field Site 1 of 3D Mapping Figures).

Photo 25 – South of East Riverbank – Looking west at central anthropogenic gully, boulder pile on left (at Field Site 1 of 3D Mapping Figures).

Photo 26 – South of East Riverbank – Looking north at central anthropogenic gully, smaller sub-gully in front of person standing within larger gully (at Field Site 1 of 3D Mapping Figures).

Photo 27 – South /middle of East Riverbank – Looking at shallow north anthropogenic gully, completely overgrown (at Field Site 2 of 3D Mapping Figures).

Photo 28 – South of East Riverbank – Looking at silty till exposed in south gully (at Field Site 1 of 3D Mapping Figures).

Appendix IV

Risk Response Levels

Table 14 – Probability Factors

PF	Natural Slope	Engineered Slopes
1	Geologically Stable. Very low probability of landslide occurrence.	$F_S > 1.5$ on basis of effective stress analysis with calibrated data and model*. Historically stable. Very low probability of landslide.
3	Inactive, apparently stable slope. Low probability of landslide occurrence or remobilization.	$1.5 > F_S > 1.3$ on basis of effective stress analysis with calibrated data and model. Historically stable. Low probability of landslide.
5	Inactive landslide with moderate probability of remobilization. Moderate uncertainty level; or, active slope with very slow constant rate of movement; or, indeterminate movement pattern.	$1.3 > F_S > 1.2$ on basis of effective stress analysis with calibrated data and model. Minor signs of visible movement. Moderate probability of landslide
7	Inactive landslide with high probability of remobilization, or additional hazards present. Uncertainty level high. Perceptible movement rate with defined zones of movement.	$1.2 > F_S > 1.1$. on basis of effective stress analysis with calibrated data and model. Perceptible signs of movement, or additional hazards present. High probability of landslide.
9	Active landslide with moderate, steady or decreasing rate of movement in defined shear zone.	$F_S < 1.1$ on basis of effective stress analysis with calibrated data and model. Obvious signs of ongoing slow to moderate movement.
11	Active landslide with moderate, increasing rate of movement.	Active landslide with moderate, increasing rate of movement.
13	Active landslide with high rate of movement at steady or increasing rate.	Active landslide with high rate of movement at steady or increasing rate.
15	Active landslide with high rate of movement with additional hazards**.	Active landslide with high rate of movement with additional hazards.
20	Catastrophic landslide is occurring.	Catastrophic landslide is occurring.

Notes:
* If the described conditions for slope analysis are unknown or not met, increase the PF by one category, e.g. if quality of data used in analysis is not known, increase PF from 1 to 3. F_S = Factor of Safety.
** Additional hazards are factors which can greatly increase the rate of movement, e.g. eroding toe, groundwater, etc.

Table 15 – Consequence factors

CF	Typical Consequences
1	Shallow cut slopes where slide may spill into ditches or fills where slide does not impact pavement to driver safety, maintenance issue.
2	Moderate fills and cuts, not including bridge approach fill or head slopes, loss of portion of the roadway or slide onto road possible, small volume. Shallow fills where private land, waterbodies or structures may be impacted. Slides affecting use of roadways and safety of motorists, but not requiring closure of the roadway. Potential rock fall hazard sites.
4	Fills and cuts associated with bridges, intersectional treatments, culverts and other structures, high fills, deep cuts, historic rock fall hazard areas. Sites where partial closure of the road or significant detours would be a direct and avoidable result of a slide occurrence.
6	Sites where closure of the road would be a direct and unavoidable result of a slide occurrence.
10	Sites where the safety of public and significant loss of infrastructure facilities (such as a bridge abutment) or privately owned structures will occur if a slide occurs. Sites where rapid mobilization of a large-scale slide is possible.

Table 16 – Response levels and management approach

Risk Level (RL)	Response Level	Management Approach
>125	Urgent	Inspect at least once per year. Monitor instrumentation at least twice per year in the spring and fall. Investigate and evaluate mitigation measures.
>75 to 125	Priority	Inspect once per year. Monitor instrumentation at least once per year.
27.5 to 75	Routine	Inspect every 3 years. Monitor instrumentation at least every 3 years with an increased frequency for selected sites as required.
< 27.5	Inactive	No set instrumentation monitoring or inspection schedule. Monitored and inspected as required in response to maintenance requests

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APPENDIX I

Multiple Account Evaluation Results

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - Northeast Swale and Small Swale

MULTIPLE ACCOUNT EVALUATION (MAE): Summary

		Concept 1 (Base Case - Red Route)			Concept 2 (Yellow Route)			Concept 3 (Blue Route)			Concept 4 (Hwy 41 Re-Alignment B)		
Accounts and Elements	Weighting/ Importance	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)
ROAD USER ACCOUNT	10.0		22.0	13.4%		22.0	12.9%		20.7	9.2%		21.9	10.1%
Travel Time Cost (Delay Time)	3.3	2.4	8.1		2.4	8.1		1.9	6.2		2.0	6.6	
Vehicle Operating Cost (Congestion, Start/Stop)	1.9	2.1	4.0		2.1	4.0		2.2	4.2		2.2	4.2	
Safety Cost (At-grade intersections, LOS/Congestion)	2.6	2.0	5.2		2.0	5.2		2.2	5.8		2.4	6.3	
Construction Impacts to Road Users (Detours, Delays)	1.3	2.1	2.7		2.1	2.7		2.1	2.7		2.3	3.0	
Maximized Benefits Related to Construction Schedule	0.9	2.2	2.0		2.2	2.0		1.9	1.7		1.9	1.7	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
ENVIRONMENTAL ACCOUNT	46.0		62.0	37.7%		68.4	40.1%		105.9	47.3%		97.3	45.1%
Green House Gas Costs (Construction/Operation)	0.4	2.1	0.9		2.1	0.9		1.8	0.7		1.7	0.7	
Landscape (Native Habitat/Grass Lands)	3.8	1.1	4.3		1.6	6.0		2.6	9.8		2.2	8.5	
Impact to Ecologically sensitive areas	9.6	0.9	8.5		1.2	11.7		2.2	21.3		2.0	19.2	
Other Wetlands (outside of Swales)	1.8	1.8	3.1		1.9	3.3		2.1	3.7		1.9	3.3	
Other Grasslands (outside of Swales)	1.4	1.7	2.4		1.7	2.4		2.1	3.0		2.1	3.0	
Impact to Breeding Birds and Migratory Birds	3.4	1.3	4.5		1.4	4.9		2.4	8.3		2.2	7.6	
Impact to SOCC	2.8	1.6	4.4		1.6	4.4		2.3	6.6		2.2	6.3	
Impact to SAR	4.0	1.6	6.2		1.6	6.2		2.3	9.3		2.1	8.4	
Impact to Wildlife Movement/Connectivity (to existing crossings)	5.3	1.7	8.9		1.7	8.9		2.3	12.4		2.1	11.2	
Impact Resulting from Habitat Fragmentation	4.1	1.0	4.1		1.1	4.5		2.4	10.0		2.3	9.5	
Illumination Impact	2.0	1.6	3.1		1.6	3.1		2.0	4.0		2.0	4.0	
Noise Impact	2.0	1.3	2.7		1.6	3.1		2.2	4.4		2.2	4.4	
Surface Runoff/Water Quality	4.1	1.7	6.8		1.7	6.8		2.3	9.5		2.1	8.6	
Impact to Heritage Resources	1.3	1.7	2.1		1.7	2.1		2.2	2.8		2.0	2.5	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
SOCIAL ACCOUNT	24.0		37.8	23.0%		38.8	22.7%		54.7	24.5%		54.0	25.0%
City of Saskatoon Road Network Plans (Alignment)	5.6	1.2	6.8		1.3	7.4		2.4	13.7		2.1	11.8	
RM Corman Park Road Network Plans (Alignment)	4.3	1.9	8.1		1.9	8.1		2.1	9.1		2.2	9.5	
First Nations Road Network Plans (Alignment)	2.2	1.9	4.2		1.9	4.2		2.1	4.6		1.9	4.2	
Public Information Session Feedback/Acceptance	3.3	1.0	3.3		1.1	3.7		2.9	9.5		2.6	8.4	
Land Owner Impacts/Access	3.2	1.7	5.3		1.7	5.3		2.1	6.8		2.3	7.5	
Business Impacts/Access	3.5	1.8	6.2		1.8	6.2		2.0	7.0		2.4	8.5	
Multi Use Paths (Connectivity)	1.9	2.0	3.8		2.0	3.8		2.1	4.0		2.1	4.0	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
ECONOMIC ACCOUNT	7.0		13.2	8.0%		13.2	7.7%		15.3	6.9%		16.8	7.8%
Employment During Construction	1.9	2.1	4.0		2.1	4.0		2.1	4.0		2.2	4.2	
Development Opportunities (Land Access Availability)	3.6	1.7	6.0		1.7	6.0		2.2	8.0		2.6	9.2	
Local Resource Availability	1.5	2.1	3.2		2.1	3.2		2.2	3.3		2.2	3.3	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
FINANCIAL ACCOUNT	13.0		29.4	17.9%		28.4	16.6%		27.1	12.1%		25.9	12.0%
Capital Cost (Excludes Utility Costs)	4.8	2.4	11.7		2.2	10.7		2.2	10.7		2.1	10.1	
Operating Cost	3.0	2.2	6.7		2.2	6.7		2.0	6.0		1.9	5.7	
Maintenance Cost	3.0	2.2	6.7		2.2	6.7		2.0	6.0		1.9	5.7	
Utility Cost/Impacts	2.2	2.0	4.4		2.0	4.4		2.0	4.4		2.0	4.4	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
Total Rating Points (elements) =	100.0		164.4			170.7			223.6			215.8	

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - Northeast Swale and Small Swale

MULTIPLE ACCOUNT EVALUTION (MAE) CRITERIA: Environmental Account Weighting Developed at Environmental Workshop August 25, 2020

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Criteria Weighting	Account % Weighting
ROAD USER ACCOUNT												Account Average Weighting (Rounded) =				2	10
Travel Time Cost (Delay Time)	3	2	2	3	3	5	5		3	4	3					3.3	33.0%
Vehicle Operating Cost (Congestion, Start/Stop)	3	1	1	2	3	1	3		1	2	2					1.9	19.0%
Safety Cost (At-grade intersections, LOS/Congestion)	2	5	3	3	1	2	1		4	2	3					2.6	26.0%
Construction Impacts to Road Users (Detours, Delays)	1	1	3	1	2	1	1		1	1	1					1.3	13.0%
Maximized Benefits Related to Construction Schedule	1	1	1	1	1	1	0		1	1	1					0.9	9.0%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	10	10	10	10	10	10	10	0	10	10	10	0	0	0	0	10	100%
ENVIRONMENTAL ACCOUNT												Account Average Weighting (Rounded) =				3.29	46
Green House Gas Costs (Construction/Operation)	2	0	0	1	0	0	0	0	0	0	0	2				0.42	0.91%
Landscape (Native Habitat/Grass Lands)	5	5	5	4	6	1	2	1	2	4	7	4				3.83	8.33%
Impact to Ecologically sensitive areas	5	10	10	4	13	5	15	11	12	10	10	10				9.58	20.83%
Other Wetlands (outside of Swales)	1	2	2	1	2	2	2	3	2	1	2	1				1.75	3.80%
Other Grasslands (outside of Swales)	1	1	2	1	2	1	2	1	2	1	2	1				1.42	3.09%
Impact to Breeding Birds and Migratory Birds	3	3	2	4	0	5	3	3	4	3	4	7				3.42	7.43%
Impact to SOCC	1	2	2	4	1	3	3	2	5	4	3	4				2.83	6.15%
Impact to SAR	2	5	2	4	3	5	3	4	5	4	7	4				4	8.70%
Impact to Wildlife Movement/Connectivity (to existing crossings)	4	6	6	4	5	5	7	8	6	4	5	4				5.33	11.59%
Impact Resulting from Habitat Fragmentation	4	4	5	4	6	5	7	3	2	5	3	1				4.08	8.87%
Illumination Impact	5	0	3	4	3	5	0	0	1	1	0	2				2	4.35%
Noise Impact	6	0	2	3	3	5	0	0	2	1	0	2				2	4.35%
Surface Runoff/Water Quality	6	5	5	4	2	4	2	10	1	4	3	3				4.08	8.87%
Impact to Heritage Resources	1	3	0	4	0	0	0	0	2	4	0	1				1.25	2.72%
-																Equal or N/A	0.00%
Person/Evaluator Account Criteria Total =	46	46	46	46	46	46	46	46	46	46	46	46	0	0	0	45.99	100%
SOCIAL ACCOUNT												Account Average Weighting (Rounded) =				3	24
City of Saskatoon Road Network Plans (Alignment)	4	9	3	6	5	7	4		6	6	6					5.6	23.33%
RM Corman Park Road Network Plans (Alignment)	2	4	5	2	5	7	2		6	5	5					4.3	17.92%
First Nations Road Network Plans (Alignment)	2	5	3	1	4	0	0		1	3	3					2.2	9.17%
Public Information Session Feedback/Acceptance	4	2	2	5	3	4	8		2	1	2					3.3	13.75%
Land Owner Impacts/Access	5	1	5	4	2	2	4		3	3	3					3.2	13.33%
Business Impacts/Access	5	1	5	4	2	2	6		3	4	3					3.5	14.58%
Multi Use Paths (Connectivity)	2	2	1	2	3	2	0		3	2	2					1.9	7.92%
-																Equal or N/A	0.00%
Person/Evaluator Account Criteria Total =	24	24	24	24	24	24	24	0	24	24	24	0	0	0	0	24	100%
ECONOMIC ACCOUNT												Account Average Weighting (Rounded) =				4	7
Employment During Construction	2	1	1	2	2	3	2		1	4	1					1.9	27.14%
Development Opportunities (Land Access Availability)	4	5	5	3	3	3	4		4	1	4					3.6	51.43%
Local Resource Availability	1	1	1	2	2	1	1		2	2	2					1.5	21.43%
-																Equal or N/A	0.00%
Person/Evaluator Account Criteria Total =	7	7	7	7	7	7	7	0	7	7	7	0	0	0	0	7	100%
FINANCIAL ACCOUNT												Account Average Weighting (Rounded) =				3	13
Capital Cost (Excludes Utility Costs)	6	3	3	4	5	6	4		8	5	4					4.8	36.92%
Operating Cost	3	3	4	3	3	3	3		1	3	4					3	23.08%
Maintenance Cost	2	4	3	4	3	2	3		3	3	3					3	23.08%
Utility Cost/Impacts	2	3	3	2	2	2	3		1	2	2					2.2	16.92%
-																Equal or N/A	0.00%
Person/Evaluator Account Criteria Total =	13	13	13	13	13	13	13	0	13	13	13	0	0	0	0	13	100%
Total	100	100	100	100	100	100	100	46	100	100	100	46	0	0	0	15.29	100

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - Northeast Swale and Small Swale

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Concept 1 (Base Case - Red Route)

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.2
Travel Time Cost (Delay Time)	2	3		3	2	2	2		3	2	3					2.4
Vehicle Operating Cost (Congestion, Start/Stop)	2	3		2	2	2	2		2	1	3					2.1
Safety Cost (At-grade intersections, LOS/Congestion)	2	3		2	2	1	2		2	1	3					2.0
Construction Impacts to Road Users (Detours, Delays)	2	2		2	2	2	2		3	2	2					2.1
Maximized Benefits Related to Construction Schedule	2	2		3	2	2	2		3	2	2					2.2
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				1.5
Green House Gas Costs (Construction/Operation)	2	2		2	2	2	2		2	2	3					2.1
Landscape (Native Habitat/Grass Lands)	1	0		2	0	1	1		2	1	2					1.1
Impact to Ecologically sensitive areas	0	0		2	0	1	1		1	1	2					0.9
Other Wetlands (outside of Swales)	2	0		2	2	1	2		2	2	3					1.8
Other Grasslands (outside of Swales)	2	0		2	2	2	1		2	2	2					1.7
Impact to Breeding Birds and Migratory Birds	2	0		2	0	1	1		2	2	2					1.3
Impact to SOCC	2	0		2	1	2	1		2	2	2					1.6
Impact to SAR	2	0		2	1	2	1		2	2	2					1.6
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	0		3	2	2	2		1	1	2					1.7
Impact Resulting from Habitat Fragmentation	0	0		2	0	1	1		2	1	2					1.0
Illumination Impact	1	0		2	2	2	2		2	1	2					1.6
Noise Impact	0	0		2	2	2	1		2	1	2					1.3
Surface Runoff/Water Quality	2	0		2	2	2	2		2	1	2					1.7
Impact to Heritage Resources	2	0		2	1	2	2		2	2	2					1.7
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				1.6
City of Saskatoon Road Network Plans (Alignment)	2	0		2	2	0	1		1	1	2					1.2
RM Corman Park Road Network Plans (Alignment)	2	0		2	2	2	2		2	2	3					1.9
First Nations Road Network Plans (Alignment)	2	0		2	2	2	2		2	2	3					1.9
Public Information Session Feedback/Acceptance	1	0		1	1	2	1		0	1	2					1.0
Land Owner Impacts/Access	2	0		2	2	2	1		3	1	2					1.7
Business Impacts/Access	2	0		2	2	2	1		3	2	2					1.8
Multi Use Paths (Connectivity)	2	2		2	2	2	2		2	2	2					2.0
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2		2	2	2	2		2	2	3					2.1
Development Opportunities (Land Access Availability)	2	2		2	2	1	1		2	1	2					1.7
Local Resource Availability	2	2		2	2	2	2		2	2	3					2.1
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.2
Capital Cost (Excludes Utility Costs)	2	2		3	3	2	2		3	2	3					2.4
Operating Cost	2	2		2	2	2	2		3	2	3					2.2
Maintenance Cost	2	2		2	2	2	2		3	2	3					2.2
Utility Cost/Impacts	2	2		2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	57	31	0	69	55	57	53	0	69	53	78	0	0	0	0	9.5

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - Northeast Swale and Small Swale

Multiple Account Evaluation: Criteria Rating

Concept 2 (Yellow Route)

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.2
Travel Time Cost (Delay Time)	2	3		3	2	2	2		3	2	3					2.4
Vehicle Operating Cost (Congestion, Start/Stop)	2	3		2	2	2	2		2	1	3					2.1
Safety Cost (At-grade intersections, LOS/Congestion)	2	3		2	2	1	2		2	1	3					2.0
Construction Impacts to Road Users (Detours, Delays)	2	2		2	2	2	2		3	2	2					2.1
Maximized Benefits Related to Construction Schedule	2	2		3	2	2	2		3	2	2					2.2
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				1.6
Green House Gas Costs (Construction/Operation)	2	2		2	2	2	2		2	2	3					2.1
Landscape (Native Habitat/Grass Lands)	2	0		2	1	2	2		2	1	2					1.6
Impact to Ecologically sensitive areas	1	0		2	1	1	2		1	1	2					1.2
Other Wetlands (outside of Swales)	2	0		2	2	2	2		2	2	3					1.9
Other Grasslands (outside of Swales)	2	0		2	2	2	1		2	2	2					1.7
Impact to Breeding Birds and Migratory Birds	2	0		2	1	1	1		2	2	2					1.4
Impact to SOCC	2	0		2	1	2	1		2	2	2					1.6
Impact to SAR	2	0		2	1	2	1		2	2	2					1.6
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	0		3	1	2	2		2	1	2					1.7
Impact Resulting from Habitat Fragmentation	1	0		2	0	1	1		2	1	2					1.1
Illumination Impact	1	0		2	2	2	2		2	1	2					1.6
Noise Impact	1	0		2	2	2	2		2	1	2					1.6
Surface Runoff/Water Quality	2	0		2	2	2	2		2	1	2					1.7
Impact to Heritage Resources	2	0		2	1	2	2		2	2	2					1.7
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				1.7
City of Saskatoon Road Network Plans (Alignment)	2	0		2	2	1	1		1	1	2					1.3
RM Corman Park Road Network Plans (Alignment)	2	0		2	2	2	2		2	2	3					1.9
First Nations Road Network Plans (Alignment)	2	0		2	2	2	2		2	2	3					1.9
Public Information Session Feedback/Acceptance	1	0		1	2	1	1		1	1	2					1.1
Land Owner Impacts/Access	2	0		2	2	2	1		3	1	2					1.7
Business Impacts/Access	2	0		2	2	2	1		3	2	2					1.8
Multi Use Paths (Connectivity)	2	2		2	2	2	2		2	2	2					2.0
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2		2	2	2	2		2	2	3					2.1
Development Opportunities (Land Access Availability)	2	2		2	2	1	1		2	1	2					1.7
Local Resource Availability	2	2		2	2	2	2		2	2	3					2.1
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.2
Capital Cost (Excludes Utility Costs)	2	2		3	2	2	1		3	2	3					2.2
Operating Cost	2	2		2	2	2	2		3	2	3					2.2
Maintenance Cost	2	2		2	2	2	2		3	2	3					2.2
Utility Cost/Impacts	2	2		2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	61	31	0	69	57	59	55	0	71	53	78	0	0	0	0	9.6

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - Northeast Swale and Small Swale

Multiple Account Evaluation: Criteria Rating

Concept 3 (Blue Route)

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.1
Travel Time Cost (Delay Time)	1	3		2	2	2	1		2	2	2					1.9
Vehicle Operating Cost (Congestion, Start/Stop)	2	3		2	2	2	1		3	2	3					2.2
Safety Cost (At-grade intersections, LOS/Congestion)	2	3		2	2	1	2		3	2	3					2.2
Construction Impacts to Road Users (Detours, Delays)	2	2		2	2	2	2		3	2	2					2.1
Maximized Benefits Related to Construction Schedule	1	2		2	2	2	1		3	2	2					1.9
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.2
Green House Gas Costs (Construction/Operation)	1	2		2	2	2	2		2	1	2					1.8
Landscape (Native Habitat/Grass Lands)	3	2		3	4	2	2		3	2	2					2.6
Impact to Ecologically sensitive areas	2	2		3	4	2	2		1	2	2					2.2
Other Wetlands (outside of Swales)	2	2		2	2	2	2		2	2	3					2.1
Other Grasslands (outside of Swales)	2	2		2	2	2	3		2	2	2					2.1
Impact to Breeding Birds and Migratory Birds	2	2		2	4	2	3		3	2	2					2.4
Impact to SOCC	2	2		2	4	2	2		3	2	2					2.3
Impact to SAR	2	2		2	4	2	2		3	2	2					2.3
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2		3	4	2	2		2	2	2					2.3
Impact Resulting from Habitat Fragmentation	2	2		2	4	2	3		3	2	2					2.4
Illumination Impact	2	2		2	2	2	2		2	2	2					2.0
Noise Impact	3	2		2	2	2	3		2	2	2					2.2
Surface Runoff/Water Quality	2	2		3	4	2	2		2	2	2					2.3
Impact to Heritage Resources	2	2		2	4	2	2		2	2	2					2.2
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.3
City of Saskatoon Road Network Plans (Alignment)	2	2		2	2	3	3		3	3	2					2.4
RM Corman Park Road Network Plans (Alignment)	2	2		2	2	2	2		3	2	2					2.1
First Nations Road Network Plans (Alignment)	2	2		2	2	2	2		2	2	3					2.1
Public Information Session Feedback/Acceptance	3	2		3	4	3	2		3	3	3					2.9
Land Owner Impacts/Access	2	2		2	2	2	2		2	2	3					2.1
Business Impacts/Access	2	2		2	2	2	2		2	2	2					2.0
Multi Use Paths (Connectivity)	2	2		2	2	2	2		2	2	3					2.1
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.2
Employment During Construction	2	2		2	2	2	2		2	2	3					2.1
Development Opportunities (Land Access Availability)	2	2		2	2	2	2		3	2	3					2.2
Local Resource Availability	2	2		3	2	2	2		2	2	3					2.2
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Capital Cost (Excludes Utility Costs)	2	2		2	2	3	2		3	2	2					2.2
Operating Cost	2	2		2	2	2	2		2	2	2					2.0
Maintenance Cost	2	2		2	2	2	2		2	2	2					2.0
Utility Cost/Impacts	2	2		2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	66	69	0	72	86	68	68	0	79	67	76	0	0	0	0	10.8

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - Northeast Swale and Small Swale

Multiple Account Evaluation: Criteria Rating

Concept 4 (Hwy 41 Re-Alignment B)

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.2
Travel Time Cost (Delay Time)	1	0		2	3	3	3		2	2	2					2.0
Vehicle Operating Cost (Congestion, Start/Stop)	2	0		2	3	2	3		3	2	3					2.2
Safety Cost (At-grade intersections, LOS/Congestion)	2	2		2	2	3	2		3	3	3					2.4
Construction Impacts to Road Users (Detours, Delays)	2	2		3	2	3	2		2	2	3					2.3
Maximized Benefits Related to Construction Schedule	1	2		2	2	2	2		2	2	2					1.9
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Green House Gas Costs (Construction/Operation)	1	0		2	2	2	3		2	1	2					1.7
Landscape (Native Habitat/Grass Lands)	3	2		2	2	2	2		3	2	2					2.2
Impact to Ecologically sensitive areas	2	2		3	2	2	2		1	2	2					2.0
Other Wetlands (outside of Swales)	2	2		2	2	1	2		2	2	2					1.9
Other Grasslands (outside of Swales)	2	2		2	2	2	3		2	2	2					2.1
Impact to Breeding Birds and Migratory Birds	2	2		2	2	2	3		3	2	2					2.2
Impact to SOCC	2	2		2	2	2	3		3	2	2					2.2
Impact to SAR	2	2		2	2	2	2		3	2	2					2.1
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2		3	2	2	2		2	2	2					2.1
Impact Resulting from Habitat Fragmentation	2	2		3	2	2	3		3	2	2					2.3
Illumination Impact	2	2		2	2	2	2		2	2	2					2.0
Noise Impact	3	2		2	2	2	3		2	2	2					2.2
Surface Runoff/Water Quality	2	2		2	2	2	3		2	2	2					2.1
Impact to Heritage Resources	2	2		2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.2
City of Saskatoon Road Network Plans (Alignment)	2	0		2	2	3	3		3	2	2					2.1
RM Corman Park Road Network Plans (Alignment)	2	0		2	2	3	3		3	3	2					2.2
First Nations Road Network Plans (Alignment)	2	0		2	2	2	2		2	2	3					1.9
Public Information Session Feedback/Acceptance	3	0		3	2	3	3		3	3	3					2.6
Land Owner Impacts/Access	2	2		3	3	2	2		2	2	3					2.3
Business Impacts/Access	2	2		3	3	3	3		2	2	2					2.4
Multi Use Paths (Connectivity)	2	2		2	2	2	2		2	2	3					2.1
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.3
Employment During Construction	2	2		2	3	2	2		2	2	3					2.2
Development Opportunities (Land Access Availability)	2	2		2	3	3	3		3	2	3					2.6
Local Resource Availability	2	2		3	2	2	2		2	2	3					2.2
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Capital Cost (Excludes Utility Costs)	2	2		2	3	3	1		2	2	2					2.1
Operating Cost	2	2		2	2	2	1		2	2	2					1.9
Maintenance Cost	2	2		2	2	2	1		2	2	2					1.9
Utility Cost/Impacts	2	2		2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	66	52	0	74	73	74	77	0	76	68	76	0	0	0	0	10.8

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Summary

		Central Avenue Interchange Concept 1			Central Avenue Interchange Concept 2			Highway 41 Interchange Concept 1			Highway 41 Interchange Concept 2		
Accounts and Elements	Weighting/ Importance	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)
ROAD USER ACCOUNT	21.2		199.0	16.5%		225.8	18.9%		235.2	20.9%		188.7	16.1%
Travel Time Cost (Delay Time)	23.5	2.1	49.4		2.6	61.1		2.7	63.5		1.9	44.7	
Vehicle Operating Cost (Congestion, Start/Stop)	22.3	2.2	49.1		2.5	55.8		2.6	58.0		1.8	40.1	
Safety Cost (At-grade intersections, LOS/Congestion)	20.8	2.0	41.6		2.4	49.9		2.7	56.2		1.9	39.3	
Construction Impacts to Road Users (Detours, Delays)	13.7	2.1	28.8		2.1	28.8		2.1	28.8		2.4	32.9	
Maximized Benefits Related to Construction Schedule	14.4	2.1	30.2		2.1	30.2		2.0	28.8		2.2	31.7	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
ENVIRONMENTAL ACCOUNT	6.1		453.9	37.7%		438.6	36.7%		418.5	37.1%		429.0	36.5%
Green House Gas Costs (Construction/Operation)	14.8	2.0	29.6		2.3	34.0		2.2	32.6		1.9	28.1	
Landscape (Native Habitat/Grass Lands)	16.6	2.4	39.8		1.9	31.5		2.0	33.2		2.2	36.5	
Impact to Ecologically sensitive areas	17.4	2.2	38.3		1.8	31.3		2.0	34.8		2.1	36.5	
Other Wetlands (outside of Swales)	12.1	2.1	25.4		2.1	25.4		1.9	23.0		1.9	23.0	
Other Grasslands (outside of Swales)	12.1	2.2	26.6		2.1	25.4		2.0	24.2		2.2	26.6	
Impact to Breeding Birds and Migratory Birds	14.8	2.1	31.1		2.1	31.1		2.0	29.6		2.0	29.6	
Impact to SOCC	16.8	2.1	35.3		2.1	35.3		2.0	33.6		2.0	33.6	
Impact to SAR	16.4	2.1	34.4		2.1	34.4		2.0	32.8		2.0	32.8	
Impact to Wildlife Movement/Connectivity (to existing crossings)	17.0	2.2	37.4		2.1	35.7		1.9	32.3		2.0	34.0	
Impact Resulting from Habitat Fragmentation	14.7	2.1	30.9		2.0	29.4		2.0	29.4		2.0	29.4	
Illumination Impact	14.0	2.1	29.4		2.1	29.4		1.7	23.8		2.1	29.4	
Noise Impact	15.9	2.1	33.4		2.2	35.0		2.1	33.4		2.0	31.8	
Surface Runoff/Water Quality	17.1	2.2	37.6		2.1	35.9		1.9	32.5		2.0	34.2	
Impact to Heritage Resources	11.7	2.1	24.7		2.1	24.7		2.0	23.4		2.0	23.4	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
SOCIAL ACCOUNT	14.6		275.1	22.8%		268.8	22.5%		247.1	21.9%		288.3	24.5%
City of Saskatoon Road Network Plans (Alignment)	22.6	2.2	49.7		2.2	49.7		2.1	47.5		2.5	56.5	
RM Corman Park Road Network Plans (Alignment)	19.4	2.0	38.8		2.2	42.7		2.1	40.7		2.3	44.6	
First Nations Road Network Plans (Alignment)	14.9	2.1	31.3		2.1	31.3		2.1	31.3		2.1	31.3	
Public Information Session Feedback/Acceptance	18.8	2.3	43.2		2.0	37.6		2.0	37.6		2.3	43.2	
Land Owner Impacts/Access	19.3	2.2	42.5		2.1	40.5		1.7	32.8		2.5	48.3	
Business Impacts/Access	19.6	2.1	41.2		2.1	41.2		1.8	35.3		2.1	41.2	
Multi Use Paths (Connectivity)	12.9	2.2	28.4		2.0	25.8		1.7	21.9		1.8	23.2	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
ECONOMIC ACCOUNT	30.8		103.7	8.6%		102.6	8.6%		102.5	9.1%		96.9	8.2%
Employment During Construction	18.6	2.1	39.1		2.1	39.1		2.2	40.9		1.9	35.3	
Development Opportunities (Land Access Availability)	19.0	2.1	39.9		2.1	39.9		2.0	38.0		2.0	38.0	
Local Resource Availability	11.8	2.1	24.8		2.0	23.6		2.0	23.6		2.0	23.6	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
FINANCIAL ACCOUNT	27.3		172.0	14.3%		160.4	13.4%		124.0	11.0%		172.6	14.7%
Capital Cost (Excludes Utility Costs)	20.6	2.5	51.5		1.9	39.1		1.2	24.7		2.5	51.5	
Operating Cost	22.3	2.1	46.8		2.2	49.1		1.8	40.1		2.1	46.8	
Maintenance Cost	20.2	2.1	42.4		2.1	42.4		1.6	32.3		2.2	44.4	
Utility Cost/Impacts	14.9	2.1	31.3		2.0	29.8		1.8	26.8		2.0	29.8	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
	100.0		1203.8			1196.1			1127.3			1175.4	

SASKATOON FREEWAY FUNCTION PLANNING STUDY:
Phase 2 - North Interchange Concepts

Summary Page 2 of 2

MULTIPLE ACCOUNT EVALUATION (MAE): Summary

Accounts and Elements	Weighting/ Importance	Blackley Road Interchange Concept 1 			Blackley Road Interchange Concept 2 			Highway 5 Interchange Concept 1 			Highway 5 Interchange Concept 2 		
		Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)
ROAD USER ACCOUNT	21.2		199.7	16.8%		231.1	20.7%		223.0	19.5%		187.6	16.6%
Travel Time Cost (Delay Time)	23.5	2.2	51.7		2.7	63.5		2.6	61.1		2.1	49.4	
Vehicle Operating Cost (Congestion, Start/Stop)	22.3	2.0	44.6		2.7	60.2		2.5	55.8		2.0	44.6	
Safety Cost (At-grade intersections, LOS/Congestion)	20.8	2.0	41.6		2.6	54.1		2.4	49.9		1.8	37.4	
Construction Impacts to Road Users (Detours, Delays)	13.7	2.2	30.1		1.9	26.0		2.0	27.4		2.0	27.4	
Maximized Benefits Related to Construction Schedule	14.4	2.2	31.7		1.9	27.4		2.0	28.8		2.0	28.8	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
ENVIRONMENTAL ACCOUNT	6.1		433.5	36.6%		400.0	35.9%		424.3	37.1%		422.8	37.4%
Green House Gas Costs (Construction/Operation)	14.8	2.1	31.1		2.2	32.6		2.3	34.0		2.1	31.1	
Landscape (Native Habitat/Grass Lands)	16.6	2.2	36.5		1.6	26.6		2.0	33.2		2.0	33.2	
Impact to Ecologically sensitive areas	17.4	2.1	36.5		1.8	31.3		2.0	34.8		2.0	34.8	
Other Wetlands (outside of Swales)	12.1	2.0	24.2		2.0	24.2		1.9	23.0		1.9	23.0	
Other Grasslands (outside of Swales)	12.1	2.1	25.4		2.0	24.2		2.0	24.2		2.0	24.2	
Impact to Breeding Birds and Migratory Birds	14.8	2.0	29.6		1.9	28.1		2.0	29.6		2.0	29.6	
Impact to SOCC	16.8	2.0	33.6		1.9	31.9		2.0	33.6		2.0	33.6	
Impact to SAR	16.4	2.0	32.8		1.9	31.2		2.0	32.8		2.0	32.8	
Impact to Wildlife Movement/Connectivity (to existing crossings)	17.0	2.0	34.0		1.9	32.3		2.0	34.0		2.0	34.0	
Impact Resulting from Habitat Fragmentation	14.7	1.9	27.9		1.8	26.5		2.0	29.4		2.0	29.4	
Illumination Impact	14.0	2.2	30.8		1.8	25.2		2.0	28.0		2.1	29.4	
Noise Impact	15.9	2.1	33.4		2.0	31.8		2.0	31.8		2.0	31.8	
Surface Runoff/Water Quality	17.1	2.0	34.2		1.8	30.8		1.9	32.5		1.9	32.5	
Impact to Heritage Resources	11.7	2.0	23.4		2.0	23.4		2.0	23.4		2.0	23.4	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
SOCIAL ACCOUNT	14.6		267.8	22.6%		249.7	22.4%		262.2	22.9%		244.5	21.6%
City of Saskatoon Road Network Plans (Alignment)	22.6	2.0	45.2		2.3	52.0		2.1	47.5		2.0	45.2	
RM Corman Park Road Network Plans (Alignment)	19.4	2.1	40.7		2.4	46.6		1.9	36.9		1.9	36.9	
First Nations Road Network Plans (Alignment)	14.9	2.0	29.8		2.0	29.8		2.0	29.8		2.0	29.8	
Public Information Session Feedback/Acceptance	18.8	2.2	41.4		1.7	32.0		2.3	43.2		1.8	33.8	
Land Owner Impacts/Access	19.3	2.2	42.5		1.5	29.0		2.2	42.5		1.9	36.7	
Business Impacts/Access	19.6	2.1	41.2		1.9	37.2		2.0	39.2		2.0	39.2	
Multi Use Paths (Connectivity)	12.9	2.1	27.1		1.8	23.2		1.8	23.2		1.8	23.0	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
ECONOMIC ACCOUNT	30.8		103.7	8.8%		104.4	9.4%		98.8	8.6%		98.8	8.7%
Employment During Construction	18.6	2.1	39.1		2.2	40.9		2.1	39.1		2.1	39.1	
Development Opportunities (Land Access Availability)	19.0	2.1	39.9		2.1	39.9		1.9	36.1		1.9	36.1	
Local Resource Availability	11.8	2.1	24.8		2.0	23.6		2.0	23.6		2.0	23.6	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
FINANCIAL ACCOUNT	27.3		180.9	15.3%		129.4	11.6%		135.3	11.8%		176.8	15.6%
Capital Cost (Excludes Utility Costs)	20.6	2.5	51.5		1.3	26.8		1.3	26.8		2.5	51.5	
Operating Cost	22.3	2.2	49.1		1.8	40.1		1.9	42.4		2.2	49.1	
Maintenance Cost	20.2	2.5	50.5		1.7	34.3		1.8	36.4		2.3	46.5	
Utility Cost/Impacts	14.9	2.0	29.8		1.9	28.2		2.0	29.8		2.0	29.8	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A			Equal or N/A		
	100.0		1185.6			1114.7			1143.6			1130.5	

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Weighting

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Criteria Weighting	Account % Weighting
ROAD USER ACCOUNT												Account Average Weighting (Rounded) =				3.8	21.2
Travel Time Cost (Delay Time)	31	24	21	29	33	33	28		2	33	1					23.5	24.8%
Vehicle Operating Cost (Congestion, Start/Stop)	30	23	16	28	32	25	23		12	32	2					22.3	23.5%
Safety Cost (At-grade intersections, LOS/Congestion)	20	33	20	31	24	28	17		1	31	3					20.8	22.0%
Construction Impacts to Road Users (Detours, Delays)	5	2	10	2	6	19	18		17	28	30					13.7	14.5%
Maximized Benefits Related to Construction Schedule	4	1	1	3	5	17	22		30	30	31					14.4	15.2%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	90	83	68	93	100	122	108	0	62	154	67	0	0	0	0	94.7	100.0%
ENVIRONMENTAL ACCOUNT												Account Average Weighting (Rounded) =				1.1	6.1
Green House Gas Costs (Construction/Operation)	12	22	7	22	11	9	5		22	19	19					14.8	7.0%
Landscape (Native Habitat/Grass Lands)	17	28	15	11	31	8	6		25	15	10					16.6	7.9%
Impact to Ecologically sensitive areas	18	32	25	20	30	7	9		4	14	15					17.4	8.2%
Other Wetlands (outside of Swales)	16	16	9	10	12	1	7		28	2	20					12.1	5.7%
Other Grasslands (outside of Swales)	11	10	8	9	13	2	8		27	1	32					12.1	5.7%
Impact to Breeding Birds and Migratory Birds	1	12	12	16	29	11	10		26	7	24					14.8	7.0%
Impact to SOCC	13	17	14	15	28	12	11		29	8	21					16.8	7.9%
Impact to SAR	14	31	13	19	27	13	12		19	9	7					16.4	7.8%
Impact to Wildlife Movement/Connectivity (to existing crossings)	19	29	6	14	26	5	13		18	12	28					17	8.0%
Impact Resulting from Habitat Fragmentation	10	25	5	8	25	4	14		16	13	27					14.7	7.0%
Illumination Impact	15	21	18	6	17	10	1		24	3	25					14	6.6%
Noise Impact	29	18	17	5	16	14	2		23	6	29					15.9	7.5%
Surface Runoff/Water Quality	6	26	19	17	15	15	15		21	11	26					17.1	8.1%
Impact to Heritage Resources	3	11	11	18	14	3	16		15	10	16					11.7	5.5%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	184	298	179	190	294	114	129	0	297	130	299	0	0	0	0	211.4	100.0%
SOCIAL ACCOUNT												Account Average Weighting (Rounded) =				2.6	14.6
City of Saskatoon Road Network Plans (Alignment)	26	30	29	30	21	31	26		7	21	5					22.6	17.7%
RM Corman Park Road Network Plans (Alignment)	25	15	33	12	20	30	25		8	20	6					19.4	15.2%
First Nations Road Network Plans (Alignment)	7	14	28	4	19	6	3		32	22	14					14.9	11.7%
Public Information Session Feedback/Acceptance	27	8	22	27	18	23	27		10	4	22					18.8	14.7%
Land Owner Impacts/Access	24	19	31	23	7	24	24		5	23	13					19.3	15.1%
Business Impacts/Access	28	13	30	26	8	26	29		6	18	12					19.6	15.4%
Multi Use Paths (Connectivity)	8	27	2	21	9	21	4		9	5	23					12.9	10.1%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	145	126	175	143	102	161	138	0	77	113	95	0	0	0	0	127.5	100.0%
ECONOMIC ACCOUNT												Account Average Weighting (Rounded) =				5.5	30.8
Employment During Construction	9	9	4	25	3	20	21		33	29	33					18.6	37.7%
Development Opportunities (Land Access Availability)	21	20	32	24	2	18	19		13	24	17					19	38.5%
Local Resource Availability	2	5	3	7	1	16	20		20	26	18					11.8	23.9%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	32	34	39	56	6	54	60	0	66	79	68	0	0	0	0	49.4	100.0%
FINANCIAL ACCOUNT												Account Average Weighting (Rounded) =				4.9	27.3
Capital Cost (Excludes Utility Costs)	33	3	26	32	23	32	33		3	17	4					20.6	26.4%
Operating Cost	32	4	27	13	22	29	32		31	25	8					22.3	28.6%
Maintenance Cost	23	7	24	33	10	27	31		11	27	9					20.2	25.9%
Utility Cost/Impacts	22	6	23	1	4	22	30		14	16	11					14.9	19.1%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	110	20	100	79	59	110	126	0	59	85	32	0	0	0	0	78	100.0%
Total	561	561	561	561	561	561	561	0	561	561	561	0	0	0	0	17.8	100.0

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Central Avenue Interchange Concept 1

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.1
Travel Time Cost (Delay Time)	2	2	2	2	3	2	2		2	2	2					2.1
Vehicle Operating Cost (Congestion, Start/Stop)	3	2	2	2	3	2	2		2	2	2					2.2
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	2	2	2	2	2		2	1	3					2.0
Construction Impacts to Road Users (Detours, Delays)	2	2	2	2	2	2	2		2	2	3					2.1
Maximized Benefits Related to Construction Schedule	2	2	2	3	2	2	2		2	2	2					2.1
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	2	2		2	2	2					2.0
Landscape (Native Habitat/Grass Lands)	2	2	2	3	2	3	2		3	2	3					2.4
Impact to Ecologically sensitive areas	2	2	2	2	2	3	2		2	2	3					2.2
Other Wetlands (outside of Swales)	2	2	2	2	2	2	2		2	2	3					2.1
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		3	2	3					2.2
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	3					2.1
Impact to SOCC	2	2	2	2	2	2	2		2	2	3					2.1
Impact to SAR	2	2	2	2	2	2	2		2	2	3					2.1
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	3	2	2	2		2	2	3					2.2
Impact Resulting from Habitat Fragmentation	2	2	2	2	2	2	2		2	2	3					2.1
Illumination Impact	2	2	2	2	2	2	2		2	2	3					2.1
Noise Impact	2	2	2	2	2	2	2		2	2	3					2.1
Surface Runoff/Water Quality	2	2	2	2	2	2	2		3	2	3					2.2
Impact to Heritage Resources	2	2	2	2	2	2	2			2	3					2.1
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.2
City of Saskatoon Road Network Plans (Alignment)	2	2	3	2	2	2	2		2	2	3					2.2
RM Corman Park Road Network Plans (Alignment)	2	2	1	2	2	2	2		2	2	3					2.0
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	3					2.1
Public Information Session Feedback/Acceptance	2	2	2	2	3	3	2		2	2	3					2.3
Land Owner Impacts/Access	2	2	2	3	2	2	2		2	2	3					2.2
Business Impacts/Access	2	2	2	2	2	2	2		2	2	3					2.1
Multi Use Paths (Connectivity)	2	2	2	2	2	2	2		3	2	3					2.2
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	2	2	2	2	2		2	2	3					2.1
Development Opportunities (Land Access Availability)	2	2	2	2	2	2	2		2	2	3					2.1
Local Resource Availability	2	2	2	2	2	2	2		2	2	3					2.1
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.2
Capital Cost (Excludes Utility Costs)	2	2	2	3	3	3	2		3	2	3					2.5
Operating Cost	2	2	2	2	2	2	2		2	2	3					2.1
Maintenance Cost	2	2	2	2	2	2	2		2	2	3					2.1
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2	3					2.1
-																Equal or N/A
Total Rating Points per person =	67	66	66	71	70	70	66	0	69	65	95	0	0	0	0	10.6

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Central Avenue Interchange Concept 2

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.3
Travel Time Cost (Delay Time)	2	3	2	3	2	3	3		3	2	3					2.6
Vehicle Operating Cost (Congestion, Start/Stop)	2	3	2	2	2	3	3		3	2	3					2.5
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	2	2	2	3	2		3	3	3					2.4
Construction Impacts to Road Users (Detours, Delays)	2	2	2	2	2	2	2		2	2	3					2.1
Maximized Benefits Related to Construction Schedule	2	2	2	2	2	2	2		2	2	3					2.1
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	2	3		3	2	3					2.3
Landscape (Native Habitat/Grass Lands)	1	2	1	3	2	2	2		2	1	3					1.9
Impact to Ecologically sensitive areas	1	2	1	2	2	2	2		2	1	3					1.8
Other Wetlands (outside of Swales)	2	2	2	2	2	2	2		2	2	3					2.1
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	3					2.1
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	3					2.1
Impact to SOCC	2	2	2	2	2	2	2		2	2	3					2.1
Impact to SAR	2	2	2	2	2	2	2		2	2	3					2.1
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	2	2	2	2		2	2	3					2.1
Impact Resulting from Habitat Fragmentation	2	2	1	2	2	2	2		2	2	3					2.0
Illumination Impact	2	2	2	2	2	2	2		2	2	3					2.1
Noise Impact	2	2	2	2	2	2	3		2	2	3					2.2
Surface Runoff/Water Quality	2	2	2	2	2	2	2		2	2	3					2.1
Impact to Heritage Resources	2	2	2	2	2	2	2			2	3					2.1
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.1
City of Saskatoon Road Network Plans (Alignment)	2	2	3	2	2	2	2		2	2	3					2.2
RM Corman Park Road Network Plans (Alignment)	2	2	1	2	2	2	3		3	2	3					2.2
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	3					2.1
Public Information Session Feedback/Acceptance	2	2	2	2	1	2	3		2	1	3					2.0
Land Owner Impacts/Access	2	2	2	2	2	2	2		2	2	3					2.1
Business Impacts/Access	2	2	2	2	2	2	2		2	2	3					2.1
Multi Use Paths (Connectivity)	2	2	2	1	2	2	2		2	2	3					2.0
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	2	2	2	2	2		2	2	3					2.1
Development Opportunities (Land Access Availability)	2	2	2	2	2	2	2		2	2	3					2.1
Local Resource Availability	2	2	2	1	2	2	2		2	2	3					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Capital Cost (Excludes Utility Costs)	2	2	2	2	2	2	1		2	2	2					1.9
Operating Cost	2	2	2	2	2	2	3		2	2	3					2.2
Maintenance Cost	2	2	2	2	2	2	2		2	2	3					2.1
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2						2.0
-																Equal or N/A
Total Rating Points per person =	64	68	63	66	65	69	72	0	69	64	95	0	0	0	0	10.6

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Blackley Road Interchange Concept 1

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.1
Travel Time Cost (Delay Time)	2	2	2	3	3	2	2		2	2	2					2.2
Vehicle Operating Cost (Congestion, Start/Stop)	2	2	2	2	3	2	2		2	1	2					2.0
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	2	2	2	3	2		2	1	2					2.0
Construction Impacts to Road Users (Detours, Delays)	2	2	2	3	2	2	2		3	2	2					2.2
Maximized Benefits Related to Construction Schedule	2	2	2	3	2	2	2		3	2	2					2.2
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	2	2		2	3	2					2.1
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	3	2		3	2	2					2.2
Impact to Ecologically sensitive areas	2	2	2	2	2	3	2		2	2	2					2.1
Other Wetlands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		3	2	2					2.1
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	1	3	2	2	2		2	2	2					2.0
Impact Resulting from Habitat Fragmentation	2	2	1	2	2	2	2		2	2	2					1.9
Illumination Impact	2	2	2	2	2	3	2		2	2	3					2.2
Noise Impact	2	2	2	2	2	2	2		2	2	3					2.1
Surface Runoff/Water Quality	2	2	1	2	2	2	2		3	2	2					2.0
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.1
City of Saskatoon Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
RM Corman Park Road Network Plans (Alignment)	2	2	3	2	2	2	2		2	2	2					2.1
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
Public Information Session Feedback/Acceptance	2	2	2	2	3	3	2		2	2	2					2.2
Land Owner Impacts/Access	2	2	2	3	2	2	2		2	2	3					2.2
Business Impacts/Access	2	2	2	2	2	2	2		2	2	3					2.1
Multi Use Paths (Connectivity)	2	2	2	2	2	2	2		3	2	2					2.1
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	2	2	2	2	2		3	2	2					2.1
Development Opportunities (Land Access Availability)	2	2	2	3	2	2	2		2	2	2					2.1
Local Resource Availability	2	2	2	2	2	2	2		2	2	3					2.1
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.3
Capital Cost (Excludes Utility Costs)	2	2	2	3	2	3	3		3	2	3					2.5
Operating Cost	2	2	2	2	2	2	3		3	1	3					2.2
Maintenance Cost	2	2	2	3	2	3	3		3	2	3					2.5
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	66	66	64	74	69	73	69	0	76	64	74	0	0	0	0	10.6

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Blackley Road Interchange Concept 2

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.4
Travel Time Cost (Delay Time)	2	3	3	2	2	3	3		3	3	3					2.7
Vehicle Operating Cost (Congestion, Start/Stop)	2	3	3	2	2	3	3		3	3	3					2.7
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	3	2	2	3	3		3	3	3					2.6
Construction Impacts to Road Users (Detours, Delays)	1	2	2	2	2	2	2		2	2	2					1.9
Maximized Benefits Related to Construction Schedule	1	2	2	2	2	2	2		2	2	2					1.9
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				1.9
Green House Gas Costs (Construction/Operation)	2	2	1	2	2	3	3		3	2	2					2.2
Landscape (Native Habitat/Grass Lands)	1	1	1	2	2	2	2		2	1	2					1.6
Impact to Ecologically sensitive areas	1	2	1	2	2	2	2		3	1	2					1.8
Other Wetlands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Breeding Birds and Migratory Birds	2	2	1	2	2	2	2		2	2	2					1.9
Impact to SOCC	2	2	1	2	2	2	2		2	2	2					1.9
Impact to SAR	2	2	1	2	2	2	2		2	2	2					1.9
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	1	2	2	2	2		2	2	2					1.9
Impact Resulting from Habitat Fragmentation	2	1	1	2	2	2	2		2	2	2					1.8
Illumination Impact	1	2	1	2	2	2	2		2	2	2					1.8
Noise Impact	1	2	2	2	2	2	3		2	2	2					2.0
Surface Runoff/Water Quality	2	2	1	2	2	2	2		2	1	2					1.8
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				1.9
City of Saskatoon Road Network Plans (Alignment)	2	2	2	2	2	3	3		2	2	3					2.3
RM Corman Park Road Network Plans (Alignment)	2	2	3	2	2	3	3		2	2	3					2.4
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
Public Information Session Feedback/Acceptance	2	2	2	2	1	2	1		2	1	2					1.7
Land Owner Impacts/Access	1	2	1	2	1	1	2		2	1	2					1.5
Business Impacts/Access	1	2	2	2	2	2	2		2	2	2					1.9
Multi Use Paths (Connectivity)	2	0	2	2	2	2	2		2	2	2					1.8
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	3	3	2	2	2		2	2	2					2.2
Development Opportunities (Land Access Availability)	2	2	2	2	2	3	2		2	2	2					2.1
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				1.7
Capital Cost (Excludes Utility Costs)	0	1	1	2	2	2	2		1	1	1					1.3
Operating Cost	1	2	1	2	2	2	2		2	2	2					1.8
Maintenance Cost	1	2	1	2	2	2	2		2	1	2					1.7
Utility Cost/Impacts	2		1	2	2	2	2		2	2	2					1.9
-																Equal or N/A
Total Rating Points per person =	54	61	56	67	64	72	72	0	70	62	70	0	0	0	0	9.9

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Highway 41 Interchange Concept 1

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.4
Travel Time Cost (Delay Time)	2	3	3	3	2	3	3		3	2	3					2.7
Vehicle Operating Cost (Congestion, Start/Stop)	2	3	3	2	2	3	3		3	2	3					2.6
Safety Cost (At-grade intersections, LOS/Congestion)	2	3	3	2	2	3	3		3	3	3					2.7
Construction Impacts to Road Users (Detours, Delays)	2	2	2	2	2	2	2		2	2	3					2.1
Maximized Benefits Related to Construction Schedule	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Green House Gas Costs (Construction/Operation)	2	2	1	2	2	3	3		3	1	3					2.2
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	1	2	2	2	2		2	2	2					1.9
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	1	2	2	2		2	2	2					1.9
Impact Resulting from Habitat Fragmentation	2	2	2	2	2	2	2		2	2	2					2.0
Illumination Impact	2	1	1	2	2	2	2		2	1	2					1.7
Noise Impact	2	1	2	2	2	3	3		2	2	2					2.1
Surface Runoff/Water Quality	2	2	1	2	2	2	2		2	2	2					1.9
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				1.9
City of Saskatoon Road Network Plans (Alignment)	2	2	2	2	3	2	2		2	2	2					2.1
RM Corman Park Road Network Plans (Alignment)	2	2	2	2	3	2	2		2	2	2					2.1
First Nations Road Network Plans (Alignment)	2	2	2	2	3	2	2		2	2	2					2.1
Public Information Session Feedback/Acceptance	2	2	2	2	1	3	2		2	2	2					2.0
Land Owner Impacts/Access	2	2	1	2	1	2	2		2	1	2					1.7
Business Impacts/Access	2	2	1	2	1	2	2		2	2	2					1.8
Multi Use Paths (Connectivity)	2	0	2	1	2	2	2		2	2	2					1.7
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	2	3	2	2	2		3	2	2					2.2
Development Opportunities (Land Access Availability)	2	2	2	2	2	2	2		2	2	2					2.0
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				1.6
Capital Cost (Excludes Utility Costs)	0	1	1	2	1	2	2		1	1	1					1.2
Operating Cost	1	2	1	2	2	2	2		1	3	2					1.8
Maintenance Cost	1	2	1	2	2	2	2		1	1	2					1.6
Utility Cost/Impacts	1	2	1	2	2	2	2		2	2	2					1.8
-																Equal or N/A
Total Rating Points per person =	61	64	59	66	65	72	71	0	68	63	70	0	0	0	0	9.9

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Highway 41 Interchange Concept 2

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT															Account Average Rating (Rounded) =	2.0
Travel Time Cost (Delay Time)	2	2	2	2	3	1	2		2	1	2					1.9
Vehicle Operating Cost (Congestion, Start/Stop)	2	2	2	2	2	1	2		2	1	2					1.8
Safety Cost (At-grade intersections, LOS/Congestion)	2		2	2	2	1	2		2	2	2					1.9
Construction Impacts to Road Users (Detours, Delays)	3	2	2	3	2	2	3		3	2	2					2.4
Maximized Benefits Related to Construction Schedule	2	2	2	3	2	2	2		3	2	2					2.2
-																Equal or N/A
ENVIRONMENTAL ACCOUNT															Account Average Rating (Rounded) =	2.0
Green House Gas Costs (Construction/Operation)	2	1	2	2	2	2	2		2	2	2					1.9
Landscape (Native Habitat/Grass Lands)	3	2	2	2	2	2	2		3	2	2					2.2
Impact to Ecologically sensitive areas	3	2	2	2	2	2	2		2	2	2					2.1
Other Wetlands (outside of Swales)	2	2	1	2	2	2	2		2	2	2					1.9
Other Grasslands (outside of Swales)	3	2	2	2	2	2	2		3	2	2					2.2
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	2	2	2	2		2	2	2					2.0
Impact Resulting from Habitat Fragmentation	2	2	2	2	2	2	2		2	2	2					2.0
Illumination Impact	2	2	2	2	2	3	2		2	2	2					2.1
Noise Impact	2	2	2	2	2	2	2		2	2	2					2.0
Surface Runoff/Water Quality	2	2	1	2	2	2	2		3	2	2					2.0
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT															Account Average Rating (Rounded) =	2.2
City of Saskatoon Road Network Plans (Alignment)	2	2	2	3	3	2	3		3	2	3					2.5
RM Corman Park Road Network Plans (Alignment)	2	2	2	2	3	2	3		2	2	3					2.3
First Nations Road Network Plans (Alignment)	2	2	2	2	3	2	2		2	2	2					2.1
Public Information Session Feedback/Acceptance	2	2	2	3	3	2	3		2	2	2					2.3
Land Owner Impacts/Access	2	2	2	3	2	3	3		3	2	3					2.5
Business Impacts/Access	2	2	1	2	2	3	2		3	2	2					2.1
Multi Use Paths (Connectivity)	2	1	2	1	2	2	2		2	2	2					1.8
-																Equal or N/A
ECONOMIC ACCOUNT															Account Average Rating (Rounded) =	2.0
Employment During Construction	2	2	1	2	2	2	2		2	2	2					1.9
Development Opportunities (Land Access Availability)	2	2	2	2	2	2	2		2	2	2					2.0
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT															Account Average Rating (Rounded) =	2.2
Capital Cost (Excludes Utility Costs)	2	2	2	3	2	3	3		3	2	3					2.5
Operating Cost	2	2	2	2	2	2	2		2	2	3					2.1
Maintenance Cost	2	2	2	3	2	2	2		2	2	3					2.2
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	70	62	62	72	71	67	72	0	75	64	72	0	0	0	0	10.5

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Highway 5 Interchange Concept 1

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.3
Travel Time Cost (Delay Time)	2	3	3	3	2	3	3		3	2	2					2.6
Vehicle Operating Cost (Congestion, Start/Stop)	2	3	2	2	3	3	3		3	2	2					2.5
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	2	2	2	3	2		3	3	3					2.4
Construction Impacts to Road Users (Detours, Delays)	2	2	2	2	2	2	2		2	2	2					2.0
Maximized Benefits Related to Construction Schedule	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	3	3		3	2	2					2.3
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	1	2	2	2	2		2	2	2					1.9
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	2	2	2	2		2	2	2					2.0
Impact Resulting from Habitat Fragmentation	2	2	2	2	2	2	2		2	2	2					2.0
Illumination Impact	2	2	2	2	2	2	2		2	2	2					2.0
Noise Impact	2	2	1	2	2	2	3		2	2	2					2.0
Surface Runoff/Water Quality	2	2	1	2	2	2	2		2	2	2					1.9
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.0
City of Saskatoon Road Network Plans (Alignment)	2	2	2	2	2	2	3		2	2	2					2.1
RM Corman Park Road Network Plans (Alignment)	2	2	1	2	2	2	2		2	2	2					1.9
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
Public Information Session Feedback/Acceptance	2	2	2	2	3	3	3		2	2	2					2.3
Land Owner Impacts/Access	2	2	2	3	2	3	2		2	2	2					2.2
Business Impacts/Access	2	2	2	2	2	2	2		2	2	2					2.0
Multi Use Paths (Connectivity)	2	0	2	2	2	2	2		2	2	2					1.8
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	3	2	2	2	2		2	2	2					2.1
Development Opportunities (Land Access Availability)	2	2	1	2	2	2	2		2	2	2					1.9
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				1.8
Capital Cost (Excludes Utility Costs)	0	1	1	3	1	2	2		1	1	1					1.3
Operating Cost	1	2	2	2	2	2	2		2	2	2					1.9
Maintenance Cost	1	2	1	3	2	2	2		2	1	2					1.8
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	62	65	61	70	67	72	72	0	69	65	66	0	0	0	0	10.1

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - North Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

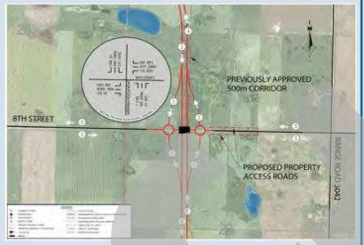
Highway 5 Interchange Concept 2

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.0
Travel Time Cost (Delay Time)	2	2	2	2	2	3	2		2	2	2					2.1
Vehicle Operating Cost (Congestion, Start/Stop)	2	2	2	2	1	3	2		2	2	2					2.0
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	2	2	1	2	2		2	1	2					1.8
Construction Impacts to Road Users (Detours, Delays)	2	2	2	2	2	2	2		2	2	2					2.0
Maximized Benefits Related to Construction Schedule	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	3	2		2	2	2					2.1
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	1	2	2	2	2		2	2	2					1.9
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	2	2	2	2		2	2	2					2.0
Impact Resulting from Habitat Fragmentation	2	2	2	2	2	2	2		2	2	2					2.0
Illumination Impact	2	2	2	2	2	2	2		2	2	3					2.1
Noise Impact	2	2	1	2	2	2	2		2	2	3					2.0
Surface Runoff/Water Quality	2	2	1	2	2	2	2		2	2	2					1.9
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				1.9
City of Saskatoon Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
RM Corman Park Road Network Plans (Alignment)	2	2	1	2	2	2	2		2	2	2					1.9
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
Public Information Session Feedback/Acceptance	2	2	2	2	1	2	2		2	1	2					1.8
Land Owner Impacts/Access	2	2	1	2	1	2	3		2	2	2					1.9
Business Impacts/Access	2	2	2	2	2	2	2		2	2	2					2.0
Multi Use Paths (Connectivity)	2	0	2		2	2	2		2	2	2					1.8
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	2	3	2	2	2		2	2	2					2.1
Development Opportunities (Land Access Availability)	2	2	1	2	2	2	2		2	2	2					1.9
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.3
Capital Cost (Excludes Utility Costs)	2	2	2	2	3	3	3		3	2	3					2.5
Operating Cost	2	2	2	2	2	2	2		3	2	3					2.2
Maintenance Cost	2	2	2	2	2	3	2		3	2	3					2.3
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	66	64	60	65	63	71	68	0	69	64	71	0	0	0	0	10.1

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Summary

		8th Street Interchange Concept 1			**8th Street Interchange Concept 2**		
Accounts and Elements	Weighting/ Importance	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)
ROAD USER ACCOUNT	21.2		187.9	16.3%		222.4	19.2%
Travel Time Cost (Delay Time)	23.5	2.0	47.0		2.4	56.4	
Vehicle Operating Cost (Congestion, Start/Stop)	22.3	1.9	42.4		2.5	55.8	
Safety Cost (At-grade intersections, LOS/Congestion)	20.8	1.9	39.5		2.6	54.1	
Construction Impacts to Road Users (Detours, Delays)	13.7	2.1	28.8		2.0	27.4	
Maximized Benefits Related to Construction Schedule	14.4	2.1	30.2		2.0	28.8	
-	Equal or N/A	Equal or N/A			Equal or N/A		
ENVIRONMENTAL ACCOUNT	6.1		424.0	36.7%		428.6	37.0%
Green House Gas Costs (Construction/Operation)	14.8	2.0	29.6		2.4	35.5	
Landscape (Native Habitat/Grass Lands)	16.6	2.0	33.2		2.0	33.2	
Impact to Ecologically sensitive areas	17.4	2.0	34.8		2.0	34.8	
Other Wetlands (outside of Swales)	12.1	2.0	24.2		2.0	24.2	
Other Grasslands (outside of Swales)	12.1	2.1	25.4		2.0	24.2	
Impact to Breeding Birds and Migratory Birds	14.8	2.0	29.6		2.0	29.6	
Impact to SOCC	16.8	2.0	33.6		2.0	33.6	
Impact to SAR	16.4	2.0	32.8		2.0	32.8	
Impact to Wildlife Movement/Connectivity (to existing crossings)	17.0	1.9	32.3		1.9	32.3	
Impact Resulting from Habitat Fragmentation	14.7	2.0	29.4		2.0	29.4	
Illumination Impact	14.0	2.0	28.0		2.0	28.0	
Noise Impact	15.9	2.0	31.8		2.1	33.4	
Surface Runoff/Water Quality	17.1	2.1	35.9		2.0	34.2	
Impact to Heritage Resources	11.7	2.0	23.4		2.0	23.4	
-	Equal or N/A	Equal or N/A			Equal or N/A		
SOCIAL ACCOUNT	14.6		273.9	23.7%		254.4	22.0%
City of Saskatoon Road Network Plans (Alignment)	22.6	2.1	47.5		2.2	49.7	
RM Corman Park Road Network Plans (Alignment)	19.4	2.1	40.7		2.0	38.8	
First Nations Road Network Plans (Alignment)	14.9	2.0	29.8		2.0	29.8	
Public Information Session Feedback/Acceptance	18.8	2.2	41.4		1.9	35.7	
Land Owner Impacts/Access	19.3	2.5	48.3		1.9	36.7	
Business Impacts/Access	19.6	2.0	39.2		2.0	39.2	
Multi Use Paths (Connectivity)	12.9	2.1	27.1		1.9	24.5	
-	Equal or N/A	Equal or N/A			Equal or N/A		
ECONOMIC ACCOUNT	30.8		102.6	8.9%		98.8	8.5%
Employment During Construction	18.6	2.0	37.2		2.1	39.1	
Development Opportunities (Land Access Availability)	19.0	2.2	41.8		1.9	36.1	
Local Resource Availability	11.8	2.0	23.6		2.0	23.6	
-	Equal or N/A	Equal or N/A			Equal or N/A		
FINANCIAL ACCOUNT	27.3		166.3	14.4%		154.1	13.3%
Capital Cost (Excludes Utility Costs)	20.6	2.4	49.4		1.8	37.1	
Operating Cost	22.3	2.0	44.6		2.1	46.8	
Maintenance Cost	20.2	2.1	42.4		2.0	40.4	
Utility Cost/Impacts	14.9	2.0	29.8		2.0	29.8	
-	Equal or N/A	Equal or N/A			Equal or N/A		
	100.0		1154.7			1158.3	

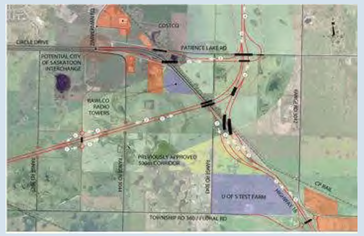
SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Summary

Highway 16 Interchange Concept 1

Highway 16 Interchange Concept 2

Highway 16 Interchange Concept 3



Accounts and Elements	Weighting/ Importance	Highway 16 Interchange Concept 1 Average Rating	Highway 16 Interchange Concept 1 Total Evaluation Points	Highway 16 Interchange Concept 1 Total Evaluation Points (%)	Highway 16 Interchange Concept 2 Average Rating	Highway 16 Interchange Concept 2 Total Evaluation Points	Highway 16 Interchange Concept 2 Total Evaluation Points (%)	Highway 16 Interchange Concept 3 Average Rating	Highway 16 Interchange Concept 3 Total Evaluation Points	Highway 16 Interchange Concept 3 Total Evaluation Points (%)
ROAD USER ACCOUNT	21.2		194.9	17.2%		192.5	17.1%		208.7	17.8%
Travel Time Cost (Delay Time)	23.5	2.3	54.8		2.1	49.4		2.3	54.8	
Vehicle Operating Cost (Congestion, Start/Stop)	22.3	1.9	42.4		2.0	44.6		2.2	49.1	
Safety Cost (At-grade intersections, LOS/Congestion)	20.8	1.8	37.4		1.9	39.5		2.2	45.8	
Construction Impacts to Road Users (Detours, Delays)	13.7	2.2	30.1		2.1	28.8		2.0	27.4	
Maximized Benefits Related to Construction Schedule	14.4	2.1	30.2		2.1	30.2		2.2	31.7	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A		
ENVIRONMENTAL ACCOUNT	6.1		433.7	38.2%		423.9	37.7%		435.8	37.1%
Green House Gas Costs (Construction/Operation)	14.8	2.2	32.6		2.0	29.6		2.3	34.0	
Landscape (Native Habitat/Grass Lands)	16.6	2.1	34.9		2.0	33.2		2.1	34.9	
Impact to Ecologically sensitive areas	17.4	2.0	34.8		2.0	34.8		2.0	34.8	
Other Wetlands (outside of Swales)	12.1	2.0	24.2		2.1	25.4		2.1	25.4	
Other Grasslands (outside of Swales)	12.1	2.0	24.2		2.0	24.2		2.1	25.4	
Impact to Breeding Birds and Migratory Birds	14.8	2.0	29.6		2.0	29.6		2.0	29.6	
Impact to SOCC	16.8	2.0	33.6		2.0	33.6		2.0	33.6	
Impact to SAR	16.4	2.0	32.8		2.0	32.8		2.0	32.8	
Impact to Wildlife Movement/Connectivity (to existing crossings)	17.0	2.1	35.7		2.0	34.0		2.0	34.0	
Impact Resulting from Habitat Fragmentation	14.7	2.0	29.4		2.1	30.9		1.9	27.9	
Illumination Impact	14.0	2.1	29.4		2.0	28.0		2.2	30.8	
Noise Impact	15.9	2.2	35.0		1.9	30.2		2.2	35.0	
Surface Runoff/Water Quality	17.1	2.0	34.2		2.0	34.2		2.0	34.2	
Impact to Heritage Resources	11.7	2.0	23.4		2.0	23.4		2.0	23.4	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A		
SOCIAL ACCOUNT	14.6		233.1	20.5%		269.6	24.0%		262.0	22.3%
City of Saskatoon Road Network Plans (Alignment)	22.6	2.0	45.2		2.2	49.7		2.0	45.2	
RM Corman Park Road Network Plans (Alignment)	19.4	1.8	34.9		2.2	42.7		2.2	42.7	
First Nations Road Network Plans (Alignment)	14.9	2.0	29.8		2.0	29.8		2.0	29.8	
Public Information Session Feedback/Acceptance	18.8	1.8	33.8		2.5	47.0		2.2	41.4	
Land Owner Impacts/Access	19.3	1.6	30.9		2.0	38.6		2.1	40.5	
Business Impacts/Access	19.6	1.8	35.3		1.9	37.2		2.0	39.2	
Multi Use Paths (Connectivity)	12.9	1.8	23.2		1.9	24.5		1.8	23.2	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A		
ECONOMIC ACCOUNT	30.8		93.1	8.2%		104.5	9.3%		100.7	8.6%
Employment During Construction	18.6	2.0	37.2		2.1	39.1		2.1	39.1	
Development Opportunities (Land Access Availability)	19.0	1.7	32.3		2.2	41.8		2.0	38.0	
Local Resource Availability	11.8	2.0	23.6		2.0	23.6		2.0	23.6	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A		
FINANCIAL ACCOUNT	27.3		179.7	15.8%		133.3	11.9%		167.3	14.2%
Capital Cost (Excludes Utility Costs)	20.6	2.8	57.7		1.2	24.7		2.1	43.3	
Operating Cost	22.3	2.1	46.8		1.9	42.4		2.3	51.3	
Maintenance Cost	20.2	2.1	42.4		1.8	36.4		2.2	44.4	
Utility Cost/Impacts	14.9	2.2	32.8		2.0	29.8		1.9	28.3	
-	Equal or N/A	Equal or N/A			Equal or N/A			Equal or N/A		
	100.0		1134.6			1123.6			1174.4	

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Summary

		Highway 11 Interchange Concept 1			Highway 11 Interchange Concept 2		
Accounts and Elements	Weighting/ Importance	Average Rating	Total Evaluation Points	Total Evaluation Points (%)	Average Rating	Total Evaluation Points	Total Evaluation Points (%)
ROAD USER ACCOUNT	21.2		208.1	17.9%		146.0	12.8%
Travel Time Cost (Delay Time)	23.5	2.2	51.7		2.2	51.7	
Vehicle Operating Cost (Congestion, Start/Stop)	22.3	2.1	46.8		2.1	46.8	
Safety Cost (At-grade intersections, LOS/Congestion)	20.8	2.5	52.0		2.0	41.6	
Construction Impacts to Road Users (Detours, Delays)	13.7	2.1	28.8		2.1	28.8	
Maximized Benefits Related to Construction Schedule	14.4	2.0	28.8		2.0	28.8	
-	Equal or N/A	Equal or N/A			Equal or N/A		
ENVIRONMENTAL ACCOUNT	6.1		424.4	36.6%		422.8	37.0%
Green House Gas Costs (Construction/Operation)	14.8	2.0	29.6		2.0	29.6	
Landscape (Native Habitat/Grass Lands)	16.6	2.0	33.2		2.0	33.2	
Impact to Ecologically sensitive areas	17.4	2.0	34.8		2.0	34.8	
Other Wetlands (outside of Swales)	12.1	2.0	24.2		2.0	24.2	
Other Grasslands (outside of Swales)	12.1	2.0	24.2		2.0	24.2	
Impact to Breeding Birds and Migratory Birds	14.8	2.0	29.6		2.0	29.6	
Impact to SOCC	16.8	2.0	33.6		2.0	33.6	
Impact to SAR	16.4	2.0	32.8		2.0	32.8	
Impact to Wildlife Movement/Connectivity (to existing crossings)	17.0	2.0	34.0		2.0	34.0	
Impact Resulting from Habitat Fragmentation	14.7	2.0	29.4		2.0	29.4	
Illumination Impact	14.0	2.0	28.0		2.0	28.0	
Noise Impact	15.9	2.1	33.4		2.0	31.8	
Surface Runoff/Water Quality	17.1	2.0	34.2		2.0	34.2	
Impact to Heritage Resources	11.7	2.0	23.4		2.0	23.4	
-	Equal or N/A	Equal or N/A			Equal or N/A		
SOCIAL ACCOUNT	14.6		256.2	22.1%		268.4	23.5%
City of Saskatoon Road Network Plans (Alignment)	22.6	2.1	47.5		2.3	52.0	
RM Corman Park Road Network Plans (Alignment)	19.4	2.1	40.7		2.2	42.7	
First Nations Road Network Plans (Alignment)	14.9	2.1	31.3		2.1	31.3	
Public Information Session Feedback/Acceptance	18.8	2.0	37.6		2.1	39.5	
Land Owner Impacts/Access	19.3	1.9	36.7		2.1	40.5	
Business Impacts/Access	19.6	2.0	39.2		2.0	39.2	
Multi Use Paths (Connectivity)	12.9	1.8	23.2		1.8	23.2	
-	Equal or N/A	Equal or N/A			Equal or N/A		
ECONOMIC ACCOUNT	30.8		98.8	8.5%		98.8	8.6%
Employment During Construction	18.6	2.0	37.2		2.0	37.2	
Development Opportunities (Land Access Availability)	19.0	2.0	38.0		2.0	38.0	
Local Resource Availability	11.8	2.0	23.6		2.0	23.6	
-	Equal or N/A	Equal or N/A			Equal or N/A		
FINANCIAL ACCOUNT	27.3		172.4	14.9%		156.0	13.6%
Capital Cost (Excludes Utility Costs)	20.6	2.7	55.6		2.0	41.2	
Operating Cost	22.3	2.0	44.6		2.0	44.6	
Maintenance Cost	20.2	2.1	42.4		2.0	40.4	
Utility Cost/Impacts	14.9	2.0	29.8		2.0	29.8	
-	Equal or N/A	Equal or N/A			Equal or N/A		
	100.0		1159.9			1143.7	

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUTION (MAE): Criteria Weighting

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Criteria Weighting	Account % Weighting
ROAD USER ACCOUNT												Account Average Weighting (Rounded) =				3.8	21.2
Travel Time Cost (Delay Time)	31	24	21	29	33	33	28		2	33	1					23.5	24.8%
Vehicle Operating Cost (Congestion, Start/Stop)	30	23	16	28	32	25	23		12	32	2					22.3	23.5%
Safety Cost (At-grade intersections, LOS/Congestion)	20	33	20	31	24	28	17		1	31	3					20.8	22.0%
Construction Impacts to Road Users (Detours, Delays)	5	2	10	2	6	19	18		17	28	30					13.7	14.5%
Maximized Benefits Related to Construction Schedule	4	1	1	3	5	17	22		30	30	31					14.4	15.2%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	90	83	68	93	100	122	108	0	62	154	67	0	0	0	0	94.7	100.0%
ENVIRONMENTAL ACCOUNT												Account Average Weighting (Rounded) =				1.1	6.1
Green House Gas Costs (Construction/Operation)	12	22	7	22	11	9	5		22	19	19					14.8	7.0%
Landscape (Native Habitat/Grass Lands)	17	28	15	11	31	8	6		25	15	10					16.6	7.9%
Impact to Ecologically sensitive areas	18	32	25	20	30	7	9		4	14	15					17.4	8.2%
Other Wetlands (outside of Swales)	16	16	9	10	12	1	7		28	2	20					12.1	5.7%
Other Grasslands (outside of Swales)	11	10	8	9	13	2	8		27	1	32					12.1	5.7%
Impact to Breeding Birds and Migratory Birds	1	12	12	16	29	11	10		26	7	24					14.8	7.0%
Impact to SOCC	13	17	14	15	28	12	11		29	8	21					16.8	7.9%
Impact to SAR	14	31	13	19	27	13	12		19	9	7					16.4	7.8%
Impact to Wildlife Movement/Connectivity (to existing crossings)	19	29	6	14	26	5	13		18	12	28					17	8.0%
Impact Resulting from Habitat Fragmentation	10	25	5	8	25	4	14		16	13	27					14.7	7.0%
Illumination Impact	15	21	18	6	17	10	1		24	3	25					14	6.6%
Noise Impact	29	18	17	5	16	14	2		23	6	29					15.9	7.5%
Surface Runoff/Water Quality	6	26	19	17	15	15	15		21	11	26					17.1	8.1%
Impact to Heritage Resources	3	11	11	18	14	3	16		15	10	16					11.7	5.5%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	184	298	179	190	294	114	129	0	297	130	299	0	0	0	0	211.4	100.0%
SOCIAL ACCOUNT												Account Average Weighting (Rounded) =				2.6	14.6
City of Saskatoon Road Network Plans (Alignment)	26	30	29	30	21	31	26		7	21	5					22.6	17.7%
RM Corman Park Road Network Plans (Alignment)	25	15	33	12	20	30	25		8	20	6					19.4	15.2%
First Nations Road Network Plans (Alignment)	7	14	28	4	19	6	3		32	22	14					14.9	11.7%
Public Information Session Feedback/Acceptance	27	8	22	27	18	23	27		10	4	22					18.8	14.7%
Land Owner Impacts/Access	24	19	31	23	7	24	24		5	23	13					19.3	15.1%
Business Impacts/Access	28	13	30	26	8	26	29		6	18	12					19.6	15.4%
Multi Use Paths (Connectivity)	8	27	2	21	9	21	4		9	5	23					12.9	10.1%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	145	126	175	143	102	161	138	0	77	113	95	0	0	0	0	127.5	100.0%
ECONOMIC ACCOUNT												Account Average Weighting (Rounded) =				5.5	30.8
Employment During Construction	9	9	4	25	3	20	21		33	29	33					18.6	37.7%
Development Opportunities (Land Access Availability)	21	20	32	24	2	18	19		13	24	17					19	38.5%
Local Resource Availability	2	5	3	7	1	16	20		20	26	18					11.8	23.9%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	32	34	39	56	6	54	60	0	66	79	68	0	0	0	0	49.4	100.0%
FINANCIAL ACCOUNT												Account Average Weighting (Rounded) =				4.9	27.3
Capital Cost (Excludes Utility Costs)	33	3	26	32	23	32	33		3	17	4					20.6	26.4%
Operating Cost	32	4	27	13	22	29	32		31	25	8					22.3	28.6%
Maintenance Cost	23	7	24	33	10	27	31		11	27	9					20.2	25.9%
Utility Cost/Impacts	22	6	23	1	4	22	30		14	16	11					14.9	19.1%
-																Equal or N/A	0.0%
Person/Evaluator Account Criteria Total =	110	20	100	79	59	110	126	0	59	85	32	0	0	0	0	78	100.0%
Total	561	561	561	561	561	561	561	0	561	561	561	0	0	0	0	17.8	100.0

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

8th Street Interchange Concept 1

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.0
Travel Time Cost (Delay Time)	2	2	2	3	1	2	2		2	2	2					2.0
Vehicle Operating Cost (Congestion, Start/Stop)	2	2	2	2	1	2	2		2	2	2					1.9
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	2	2	1	2	2		2	2	2					1.9
Construction Impacts to Road Users (Detours, Delays)	2	2	2	3	2	2	2		2	2	2					2.1
Maximized Benefits Related to Construction Schedule	2	2	2	3	2	2	2		2	2	2					2.1
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	2	2		2	2	2					2.0
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		3	2	2					2.1
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	1	2	2	2		2	2	2					1.9
Impact Resulting from Habitat Fragmentation	2	2	2	2	2	2	2		2	2	2					2.0
Illumination Impact	2	2	2	2	2	2	2		2	2	2					2.0
Noise Impact	2	2	2	2	2	2	2		2	2	2					2.0
Surface Runoff/Water Quality	2	2	2	2	2	2	2		3	2	2					2.1
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.1
City of Saskatoon Road Network Plans (Alignment)	2	2	2	3	2	2	2		2	2	2					2.1
RM Corman Park Road Network Plans (Alignment)	2	2	2	3	2	2	2		2	2	2					2.1
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
Public Information Session Feedback/Acceptance	2	2	2	2	2	3	2		2	3	2					2.2
Land Owner Impacts/Access	2	2	3	3	2	3	3		3	2	2					2.5
Business Impacts/Access	2	2	2	2	2	2	2		2	2	2					2.0
Multi Use Paths (Connectivity)	2	2	2	2	2	2	2		3	2	2					2.1
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	2	2	2	2	2		2	2	2					2.0
Development Opportunities (Land Access Availability)	2	2	3	2	2	3	2		2	2	2					2.2
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Capital Cost (Excludes Utility Costs)	2	2	2	3	2	3	2		3	2	3					2.4
Operating Cost	2	2	2	2	2	2	2		2	2	2					2.0
Maintenance Cost	2	2	2	3	2	2	2		2	2	2					2.1
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	66	66	68	73	63	70	67	0	71	67	67	0	0	0	0	10.3

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

8th Street Interchange Concept 2

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.3
Travel Time Cost (Delay Time)	2	3	1	2	2	3	3		3	2	3					2.4
Vehicle Operating Cost (Congestion, Start/Stop)	2	3	3	2	2	3	2		3	2	3					2.5
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	3	2	2	3	3		3	3	3					2.6
Construction Impacts to Road Users (Detours, Delays)	2	2	2	2	2	2	2		2	2	2					2.0
Maximized Benefits Related to Construction Schedule	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	3	3		3	2	3					2.4
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	1	2	2	2		2	2	2					1.9
Impact Resulting from Habitat Fragmentation	2	2	2	2	2	2	2		2	2	2					2.0
Illumination Impact	2	2	2	2	2	2	2		2	2	2					2.0
Noise Impact	2	2	2	2	2	2	3		2	2	2					2.1
Surface Runoff/Water Quality	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.0
City of Saskatoon Road Network Plans (Alignment)	2	2	1	3	2	2	3		3	2	2					2.2
RM Corman Park Road Network Plans (Alignment)	2	2	1	3	2	2	2		2	2	2					2.0
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
Public Information Session Feedback/Acceptance	2	2	2	2	1	2	2		2	2	2					1.9
Land Owner Impacts/Access	2	2	1	2	2	2	2		2	2	2					1.9
Business Impacts/Access	2	2	2	2	2	2	2		2	2	2					2.0
Multi Use Paths (Connectivity)	2	1	2	2	2	2	2		2	2	2					1.9
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	2	3	2	2	2		2	2	2					2.1
Development Opportunities (Land Access Availability)	2	2	1	2	2	2	2		2	2	2					1.9
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Capital Cost (Excludes Utility Costs)	2	1	2	2	1	2	2		2	2	2					1.8
Operating Cost	2	2	2	2	2	2	3		2	2	2					2.1
Maintenance Cost	2	2	2	2	2	2	2		2	2	2					2.0
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	66	66	63	68	64	70	72	0	71	67	70	0	0	0	0	10.3

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Highway 16 Interchange Concept 1

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.1
Travel Time Cost (Delay Time)	2	2	1	2		3	3		3	2	3					2.3
Vehicle Operating Cost (Congestion, Start/Stop)	2	2	1	2	1	2	3		2	2	2					1.9
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	1	2	1	2	2		2	2	2					1.8
Construction Impacts to Road Users (Detours, Delays)	2	2	2	3	2	2	2		2	2	3					2.2
Maximized Benefits Related to Construction Schedule	2	2	2	3	2	2	2		2	2	2					2.1
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	2	3		3	2	2					2.2
Landscape (Native Habitat/Grass Lands)	2	2	2	3	2	2	2		2	2	2					2.1
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	3	2	2	2		2	2	2					2.1
Impact Resulting from Habitat Fragmentation	2	1	2	3	2	2	2		2	2	2					2.0
Illumination Impact	2	2	2	2	2	2	2		2	2	3					2.1
Noise Impact	2	2	2	2	2	2	3		2	2	3					2.2
Surface Runoff/Water Quality	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				1.8
City of Saskatoon Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
RM Corman Park Road Network Plans (Alignment)	2	2	0	2	2	2	2		2	2	2					1.8
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
Public Information Session Feedback/Acceptance	2	2	2	2	1	2	2		2	1	2					1.8
Land Owner Impacts/Access	2	1	1	3	2	1	1		2	1	2					1.6
Business Impacts/Access	2	2	0	2	2	2	2		2	2	2					1.8
Multi Use Paths (Connectivity)	2	0	2	2	2	2	2		2	2	2					1.8
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				1.9
Employment During Construction	2	2	2	2	2	2	2		2	2	2					2.0
Development Opportunities (Land Access Availability)	2	2	0	2	2	1	2		2	2	2					1.7
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.3
Capital Cost (Excludes Utility Costs)	3	2	2	3	3	3	2		3	3	4					2.8
Operating Cost	2	2	2	2	2	2	2		2	2	3					2.1
Maintenance Cost	2	2	2	2	2	3	2		2	2	2					2.1
Utility Cost/Impacts	2	2	2	3	2	3	2		2	2	2					2.2
-																Equal or N/A
Total Rating Points per person =	67	62	56	74	62	68	69	0	69	65	73	0	0	0	0	10.2

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Highway 16 Interchange Concept 2

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.0
Travel Time Cost (Delay Time)	2	2	1	3	3	2	2		2	2	2					2.1
Vehicle Operating Cost (Congestion, Start/Stop)	2	2	2	2	2	2	2		2	2	2					2.0
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	1	2	2	2	2		2	2	2					1.9
Construction Impacts to Road Users (Detours, Delays)	2	2	1	2	2	2	3		2	2	3					2.1
Maximized Benefits Related to Construction Schedule	2	2	2	3	2	2	2		2	2	2					2.1
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Green House Gas Costs (Construction/Operation)	2	2	1	2	2	2	2		2	2	3					2.0
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	2	2	2	2	3		2	2	2					2.1
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	2	2	2	2		2	2	2					2.0
Impact Resulting from Habitat Fragmentation	2	2	2	3	2	2	2		2	2	2					2.1
Illumination Impact	2	2	2	2	2	2	2		2	2	2					2.0
Noise Impact	2	2	2	2	2	1	2		2	2	2					1.9
Surface Runoff/Water Quality	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.1
City of Saskatoon Road Network Plans (Alignment)	2	2	1	3	2	2	3		2	2	3					2.2
RM Corman Park Road Network Plans (Alignment)	2	2	2	2	2	2	3		2	2	3					2.2
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
Public Information Session Feedback/Acceptance	2	2	2	3	3	3	3		2	2	3					2.5
Land Owner Impacts/Access	2	2	2	2	2	2	2		2	2	2					2.0
Business Impacts/Access	2	2	1	2	2	2	1		2	3	2					1.9
Multi Use Paths (Connectivity)	2	0	2	3	2	2	2		2	2	2					1.9
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.1
Employment During Construction	2	2	2	3	2	2	2		2	2	2					2.1
Development Opportunities (Land Access Availability)	2	2	3	2	2	2	3		2	2	2					2.2
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				1.7
Capital Cost (Excludes Utility Costs)	1	1	1	2	1	1	2		1	2	0					1.2
Operating Cost	2	2	1	2	2	2	2		2	2	2					1.9
Maintenance Cost	2	2	1	2	2	1	2		2	2	2					1.8
Utility Cost/Impacts	2	2	2	3	2	1	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	65	63	58	74	67	63	71	0	65	67	69	0	0	0	0	10.0

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Highway 16 Interchange Concept 3

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.2
Travel Time Cost (Delay Time)	2	2	2	2		3	3		3	2	2					2.3
Vehicle Operating Cost (Congestion, Start/Stop)	2	2	2	2	3	2	3		2	2	2					2.2
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	2	2	3	2	2		3	2	2					2.2
Construction Impacts to Road Users (Detours, Delays)	2	2	1	2	2	2	3		2	2	2					2.0
Maximized Benefits Related to Construction Schedule	2	2	2	2	2	2	3		2	2	3					2.2
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Green House Gas Costs (Construction/Operation)	2	2	1	3	2	2	3		3	2	3					2.3
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	2	2		3	2	2					2.1
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	2	2	2	2	3		2	2	2					2.1
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		3	2	2					2.1
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	2	2	2	2		2	2	2					2.0
Impact Resulting from Habitat Fragmentation	2	1	2	2	2	2	2		2	2	2					1.9
Illumination Impact	2	2	2	2	2	2	3		2	2	3					2.2
Noise Impact	2	2	2	2	2	2	3		2	2	3					2.2
Surface Runoff/Water Quality	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.0
City of Saskatoon Road Network Plans (Alignment)	2	2	1	2	2	2	2		3	2	2					2.0
RM Corman Park Road Network Plans (Alignment)	2	2	2	2	2	3	2		2	2	3					2.2
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	2		2	2	2					2.0
Public Information Session Feedback/Acceptance	2	2	2	2	2	2	3		3	2	2					2.2
Land Owner Impacts/Access	2	1	2	2	2	2	2		3	2	3					2.1
Business Impacts/Access	2	2	2		2	2	2		2	2	2					2.0
Multi Use Paths (Connectivity)	2	0	2	2	2	2	2		2	2	2					1.8
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	2	3	2	2	2		2	2	2					2.1
Development Opportunities (Land Access Availability)	2	2	1	2	2	2	2		3	2	2					2.0
Local Resource Availability	2	2	2		2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.1
Capital Cost (Excludes Utility Costs)	2	2	2	2	2	2	3		2	2	2					2.1
Operating Cost	2	2	2	2	2	2	3		3	2	3					2.3
Maintenance Cost	2	2	2	2	2	2	3		3	2	2					2.2
Utility Cost/Impacts	2	2	2	2	2	1	2		2	2	2					1.9
-																Equal or N/A
Total Rating Points per person =	66	62	62	64	66	67	78	0	77	66	73	0	0	0	0	10.5

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Highway 11 Interchange Concept 1

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT															Account Average Rating (Rounded) =	2.2
Travel Time Cost (Delay Time)	2	2	3	3	2	2	2		2	2	2					2.2
Vehicle Operating Cost (Congestion, Start/Stop)	2	2	3	2	2	2	2		2	2	2					2.1
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	2	2	2	3	3		3	3	3					2.5
Construction Impacts to Road Users (Detours, Delays)	2	2	2	2	2	2	3		2	1	3					2.1
Maximized Benefits Related to Construction Schedule	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
ENVIRONMENTAL ACCOUNT															Account Average Rating (Rounded) =	2.0
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	2	2		2	2	2					2.0
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	2	2	2	2		2	2	2					2.0
Impact Resulting from Habitat Fragmentation	2	2	2	2	2	2	2		2	2	2					2.0
Illumination Impact	2	2	2	2	2	2	2		2	2	2					2.0
Noise Impact	2	2	2	2	2	2	3		2	2	2					2.1
Surface Runoff/Water Quality	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT															Account Average Rating (Rounded) =	2.0
City of Saskatoon Road Network Plans (Alignment)	2	2	2	3	2	2	2		2	2	2					2.1
RM Corman Park Road Network Plans (Alignment)	2	2	2	3	2	2	2		2	2	2					2.1
First Nations Road Network Plans (Alignment)	2	2	2	2	2	2	3		2	2	2					2.1
Public Information Session Feedback/Acceptance	2	2	2	2	2	2	2		2	2	2					2.0
Land Owner Impacts/Access	2	2	2	2	2	2	2		2	1	2					1.9
Business Impacts/Access	2	2	2	2	2	2	2		2	2	2					2.0
Multi Use Paths (Connectivity)	2	0	2	2	2	2	2		2	2	2					1.8
-																Equal or N/A
ECONOMIC ACCOUNT															Account Average Rating (Rounded) =	2.0
Employment During Construction	2	2	2	2	2	2	2		2	2	2					2.0
Development Opportunities (Land Access Availability)	2	2	2	2	2	2	2		2	2	2					2.0
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT															Account Average Rating (Rounded) =	2.2
Capital Cost (Excludes Utility Costs)	2	2	2	3	3	3	3		3	3	3					2.7
Operating Cost	2	2	2	2	2	2	2		2	2	2					2.0
Maintenance Cost	2	2	2	2	2	2	2		3	2	2					2.1
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	66	64	68	70	67	68	71	0	69	66	69	0	0	0	0	10.4

SASKATOON FREEWAY FUNCTION PLANNING STUDY: Phase 2 - South Interchange Concepts

MULTIPLE ACCOUNT EVALUATION (MAE): Criteria Rating

Highway 11 Interchange Concept 2

Rating: 0 = Unacceptable 1 = Marginally Acceptable 2 = Acceptable 3 = Excellent 4 = Exemplary

Person/Evaluator Number =	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average Rating
ROAD USER ACCOUNT												Account Average Rating (Rounded) =				2.1
Travel Time Cost (Delay Time)	2	2	3	3	2	2	2		2	2	2					2.2
Vehicle Operating Cost (Congestion, Start/Stop)	2	2	3	2	2	2	2		2	2	2					2.1
Safety Cost (At-grade intersections, LOS/Congestion)	2	2	3	2	2	2	2		2	1	2					2.0
Construction Impacts to Road Users (Detours, Delays)	2	2	2	3	2	2	2		2	2	2					2.1
Maximized Benefits Related to Construction Schedule	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
ENVIRONMENTAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Green House Gas Costs (Construction/Operation)	2	2	2	2	2	2	2		2	2	2					2.0
Landscape (Native Habitat/Grass Lands)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Ecologically sensitive areas	2	2	2	2	2	2	2		2	2	2					2.0
Other Wetlands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Other Grasslands (outside of Swales)	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Breeding Birds and Migratory Birds	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SOCC	2	2	2	2	2	2	2		2	2	2					2.0
Impact to SAR	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Wildlife Movement/Connectivity (to existing crossings)	2	2	2	2	2	2	2		2	2	2					2.0
Impact Resulting from Habitat Fragmentation	2	2	2	2	2	2	2		2	2	2					2.0
Illumination Impact	2	2	2	2	2	2	2		2	2	2					2.0
Noise Impact	2	2	2	2	2	2	2		2	2	2					2.0
Surface Runoff/Water Quality	2	2	2	2	2	2	2		2	2	2					2.0
Impact to Heritage Resources	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
SOCIAL ACCOUNT												Account Average Rating (Rounded) =				2.1
City of Saskatoon Road Network Plans (Alignment)	2	2	3	3	2	2	2		2	2	3					2.3
RM Corman Park Road Network Plans (Alignment)	2	2	3	3	2	2	2		2	2	2					2.2
First Nations Road Network Plans (Alignment)	2	2	3	2	2	2	2		2	2	2					2.1
Public Information Session Feedback/Acceptance	2	2	2	2	2	3	2		2	2	2					2.1
Land Owner Impacts/Access	2	2	2	3	2	2	2		2	2	2					2.1
Business Impacts/Access	2	2	2	2	2	2	2		2	2	2					2.0
Multi Use Paths (Connectivity)	2	0	2	2	2	2	2		2	2	2					1.8
-																Equal or N/A
ECONOMIC ACCOUNT												Account Average Rating (Rounded) =				2.0
Employment During Construction	2	2	2	2	2	2	2		2	2	2					2.0
Development Opportunities (Land Access Availability)	2	2	2	2	2	2	2		2	2	2					2.0
Local Resource Availability	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
FINANCIAL ACCOUNT												Account Average Rating (Rounded) =				2.0
Capital Cost (Excludes Utility Costs)	1	2	2	3	2	2	2		2	2	2					2.0
Operating Cost	2	2	2	2	2	2	2		2	2	2					2.0
Maintenance Cost	2	2	2	2	2	2	2		2	2	2					2.0
Utility Cost/Impacts	2	2	2	2	2	2	2		2	2	2					2.0
-																Equal or N/A
Total Rating Points per person =	65	64	72	72	66	67	66	0	66	65	67	0	0	0	0	10.2

APPENDIX J

Phase 2 Factual Geotechnical Report

Saskatoon Freeway Functional Planning Study

Phase 2 (Eastern Segment)
Factual Geotechnical Data Report

Saskatchewan Ministry of Highways

May 24, 2023

20230524_659183_SFFPS Phase 2 Factual Geotechnical Data Report_Final_V00.Docx

Notice to Reader / Sign-Off Sheet

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The findings, conclusions and recommendations in this report (i) have been developed in a manner consistent with the level of skill normally exercised by professionals currently practicing under similar conditions in the area, and (ii) reflect SNC-Lavalin's best judgment based on information available at the time of preparation of this report. No other warranties, either expressed or implied, are made with respect to the professional services provided to the Client or the findings, conclusions and recommendations contained in this report. The findings and conclusions contained in this report are valid only as of the date of this report and may be based, in part, upon information provided by others. If any of the information is inaccurate, new information is discovered or project parameters change, modifications to this report may be necessary.

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Appendix VII	Laboratory Testing Results

1 Introduction

The Saskatchewan Ministry of Highways (the Ministry) has selected SNC-Lavalin Inc. (SNC-Lavalin), partnered with AECOM, and Praxis Consulting (Praxis) for the completion of the Saskatoon Freeway Functional Planning Study (SFFPS). The objective of the SFFPS is to finalize the route for approximately 65 km of freeway around the City of Saskatoon (CoS) with Right of Way Plan. Given the variability of ground conditions that are anticipated to be encountered along the alignment, the collection of reliable geotechnical information is vital to the successful delivery of a functional design.

This report provides the geotechnical data collected as part of the Phase 2 Functional Design. The Functional Design is divided into three geographic locations:

- The Northern Segment;
- The Western Segment; and,
- The Eastern Segment.

The Phase 1 Factual Geotechnical Report (SNC-Lavalin, 2021) was submitted to the Ministry in March 2021. Completion of Phase 3 of the SFFPS has been deferred by the Ministry. Phase 2 encompasses the geotechnical investigation that was completed along the Eastern Segment, extending from the South Saskatchewan River (including the bridge crossing boreholes) on the northeast side of the CoS to Highway 11 south of Saskatoon.

The geotechnical investigation is comprised of two principal components: a field program and a laboratory testing program. The field program scope of work was executed between 15 November 2021 and 26 November 2021 and between 12 January 2022 and 7 February 2022 followed by subsequent laboratory testing programs.

This report provides data related to the physical, geotechnical, and geological conditions at the time of the geotechnical investigation. This report does not provide any data related to environmental contamination, environmentally sensitive areas, or any heritage concerns as this is not part of the scope of this geotechnical ground investigation. This report will provide an understanding of subsurface conditions along the freeway alignment, as well as at the proposed locations for interchanges and railway crossings, within the Eastern Segment. While this report provides data collected for the Project, no interpretation is provided with respect to conditions between samples, tests, or borehole locations or with respect to the overall geotechnical conditions as they relate to the proposed construction. The stratigraphic boundaries shown on the record of borehole sheets are inferred from observations of drilling progress and the results of field and laboratory testing. These boundaries; therefore, may represent transitions between soil types rather than exact planes of geological change. Furthermore, subsurface conditions will vary between and beyond the borehole and sample locations.

2 Background Information

Throughout this report, three different types of boreholes will be discussed: Preliminary, Stratigraphic, and Foundation boreholes. The Preliminary and Stratigraphic boreholes are defined within the Ministry's Construction Manual for Soils Testing (CM 303-01) and the Ministry Standard Test Procedure (STP 104-1). The Preliminary boreholes will be referred to as the PH series and are a minimum of 4.6 m (15 ft) in depth. The Stratigraphic boreholes will be referred to as the SH series and are a minimum of 13.7 m (45 ft) in depth. The purpose of the PH and SH series boreholes, drilled along the greenfield alignment, is to gather information to be used for pavement design, route selection, soft soil delineation, quality evaluation of expected borrow material in the region, etc. The Foundation boreholes will be referred to as the FH series and are at the location of proposed future interchanges or overpasses. The FH series boreholes were planned to be 24.3 m (80ft) in depth; however, select boreholes were drilled to deeper depths (up to 36 m) to obtain additional data based on the soil stratigraphy encountered. The PH, SH and FH series boreholes are defined as the secondary naming convention and are referred to as the SNC-Lavalin Borehole ID. The borehole identification also follows the Ministry's naming convention that uses Year-Borehole # in the format of "YY-ID" for each Ministry project identification number (PID).

The originally planned field investigation was based on SNC-Lavalin's Geotechnical Investigation Work Plan (revised on 26 October 2021). The workplan was developed in collaboration with Ministry requirements and input. SNC-Lavalin and the Ministry worked together as the field program continued in order to collect the required geotechnical information for the Eastern Segment.

One Foundation borehole (FHII 15) was not completed due to landowner concerns. SNC-Lavalin and the Ministry reviewed the drilling program in the area and determined there was sufficient information obtained from surrounding boreholes. FHII 15 was subsequently removed from the Phase 2 drilling program. There were several locations (SHII 3, SHII 5, and PHII 3) where the landowners could not be contacted; therefore, the boreholes were not completed during the field program. One Preliminary borehole (PHII 9) could not be accessed due to field conditions; therefore, it was not completed during the Phase 2 drilling program. Three Foundation borehole locations within the South Saskatchewan River were also not completed due to low water levels (verified by bathymetric survey, **Appendix I**) resulting from drought conditions. In addition, a Foundation borehole on the west shore of the South Saskatchewan River was not completed. The level of effort required to access the location with drilling equipment would have been significant and caused unnecessary environmental impact for the purpose of a functional planning study. Information obtained from this location would also not overcome the data gap remaining from not completing the three in-stream locations. After discussions with the Ministry, it was agreed that the level of effort and environmental mitigation required to access this location was not commensurate with the value of the information to be obtained. It is understood that these locations will not be completed in the future as part of the SFFPS.

2.1 General Geological Setting

Prior to planning the field investigation, the Saskatoon area geology was reviewed. The Saskatoon Freeway traverses a wide range of surficial geology units such as: deltaic deposits, alluvium, ground moraines, eroded till plains, outwash deposits, glaciolacustrine plains, and valley slopes which may have active landslides and springs. The Eastern Segment of the proposed Freeway covers an area that consists of morainal plain, alluvial plain, glaciofluvial plain and glaciolacustrine delta (see **Figure 2–1**). The stratigraphic profile in the vicinity of the Saskatoon area, modified by Christiansen (1992), is provided in **Figure 2–2**. The stratigraphic profile, modified by Christiansen, was taken from SNC-Lavalin's (formerly MDH Engineered Solutions Corp.) report entitled, *Preliminary Geotechnical Analysis - Proposed Saskatoon Perimeter Road North Bridge Crossing*. A site plan showing an overall surficial geology base map, similar to **Figure 2–1,** is provided in **Appendix II**.

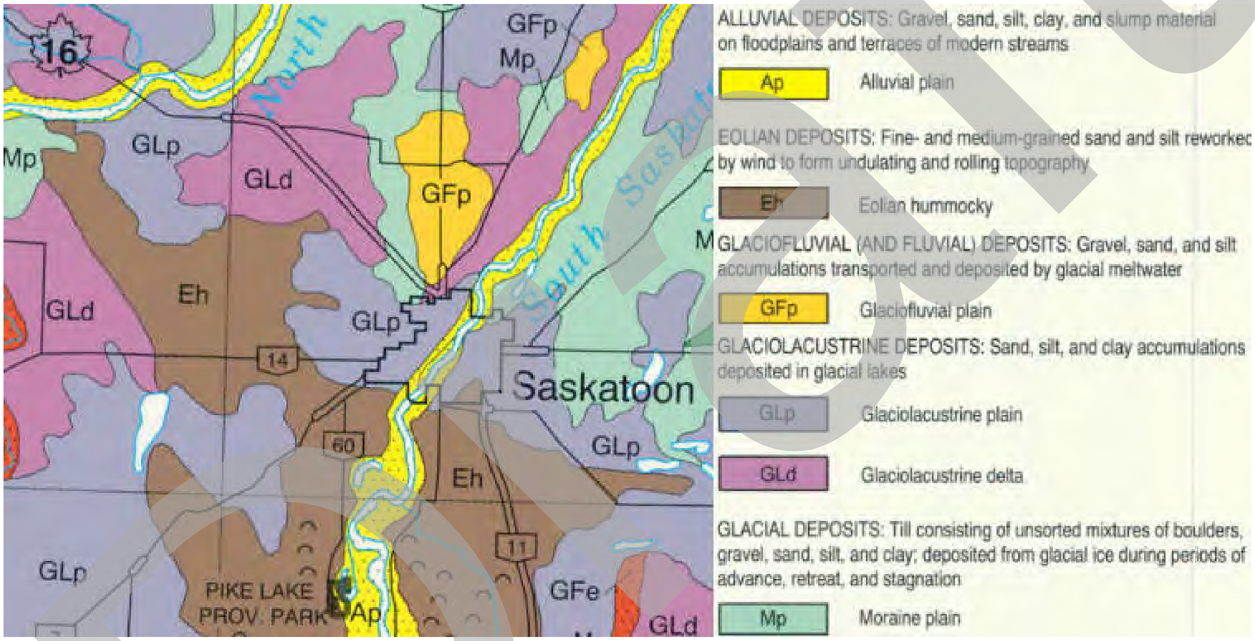
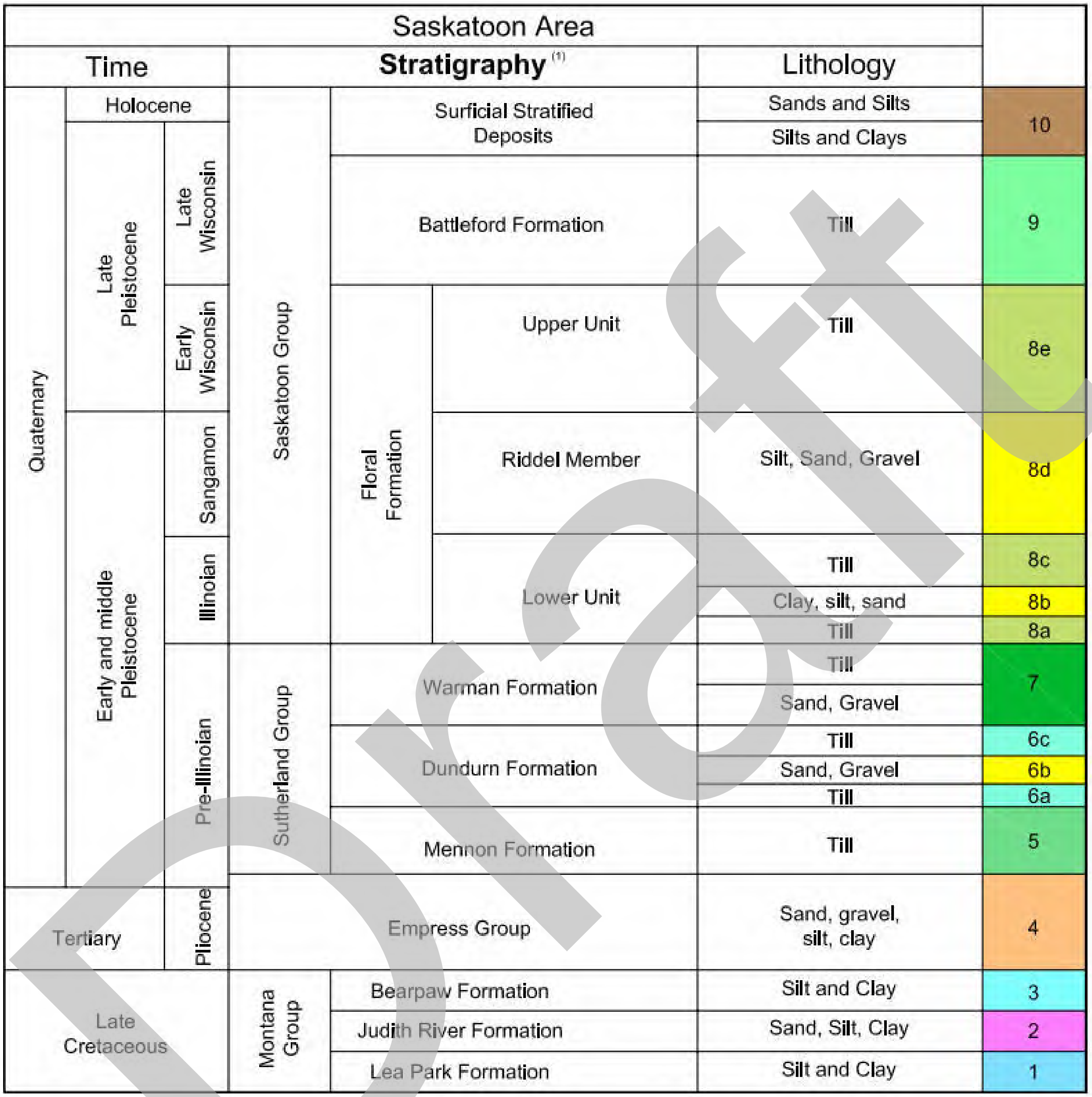


Figure 2–1 Surficial Geology Saskatoon Area (SEM & SRC, 1997).



Saskatoon Area							
Time			Stratigraphy (1)			Lithology	
Quaternary	Holocene		Saskatoon Group	Surficial Stratified Deposits		Sands and Silts	10
						Silts and Clays	
	Late Pleistocene	Late Wisconsin		Battleford Formation		Till	9
		Early Wisconsin		Floral Formation	Upper Unit	Till	8e
	Early and middle Pleistocene	Sangamon			Riddel Member	Silt, Sand, Gravel	8d
		Illinoian			Lower Unit	Till	8c
						Clay, silt, sand	8b
						Till	8a
		Pre-Illinoian	Sutherland Group	Warman Formation		Till	7
						Sand, Gravel	
				Dundurn Formation		Till	6c
						Sand, Gravel	6b
						Till	6a
				Mennon Formation		Till	5
Tertiary		Pliocene	Empress Group			Sand, gravel, silt, clay	4
Late Cretaceous			Montana Group	Bearpaw Formation		Silt and Clay	3
				Judith River Formation		Sand, Silt, Clay	2
				Lea Park Formation		Silt and Clay	1

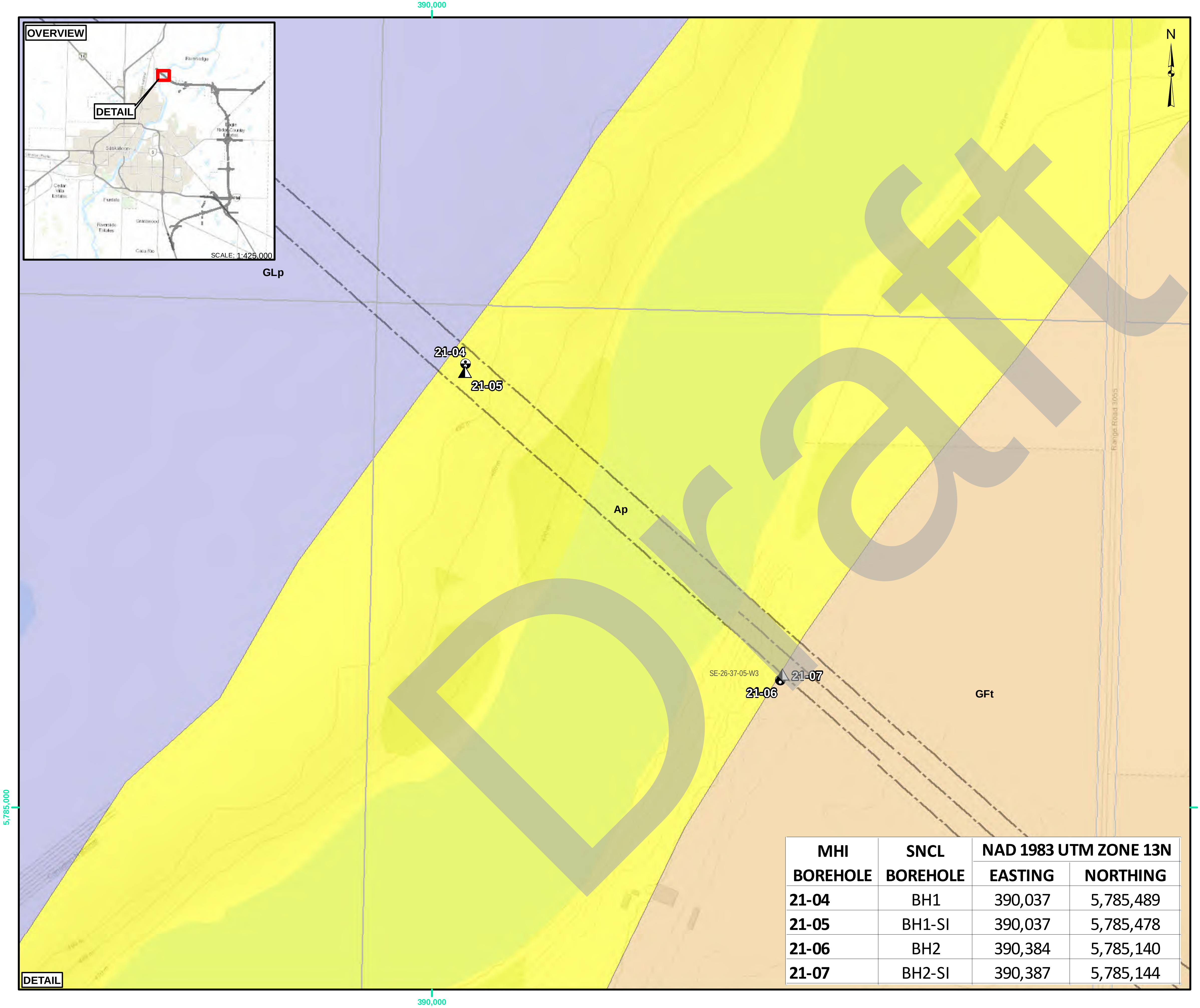
(1) modified after Christiansen, 1992

Figure 2–2 Quaternary Stratigraphy and Lithology in the Saskatoon Area (MDH, 2004).

3 Site Location and Description

This report covers the geotechnical investigation that was carried out for Phase 2, along the Eastern Segment, as the second phase of finalizing the route for approximately 65 km of freeway around the CoS. The project area extended from the South Saskatchewan River (including the bridge crossing boreholes) on the northeast side of the CoS (Range Road 3051) to Highway 11 south of Saskatoon. The Site Plans for the Phase 2 investigation, showing the current proposed alignment and location of boreholes drilled for the Eastern Segment, are provided in **Figure 3–1** to **Figure 3–11**.

The investigation occurred over two different drilling programs. The riverbank drilling occurred between 15 November 2021 and 26 November 2021 and the remaining drilling between 12 January 2022 and 7 February 2022. The drilling was completed during winter conditions. The surface was snow covered and temperatures ranged between -20 and -30 degrees Celsius. Snow removal was required to access drilling locations.



MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N	
		EASTING	NORTHING
21-04	BH1	390,037	5,785,489
21-05	BH1-SI	390,037	5,785,478
21-06	BH2	390,384	5,785,140
21-07	BH2-SI	390,387	5,785,144

LEGEND

- ● BOREHOLE
- ▲ BOREHOLE (SLOPE INCLINOMETER INSTALLED)
- ⊗ BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)
- - - PRELIMINARY FREEWAY ALIGNMENT
- ═ HIGHWAY

SURFICIAL GEOLOGY

- 🟨 ALLUVIAL PLAIN (Ap)
- 🟧 GLACIOFLUVIAL TERRACE (GFt)
- 🟪 GLACIOLACUSTRINE PLAIN (GLp)

NOTES

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7. FH (FOUNDATION HOLES) DEPTH VARIES BUT ARE DRILLED TO A MINIMUM OF 18 M (60 FT).
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SCALE: 1:4,178

SNC·LAVALIN

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
SOUTH SASKATCHEWAN RIVER BOREHOLES

DATE	2022 05 25	DWG No.	659183-0000-4GDD-0072	FIG No.	3-1	REV	00

SIZE 11x17

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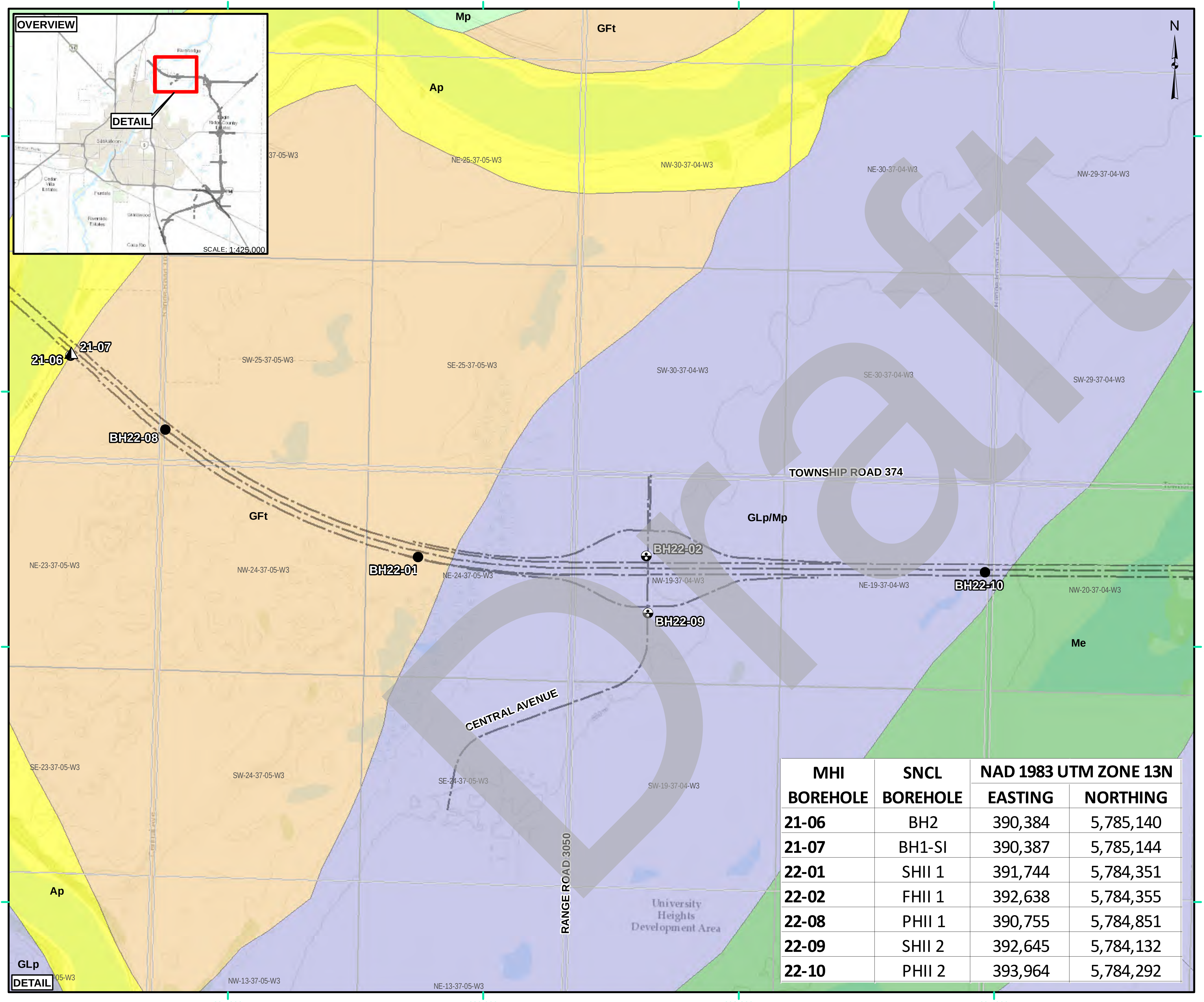

MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N EASTING	NORTHING
21-06	BH2	390,384	5,785,140
21-07	BH1-SI	390,387	5,785,144
22-01	SHII 1	391,744	5,784,351
22-02	FHII 1	392,638	5,784,355
22-08	PHII 1	390,755	5,784,851
22-09	SHII 2	392,645	5,784,132
22-10	PHII 2	393,964	5,784,292

LEGEND

● BOREHOLE
▲ BOREHOLE (SLOPE INCLINOMETER INSTALLED)
⊕ BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)
- - - PRELIMINARY FREEWAY ALIGNMENT
═ HIGHWAY

SURFICIAL GEOLOGY

🟨 ALLUVIAL PLAIN (Ap)
🟧 GLACIOFLUVIAL TERRACE (GFt)
🟪 GLACIOLACUSTRINE PLAIN (GLp)
🟩 MORAINAL ERODED (Me)
🟩 MORAINAL PLAIN (Mp)

NOTES

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SCALE: 1:15,000

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
CENTRAL INTERCHANGE BOREHOLES

DATE 2022 05 25 **DWG No.** 659183-0000-4GDD-0061 **FIG No.** 3-2 **REV** 00

SIZE 11x17

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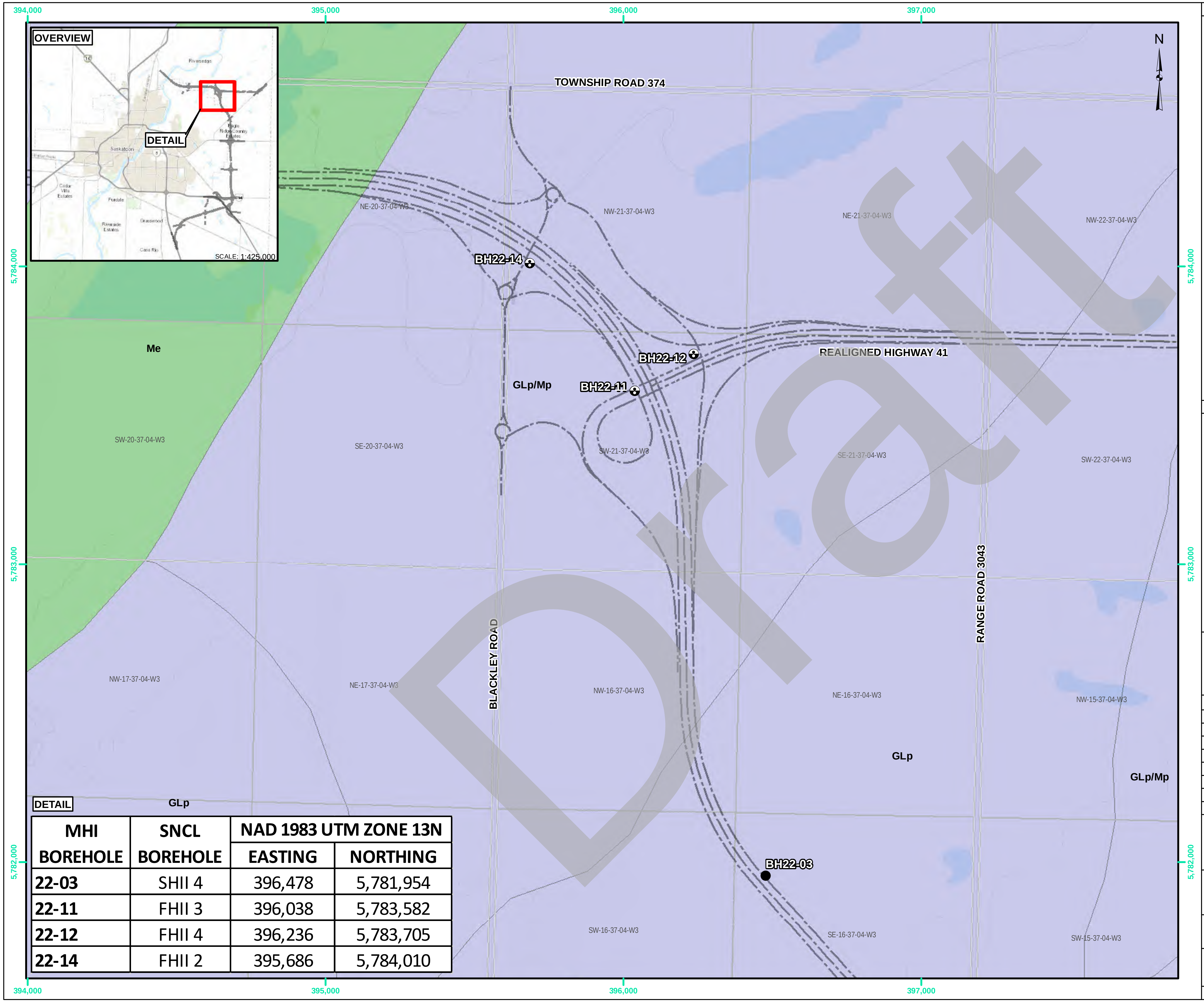

MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N	
		EASTING	NORTHING
22-03	SHII 4	396,478	5,781,954
22-11	FHII 3	396,038	5,783,582
22-12	FHII 4	396,236	5,783,705
22-14	FHII 2	395,686	5,784,010

SIZE 11x17

LEGEND

● BOREHOLE

⊕ BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)

-·- PRELIMINARY FREEWAY ALIGNMENT

═ HIGHWAY

SURFICIAL GEOLOGY

🟪 GLACIOLACUSTRINE PLAIN (GLp)

🟩 MORAINAL ERODED (Me)

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SCALE: 1:12,500

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OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
BLACKLEY ROAD INTERCHANGE BOREHOLES

DATE 2022 05 25 | **DWG No.** 659183-0000-4GDD-0062 | **FIG No.** 3-3 | **REV** 00

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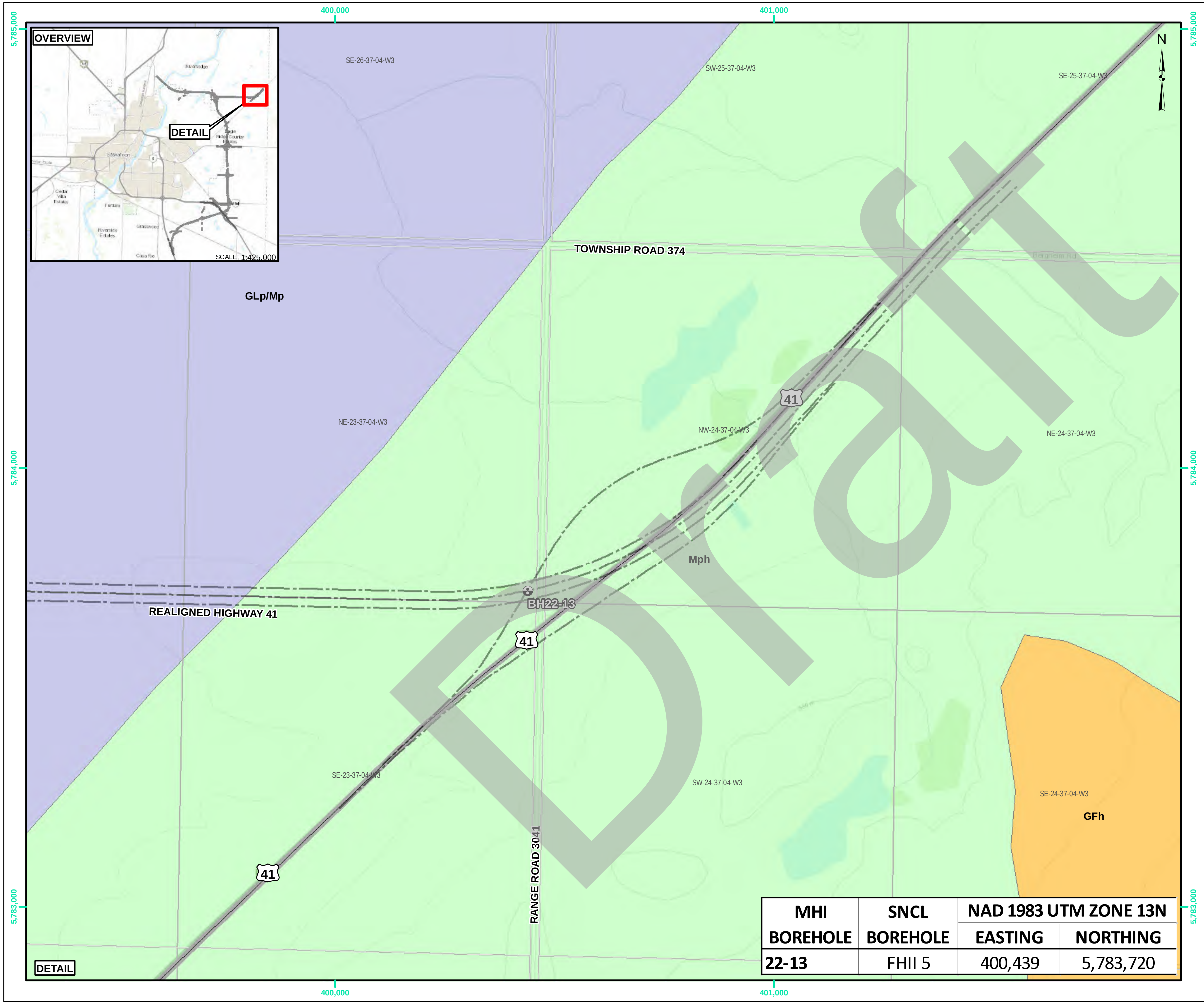

MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N EASTING	NAD 1983 UTM ZONE 13N NORTHING
22-13	FHII 5	400,439	5,783,720

LEGEND

⊕	BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)
- · -	PRELIMINARY FREEWAY ALIGNMENT
═	HIGHWAY

SURFICIAL GEOLOGY

🟧	GLACIOFLUVIAL HUMMOCKY (GFh)
🟪	GLACIOLACUSTRINE PLAIN (GLp)
🟩	MORAINAL PLAIN (Mp)

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0 125 250 500 METRES

SCALE: 1:8,500

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TITLE

HIGHWAY 41 INTERCHANGE BOREHOLES

DATE	2022 05 25	**DWG No.**	659183-0000-4GDD-0063	**FIG No.**	**3-4**	**REV**	00

SIZE 11x17

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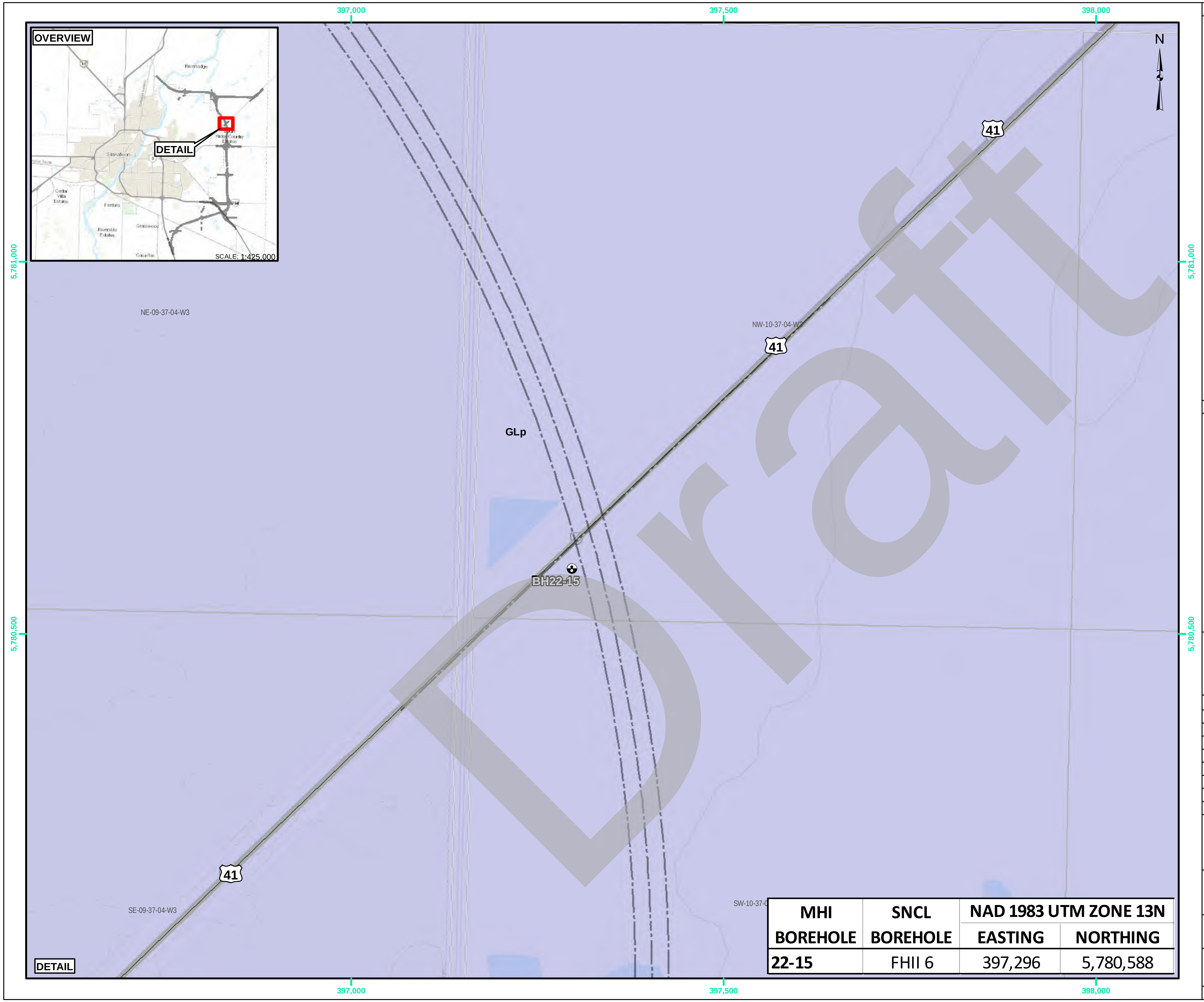

MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N EASTING	NAD 1983 UTM ZONE 13N NORTHING
22-15	FHII 6	397,296	5,780,588

LEGEND

⊕	BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)
- - -	PRELIMINARY FREEWAY ALIGNMENT
═	HIGHWAY

SURFICIAL GEOLOGY

▨	GLACIOLACUSTRINE PLAIN (GLp)

NOTES

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SCALE: 1:5,000

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PROJECT LOCATION
SASKATOON FREEWAY

TITLE
HIGHWAY 41 INTERCHANGE BOREHOLES

DATE	DWG No.	FIG No.	REV
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SIZE 11x17

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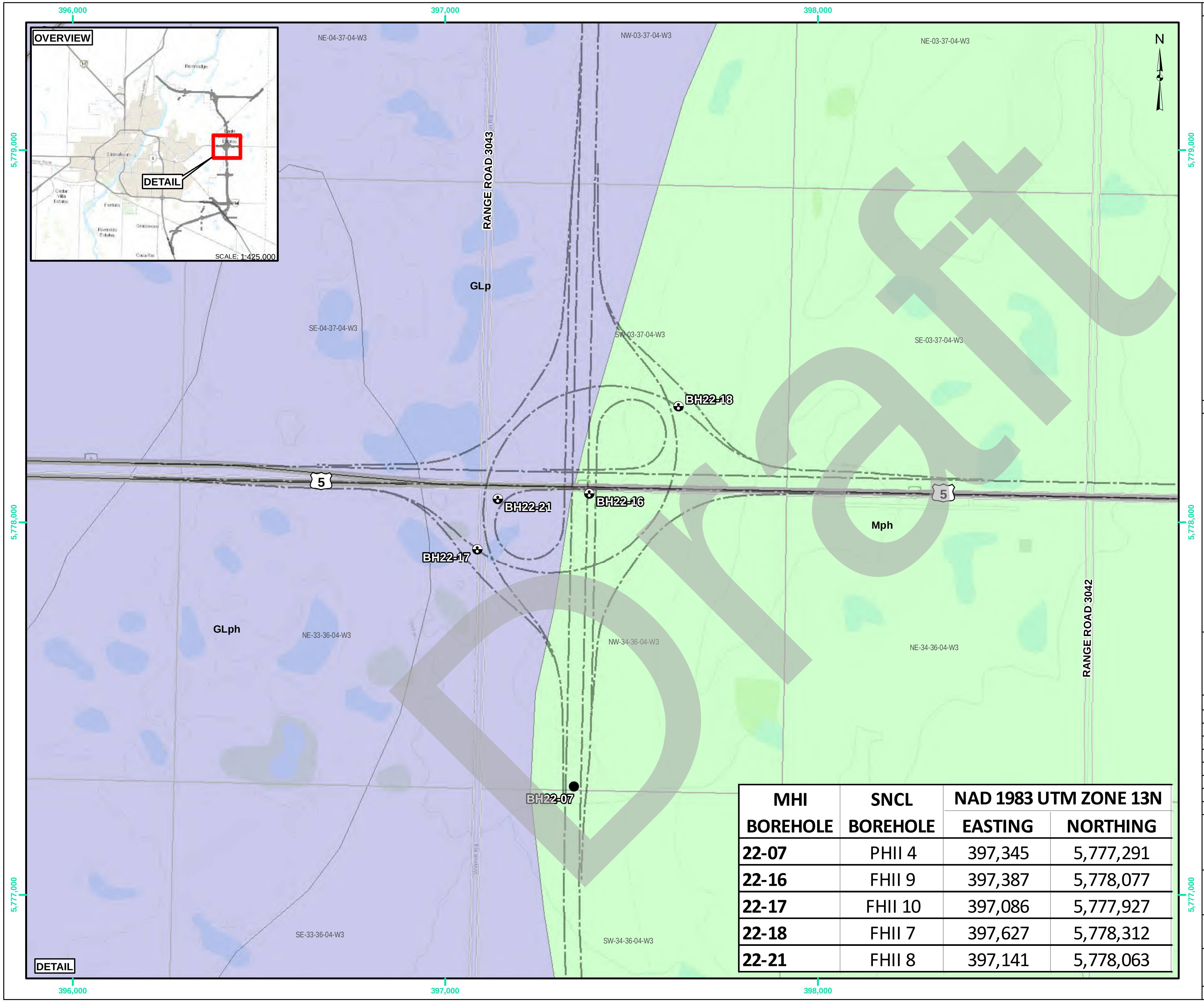

MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N	
		EASTING	NORTHING
22-07	PHII 4	397,345	5,777,291
22-16	FHII 9	397,387	5,778,077
22-17	FHII 10	397,086	5,777,927
22-18	FHII 7	397,627	5,778,312
22-21	FHII 8	397,141	5,778,063

LEGEND

●	BOREHOLE
☢	BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)
- - -	PRELIMINARY FREEWAY ALIGNMENT
═	HIGHWAY

SURFICIAL GEOLOGY

🟪	GLACIOLACUSTRINE PLAIN (GLp)
🟩	MORAINAL PLAIN (Mp)

NOTES

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0 125 250 500 METRES

SCALE: 1:10,000

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CLIENT
SASKATCHEWAN MINISTRY
OF HIGHWAYS

PROJECT LOCATION
SASKATOON FREEWAY

TITLE
HIGHWAY 5 FLYOVER INTERCHANGE BOREHOLES

DATE 2022 05 25 **DWG No.** 659183-0000-4GDD-0065 **FIG No.** 3-6 **REV** 00

SIZE 11x17

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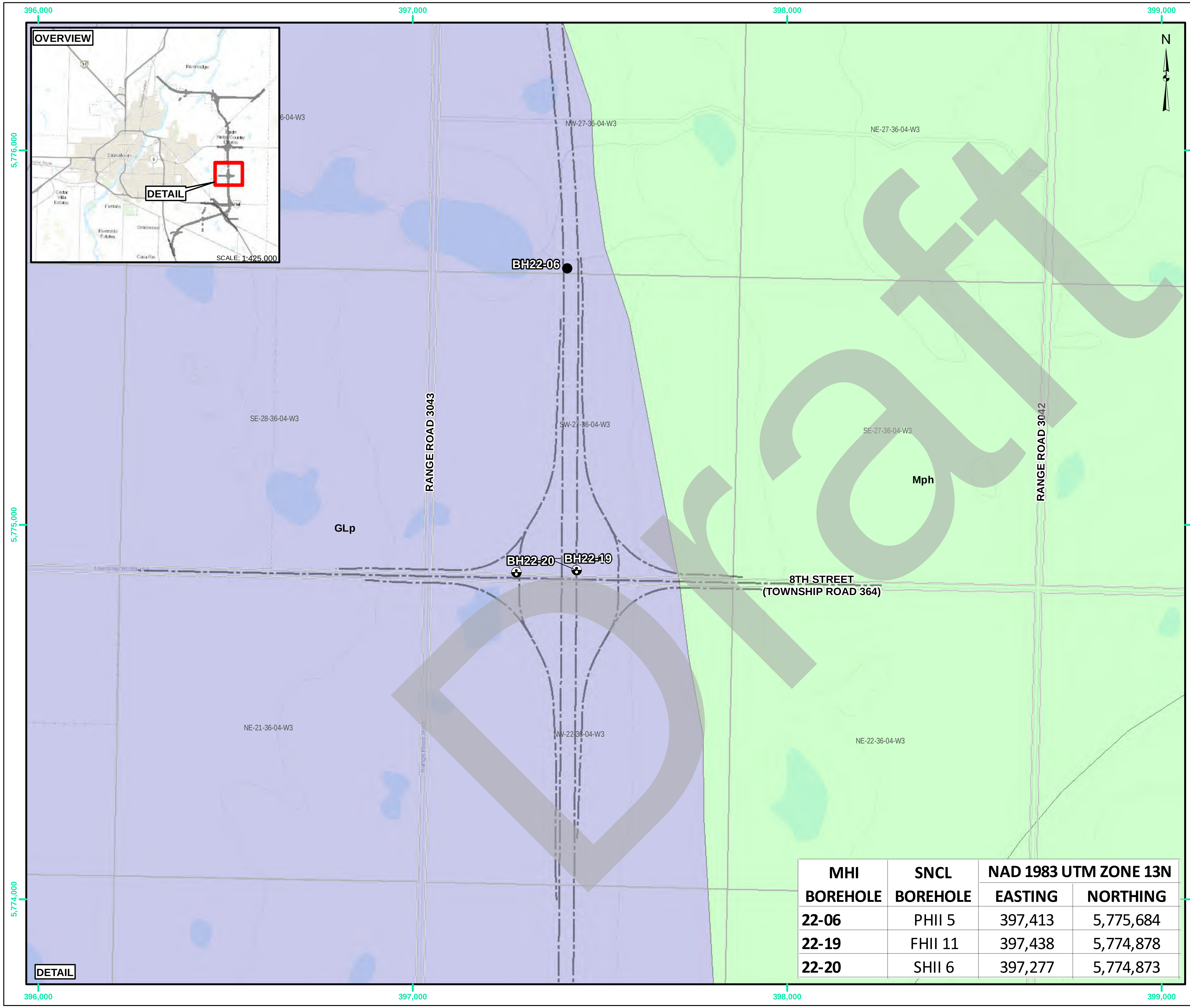

MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N EASTING	NAD 1983 UTM ZONE 13N NORTHING
22-06	PHII 5	397,413	5,775,684
22-19	FHII 11	397,438	5,774,878
22-20	SHII 6	397,277	5,774,873

LEGEND

● BOREHOLE

BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)

PRELIMINARY FREEWAY ALIGNMENT

HIGHWAY

SURFICIAL GEOLOGY

GLACIOLACUSTRINE PLAIN (GLp)

MORAINAL PLAIN (Mp)

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SCALE: 1:10,000

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CLIENT
SASKATCHEWAN MINISTRY
OF HIGHWAYS

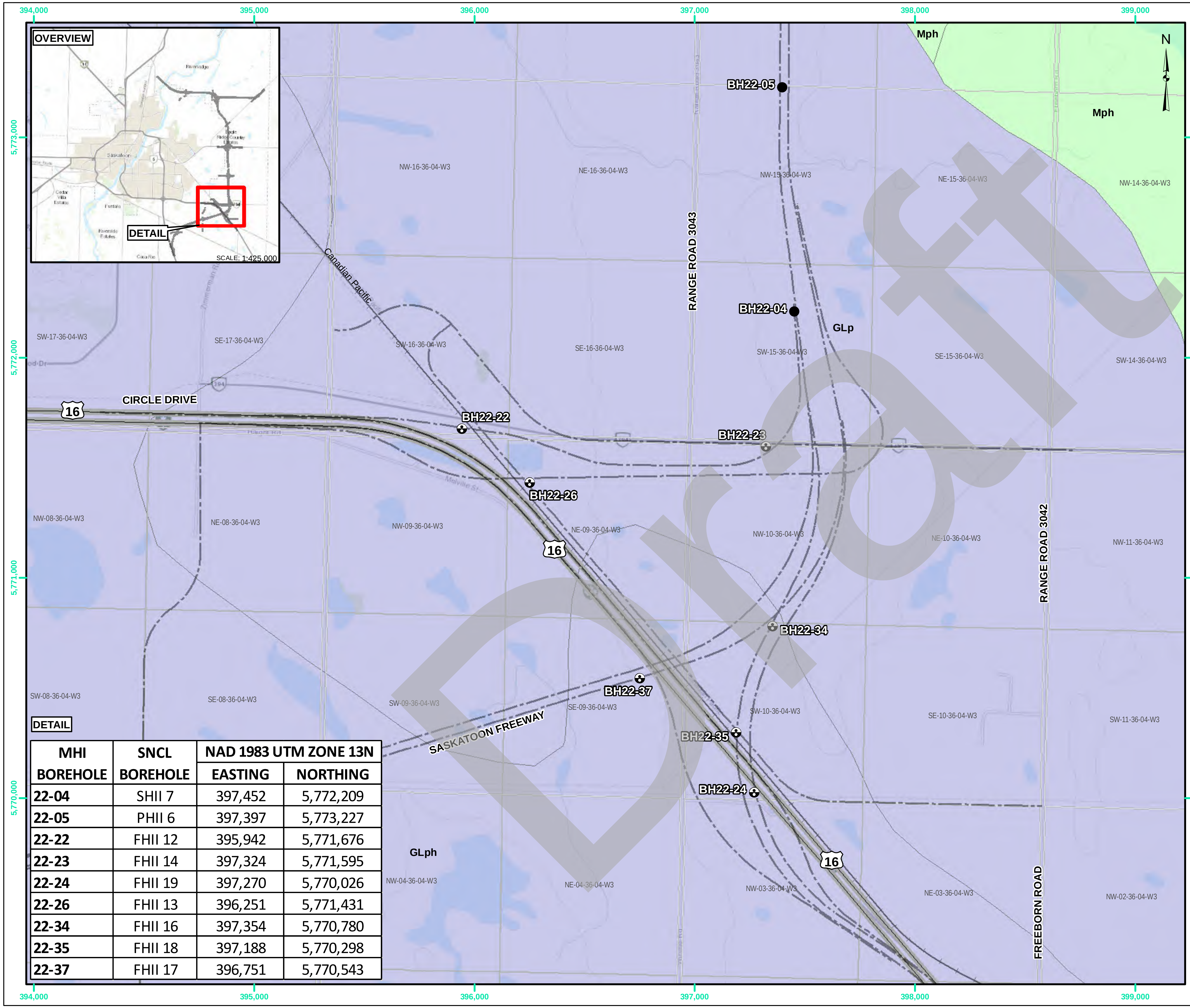
PROJECT LOCATION
SASKATOON FREEWAY

TITLE
8th STREET INTERCHANGE BOREHOLES

DATE 2022 05 25 | DWG No. 659183-0000-4GDD-0066 | FIG No. 3-7 | REV 00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Geotech\659183-0000-4GDD-0066 Borehole 8th Street.mxd



DETAIL

MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N EASTING	NAD 1983 UTM ZONE 13N NORTHING
22-04	SHII 7	397,452	5,772,209
22-05	PHII 6	397,397	5,773,227
22-22	FHII 12	395,942	5,771,676
22-23	FHII 14	397,324	5,771,595
22-24	FHII 19	397,270	5,770,026
22-26	FHII 13	396,251	5,771,431
22-34	FHII 16	397,354	5,770,780
22-35	FHII 18	397,188	5,770,298
22-37	FHII 17	396,751	5,770,543

LEGEND

- ● BOREHOLE
- ☢ BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)
- – · – PRELIMINARY FREEWAY ALIGNMENT
- ═ HIGHWAY

SURFICIAL GEOLOGY

- ▨ GLACIOLACUSTRINE PLAIN (GLp)
- 🟩 MORAINAL PLAIN (Mp)

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0 125 250 500
METRES

SCALE: 1:17,000

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CLIENT SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION** SASKATOON FREEWAY

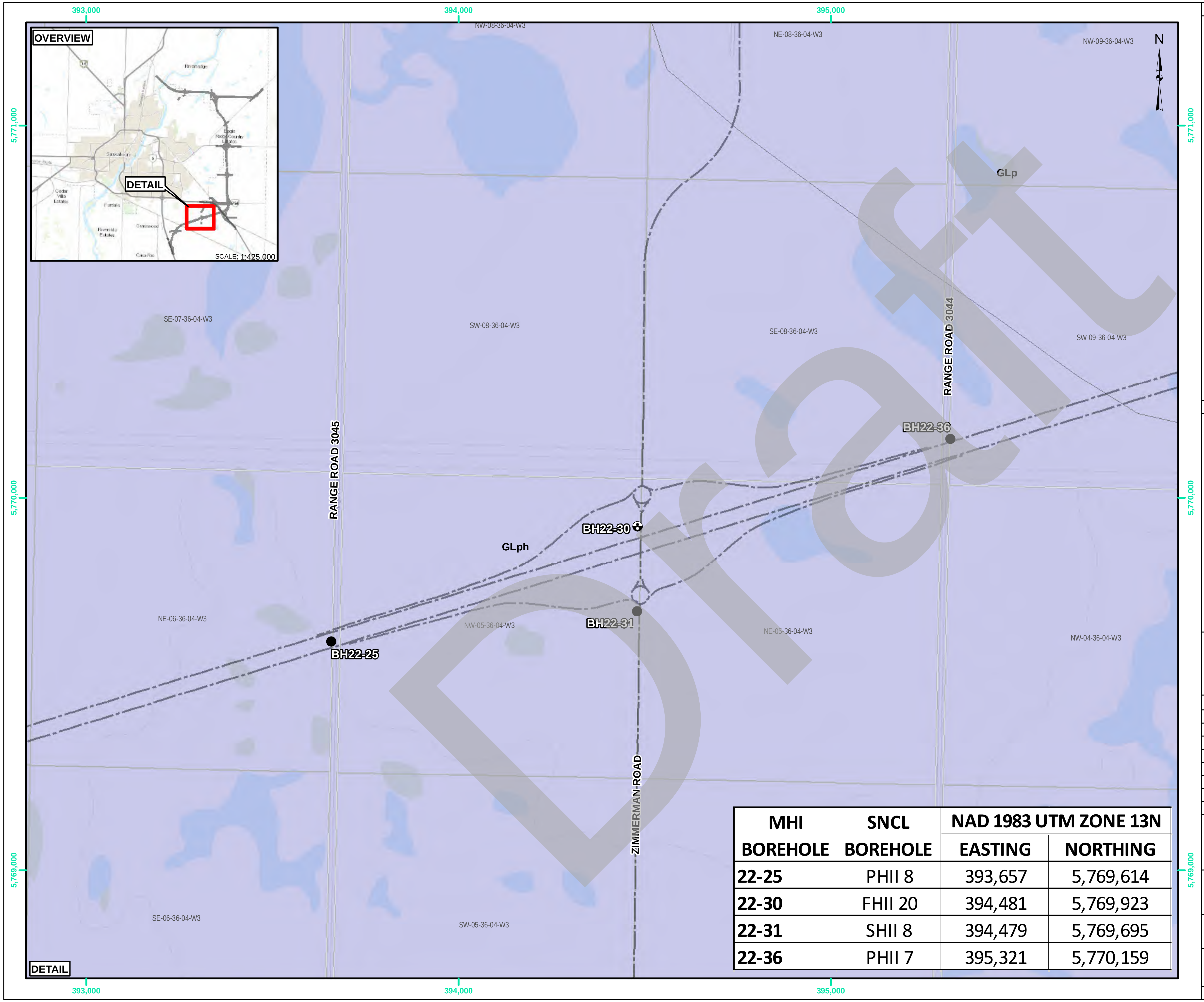
TITLE

HIGHWAY 16 INTERCHANGE BOREHOLES

DATE	2022 05 25	DWG No.	659183-0000-4GDD-0067	FIG No.	3-8	REV	00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Geotech\659183-0000-4GDD-0067 Borehole Hwy 16.mxd



MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N	
		EASTING	NORTHING
22-25	PHII 8	393,657	5,769,614
22-30	FHII 20	394,481	5,769,923
22-31	SHII 8	394,479	5,769,695
22-36	PHII 7	395,321	5,770,159

LEGEND

- ● BOREHOLE
- ⊛ BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)
- - - PRELIMINARY FREEWAY ALIGNMENT
- ═ HIGHWAY

SURFICIAL GEOLOGY

- ▨ GLACIOLACUSTRINE PLAIN (GLp)

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0 125 250 500 METRES

SCALE: 1:10,000

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CLIENT
SASKATCHEWAN MINISTRY OF HIGHWAYS

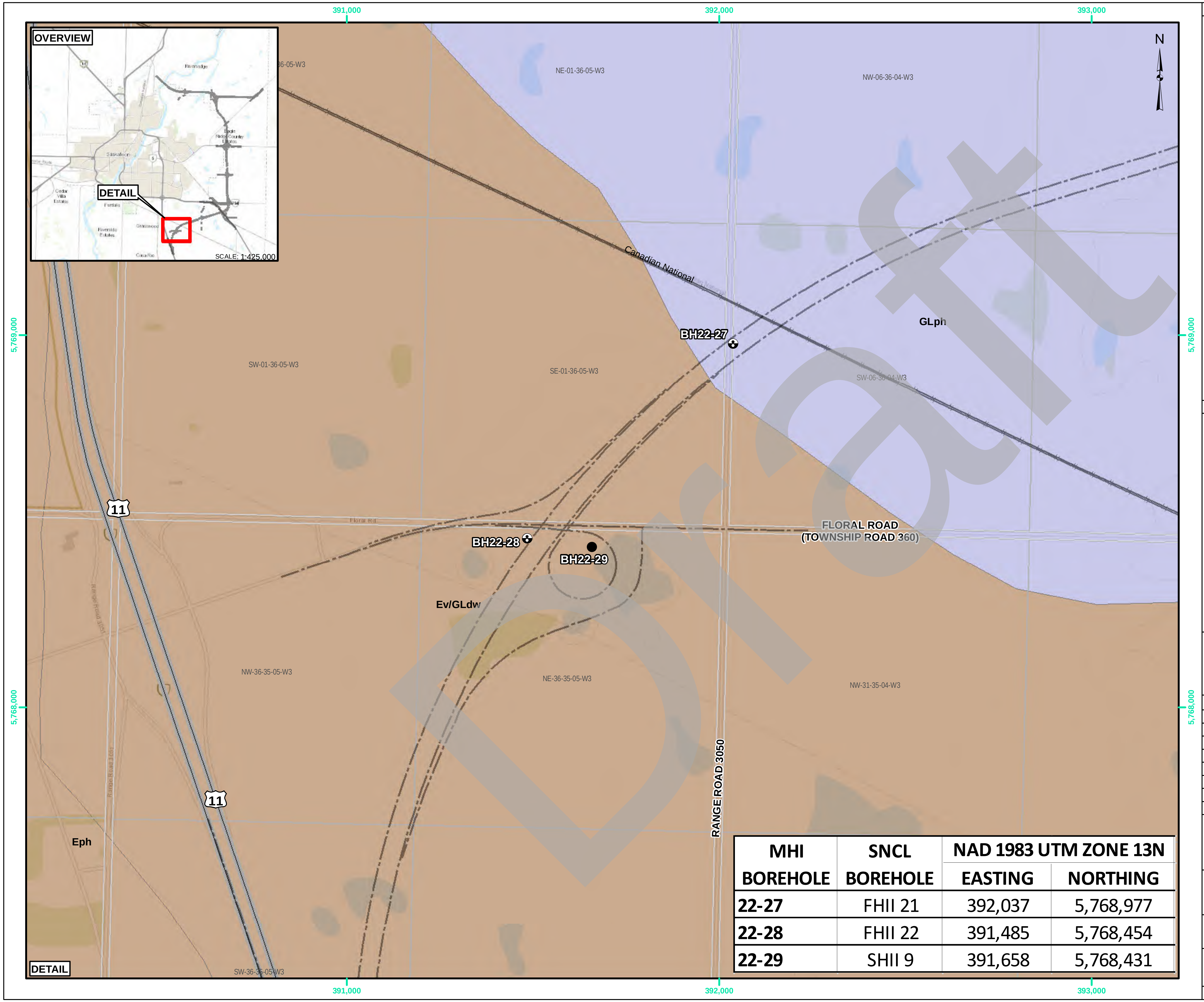
PROJECT LOCATION
SASKATOON FREEWAY

TITLE
ZIMMERMAN INTERCHANGE BOREHOLES

DATE	2022 05 25	DWG No.	659183-0000-4GDD-0068	FIG No.	3-9	REV	00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Geotech\659183-0000-4GDD-0068 Borehole Zimmerman.mxd



MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N	
		EASTING	NORTHING
22-27	FHII 21	392,037	5,768,977
22-28	FHII 22	391,485	5,768,454
22-29	SHII 9	391,658	5,768,431

LEGEND

● BOREHOLE

⊕ BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)

- - PRELIMINARY FREEWAY ALIGNMENT

═ HIGHWAY

SURFICIAL GEOLOGY

🟫	EOLIAN (E)
🟫	EOILIAN PLAIN (Ep)
🟪	GLACIOLACUSTRINE PLAIN (GLp)

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SCALE: 1:10,000

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON FREEWAY

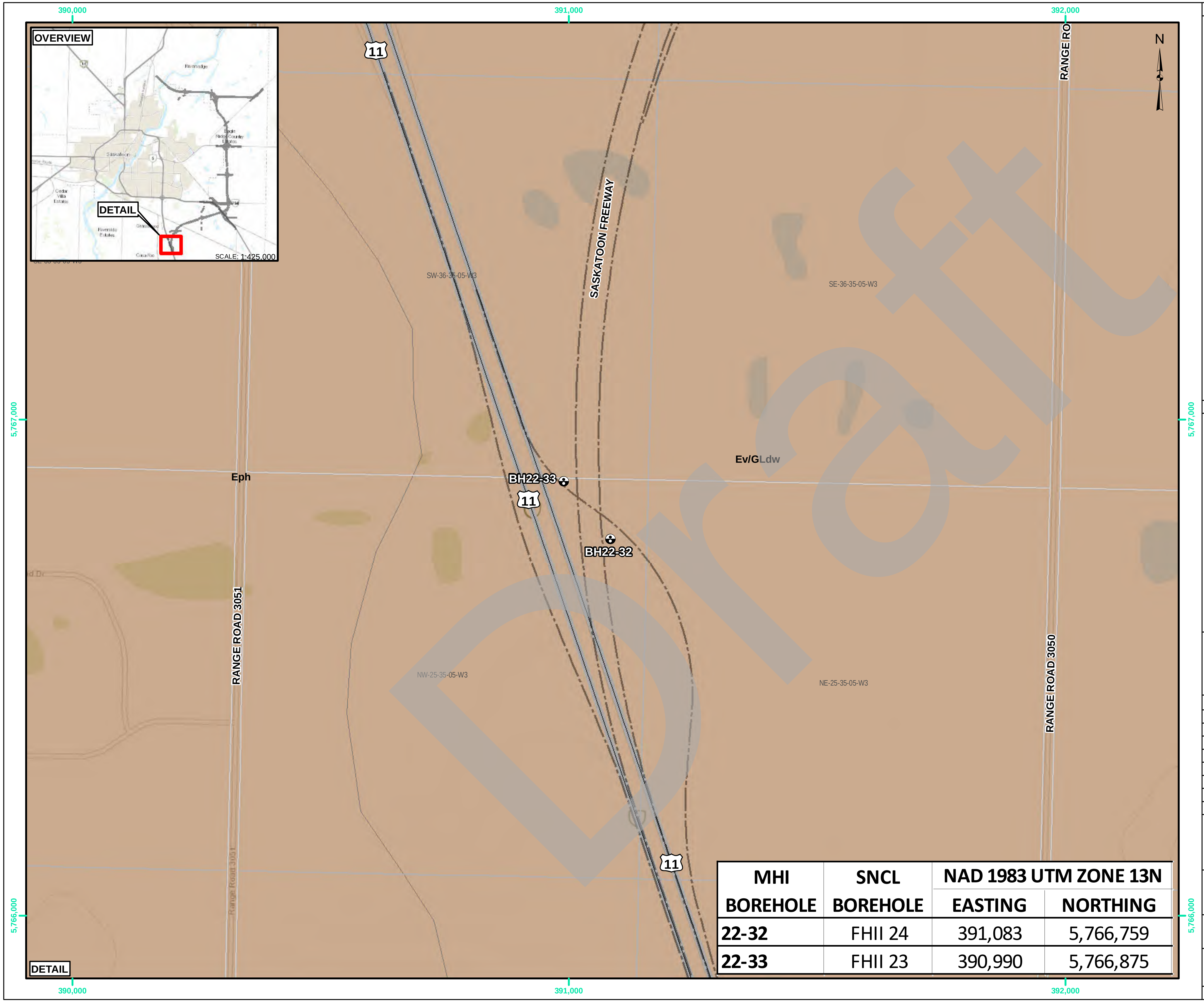
TITLE

FLORAL ROAD INTERCHANGE BOREHOLES

DATE	DWG No.	FIG No.	REV
2022 05 25	659183-0000-4GDD-0069	3-10	00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Geotech\659183-0000-4GDD-0069 Borehole Floral.mxd



MHI BOREHOLE	SNCL BOREHOLE	NAD 1983 UTM ZONE 13N EASTING	NAD 1983 UTM ZONE 13N NORTHING
22-32	FHII 24	391,083	5,766,759
22-33	FHII 23	390,990	5,766,875

LEGEND

⊕	BOREHOLE (VIBRATING WIRE PIEZOMETERS INSTALLED)
- - -	PRELIMINARY FREEWAY ALIGNMENT
═	HIGHWAY

SURFICIAL GEOLOGY

▨	EOLIAN (E)
▨	EOILIAN PLAIN (Ep)

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0 100 200 400 METRES

SCALE: 1:7,500

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CLIENT SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION** SASKATOON FREEWAY

TITLE

HIGHWAY 11 INTERCHANGE BOREHOLES

DATE	2022 05 25	DWG No.	659183-0000-4GDD-0070	FIG No.	3-11	REV	00

SIZE 11x17

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4 Method of Investigation

The boreholes along the South Saskatchewan River were drilled using a mud rotary drill rig (model: R408), and the boreholes along the Eastern Segment were drilled using a sonic drill rig (model: R702) supplied and operated by Forged Drilling Ltd. The geotechnical investigation was supervised by SNC-Lavalin. The SNC-Lavalin supervisors directed drilling, sampling, in-situ testing operations, piezometer installation, and logged the lithology of the boreholes. The drilling was complete during the day and at night with two separate shifts working approximately 12-hour intervals. The SNC-Lavalin supervisors surveyed the final borehole testing locations using a handheld GPS at the time of drilling. Additional survey using real time kinematic (RTK) survey equipment was also completed at boreholes with instrumentation. As previously indicated, three different types of boreholes were drilled for the investigation: Preliminary, Stratigraphic, and Foundation boreholes. The Preliminary boreholes were backfilled with cuttings and topped with bentonite chips. The Stratigraphic boreholes and Foundation boreholes were grouted with a cement-bentonite mixture that conforms to the Ministry requirement (specific gravity between 1.35 and 1.4) to secure the installed vibrating wire (VW) piezometers and slope inclinometer casing, as well as for proper borehole abandonment.

The following sections provide the details of the drilling program, installed geotechnical instrumentation and laboratory testing program completed for the Eastern Segment and River Crossing.

4.1 Drilling Program

4.1.1 Borehole Stake-out and Utility Clearance Permits

Prior to the geotechnical investigation, a Sask 1st Call was completed along the Project alignment to ensure that there were no utility conflicts with the chosen borehole locations. Access Communications, the RM and the CoS were also contacted regarding utility locates. SNC-Lavalin completed the appropriate environmental screenings prior to any drilling; this included precautions in order to mitigate the spread of clubroot disease onto agricultural land. An Aquatic Habitat Protection Permit (AHPP) (**Appendix III**) was obtained for this investigation.

In accordance with Ministry guidelines, all landowners with proposed boreholes on their property were sent a Form A Notice to Enter Upon Land, prior to drilling the applicable borehole. **Table 4-1** shows the list of landowners that were contacted for each borehole location.

Table 4-1 Landowner Summary

Ministry Borehole ID	Contacted Landowner
21-04, 21-05	ERCO
21-06, 21-07	L&L Gravel Ranch & Ranching CO. Ltd.
22-01, 22-02, 22-26	John Germs
22-03, 22-04, 22-25, 22-33	Lionel Duh & Darren Duh
22-05	Darrell Stefaniuk
22-06	Myrna Wilson
22-07	Ralph Stevenson
22-08	Ivan Russell Bodnaryk
22-09	Ray Schafer
22-10	Dream Asset Management Corp
22-11, 22-28, 22-36	Robert Risling
22-12, 22-19, 22-35	Crown
22-13	Don Priddy
22-14, 22-29	Glenn Douglas Pichler
22-16, 22-18	Leslie Catherine Blacklock
22-17	Doug Winmill (Jim Appelt - renter)
22-20, 22-30	Roy Greva & Michelle Greva
22-21	Patricia Anne Ellis & Bob Knock
22-22, 22-31	Dennis Lance Barton
22-23, 22-24	Arnold Lawley
22-27	Cindercrete
22-32	Robert Finley
22-34	Marla Lee Adams & Seth Eric Adams
22-37	Kirsten Jewitt
22-38, 22-39	Tim Zerr

4.1.2 Traffic Accommodation

The appropriate traffic control plans and procedures were implemented where required. Traffic accommodation plans varied depending on the location of the borehole and whether it was adjacent to a highway or other City or RM road.

4.1.3 Borehole Summary

Observations made during drilling were recorded and included on the borehole logs (**Appendix IV**).

Four boreholes were drilled to depths ranging from 35.1 metres below ground surface (mbgs) and 100.5 mbgs on the West and East side of the South Saskatchewan River. The two Foundation boreholes were drilled to collect soil samples for laboratory testing. Standard penetration tests (SPTs) were completed at select depths, and samples were recovered from the SPT sampler. Shelby tube samples were also collected at select depths. On each side of the river, a Slope Inclinometer (SI) was installed to monitor slope movement. Shelby tube samples were obtained at select depths in the SI boreholes to correspond with depths where Shelby tube samples could not be retrieved in the two Foundation boreholes.

Seven Preliminary boreholes (PH series) were drilled to a minimum depth of 4.6 mbgs (15 ft) within the Eastern Segment to obtain detailed soil information and to determine the engineering properties of the subgrade and foundation along the general alignment. Moisture content samples were taken at 0.6 m, 1.2 m, 1.8 m, 2.4 m, 3.0 m and 4.6 m.

Seven Stratigraphic boreholes (SH series) were drilled to a minimum depth of 13.7 mbgs (45 ft) within the Eastern Segment to understand the stratigraphy of the area, determine the engineering properties of the subgrade and foundation along the general alignment, and determine the type and quality of expected adjacent borrow sources. Soil samples were collected at 0.6 m, 1.5 m, and at subsequent 1.5 m intervals to the terminal depth. For each of the Stratigraphic boreholes, SPTs were completed at select depths.

Twenty-three Foundation boreholes (FH series) were drilled to depths ranging between 24.3 mbgs and 36.0 mbgs at the interchange/overpass locations within the Eastern Segment to obtain soil information and to collect soil samples for laboratory testing. Depending on the location of the borehole and the material encountered, some boreholes were drilled deeper, with a maximum depth of 36 m. SPTs were completed at select depths and samples were recovered from the SPT sampler. Shelby tube samples were also collected at select depths.

Table 4-2 provides the summary of borehole coordinates and termination depths/elevations. Detailed borehole logs are provided in **Appendix IV**. **Appendix IV** also includes an outline of the terms and symbols used during logging of the boreholes in the field, as well as the Ministry's requirement for sequence of soil descriptions. The Ministry borehole summary sheet, in Microsoft Excel format, will be provided electronically in addition to the borehole logs.

Table 4-2 Eastern Segment Borehole Summary

Ministry Borehole ID	SNCL Borehole ID	Zone 13 U	Zone 13 U	Ground Elevation (masl)	Type of Borehole	Type of Drilling	Location	Termination Depth (m)	Termination Depth (masl)	Instrument
21-04	BH1	5785489.27	390037.30	499.1	Foundation	Mud Rotary	North River Crossing	100.3	398.8	VWP x3
21-05	BH1-SI	5785478.12	390036.59	499.1	Foundation	Mud Rotary	North River Crossing	55.0	444.1	SI
21-06	BH2	5785139.94	390384.44	482.3	Foundation	Mud Rotary	North River Crossing	100.5	381.9	VWP x3
21-07	BH2-SI	5785144.33	390386.78	482.4	Foundation	Mud Rotary	North River Crossing	35.1	447.3	SI
22-01	SHII 1	5784351	391744	489	Stratigraphic	Sonic	General Alignment	14.2	474.8	No
22-02	FHII 1	5784355.17	392638.41	498.7	Foundation	Sonic	Central Avenue Interchange	24.8	473.8	VWP x3
22-03	SHII 4	5781954	396478	508	Stratigraphic	Sonic	General Alignment	14.0	494.0	No
22-04	SHII 7	5772209	397452	536	Stratigraphic	Sonic	General Alignment	14.2	521.8	No
22-05	PHII 6	5773227	397397	531	Preliminary	Sonic	General Alignment	5.5	525.5	No
22-06	PHII 5	5775684	397413	523	Preliminary	Sonic	General Alignment	5.5	517.5	No
22-07	PHII 4	5777291	397345	529	Preliminary	Sonic	General Alignment	5.5	523.5	No
22-08	PHII 1	5784851	390755	496	Preliminary	Sonic	General Alignment	5.5	490.5	No
22-09	SHII 2	5784131.83	392645.44	499.8	Stratigraphic	Sonic	Central Avenue Interchange	14.2	485.6	VWP x2
22-10	PHII 2	5784292	393964	502	Preliminary	Sonic	General Alignment	4.6	497.4	No
22-11	FHII 3	5783581.89	396037.94	505.1	Foundation	Sonic	Blackley Road Interchange	32.6	472.4	VWP x4
22-12	FHII 4	5783705.10	396236.36	505.1	Foundation	Sonic	Blackley Road Interchange	32.8	472.4	VWP x3
22-13	FHII 5	5783719.59	400439.47	525.8	Foundation	Sonic	Highway 41 Realignment	24.7	501.1	VWP x3
22-14	FHII 2	5784010.09	395686.34	500.8	Foundation	Sonic	Blackley Road Interchange	29.7	471.1	VWP x3
22-15	FHII 6	5780587.75	397296.46	517.5	Foundation	Sonic	Highway 41 Flyover	36.0	481.5	VWP x3
22-16	FHII 9	5778077.49	397387.02	529.5	Foundation	Sonic	Highway 5 Interchange	24.8	504.7	VWP x3
22-17	FHII 10	5777926.99	397085.68	523.5	Foundation	Sonic	Highway 5 Interchange	24.8	498.7	VWP x3
22-18	FHII 7	5778311.54	397626.55	537.3	Foundation	Sonic	Highway 5 Interchange	24.8	512.5	VWP x2
22-19	FHII 11	5774878.19	397437.57	527.5	Foundation	Sonic	8th Street Interchange	24.5	502.9	VWP x2
22-20	SHII 6	5774872.76	397276.94	524.1	Stratigraphic	Sonic	8th Street Interchange	14.2	509.9	VWP x1
22-21	FHII 8	5778062.63	397141.05	522.3	Foundation	Sonic	Highway 5 Interchange	24.8	497.5	VWP x3
22-22	FHII 12	5771676.13	395942.28	515.2	Foundation	Sonic	Highway 16 Interchange	24.7	490.5	VWP x3
22-23	FHII 14	5771595.48	397323.53	530.0	Foundation	Sonic	Highway 16 Interchange	24.4	505.6	VWP x2
22-24	FHII 19	5770026.22	397270.48	523.8	Foundation	Sonic	Highway 16 Interchange	24.8	498.9	VWP x2
22-25	PHII 8	5769614	393657	513	Preliminary	Sonic	General Alignment	4.6	508.4	No
22-26	FHII 13	5771431.49	396250.68	516.1	Foundation	Sonic	Highway 16 Interchange	24.6	491.5	VWP x3
22-27	FHII 21	5768977.46	392037.41	513.1	Foundation	Sonic	Floral Road Interchange	30.3	482.8	VWP x2
22-28	FHII 22	5768454.18	391484.62	509.8	Foundation	Sonic	Floral Road Interchange	25.0	484.8	VWP x2
22-29	SHII 9	5768431	391658	511	Stratigraphic	Sonic	Floral Road Interchange	13.9	497.1	No
22-30	FHII 20	5769922.78	394480.90	516.8	Foundation	Sonic	Zimmerman Road Interchange	24.8	492.0	VWP x2
22-31	SHII 8	5769695	394479	515	Stratigraphic	Sonic	Zimmerman Road Interchange	14.1	500.9	No
22-32	FHII 24	5766758.86	391083.42	512.8	Foundation	Sonic	Highway 11 Interchange	24.8	487.9	VWP x2
22-33	FHII 23	5766875.09	390989.72	514.2	Foundation	Sonic	Highway 11 Interchange	29.9	484.3	VWP x2
22-34	FHII 16	5770779.96	397353.59	529.6	Foundation	Sonic	Highway 16 Interchange	25.2	504.4	VWP x2
22-35	FHII 18	5770298.27	397187.79	524.4	Foundation	Sonic	Highway 16 Interchange	24.8	499.6	VWP x2
22-36	PHII 7	5770159	395321	515	Preliminary	Sonic	General Alignment	5.5	509.5	No
22-37	FHII 17	5770543.15	396750.85	521.2	Foundation	Sonic	Highway 16 Interchange	24.8	496.3	VWP x2

4.2 In-situ and Field Soil Tests

The following sections outline the in-situ and field soil tests that were carried out during the geotechnical investigation.

4.2.1 Field Soil Classification

Field soil classification was carried out on all recovered samples as observed during drilling. Field soil classification was verified through laboratory testing as detailed in Section 4.4.

4.2.2 Standard Penetration Test (SPT)

SPTs were completed in Stratigraphic and Foundation boreholes. The test is an in-situ dynamic penetration test that provides qualitative evaluations of compactness and qualitative comparison of subsoil stratification. This test method allowed the collection of soil samples at various depths for further visual and laboratory testing. The SPTs performed during drilling conformed to ASTM D1586. A 63.5 kg weight hammer having a free fall of 760 mm was utilized for the SPTs. The results (N-values) of the SPTs are provided in **Appendix IV** on each individual borehole log.

The Ministry Standard Test Procedure (STP 240-6) for Penetration Test and Split-Barrell Sampling was initially followed, which recommends terminating the test when the blow count exceeds 100 in total. After following this procedure for several boreholes, the split barrel sampler was sustaining damaged within the hard till units; therefore, SNC-Lavalin requested Ministry approval for a maximum of 50 blow counts for each 150 mm depth interval (ASTM standard practice) to be used for SPT termination going forward. The Ministry agreed to this modification, and the drill program went forward with terminating the tests after a maximum of 50 blow counts were recorded for any of the three 150 mm increments.

4.2.3 Pocket Penetrometer Test

Pocket penetrometer testing was performed on all cohesive soil samples in order to approximate an unconfined compressive strength. The results of the pocket penetrometer testing are provided in **Appendix IV** on each individual borehole log.

4.3 Geotechnical Instrumentation

4.3.1 Vibrating Wire Piezometers

Sixty-seven VW piezometers were installed at twenty-seven borehole locations drilled within the Eastern Segment to monitor and record groundwater levels in the Project area. Most boreholes have a stack of two to three VW piezometers and one multi-channel logger. One borehole (22-11) location had a stack of four VW piezometers and one multi-channel logger. Borehole 22-20 had one VW piezometer and one multi-channel logger installed.

All VW piezometers were grouted in place utilizing a cement-bentonite grout mixture (4.5: 1: 0.1 water: cement: bentonite by weight) specified in Section 300.120 of the Ministry Foundation Investigation Manual (MoH, 2018). **Table 4-3** summarizes the installation details of each piezometer, which are also shown on the borehole logs provided in **Appendix IV.** The calibration sheets for each VW piezometer are provided in **Appendix V**.

4.3.2 Slope Inclinometers

One SI was installed on the west side of the river at 21-05 to a depth of 55 mbgs, and another SI was installed on the east side of the river at 21-07 to a depth of 35.1 mbgs. Both SI casings were baselined after the completion of the borehole. The SI's were grouted in place utilizing the cement-bentonite grout mixture specified by the Ministry (MoH, 2018). A locked steel protective casing was placed overtop of both SI's to prevent damage and vandalism. The details of the SI's can be seen in **Appendix VI**.

Table 4-3 Summary of VW Piezometers

MHI Borehole ID	SNCL Borehole ID	Zone 13 U Northing (m)	Zone 13 U Easting (m)	Ground Elevation (masl)	VW Serial Number	Installed Depth (mbgs)	Initial Field Reading, Ro (Hz)	Initial Field Temperature (°C)	Total Head (m) April 2022	Total Head (masl) April 2022	Lithology
21-04	BH 1	5785489.3	390037.3	499.1	139492	29.0	3095.9	10.1	8.1	478.2	Unoxidized Till
					138458	52.5	3081.9	11.9	33.8	480.4	Unoxidized Till
					138151	77.5	3035.9	13.8	NA	NA	Sand
21-06	BH 2	5785139.9	390384.4	482.3	139465	10.0	3003.0	15.9	5.5	477.8	Unoxidized Till
					138631	19.0	3022.0	15.9	16.5	479.8	Unoxidized Till
					138167	74.0	3081.0	17.7	81.0	489.3	Unoxidized Till
22-02	FHII 1	5784355.2	392638.4	498.7	2026004	9.3	2998.4	19.5	1.7	491.0	Sand
					2025998	17.8	3001.3	19.6	7.0	487.9	Unoxidized Till
					2021005	23.9	3007.2	19.5	12.9	487.7	Sand
22-09	SHII 2	5784131.8	392645.4	499.8	2153172	5.8	2945.7	12.0	-0.5	493.5	Sand
					2153163	11.9	2963.8	11.6	3.0	490.9	Sand
22-11	FHII 3	5783581.9	396037.9	505.1	2153167	4.6	2981.1	37.3	1.4	501.8	Oxidized Till
					2153131	4.6	3036.2	37.1	1.4	501.8	Sand
					2153156	14.0	2932.4	20.4	8.3	499.3	Oxidized Till
					2154588	15.9	2962.2	35.8	10.0	499.2	Sand
22-12	FHII 4	5783705.1	396236.4	505.1	2153863	5.8	3026.1	4.5	0.0	499.3	Oxidized Till
					2153132	12.5	2974.2	5.4	6.7	499.3	Sand
					2154583	28.7	2935.1	5.0	21.9	498.3	Sand
22-13	FHII 5	5783719.6	400439.5	525.8	2153865	8.8	3022.1	15.3	9.6	526.6	Sand
					2153155	11.3	2976.9	17.5	6.6	521.2	Oxidized Clay
					2154582	23.8	2978.1	18.7	13.0	515.0	Unoxidized Till
22-14	FHII 2	5784010.1	395686.3	500.8	2153866	8.8	3028.0	30.9	5.4	497.4	Sand
					2153154	11.3	3005.1	32.3	7.6	497.1	Oxidized Till
					2154584	25.3	2911.4	30.4	20.3	495.8	Sand
22-15	FHII 6	5780587.8	397296.5	517.5	2153173	6.1	2997.9	7.8	-0.3	511.1	Oxidized Till
					2153141	17.7	3002.6	8.4	22.0	521.8	Oxidized Till
					2154590	28.1	2956.4	8.4	15.2	504.6	Sand
22-16	FHII 9	5778077.5	397387.0	529.5	2153175	6.4	2844.0	19.2	-2.8	520.3	Oxidized Till
					2153142	7.9	3006.7	20.3	1.9	523.5	Oxidized Till
					2154593	23.8	2947.1	21.3	15.8	521.5	Unoxidized Till
22-17	FHII 10	5777927	397085.7	523.5	2153166	2.1	2979.4	34.6	-0.1	521.2	Sand
					2153129	8.8	3019.4	34.6	6.3	520.9	Oxidized Till
					2154592	23.8	2927.4	34.4	20.8	520.4	Unoxidized Till
22-18	FHII 7	5778312	397626.5	537.3	2153139	14.0	3017.4	20.0	8.5	531.7	Oxidized Till
					2154598	23.8	2979.3	16.5	17.3	530.8	Unoxidized Till
22-19	FHII 11	5774878	397437.6	527.5	2153134	10.1	2940.7	15.3	8.5	525.9	Oxidized Till
					2154599	23.8	3017.5	16.5	19.0	522.7	Unoxidized Till
22-20	SHII 6	5774873	397276.9	524.1	2153168	11.9	2995.4	23.4	9.1	521.3	Oxidized Till
22-21	FHII 8	5778063	397141.0	522.3	2153170	6.4	2962.8	8.1	3.5	519.4	Oxidized Till
					2153136	14.9	3010.6	7.8	11.6	519.0	Sand
					2154595	23.8	2958.1	8.0	20.2	518.7	Unoxidized Till
22-22	FHII 12	5771676	395942.3	515.2	2353165	10.7	3008.7	22.0	3.3	507.8	Unoxidized Clay
					2153138*	19.4	2973.1	22.1	16.7	512.6	Sand
					2154591	23.8	2998.9	21.7	22.7	514.1	Unoxidized Till
22-23	FHII 14	5771595	397323.5	530.0	2153144	9.5	2994.5	11.9	3.7	524.2	Oxidized Till
					2154605	23.8	2963.4	11.5	16.7	522.9	Unoxidized Till
22-24	FHII 19	5770026	397270.5	523.8	2153171	8.2	2952.6	30.6	3.8	519.3	Oxidized Till
					2154594	23.8	2996.3	19.5	18.3	518.3	Unoxidized Till
22-26	FHII 13	5771431	396250.7	516.1	2153868	3.7	2904.1	11.5	1.7	514.1	Oxidized Clay
					2153152	9.2	2975.0	12.8	7.9	514.8	Unoxidized Silt
					2154607	23.8	2962.8	11.4	23.7	515.9	Unoxidized Till
22-27	FHII 21	5768977	392037.4	513.1	2153128	17.4	2959.6	25.6	12.8	508.5	Sand
					2154603	27.8	2944.5	26.2	23.0	508.4	Sand
22-28	FHII 22	5768454	391484.6	509.8	2153135	10.4	3013.8	10.2	8.3	507.8	Oxidized Silt
					2154589	24.1	3001.5	10.9	21.9	507.6	Unoxidized Till
22-30	FHII 20	5769923	394480.9	516.8	2153161	10.7	2977.2	8.7	6.6	512.8	Unoxidized Silt
					2154597	23.8	2966.4	12.0	20.0	513.0	Unoxidized Till
22-32	FHII 24	5766759	391083.4	512.8	2153158	5.8	2953.4	16.9	4.3	511.3	Oxidized Silt
					2154587	23.8	2949.0	16.6	21.8	510.8	Unoxidized Till
22-33	FHII 23	5766875	390989.7	514.2	2153160	9.8	3006.0	17.0	6.2	510.6	Sand
					2154596	29.3	2999.3	14.0	25.5	510.3	Unoxidized Till
22-34	FHII 16	5770780	397353.6	529.6	2153159	11.9	2835.2	23.5	5.2	522.9	Oxidized Silt
					2154600	23.8	2977.2	23.5	22.6	528.4	Oxidized Till
22-35	FHII 18	5770298	397187.8	524.4	2153162	11.0	2958.7	19.7	6.5	519.9	Oxidized Silt
					2154606	23.8	3033.0	20.3	18.6	519.3	Unoxidized Till
22-37	FHII 17	5770543	396750.9	521.2	2153867	7.9	3016.4	5.4	2.9	516.1	Oxidized Silt
					2154601	23.8	3019.6	5.2	19.2	516.5	Unoxidized Till

* Spliced with serial number 2154602.

4.4 Geotechnical Laboratory Testing

Soil samples collected from the Preliminary, Stratigraphic, and Foundation boreholes were tested to determine the geotechnical parameters of the soils. Material testing was carried out at SNC-Lavalin's Canadian Council of Independent Laboratories (CCIL) certified Centre for Advanced Material Testing in Saskatoon. The tests were chosen based on the soil conditions encountered. A summary of the quantity of laboratory tests completed is provided in **Table 4-4**.

Table 4-4 Quantity of Laboratory Tests Completed for Phase 2 Investigation

Geotechnical Laboratory Test	Number of Tests Completed
Natural Water Content (ASTM D2216)	1064
Atterberg Limits (ASTM D4318)	38
Wash Sieve Analysis (ASTM C117)	56
Hydrometer and Sieve Test (ASTM D7928 and C136)	52
Group Index / Classification (Ministry STP 205-01 & 02 and ASTM D2487)	74
Triaxial CU < 3 MPa (ASTM D4767)	4
Unconfined Compression Strength (ASTM D2166)	27
Consolidation (ASTM D2435)	4
Unit Weight	85
Carbonate Content (ASTM D4373)	68

The following pages provide summaries of the laboratory test results for most of the tests listed in the table above (**Table 4-5** through **Table 4-11**). Select lab results are also shown on each borehole log (provided in **Appendix IV**) and the individual results for each test are provided in **Appendix VII**. The full list of moisture content results is provided in **Appendix VII**.

Table 4-5 Atterberg Limits Results

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	Moisture (%)	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Classification
21-04	BH1	NLB-1004	3.0 - 4.5	8.7	12.0	20.7	8.7	CL
21-04	BH1	NLB-1026	27.0 - 28.5	16.3	13.7	33.9	20.3	CL
21-04	BH1	NLB-1033	36.0 - 36.45	14.6	14.3	36.5	22.2	CL
21-06	BH2	NLB-1098	1.5 - 3.0	10.4	13.6	29.3	15.7	CL
21-06	BH2	NLB-1116	16.0	1.2	13.8	33.1	19.3	CL
21-06	BH2	NLB-1123	21.0 - 22.5	12.2	14.9	36.9	22.0	CL
21-06	BH2	NLB-1128	26.0	12.5	15.0	38.4	23.4	CL
21-06	BH2	NLB-1175	100.0 - 100.5	19.0	16.9	69.7	52.8	CH
22-11	FHII 3	NLB-156	6.9	12.2	15.7	24.8	9.0	CL
22-11	FHII 3	NLB-162	10.1 - 10.4	12.8	16.4	23.3	6.8	CL-ML
22-11	FHII 3	NLB-169	14.6 - 15.1	13.1	14.3	33.9	19.7	CL
22-11	FHII 3	NLB-187	29.6 - 29.9	12.8	14.7	32.0	17.2	CL
22-12	FHII 4	NLB-194	4.3	10.9	14.5	28.5	14.1	CL
22-12	FHII 4	NLB-208	13.2	15.8	18.5	40.5	22.0	CL
22-12	FHII 4	NLB-227	100.0	15.4	15.6	44.3	28.7	CL
22-13	FHII 5	NLB-236	4.9	13.9	12.1	19.7	7.6	CL
22-13	FHII 5	NLB-242	9.6	18.6	17.7	40.0	22.3	CL
22-13	FHII 5	NLB-248	12.3	30.8	26.1	76.2	50.1	CH
22-13	FHII 5	NLB-257	20.7 - 21.2	11.0	15.0	32.9	17.9	CL
22-14	FHII 2	NLB-276	9.6	9.1	14.3	28.1	13.8	CL
22-14	FHII 2	NLB-295	26.2	12.8	11.6	28.1	16.4	CL
22-16	FHII 9	NLB-349	4.9	13.3	12.6	26.1	13.5	CL
22-18	FHII 7	NLB-414	7.8	11.7	11.9	25.9	13.9	CL
22-19	FHII 11	NLB-452	11.0	20.9	21.2	46.3	25.1	CL
22-21	FHII 8	NLB-495	3.7	18.9	15.2	30.8	15.6	CL
22-22	FHII 12	NLB-551	23.8	11.1	13.4	34.6	21.2	CL
22-23	FHII 14	NLB-571	13.9	12.1	13.4	29.0	15.6	CL
22-24	FHII 19	NLB-584	0.9 - 1.4	32.0	23.4	56.5	33.1	CH
22-24	FHII 19	NLB-607	19.5	13.9	13.2	29.8	16.7	CL
22-26	FHII 13	NLB-625	2.4 - 2.9	40.1	23.1	55.8	32.7	CH
22-26	FHII 13	NLB-633	8.5 - 8.7	21.4	21.0	52.3	31.2	CH
22-27	FHII 21	NLB-665	8.5 - 9.0	39.4	28.5	61.4	32.8	CH
22-27	FHII 21	NLB-691	29.9 - 30.3	15.4	12.3	22.1	9.8	CL
22-30	FHII 20	NLB-752	7.0 - 7.5	35.5	23.7	37.1	13.4	CL
22-30	FHII 20	NLB-766	17.7 - 18.1	39.8	26.6	66.7	40.1	CH
22-30	FHII 20	NLB-771	20.7 - 21.2	37.8	24.4	74.4	50.0	CH
22-32	FHII 24	NLB-827	24.4 - 24.8	11.9	11.8	24.0	12.1	CL
22-35	FHII 18	NLB-924	14.0	10.7	13.4	28.2	14.8	CL

Table 4-6 Wash Sieve Analysis Results

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	Moisture (%)	% Cobbles	% Gravel	% Sand	% Fines
21-04	BH 1	NLB-1010	9.0 - 9.5	13.4	0.0	3.1	79.4	17.5
21-04	BH 1	NLB-1012	12.0 - 12.4	13.2	0.0	3.7	82.3	14.0
21-06	BH 2	NLB-1167	75.0 - 75.4	21.7	0.0	0.6	82.7	16.7
21-06	BH 2	NLB-1169	81.0 - 81.5	8.2	0.0	12.8	81.0	6.3
22-01	SHII 1	NLB-004	2.3	13.4	0.0	0.3	95.8	3.9
22-01	SHII 1	NLB-018	10.8	20.8	0.0	0.0	86.0	14.0
22-02	FHII 1	NLB-024B	2.4 - 2.7	9.8	0.0	2.8	47.1	50.1
22-02	FHII 1	NLB-031	6.9 - 7.0	17.9	0.0	0.2	83.2	16.6
22-02	FHII 1	NLB-034	9.1	18.4	0.0	0.5	96.1	3.4
22-03	SHII 4	NLB-072	10.1 - 10.4	23.2	0.0	2.9	67.4	29.7
22-03	SHII 4	NLB-076	13.1	19.5	0.0	0.0	93.2	6.8
22-04	SHII 7	NLB-079	0.8	4.7	0.0	5.8	35.1	59.1
22-04	SHII 7	NLB-096	11.6 - 12	14.4	0.0	5.6	59.7	34.7
22-05	PHII 6	NLB-101	0.5	9.2	0.0	0.0	6.3	93.7
22-05	PHII 6	NLB-104	2.4	1.7	0.0	6.2	75.1	18.6
22-07	PHII 4	NLB-112	1.5	9.6	0.0	1.1	18.1	80.8
22-08	PHII 1	NLB-119	2.1	1.2	0.0	17.6	66.6	15.9
22-09	SHII 2	NLB-122	0.5	9.6	0.0	1.1	18.1	80.8
22-09	SHII 2	NLB-134	8.9	12.6	0.0	0.0	54.6	45.4
22-10	PHII 2	NLB-143	0.6	4.2	0.0	1.0	78.9	20.1
22-11	FHII 3	NLB-150	3.4	4.3	0.0	4.5	64.7	30.8
22-11	FHII 3	NLB-168	13.9	20.4	0.0	0.0	94.0	6.0
22-11	FHII 3	NLB-179	22.9	17.3	0.0	0.0	86.1	13.9
22-12	FHII 4	NLB-199	7.6	17.6	0.0	0.0	79.3	20.7
22-12	FHII 4	NLB-205	11.3 - 11.7	15.5	0.0	0.0	71.8	28.2
22-12	FHII 4	NLB-218	21.2	20.3	0.0	0.0	90.6	9.4
22-13	FHII 5	NLB-241	8.8	12.1	0.0	28.9	67.2	3.8
22-14	FHII 2	NLB-264	1.8	10.5	0.0	0.0	77.8	22.2
22-14	FHII 2	NLB-273	7.8	17.9	0.0	0.0	95.6	4.4
22-14	FHII 2	NLB-286	18.3	20.1	0.0	0.0	67.6	32.4
22-15	FHII 6	NLB-323	19.5	16.4	0.0	0.0	73.6	26.4
22-15	FHII 6	NLB-326	20.7 - 21.0	20.3	0.0	0.2	83.3	16.5
22-15	FHII 6	NLB-331	24.4	20.1	0.0	0.0	89.7	10.3
22-16	FHII 9	NLB-344	1.5	14.3	0.0	0.0	16.2	83.8
22-16	FHII 9	NLB-351	5.9	12.6	0.0	8.1	86.2	5.7
22-17	FHII 10	NLB-375	2.1	17.7	0.0	0.1	28.3	71.6
22-18	FHII 7	NLB-406	1.5	0.8	0.0	1.0	91.7	7.3
22-19	FHII 11	NLB-434	0.6	4.8	0.0	1.7	47.4	50.9

Wash Sieve Analysis Results Continued

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	Moisture (%)	% Cobbles	% Gravel	% Sand	% Fines
22-21	FHII 8	NLB-510	14.6 - 15.1	19.1	0.0	3.9	56.6	39.6
22-22	FHII 12	NLB-546	19.2 - 19.6	18.5	0.0	0.0	96.6	3.4
22-23	FHII 14	NLB-555	1.8	7.9	0.0	3.8	35.0	61.3
22-24	FHII 19	NLB-582	0.3	7.4	0.0	16.2	32.7	51.1
22-26	FHII 13	NLB-648	20.4	19.1	0.0	1.1	94.1	4.8
22-27	FHII 21	NLB-655	1.5	11.6	0.0	0.0	68.5	31.5
22-27	FHII 21	NLB-675	16.2	24.4	0.0	0.0	66.3	33.7
22-28	FHII 22	NLB-694	0.9 - 1.2	16.5	0.0	0.0	75.5	24.5
22-28	FHII 22	NLB-697	3.4	29.7	0.0	0.0	64.7	35.3
22-30	FHII 20	NLB-745	2.1	6.2	0.0	0.0	59.3	40.7
22-32	FHII 24	NLB-796	1.5	13.1	0.0	0.0	73.9	26.1
22-32	FHII 24	NLB-801	5.5- 5.9	32.3	0.0	0.0	21.4	78.6
22-33	FHII 23	NLB-830	0.9 - 1.3	5.8	0.0	0.0	74.3	25.7
22-33	FHII 23	NLB-836	4.9	26.1	0.0	0.0	91.2	8.8
22-33	FHII 23	NLB-846	13.1 - 13.6	20.4	0.0	0.0	75.5	24.5
22-34	FHII 16	NLB-873	0.9	16.0	0.0	3.7	13.6	82.7
22-35	FHII 18	NLB-906	0.8	10.7	0.0	0.0	40.3	59.7
22-37	FHII 17	NLB-941	0.5	15.1	0.0	0.0	32.5	67.5

Table 4-7 Hydrometer / Sieve Analysis Results

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	% Cobbles	% Gravel	% Sand	%Silt	%Clay
21-04	BH1	NLB-1003	3.0 - 3.5	0.0	1.6	44.9	34.0	19.5
21-04	BH1	NLB-1005	4.5 - 5.0	0.0	7.7	46.8	29.8	15.7
21-04	BH1	NLB-1006	4.5 - 6.0	0.0	10.1	45.6	28.3	16.0
21-04	BH1	NLB-1015	16.5 - 17.0	0.0	10.9	37.0	30.8	21.3
21-04	BH1	NLB-1025	25.5 - 25.7	0.0	0.8	31.3	37.3	30.6
21-04	BH1	NLB-1032	36.0 - 36.5	0.0	5.0	34.9	35.5	24.6
21-06	BH2	NLB-1096	0.0 - 1.5	0.0	11.8	37.2	34.4	16.6
21-06	BH2	NLB-1097	1.5 - 2.0	0.0	4.4	38.8	33.3	23.5
21-06	BH2	NLB-1099	3.0 - 3.5	0.0	4.6	41.1	32.8	21.5
21-06	BH2	NLB-1108	10.0	0.0	2.1	23.0	42.3	32.6
21-06	BH2	NLB-1115	15.0 - 15.5	0.0	5.0	31.6	39.3	24.1
21-06	BH2	NLB-1172	92.0	0.0	0.0	30.8	52.0	17.2
21-06	BH2	NLB-1175	100.0 - 100.5	0.0	0.0	15.6	51.0	33.4
22-03	SHII 4	NLB-066	6.7	0.0	1.0	27.1	66.3	5.6
22-04	SHII 7	NLB-090	8.2	0.0	6.0	36.2	34.3	23.5
22-11	FHII 3	NLB-157	7.0 - 7.5	0.0	0.0	60.6	17.2	22.2
22-11	FHII 3	NLB-162	10.1 - 10.4	0.0	0.0	70.5	11.1	18.4
22-11	FHII 3	NLB-189	32.6	0.0	1.0	31.0	35.6	32.4
22-12	FHII 4	NLB-193	3.0	0.0	3.8	42.0	37.0	17.2
22-12	FHII 4	NLB-196	5.8	0.0	7.7	40.2	29.2	22.9
22-12	FHII 4	NLB-202	9.8 - 10.2	0.0	0.0	63.5	12.5	24.0
22-12	FHII 4	NLB-228	32.0	0.0	5.1	32.8	37.7	24.4
22-13	FHII 5	NLB-239	7.0 - 7.5	0.0	9.0	47.0	30.2	13.8
22-14	FHII 2	NLB-278	10.7	0.0	7.2	32.9	36.2	23.7
22-15	FHII 6	NLB-327	21.0	0.0	0.0	48.0	22.1	29.9
22-18	FHII 7	NLB-413	7.0 - 7.5	0.0	6.0	40.0	32.0	22.0
22-19	FHII 11	NLB-438	2.1 - 2.4	0.0	0.0	17.0	66.0	17.0
22-21	FHII 8	NLB-499	6.1	0.0	4.0	42.0	42.8	11.2
22-22	FHII 12	NLB-523	1.5	0.0	0.0	4.3	69.8	25.9
22-22	FHII 12	NLB-536	11.6 - 12.0	0.0	0.0	23.8	44.0	32.2
22-24	FHII 19	NLB-584	0.9 - 1.4	0.0	0.0	7.0	48.2	44.8
22-24	FHII 19	NLB-609	20.7	0.0	5.0	35.0	34.3	25.7
22-25	PHII 8	NLB-618	3.0	0.0	0.0	49.0	39.6	11.4
22-26	FHII 13	NLB-627	4.0 - 4.4	0.0	0.0	2.0	42.2	55.8
22-26	FHII 13	NLB-632	7.9	0.0	2.0	18.0	40.5	39.5
22-27	FHII 21	NLB-666	9.3	0.0	0.0	1.0	56.8	42.2
22-27	FHII 21	NLB-679	66.0	0.0	0.0	6.0	74.0	20.0
22-27	FHII 21	NLB-691	29.9 - 30.3	0.0	1.0	43.0	34.1	21.9

Hydrometer / Sieve Analysis Results Continued

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	% Cobbles	% Gravel	% Sand	%Silt	%Clay
22-28	FHII 22	NLB-696	2.4 - 2.9	0.0	0.0	31.0	51.4	17.6
22-28	FHII 22	NLB-707	11.3	0.0	0.0	0.0	62.6	37.4
22-28	FHII 22	NLB-718	18.4	0.0	0.0	1.0	71.9	27.1
22-30	FHII 20	NLB-752	7.0 - 7.5	0.0	0.0	4.0	78.6	17.4
22-30	FHII 20	NLB-757	11.3	0.0	0.0	0.2	51.0	48.8
22-30	FHII 20	NLB-766	17.7 - 18.1	0.0	0.0	0.2	43.4	56.4
22-30	FHII 20	NLB-771	20.7 - 21.2	0.0	0.0	0.5	23.1	76.4
22-31	SHII 8	NLB-777	1.5	0.0	0.0	0.2	67.4	32.4
22-32	FHII 24	NLB-815	14.6 - 15.1	0.0	0.0	1.0	36.4	62.6
22-32	FHII 24	NLB-827	24.7 - 24.8	0.0	3.0	43.0	33.7	20.3
22-33	FHII 23	NLB-833	3.0	0.0	0.0	22.0	55.6	22.4
22-33	FHII 23	NLB-851	17.4	0.0	0.0	44.0	42.0	14.0
22-33	FHII 23	NLB-855	19.2 - 19.7	0.0	0.0	42.0	45.1	12.9
22-35	FHII 18	NLB-926	16.5	0.0	1.0	39.0	37.1	22.9

Table 4-8 Group Index / Classification Results

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	Moisture (%)	P200	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Group Index	Classification (STP 205-2)
22-01	SHII 1	NLB-009	4.7	13.9	57.1	13.6	31.9	18.3	7.6	CL
22-02	FHII 1	NLB-026	3.8 - 4.3	9.1	53.5	12.3	30.5	18.2	6.6	CL
22-02	FHII 1	NLB-041	14.0	12.3	56.9	12.6	26.8	14.2	5.8	CL
22-02	FHII 1	NLB-044	16.0 - 16.4	12.6	60.3	13.0	31.1	18.1	8.2	CL
22-03	SHII 4	NLB-062	3.0	14.5	56.4	13.0	29.5	16.5	7.1	CL
22-03	SHII 4	NLB-069	7.6	12.9	60.2	12.3	31.0	18.7	8.6	CL
22-03	SHII 4	NLB-073	10.7	14.5	37.6	13.4	27.8	14.4	1.3	SC
22-04	SHII 7	NLB-084	3.7	13.7	55.1	12.2	32.2	20.0	8.0	CL
22-04	SHII 7	NLB-092	9.8	23.0	84.3	18.1	46.1	28.0	16.5	CL
22-04	SHII 7	NLB-094	11.0	10.2	63.9	12.7	28.9	16.2	8.1	CL
22-04	SHII 7	NLB-097	12.8	15.1	69.5	14.1	32.3	18.2	10.0	CL
22-05	PHII 6	NLB-103	2.1	14.5	67.9	13.8	33.3	19.5	10.0	CL
22-05	PHII 6	NLB-105	3.7	8.9	64.0	12.3	26.6	14.3	7.2	CL
22-06	PHII 5	NLB-110	3.7	13.5	55.2	12.5	25.2	12.7	5.2	CL
22-07	PHII 4	NLB-114	2.1	21.7	70.2	17.7	36.1	18.4	10.2	CL
22-09	SHII 2	NLB-126	4.0 - 4.4	11.1	56.6	12.6	29.9	17.3	7.1	CL
22-09	SHII 2	NLB-142	13.7 - 14.2	11.7	60.4	13.3	30.9	17.6	8.2	CL
22-10	PHII 2	NLB-144	2.1	19.4	94.3	22.1	72.9	50.8	20.0	CH
22-11	FHII 3	NLB-149	2.4 - 2.8	14.5	55.0	14.0	23.2	9.2	4.0	CL
22-11	FHII 3	NLB-165	11.6 - 11.9	19.6	39.6	0.0	0.0	0.0	0.8	SM - d
22-13	FHII 5	NLB-252	15.5	12.8	63.2	13.0	33.6	20.6	10.1	CL
22-14	FHII 2	NLB-267	3.7 - 4.4	16.2	44.3	12.7	32.0	19.3	4.4	SC
22-14	FHII 2	NLB-295	26.2	12.8	57.7	11.6	28.1	16.5	7.3	CL
22-15	FHII 6	NLB-304	4.7	13.1	54.1	12.3	25.4	13.2	5.0	CL
22-15	FHII 6	NLB-335	29.3	12.1	61.5	14.7	28.9	14.2	6.8	CL
22-16	FHII 9	NLB-352	6.6	11.9	70.2	15.1	32.5	17.3	9.9	CL
22-16	FHII 9	NLB-360	13.0	12.0	64.3	14.1	31.3	17.2	8.7	CL
22-17	FHII 10	NLB-379	5.2 - 5.6	15.3	61.6	12.9	25.7	12.9	6.4	CL
22-17	FHII 10	NLB-396	18.9 - 19.4	12.8	61.7	14.3	28.8	14.5	6.8	CL
22-18	FHII 7	NLB-429	20.0	11.0	64.7	14.3	32.0	17.7	9.0	CL
22-19	FHII 11	NLB-448	8.2 - 8.7	14.1	59.1	13.6	26.1	12.5	6.0	CL
22-19	FHII 11	NLB-463	18.9 - 19.4	15.6	69.6	13.2	23.8	10.6	7.2	CL
22-20	SHII 6	NLB-471	1.5	28.7	98.9	27.6	74.6	47.0	20.0	CH
22-20	SHII 6	NLB-473	3.2	29.7	85.0	16.9	37.5	20.6	12.5	CL
22-20	SHII 6	NLB-476	5.5 - 5.9	11.2	56.4	12.5	25.5	13.0	5.4	CL
22-20	SHII 6	NLB-484	10.8	21.7	96.3	20.3	48.4	28.1	16.9	CL
22-20	SHII 6	NLB-487	13.4	22.2	95.9	20.8	44.6	23.8	14.6	CL

Group Index / Classification Results Continued

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	Moisture (%)	P200	Plastic Limit (%)	Liquid Limit (%)	Plasticity Index (%)	Group Index	Classification (STP 205-2)
22-21	FHII 8	NLB-507	12.8	12.4	63.5	14.5	30.9	16.4	8.1	CL
22-21	FHII 8	NLB-515	19.2 - 19.5	13.0	62.9	13.2	30.6	17.4	8.3	CL
22-22	FHII 12	NLB-526	4.0 - 4.4	15.1	96.3	24.8	52.9	28.1	17.9	CH
22-22	FHII 12	NLB-530	7.0 - 7.5	38.2	87.8	31.8	76.9	45.1	20.0	CH
22-23	FHII 14	NLB-562	7.0 - 7.5	12.5	64.0	14.3	32.6	18.3	8.8	CL
22-23	FHII 14	NLB-576	18.6	12.5	62.0	14.0	29.0	15.0	7.3	CL
22-24	FHII 19	NLB-590	5.5 - 5.9	24.4	69.7	16.4	36.1	19.7	10.8	CL
22-24	FHII 19	NLB-596	10.1 - 10.5	12.5	62.2	13.3	28.9	15.6	7.9	CL
22-25	PHII 8	NLB-615	0.8	9.0	56.7	19.8	33.2	13.4	5.4	CL
22-26	FHII 13	NLB-623	0.9 - 1.4	30.2	97.0	18.9	51.1	32.1	18.2	CH
22-26	FHII 13	NLB-635	10.1 - 10.5	17.1	67.5	14.4	29.9	15.6	8.9	CL
22-26	FHII 13	NLB-645	17.7 - 18.1	14.4	58.9	14.8	30.8	16.0	7.1	CL
22-26	FHII 13	NLB-651	22.3 - 22.7	14.4	62.9	14.8	35.9	21.1	9.9	CL
22-27	FHII 21	NLB-661	5.5 - 5.9	35.0	99.8	23.3	45.0	21.7	13.8	CL
22-27	FHII 21	NLB-669	11.6 - 12.0	34.0	99.3	25.6	58.5	32.9	19.6	CH
22-27	FHII 21	NLB-688A	26.8 - 27.1	32.5	95.6	13.0	39.2	26.2	14.5	CL
22-28	FHII 22	NLB-715	16.2 - 16.7	37.0	99.5	29.9	74.1	44.2	20.0	CH
22-28	FHII 22	NLB-723	22.3 - 22.8	12.0	51.0	12.9	23.2	10.3	3.2	CL
22-29	SHII 9	NLB-729	3.2	36.9	99.1	25.7	66.1	40.3	20.0	CH
22-29	SHII 9	NLB-733	6.2	20.4	99.4	22.4	48.4	26.0	16.1	CL
22-29	SHII 9	NLB-741	12.5	39.8	98.7	32.4	78.9	46.5	20.0	CH
22-30	FHII 20	NLB-759	12.5	27.1	97.2	19.0	42.9	23.9	14.2	CL
22-31	SHII 8	NLB-778	2.4 - 2.9	48.0	98.1	27.2	53.4	26.2	17.1	CH
22-31	SHII 8	NLB-781	4.0 - 4.4	36.4	98.2	19.9	55.3	35.4	19.0	CH
22-31	SHII 8	NLB-786	7.8	34.8	99.9	25.5	76.2	50.7	20.0	CH
22-32	FHII 24	NLB-808	9.4	38.1	99.9	28.8	67.4	38.6	20.0	CH
22-32	FHII 24	NLB-817	16.2 - 16.6	25.3	97.1	31.8	86.8	55.1	20.0	CH
22-33	FHII 23	NLB-863	24.4 - 24.8	38.1	99.8	23.5	53.8	30.3	18.8	CH
22-33	FHII 23	NLB-866	26.8 - 27.3	14.8	60.5	11.9	25.4	13.5	6.6	CL
22-34	FHII 16	NLB-883	6.1	14.3	60.2	13.1	28.0	15.0	7.1	CL
22-34	FHII 16	NLB-889	10.1 - 10.5	12.8	63.4	14.8	32.8	18.0	8.8	CL
22-34	FHII 16	NLB-900	17.7 - 18.1	14.4	58.8	14.0	28.7	14.7	6.7	CL
22-35	FHII 18	NLB-913	6.4	21.4	78.7	18.2	46.8	28.6	17.0	CL
22-36	PHII 7	NLB-937	0.8	31.8	96.9	24.3	39.1	14.9	10.1	CL
22-36	PHII 7	NLB-939	3.7	35.0	97.0	21.4	38.8	17.4	10.9	CL
22-37	FHII 17	NLB-948	5.5 - 5.9	26.1	80.1	18.9	41.8	22.9	13.6	CL
22-37	FHII 17	NLB-957	13.1 - 13.6	9.9	57.6	14.0	28.8	14.8	6.5	CL

Table 4-9 Unconfined Compressive Strength Results

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	Moisture (%)	Density, Wet (kg/m^3)	Density, Dry (kg/m^3)	Unconfined Compressive Strength (kPa)	Consistency
21-04	BH 1	NLB-1023	25.0	10.9	2123	1915	889	Hard
21-04	BH 1	NLB-1029	30.0 - 33.0	10.9	2141	1930	1216	Hard
21-04	BH 1	NLB-1034	37.0	11.0	2262	2037	1227	Hard
21-04	BH 1	NLB-1038	41.0	14.1	2117	1856	1354	Hard
21-04	BH 1	NLB-1041	44.0	13.6	2089	1839	1349	Hard
21-05	BH 1-SI	NLB-1095	47.6 - 47.9	16.6	2053	1760	481	Hard
22-11	FHII 3	NLB-171	16.2 - 16.3	16.5	2355	2022	1116	Hard
22-13	FHII 5	NLB-251	14.6 - 15.2	15.0	2227	1936	399	Hard
22-15	FHII 6	NLB-305	5.5 - 6.1	12.9	2291	2028	430	Hard
22-16	FHII 9	NLB-359	11.6 - 12.2	11.8	2279	2038	555	Hard
22-17	FHII 10	NLB-382	8.2 - 8.5	13.0	2313	2047	138	Stiff
22-19	FHII 11	NLB-446	6.7 - 7.1	12.6	2108	1871	212	Very Stiff
22-21	FHII 8	NLB-508	13.1 - 13.6	5.3	2199	2088	1701	Hard
22-22	FHII 12	NLB-528	5.5 - 6.0	38.5	1853	1338	114	Stiff
22-23	FHII 14	NLB-575	17.7 - 18.3	11.8	2349	2101	662	Hard
22-24	FHII 19	NLB-588	4.0 - 4.6	20.5	2152	1785	330	Very Stiff
22-26	FHII 13	NLB-639	13.1 - 13.7	10.7	2262	2044	567	Hard
22-28	FHII 22	NLB-721	20.7 - 21.3	10.7	2292	2071	429	Hard
22-30	FHII 20	NLB-768	19.5 - 20.1	35.0	1935	1434	136	Stiff
22-31	SHII 8	NLB-785	7.0 - 7.6	40.1	1914	1366	161	Stiff
22-32	FHII 24	NLB-807	8.5 - 9.1	35.5	1878	1388	127	Stiff
22-33	FHII 23	NLB-868	28.3 - 29.0	11.8	2275	2034	181	Stiff
22-34	FHII 16	NLB-882	5.5 - 5.8	9.2	2266	2075	1042	Hard
22-35	FHII 18	NLB-912	5.5 - 6.1	21.8	2133	1751	182	Stiff
22-35	FHII 18	NLB-922	13.1 - 13.7	12.8	2289	2030	617	Hard
22-37	FHII 17	NLB-946	4.0 - 4.6	21.4	1983	1634	192	Stiff
22-37	FHII 17	NLB-959	14.6 - 15.0	12.4	2322	2066	769	Hard

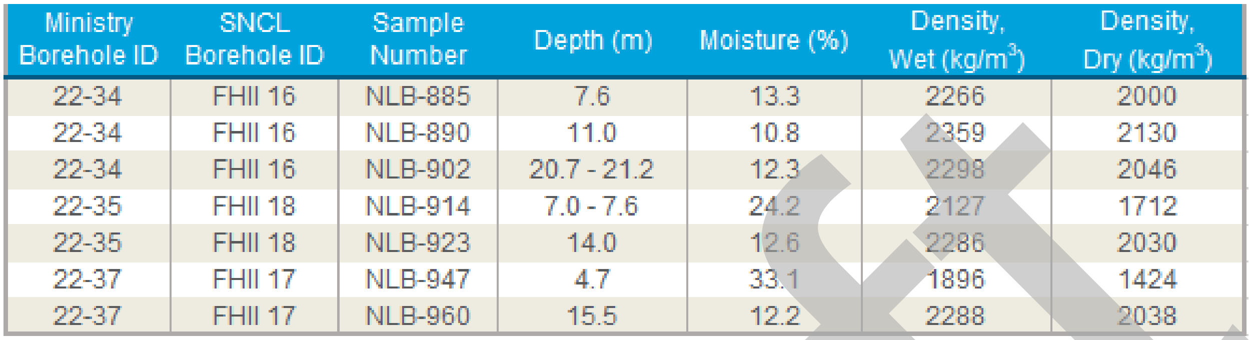
Table 4-10 Unit Weight Results

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	Moisture (%)	Density, Wet (kg/m^3)	Density, Dry (kg/m^3)
21-04	BH 1	NLB-1007	6.0 - 6.5	7.9	2356	2184
21-04	BH 1	NLB-1009	7.5 - 8.0	5.6	2061	1952
21-04	BH 1	NLB-1025	27.0 - 27.5	15.9	2201	1899
21-04	BH 1	NLB-1033	36.0 - 36.5	14.6	2234	1950
21-04	BH 1	NLB-1036	39.0 - 39.5	15.7	2217	1916
21-04	BH 1	NLB-1039	42.0 - 42.5	15.3	2214	1920
21-04	BH 1	NLB-1042	45.0 - 45.5	16.8	2188	1874
21-04	BH 1	NLB-1047	51.0 - 51.5	14.6	2228	1944
21-04	BH 1	NLB-1052	57.0 - 57.5	12.9	2284	2023
21-04	BH 1	NLB-1057	63.0 - 63.5	12.9	2276	2015
21-04	BH 1	NLB-1062	69.0 - 69.5	12.1	2291	2043
21-04	BH 1	NLB-1067	73.0	23.5	1963	1590
21-04	BH 1	NLB-1083	93.0 - 93.2	27.1	1942	1528
21-04	BH 1	NLB-1089	100.0 - 100.3	25.4	1865	1486
21-06	BH 2	NLB-1121	20.5	13.2	2240	1980
21-06	BH 2	NLB-1131	29.0	13.2	2232	1971
21-06	BH 2	NLB-1139	38.0	15.2	2232	1937
21-06	BH 2	NLB-1147	48.0 - 48.5	9.7	2376	2166
21-06	BH 2	NLB-1155	58.5	9.1	2328	2134
21-06	BH 2	NLB-1163	68.5	9.9	2298	2090
22-01	SHII 1	NLB-010	5.5 - 5.9	14.2	2293	2009
22-02	FHII 1	NLB-025	3.7	9.0	2425	2224
22-03	SHII 4	NLB-061	2.4 - 2.9	15.1	2192	1904
22-03	SHII 4	NLB-070	8.5 - 9.0	15.3	2247	1948
22-04	SHII 7	NLB-083	2.4 - 2.9	13.8	2282	2005
22-04	SHII 7	NLB-093	10.1 - 10.5	19.7	2197	1836
22-05	PHII 6	NLB-102	0.9	8.5	2187	2015
22-05	PHII 6	NLB-106	5.2	10.9	2282	2057
22-06	PHII 5	NLB-109	2.1	27.5	1844	1447
22-07	PHII 4	NLB-115	3.7	18.3	2175	1839
22-09	SHII 2	NLB-125	3.2	11.4	2223	1995
22-09	SHII 2	NLB-141	13.1	10.5	2284	2066
22-10	PHII 2	NLB-145	2.7	29.6	1911	1474
22-11	FHII 3	NLB-148	2.1	22.4	1994	1630
22-11	FHII 3	NLB-158	7.8	13.7	2154	1895
22-11	FHII 3	NLB-170	15.4	10.0	2213	2012
22-11	FHII 3	NLB-188	31.1	13.5	2226	1961
22-12	FHII 4	NLB-195	5.2 - 5.6	11.9	2387	2132
22-12	FHII 4	NLB-209	13.7	8.2	2384	2203

Unit Weight Results Continued

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	Moisture (%)	Density, Wet (kg/m^3)	Density, Dry (kg/m^3)
22-12	FHII 4	NLB-226	29.6 - 29.9	15.4	2327	2016
22-13	FHII 5	NLB-234	3.4	11.9	2277	2034
22-13	FHII 5	NLB-256	20.0	15.3	2226	1930
22-14	FHII 2	NLB-266	3.4	12.5	2174	1932
22-14	FHII 2	NLB-277	10.1 - 10.4	11.4	2304	2069
22-15	FHII 6	NLB-307	7.0 - 7.5	11.3	2373	2131
22-16	FHII 9	NLB-346	3.2	17.4	2139	1823
22-16	FHII 9	NLB-356	9.3	9.8	2311	2104
22-16	FHII 9	NLB-362	13.9	11.9	2293	2048
22-16	FHII 9	NLB-370	21.5	8.5	2331	2149
22-17	FHII 10	NLB-380	6.1	14.2	2253	1973
22-17	FHII 10	NLB-394	17.4 - 17.8	10.4	2323	2105
22-18	FHII 7	NLB-412	6.2	13.0	2281	2018
22-18	FHII 7	NLB-430	20.7 - 21.2	9.8	2369	2157
22-19	FHII 11	NLB-447	7.6	16.6	2198	1886
22-20	SHII 6	NLB-477	6.2	16.7	2192	1878
22-20	SHII 6	NLB-485	11.6 - 12	20.6	2138	1774
22-21	FHII 8	NLB-503	9.4	13.0	2261	2002
22-22	FHII 12	NLB-531	7.8	39.8	1902	1361
22-22	FHII 12	NLB-538	13.1 - 13.6	14.0	2333	2046
22-22	FHII 12	NLB-548	20.7- 21.1	11.8	2357	2109
22-23	FHII 14	NLB-564	8.5 - 9.0	12.0	2280	2036
22-24	FHII 19	NLB-591	6.7	15.8	2220	1917
22-24	FHII 19	NLB-606	19.2	17.9	2166	1837
22-26	FHII 13	NLB-628	4.9	36.1	1888	1387
22-26	FHII 13	NLB-631	7.0 - 7.4	32.3	1919	1451
22-26	FHII 13	NLB-636	11.0	15.9	2195	1893
22-26	FHII 13	NLB-644	17.4	13.7	2279	2005
22-27	FHII 21	NLB-662	6.2	36.2	1880	1381
22-28	FHII 22	NLB-701	6.4	28.3	1984	1546
22-28	FHII 22	NLB-716	16.9	36.4	1902	1394
22-28	FHII 22	NLB-724	23.0	11.7	2295	2055
22-29	SHII 9	NLB-739	11.3	37.4	1874	1364
22-30	FHII 20	NLB-767	19.2	42.7	1913	1340
22-30	FHII 20	NLB-772	21.3	36.5	1989	1457
22-31	SHII 8	NLB-789	10.1 -10.5	40.4	1974	1406
22-32	FHII 24	NLB-818	16.9	32.3	1918	1449
22-32	FHII 24	NLB-825	22.6	13.0	2342	2073
22-33	FHII 23	NLB-854	18.9	23.7	2095	1694

Unit Weight Results Continued



Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	Moisture (%)	Density, Wet (kg/m^3)	Density, Dry (kg/m^3)
22-34	FHII 16	NLB-885	7.6	13.3	2266	2000
22-34	FHII 16	NLB-890	11.0	10.8	2359	2130
22-34	FHII 16	NLB-902	20.7 - 21.2	12.3	2298	2046
22-35	FHII 18	NLB-914	7.0 - 7.6	24.2	2127	1712
22-35	FHII 18	NLB-923	14.0	12.6	2286	2030
22-37	FHII 17	NLB-947	4.7	33.1	1896	1424
22-37	FHII 17	NLB-960	15.5	12.2	2288	2038

Table 4-11 Carbonate Content Results

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	% Calcite	% Dolomite	Calcite: Dolomite	CO_2 (ml) from Calcite	CO_2 (ml) from Dolomite	Total CO_2 (ml/g)
21-04	BH 1	NLB-1016	17.5 - 18.0	8.9	8.2	1.1	20.0	20.0	40.1
21-04	BH 1	NLB-1018	19.5 - 19.7	8.0	0.6	14.1	18.8	1.4	20.2
21-04	BH 1	NLB-1019	21.0 - 21.2	7.3	4.0	1.8	16.7	10.0	26.7
21-04	BH 1	NLB-1020	22.5 - 22.8	5.9	5.4	1.1	13.4	13.3	26.7
21-06	BH 2	NLB-1103	6.0 - 6.5	9.0	9.0	1.0	20.9	22.5	43.4
21-06	BH 2	NLB-1105	7.5 - 8.0	8.3	6.6	1.3	19.2	16.7	35.9
21-06	BH 2	NLB-1108	10.0	6.8	3.6	1.9	15.9	9.2	25.0
21-06	BH 2	NLB-1111	12.0 - 12.5	8.7	5.3	1.6	20.0	13.3	33.4
21-06	BH 2	NLB-1113	13.5 - 14.0	9.2	5.1	1.8	20.9	12.5	33.4
22-02	FHII 1	NLB-028	5.2	6.5	6.7	1.0	15.0	16.7	31.7
22-02	FHII 1	NLB-037	11.3	7.3	5.3	1.4	16.7	13.3	30.0
22-02	FHII 1	NLB-045	16.5	0.0	8.5	0.0	0.0	21.2	21.2
22-02	FHII 1	NLB-053	22.1 - 22.6	3.8	9.2	0.4	8.6	22.4	31.0
22-11	FHII 3	NLB-154	5.2	5.3	10.2	0.5	12.2	25.1	37.3
22-11	FHII 3	NLB-164	11.0	4.5	2.7	1.6	10.0	6.7	16.7
22-12	FHII 4	NLB-192	2.1 - 2.5	0.0	6.7	0.0	0.0	17.2	17.2
22-13	FHII 5	NLB-235	4.0 - 4.4	4.5	8.3	0.5	10.3	20.7	31.0
22-14	FHII 2	NLB-269	5.2	2.9	5.1	0.6	6.9	12.9	19.8
22-14	FHII 2	NLB-279	11.6 - 12.0	4.4	3.7	1.2	10.0	9.2	19.2
22-14	FHII 2	NLB-295	26.2	5.6	5.2	1.1	13.0	13.0	26.0
22-15	FHII 6	NLB-336	29.9 - 30.3	1.5	11.1	0.1	3.4	27.2	30.6
22-16	FHII 9	NLB-348	4.0 - 4.3	3.2	10.6	0.3	7.5	26.7	34.2
22-16	FHII 9	NLB-358	10.8	6.5	10.6	0.6	15.0	26.7	41.7
22-16	FHII 9	NLB-361	13.1 - 13.6	3.7	11.5	0.3	8.3	28.4	36.7
22-17	FHII 10	NLB-381	7.6	1.9	8.1	0.2	4.3	19.8	24.1
22-17	FHII 10	NLB-395	18.3	3.6	9.3	0.4	8.3	23.4	31.7
22-18	FHII 7	NLB-414	7.8	2.2	7.9	0.3	4.9	19.5	24.3
22-18	FHII 7	NLB-428	18.4	4.2	8.0	0.5	9.7	20.3	30.0
22-19	FHII 11	NLB-445	6.1	3.7	6.5	0.6	8.6	16.4	25.0
22-19	FHII 11	NLB-464	19.5	4.7	7.3	0.7	10.8	18.1	28.9
22-21	FHII 8	NLB-493	2.1	3.8	4.1	0.9	8.7	10.1	18.8
22-21	FHII 8	NLB-506	11.6 - 11.9	4.1	6.7	0.6	9.4	16.6	26.0
22-21	FHII 8	NLB-516	20.1	1.5	12.5	0.1	3.4	31.0	34.5
22-22	FHII 12	NLB-524	2.4 - 2.9	5.1	4.7	1.1	11.7	11.7	23.4
22-22	FHII 12	NLB-529	6.2	1.9	4.2	0.5	4.2	10.2	14.4
22-22	FHII 12	NLB-537	12.3	1.5	10.2	0.1	3.4	25.8	29.3

Carbonate Content Results Continued

Ministry Borehole ID	SNCL Borehole ID	Sample Number	Depth (m)	% Calcite	% Dolomite	Calcite: Dolomite	CO_2 (ml) from Calcite	CO_2 (ml) from Dolomite	Total CO_2 (ml/g)
22-22	FHII 12	NLB-552	24.4 - 24.7	5.0	4.6	1.1	11.4	11.4	22.7
22-23	FHII 14	NLB-563	7.8	5.1	9.7	0.5	11.7	24.2	35.9
22-23	FHII 14	NLB-574	16.9	5.2	11.2	0.5	11.7	27.5	39.2
22-24	FHII 19	NLB-589	5.2	4.0	6.4	0.6	9.2	15.8	25.0
22-24	FHII 19	NLB-597	11.0	3.3	6.5	0.5	7.5	15.8	23.4
22-24	FHII 19	NLB-605	17.7	1.5	11.5	0.1	3.4	28.4	31.9
22-24	FHII 19	NLB-611	21.9	4.5	10.7	0.4	10.3	26.7	37.1
22-26	FHII 13	NLB-631	7.0 - 7.4	0.0	3.5	0.0	0.0	8.6	8.6
22-26	FHII 13	NLB-644	17.4	3.7	10.7	0.4	8.6	26.7	35.3
22-26	FHII 13	NLB-650	21.6	4.3	7.6	0.6	10.0	19.2	29.2
22-27	FHII 21	NLB-660	4.7	0.0	4.4	0.0	0.0	11.2	11.2
22-27	FHII 21	NLB-688A	26.8 - 27.1	1.5	5.6	0.3	3.4	13.8	17.2
22-27	FHII 21	NLB-690	29.3	3.8	5.8	0.7	8.7	14.4	23.1
22-28	FHII 22	NLB-699	5.2	4.3	5.6	0.8	9.7	13.8	23.5
22-28	FHII 22	NLB-703	8.2	3.0	2.1	1.4	6.7	5.0	11.7
22-28	FHII 22	NLB-714	15.9	2.8	3.2	0.9	6.5	7.9	14.5
22-28	FHII 22	NLB-722	21.5	4.7	7.7	0.6	10.9	19.2	30.0
22-30	FHII 20	NLB-749	5.2	2.9	2.7	1.1	6.7	6.7	13.4
22-30	FHII 20	NLB-765	17.1	0.0	4.8	0.0	0.0	12.1	12.1
22-30	FHII 20	NLB-773	21.9	3.2	7.8	0.4	7.3	19.5	26.8
22-32	FHII 24	NLB-818	16.9	4.7	5.6	0.8	10.9	14.2	25.0
22-32	FHII 24	NLB-825	22.6	1.5	9.6	0.2	3.4	24.1	27.6
22-33	FHII 23	NLB-854	18.9	3.2	3.3	1.0	7.5	8.3	15.9
22-33	FHII 23	NLB-862	23.8	5.1	5.7	0.9	11.7	14.2	25.9
22-33	FHII 23	NLB-869	29.3	5.3	4.9	1.1	12.2	12.2	24.3
22-34	FHII 16	NLB-884	7.0 - 7.5	4.6	8.4	0.5	10.3	20.7	31.0
22-34	FHII 16	NLB-890	11.0	4.9	9.7	0.5	11.4	24.3	35.7
22-34	FHII 16	NLB-901	19.8	3.3	12.9	0.3	7.8	32.7	40.5
22-35	FHII 18	NLB-915	7.8	4.2	4.2	1.0	9.7	10.5	20.3
22-35	FHII 18	NLB-925	15.5	5.5	8.9	0.6	13.0	22.7	35.7
22-37	FHII 17	NLB-949	6.2	4.2	7.7	0.5	9.7	19.5	29.2
22-37	FHII 17	NLB-958	14.0	4.6	9.9	0.5	10.3	24.1	34.5

5 Subsurface Conditions

5.1 River Crossing Area

The elevation on the west side of the river was approximately 17 m higher than the elevation on the east side of the river. The boreholes had similar stratigraphy at coinciding elevations. The soil stratigraphy across the River Crossing Area (boreholes 21-04 and 21-06 shown in **Figure 3–1**) generally consisted of glacial till (oxidized and unoxidized) with intermittent sand deposits near the surface. Underlying the unoxidized till were interchanging silt and clay layers with a few sand deposits. The deepest borehole on each side of the river was approximately 100.3 mbgs and 100.5 mbgs for the east and west side of the river, respectively.

The oxidized till, generally stiff to hard (with depth), consisted of mainly sand and silt and extended approximately 4.5 mbgs (east side, borehole 21-06) and 17.7 mbgs (west side, borehole 21-04). Several interbedded sand deposits were present within the oxidized till with a maximum thickness of 0.5 m and 8.5 m for the east and west sides, respectively. The oxidized till was underlain by hard unoxidized till with a maximum thickness of 48.3 m to 70.0 m for the east and west sides, respectively. On the east side of the river underlying the unoxidized till was interchanging hard silt and very dense sand layers with thicknesses ranging from 0.5 m to 5.5 m and 5.5 to 7.0 m, respectively. A small clay layer (0.2 m) on the east side of the river was present at a depth of approximately 92.8 mbgs. On the west side of the river underlying the unoxidized till was interchanging hard silt and hard clay layers with thickness ranging from 0.3 m to 6.0 m and 0.2 m to 4.3 m, respectively. Between the silt and clay layers were several very dense sand deposits with thicknesses ranging from 0.4 m to 7.6 m.

The porewater pressure data collected from the installed VW piezometers head values varied across the site on the west side of the river. The head in the unoxidized till unit ranged from 33.8 m to 44.5 m. One piezometer installed in the sand at 21-04 has failed and is no longer providing accurate data. The cause of the failure is uncertain. The piezometer was reading correctly immediately following installation and providing reasonable data. However, the data has since become erratic, and the logger was providing unreasonable results. SNC-Lavalin attempted to connect the piezometer to a different logger, but the readings remained erratic. Rather than reinstall a piezometer at borehole 21-04, SNC-Lavalin recommends installing dataloggers to the M442 piezometer (MDH, 2004) installed in the same unit to collect ongoing data.

The porewater pressure data collected from the remaining operational installed VW piezometers varied across the site on the east side of the river. The head values in the unoxidized till ranged from 5.5 m to 81.0 m.

5.2 Central Avenue Interchange

The soil stratigraphy across the Central Avenue Interchange (boreholes 22-01, 22-02, 22-08, 22-09, and 22-10 shown in **Figure 3–2**) generally consisted of a veneer of topsoil, followed by varying thicknesses of glacial till (oxidized and unoxidized), a small silt layer near the surface and intermittent sand deposits. The largest sand deposit was approximately 7.3 m thick. The deepest borehole in the area extended to 24.8 mbgs.

The oxidized till generally was very stiff to hard (with depth) and extended approximately 10.8 to 12.6 mbgs. The oxidized till was underlain by hard unoxidized till. Several interbedded sand deposits were present at this interchange location within the oxidized and unoxidized till unit. The sand deposits ranged from compact to very dense and were moist to wet. The thickness of the sand deposits ranged from 0.3 m to 7.3 m.

The general alignment boreholes, including the Stratigraphic and Preliminary boreholes (SHII and PHII series), were completed northwest and east of the interchange location along the proposed freeway alignment. A 1.0 m thick sand layer near the surface, followed by oxidized till, was observed in Borehole 22-10 east of the interchange. Northwest of the interchange (Boreholes 22-01 and 22-08) consisted of predominately compact wet sand.

The porewater pressure data collected from the installed VW piezometers indicated varying head values across the site. The head in the unoxidized till unit was approximately 7.0 m. The head observed within some of the sand deposit units ranged from 1.7 to 12.9 m.

5.3 Blackley Road Interchange

The soil stratigraphy across the Blackley Road Interchange (boreholes 22-03, 22-11, 22-12 and 22-14 shown in **Figure 3–3**) generally consisted of a veneer of topsoil, followed by varying thicknesses of glacial till (oxidized and unoxidized) and intermittent sand deposits. The largest sand deposit was of 15.4 m thick. The deepest borehole in the area extended to 32.8 mbgs.

The oxidized till was generally stiff to hard (with depth) and extended to approximately 10.4 to 16.3 mbgs. Oxidized till in borehole 22-14 extended to 22.8 mbgs. Several interbedded sand deposits were present at this interchange location within the oxidized till unit. The oxidized till unit was underlain by a compact to very dense, moist sand deposit which varied in thickness from approximately 12.9 m to 15.4 m. The sand deposit was underlain by a hard unoxidized till.

The general alignment borehole (22-03) was a stratigraphic borehole located south of the interchange location along the proposed freeway alignment. The borehole consisted of oxidized till with intermittent sand lenses. The borehole completed in a very dense sand layer.

The porewater pressure data collected from the installed VW piezometers indicated varying head values across the site. The head in the oxidized till unit ranged from 1.4 to 10.0 m. The head observed within the sand deposits ranged from 5.4 to 21.9 m.

5.4 Highway 41 Realignment

The soil stratigraphy across the Highway 41 Realignment (borehole 22-13 shown in **Figure 3–4**) generally consisted of a veneer of topsoil, followed by varying thicknesses of glacial till (oxidized and unoxidized), a singular silt and clay layer and two sand deposits. The largest sand deposit had a thickness of 1.1 m. There was only one borehole completed in the area with a completion depth of 24.7 mbgs.

A very soft silt layer was encountered near the surface and was approximately 1.5 m thick. The very stiff oxidized till mainly consisted of sand and silt and extended to approximately 23.8 m. Several interbedded sand deposits were encountered in the oxidized till unit. The sand deposits ranged from loose to compact and were moist to wet. A very stiff, oxidized clay layer was encountered from approximately 11.1 to 13.1 mbgs. The oxidized till unit was underlain by hard unoxidized till.

The porewater pressure data collected from the installed VW piezometers indicated varying head values with the nearby Highway 41 flyover area instruments. The head observed in the upper sand deposit was approximately 9.6 m.

5.5 Highway 41 Flyover

The soil stratigraphy across the Highway 41 Flyover (borehole 22-15 shown in **Figure 3–5**) generally consisted of varying thicknesses of glacial till (oxidized) and intermittent sand deposits. The largest sand deposit was approximately 7.6 m thick. There was only one borehole drilled in the area with a completion depth of 36.0 mbgs.

The oxidized till unit, encountered at the surface, was generally very stiff to hard (with depth) and extended to the completion of the borehole. Several interbedded sand deposits were present in the oxidized till unit. The sand deposits ranged from loose to very dense and were moist.

The porewater pressure data collected from the installed VW piezometers indicated varying head values with the nearby Highway 41 realignment area. The head observed in the oxidized till unit was approximately 22.0 m. The head observed in the largest sand deposit was approximately 15.2 m. The instrument installed in the upper oxidized till at 6.1 mbgs was dry.

5.6 Highway 5 Interchange

The soil stratigraphy across the Highway 5 Interchange (boreholes 22-07, 22-16, 22-17, 22-18, and 22-21 shown in **Figure 3–6**) generally consisted of a veneer of topsoil, a sand deposit and/or silt layer near the surface, followed by varying thicknesses of glacial till (oxidized and unoxidized). The largest sand deposit was approximately 2.0 m thick. The deepest borehole in the area extended to 24.8 mbgs.

The topsoil was generally underlain by a soft silt layer varying in thickness between 1.5 m and 2.2 m. The oxidized till was soft to hard (with depth) and extended to approximately 8.5 to 14.6 mbgs. Several interbedded sand deposits were present at this interchange location within the upper portion of the oxidized till unit. With the exception of borehole 22-21, there were no sand deposits below 6.1 mbgs. The sand deposit in borehole 22-21 was less than 1.0 m thick and was encountered at an approximate depth of 14.6 mbgs. The oxidized till was underlain by hard unoxidized till.

The general alignment borehole (22-07) was a Preliminary borehole located south of the interchange location along the proposed freeway alignment. Underlying the veneer of topsoil, the borehole consisted of oxidized till completion.

The porewater pressure data collected from the installed VW piezometers indicated varying head values across the site. The head in the oxidized till unit ranged from 1.9 to 8.5 m. The head in the unoxidized till unit ranged from 15.8 to 20.8 m. The head observed within some of the sand deposits was approximately 11.6 m.

5.7 8th Street Interchange

The soil stratigraphy across the 8th Street Interchange (boreholes 22-06, 22-19, and 22-20 shown in **Figure 3–7**) generally consisted of a veneer of topsoil, a sand deposit and a silt layer near the surface, a clay layer varying in depth, followed by a varying thickness of glacial till (oxidized and unoxidized). The sand deposit and silt layers were less than 1.0 m thick. The clay layer thickness varied and was as large as 2.6 m. The deepest borehole in the area extended to 24.5 mbgs.

The sand deposit and silt layer were encountered within the top 5.0 mbgs and were loose and soft, respectively. The oxidized till was generally stiff to very stiff (with depth) and extended to approximately 10.8 to 12.2 mbgs. A clay layer was encountered from near the surface to as deep as 10.8 mbgs. It was highly plastic and firm to hard (with depth). The oxidized till was underlain by stiff to very stiff (with depth) unoxidized till.

The general alignment borehole (22-06) was a Preliminary borehole located south of the interchange location along the proposed freeway alignment. Underlying the veneer of topsoil, the borehole consisted of oxidized till extending to completion of the borehole.

The porewater pressure data collected from the installed VW piezometers indicated varying head values across the site. The head in the oxidized till unit ranged from 8.5 to 9.1 m. The head in the unoxidized till unit was approximately 19.0 m.

5.8 Highway 16 Interchange

The soil stratigraphy across the Highway 16 Interchange (boreholes 22-04, 22-05, 22-22, 22-23, 22-24, 22-26, 22-34, 22-35, and 22-37 shown in **Figure 3–8**) generally consisted of a veneer of topsoil, a small silt layer near the surface, followed by varying thicknesses of glacial till (oxidized and unoxidized). The silt layer thickness was less than 1.0 m. In the northwestern portion of the interchange, near boreholes 22-22 and 22-26, soft clay and till material was encountered with intermittent sand deposits near the surface and within the unoxidized till. The deepest borehole in the area extended to 25.2 mbgs.

The silt layer below the topsoil was generally very soft to firm with a thickness ranging from 0.3 m to 0.6 m. The oxidized till was generally stiff to very stiff (with depth) and extended to approximately 8.5 to 13.1 mbgs. The oxidized till was underlain by stiff to hard (with depth) unoxidized till.

In the northwestern portion of the interchange near boreholes 22-22 and 22-26, the oxidized till was generally soft to firm and extended to approximately 2.4 to 3.2 mbgs. The oxidized till was underlain by soft to firm (with depth) and highly plastic clay that extended to approximately 5.8 to 11.6 mbgs. The clay was underlain by stiff to hard (with depth) unoxidized till.

The general alignment boreholes, including the Stratigraphic and Preliminary boreholes (SHII and PHII series), were completed north of the interchange location along the proposed freeway alignment. A 0.3 m thick silt layer near the surface followed by oxidized till was observed in both boreholes 22-04 and 22-05. A loose, thin sand deposit was interbedded in the oxidized till at approximately 2.4 mbgs in borehole 22-05. Whereas, a very stiff clay layer was interbedded in the oxidized till at approximately 9.1 mbgs in borehole 22-04.

The porewater pressure data collected from the installed VW piezometers head values varied across the site. The head in the oxidized till unit ranged from 2.9 to 22.6 m. The head in the sand unit was approximately 16.7 m. The head in the unoxidized till was varying and ranged from 16.7 to 23.7 m. The head in the oxidized and unoxidized clay was relatively similar with the values being 1.7 and 3.3 m, respectively. The head in the unoxidized silt unit was approximately 7.9 m.

5.9 Zimmerman Road Interchange

The soil stratigraphy across the Zimmerman Road Interchange (boreholes 22-25, 22-30, 22-31 and 22-36 shown in **Figure 3–9**) generally consisted of a veneer of topsoil, a small sand deposit near the surface, followed by interchanging clay and silt layers, and interbedded glacial till layers (oxidized and unoxidized). The deepest borehole in the area extended to 24.8 mbgs.

The sand deposit below topsoil was generally compact with a thickness of 0.4 m to 2.1 m. The silt and clay layers were generally soft and firm, respectively. The largest silt and clay layers were 5.5 m and 8.6 m in thickness, respectively. The clay was generally unoxidized and medium to highly plastic. A soft oxidized till was observed in borehole 22-31 at a depth of 3.1 mbgs with a thickness of 0.5 m. The clay is underlain by stiff unoxidized till.

The general alignment boreholes (22-25 and 22-36) were Preliminary boreholes located southwest and northeast of the interchange location along the proposed freeway alignment, respectively. Borehole 22-25 consisted of compact sand to completion. Borehole 22-36 consisted of a soft silt near the surface with a thickness of 0.9 m. Underlying the silt was a soft clay layer which extended to the borehole completion depth.

The porewater pressure data collected from the installed VW piezometers indicated varying head values across the site. The head in the unoxidized silt unit was approximately 6.6 m. The head in the unoxidized till unit was approximately 20.0 m.

5.10 Floral Road Interchange

The soil stratigraphy across the Floral Road Interchange (boreholes 22-27, 22-28, and 22-29 shown in **Figure 3–10**) generally consisted of a veneer of topsoil, followed by interchanging silt and clay layers with interbedded sand deposits, and glacial till (unoxidized). The deepest borehole in the area extended to 30.3 mbgs.

The sand deposits were generally compact and near the surface of the borehole with a thickness of 1.8 m. In the unoxidized silt near the northern portion of the interchange (22-27), some interbedded compact sand deposits were encountered with a thickness ranging from 0.2 m to 6.0 m. The largest silt and clay layer was

10.7 m and 4.4 m, respectively. Underlying the silt and clay layers was very stiff unoxidized till. No oxidized till was encountered on site.

The general alignment borehole (22-29) was a Stratigraphic borehole located east of the interchange location along the proposed freeway alignment. Underlying the veneer of topsoil, the borehole consisted of interchanging silt and clay layers. A soft silt layer was encountered at a depth of 8.5 mbgs with a thickness of 1.8 m. The clay was firm to very stiff (with depth) with a maximum thickness of 4.4 m.

The porewater pressure data collected from the installed VW piezometers indicated fairly consistent head values across the site. The head in the oxidized silt unit was approximately 8.3 m. The head in the unoxidized till unit was approximately 21.9 m. The head observed within some of the sand deposits ranged from 12.8 to 23.0 m.

5.11 Highway 11 Interchange

The soil stratigraphy across the Highway 11 Interchange (boreholes 22-32 and 22-33 shown in **Figure 3–11**) generally consisted of a veneer of topsoil across the site followed by variable soil conditions. In the northern hole (22-33), the borehole consisted of sand with intermittent silt layers. Underlying the sand and silt layers was a small clay layer followed by glacial till (unoxidized). At the southern hole (22-32), the borehole consisted of interchanging silt and clay layers with sand and glacial till (oxidized) near the surface. Underlying the silt and clay layers was glacial till (unoxidized). The deepest borehole in the area extended to 29.9 mbgs.

The sand deposits in the northern section of the site were generally loose to compact (with depth) and had a thickness ranging from 2.0 m to 14.0 m. The silt layers at this location were soft to stiff (with depth) with a maximum thickness of 4.0 m. Following the silt and sand deposits was a small, stiff clay layer with a thickness ranging from 1.2 m to 1.5 m. The clay was underlain by very stiff unoxidized till.

At the southern section of the site the only sand deposit was located near the surface with a thickness of approximately 1.5 m. The silt layers at this location were soft to stiff (with depth) with a thickness ranging from 0.3 m to 1.5 m. The clay layers at this location were generally firm with a thickness ranging from 0.5 m to 3.2 m. A stiff unoxidized till was observed at a depth of approximately 15.9 mbgs with a thickness ranging from 0.5 m to 2.4 m. The unoxidized till had a stiff silt layer and a firm clay layer with thicknesses of 1.2 m and 3.2 m, respectively.

The porewater pressure data collected from the installed VW piezometers indicated varying head values across the site. The head in the oxidized silt unit was approximately 4.3 m. The head in the unoxidized till ranged from 21.8 to 25.5 m. The head observed within some of the sand deposits was approximately 6.2 m.

6 References

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Saskatchewan Energy and Mines and Saskatchewan Research Council (SEM & SRC), 1997. Surficial Geology Map of Saskatchewan. SNC Lavalin, AECOM, and Praxis Consulting, 2020. Saskatoon Freeway Functional Planning Study – Phase I, A report prepared for the Saskatchewan Ministry of Highways, Report # 659183.

Saskatchewan Ministry of Highways (MoH), 2018. Foundation Investigation Manual.

SNC Lavalin, 2021. Saskatoon Freeway Functional Planning Study – Phase I (Northern Segment) Factual Geotechnical Data Report, A report prepared for the Saskatchewan Ministry of Highways, Report # 659183.

Appendix I

Bathymetric Survey Results

AQUATICS

Aquatics Environmental Services Inc.
609 Club Road, St. Andrews, MB R1A 3P6
Telephone: 204.289.2400
Email: info@aquatics-esi.com

August 10th, 2021

SNC-Lavalin
216 1st Avenue South
Saskatoon, Saskatchewan
S7K 1K3

Attn: Brittany Kaszas, P. Eng Geological Engineer

Re: Saskatoon Freeway Bridge Bathymetric Survey

Dear Brittany,

Please find attached the results of the Saskatoon Freeway Bridge's bathymetric survey as per your project *659183 SFFPS*.

We had completed a bathymetric survey as part of this project. This report includes models of the project area showing the water depth from the water surface, the river bottom elevation, and includes the cleaned and processed data of the survey exercise.

Please feel free to contact us should you have any questions

Regards,

Darwin Monita

Darwin Monita
Director

Contents

Background

Aquatics Environmental Services Inc. (Aquatics) was engaged by SNC – Lavalin to conduct a bathymetric survey for the Saskatoon Freeway Bridge project. The survey was intended for the identification of the bottom morphology of the river, to delineate a potential passage location for the passage of a drilling barge through the area to access bore holes. The area is associated with shallow waters with an abundance of sand bars. This year has been especially dry and there was concern that there would not be sufficient clearance for the barge to transit the river where perspective bore holes are located.

The survey started on the 29th of July and was completed on the 1st of August 2021.

Location

The area surveyed is a part of the South Saskatchewan River bounded between coordinates; 106.605296 W 52.209124 N to the north and 106.606776 W 52.205939 N to the south. The area extends to about 390m in length and about 160m in width. The boat launch site was approximately 550m south of the project site as indicated in the figure below.

Figure 1: Project location with boat launching spot.

Survey Planning

The survey planning involved configuring the hydrographic survey software to cover the entire survey area. The distance of 5m as required for detailed coverage of river bottom was kept in between lines and these formed the paths for the sounding exercise.

Figure 2: Survey line drawn to cover the entire survey area.

Horizontal and Vertical Control

Aquatics was provided the location of the control pins:

Control Point	Easting	Northing	Elevation	Description
SNC-03	5783866.404	391032.041	494.658	CP on Hill North of RR 3051 Intersection
SNC-04	5783863.024	391033.833	494.403	CP on Hill North of RR 3051 Intersection
SNC-05	5784714.577	390726.969	494.204	Broken Pipe
SNC-06	5784714.134	390726.875	494.062	Legal Survey Pin

For this project we used SNC-06 nearest to the location of the survey upon which we established a Trimble RTK base station upon using the coordinates provided above. We transmitted an RTK correction signal from this base station to the mobile 'rover' on the survey vessel to correct the position data in real time.

Prior to the survey, check shots were conducted on Control Points SNC-03 and SNC-04. We found that the vertical elevation differed by 1.2 cm for SNC-03 and 3 mm for SNC-04 as per the table below. Therefore, we were confident in the control point results and proceeded with the survey.

Control Point	SNC Elevation	Aquatics Elevation	Difference
SNC- 03	494.658	494.670	0.012 m
SNC- 04	494.403	494.400	0.003 m

The project used the NAD_83_UTM_ZONE_13N projected coordinate system.

Single Beam Data Acquisition

The bathymetric data collection involved use of a single beam sonar system mounted on a boat to acquire bathymetric data as the boat traveled along the planned survey lines. The bathymetric system employed hydrographic survey software configured to integrate position and sonar data together. The GPS system on board and a radio configured to receive corrections from the base station located on SNC-06. The sonar system employed a 3.5 degree pencil beam transducer along with an onboard data processor.

A very shallow draft vessel with a surface drive motor was used in order to access the survey area. Due to a recent rain, we had abandoned the proposed survey area launch spot and had attempted to access the site by transitting upstream from the Warman Ferry crossing location. However, a sand bar running the extent of the river (bank to bank) had prevented us from travelling upstream. After the original access location had dried after the rain, we were able to launch the boat and gain access to the site to conduct the survey.

We attempted to follow the planned survey lines a much as possible. Primarily shallow waters (<20cm) along the banks had prevented coverage of the area. The substrate in the river is composed primarily of sand and rocks. We supplimented some land survey shots within very shallow waters when the boat would not float.

Water levels were surveyed. The figure on the following page shows the single beam coverage over the survey area.

Figure 3: Single Beam Survey Coverage

After completion of the survey, all the lines were then cleaned and processed. We then modeled the area at a bin spacing of 0.5 X 0.5 m. This modelled data was used to produce the charts on the following pages and is also presented in the attachments that accompany this report.

Results

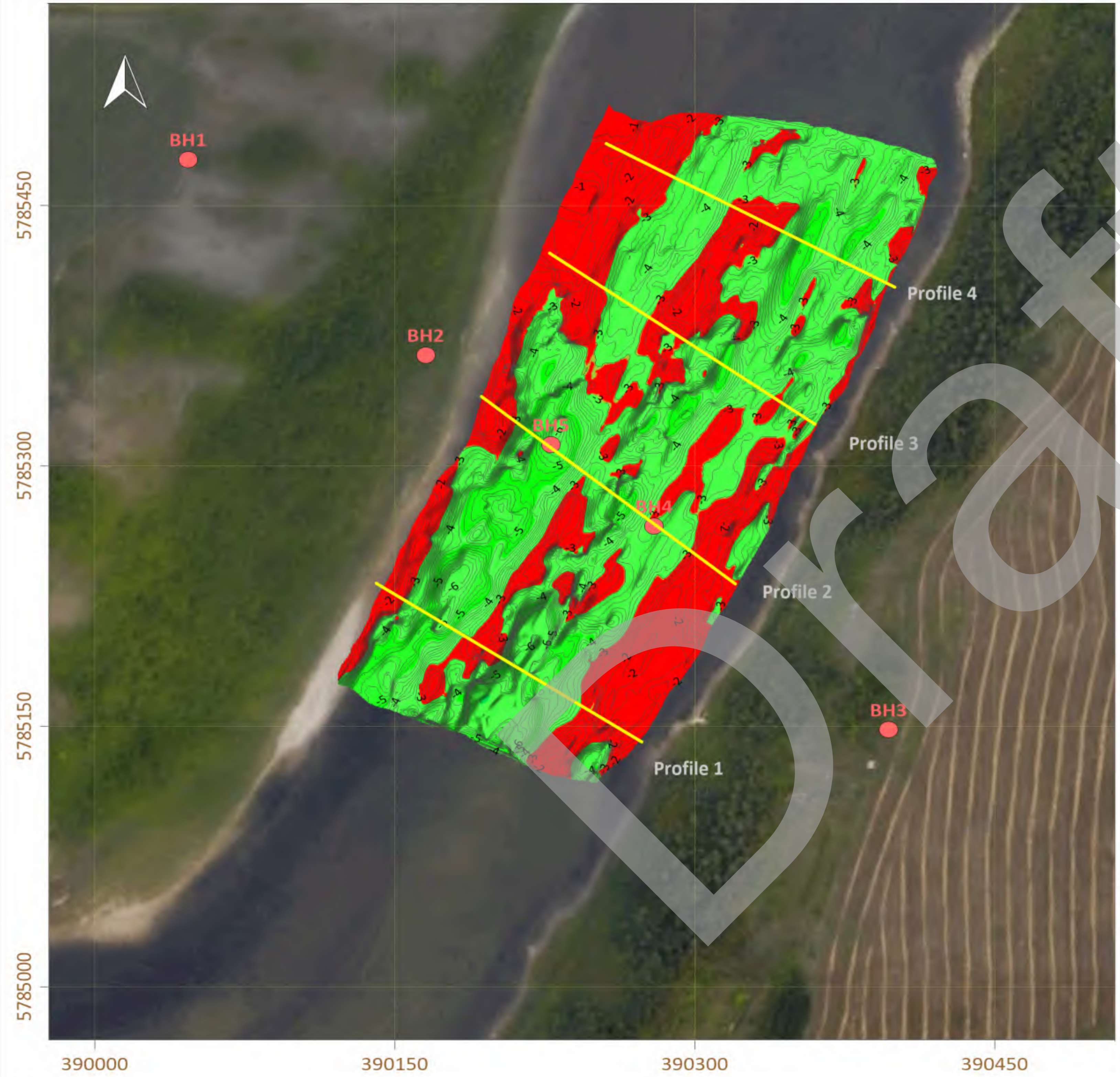
The results of the survey are presented in the following images of bathymetry (presented in feet), and bottom elevation.

Bathymetry

The Bathymetry chart on the following page shows the water depth from the water surface to the bottom of the river. At the time of the survey, the water elevation was 1532.9 feet (467.45 m) which is exceptionally low for the South Saskatchewan River at this time of year.

A two colour scale was chosen in order to clearly demonstrate the ability of a barge's ability to navigate the watercourse. We understand that the vessel requires 3 feet of draft. The areas coloured in red indicate less than 3 feet of draft, whereas the areas of green are greater than 3 feet of depth. The bathymetry is dependent upon the water level of the time of survey, and should the water levels go down further, the areas of red would increase and vice versa.

Profile 2 that cut across two proposed boreholes (BH4 and BH5) shows that BH5 falls on an estimated water depth of 5ft and BH4 on an estimated depth of 3.5ft.



Bathymetry

Saskatoon Freeway Bridge Project

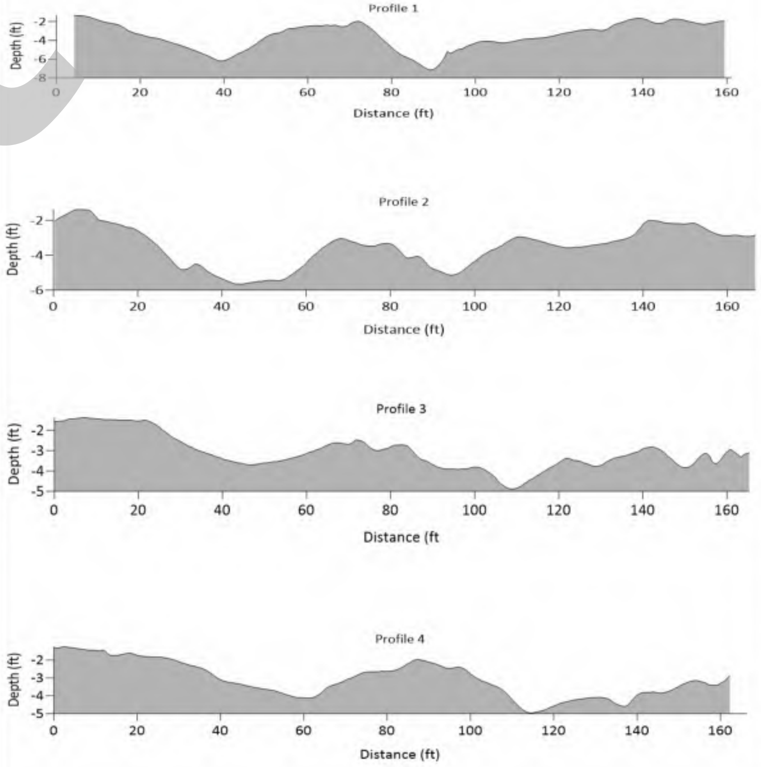
Legend

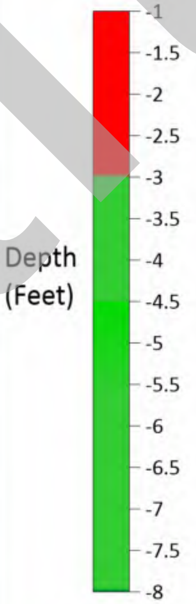
● Proposed Boreholes

Profile Line

CLIENT
SNC - LAVALIN
August 2021

PROFILES
(5 X Vertical Exageration)





SURVEY DATE:	JULY 29TH - AUGUST 1ST 2021
PROJECT LOCATION:	SASKATOON FREEWAY
SURVEY METHOD:	SINGLE BEAM ECOSOUNDER
PROJECTION:	NAD_83_UTM_ZONE_13N
BASE STATION:	SNC-06,5784714.134,390726.875,494.062,Legal Survey Pin
WATER LEVEL AT THE TIME OF SURVEY:	1532.9ft

AQUATICS ESI

Aquatics Environmental Services Ltd.
609 Club road
St. Andrews, MB. R1A 3P6

T: 204 289 2400
e: info@aquatics-esi.com
www.aquatics-esi.com

River Bottom Elevation

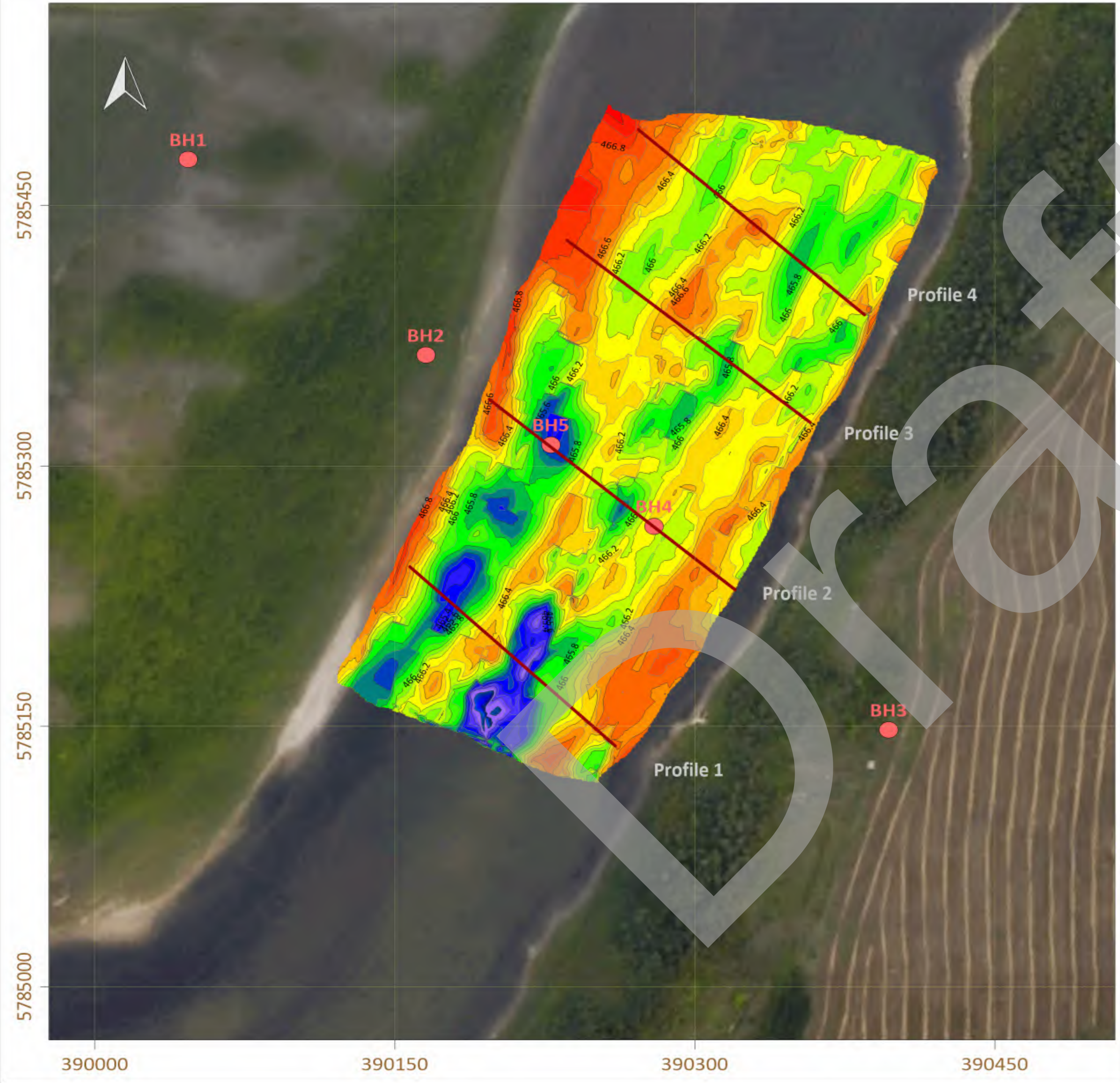
An elevation chart of the area of the South Saskatchewan River is shown in the figure on the following page.

The model shows that there is no consistency of depth across the watercourse. There are shoal areas throughout the area in the middle of the river and nearer the shorelines as expected. There are a few deeper pockets of water especially in the south end of the survey area. Generally, the watercourse was exceptionally shallow due to the unprecedented drought through the prairies during this summer.

The surveyors noted that the bottom was comprised mainly of sand with many rocks and boulders which created navigational hazards.

River Bottom Elevation

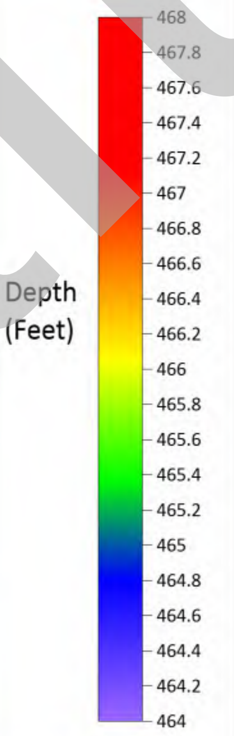
Saskatoon Freeway Bridge Project



Legend

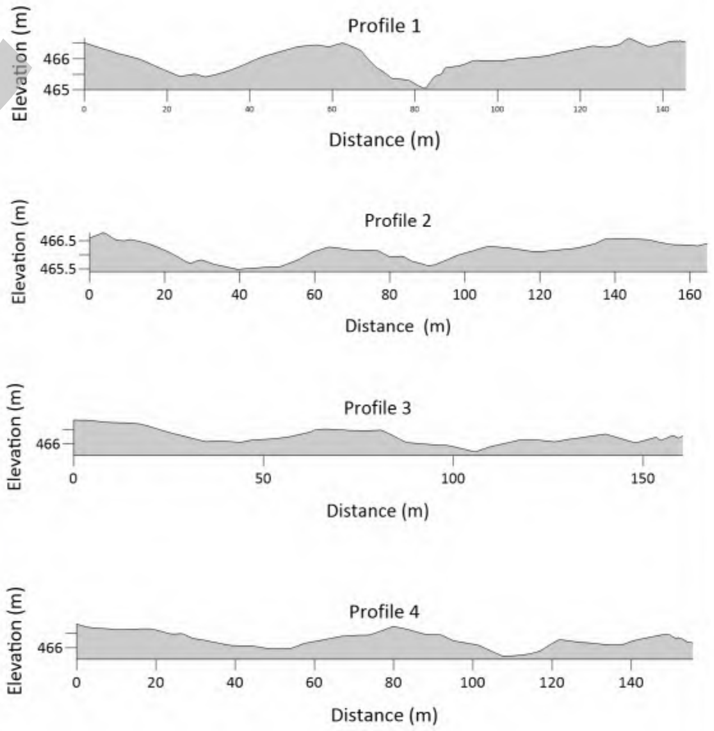
● Proposed Boreholes

Profile Line



CLIENT
SNC - LAVALIN
August 2021

PROFILES
(7.5 X Vertical Exageration)



0 25 50 75 100

SURVEY DATE:	JULY 29TH - AUGUST 1ST 2021
PROJECT LOCATION:	SASKATOON FREEWAY
SURVEY METHOD:	SINGLE BEAM ECOSOUNDER
PROJECTION:	NAD_83_UTM_ZONE_13N
BASE STATION:	SNC-06,5784714.134,390726.875,494.062,Legal Survey Pin

WATER LEVEL AT THE TIME OF SURVEY: 467.45m

AQUATICS ESI
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www.aquatics-esi.com

Survey Data

Also included in this report are the asci XYZ survey data for both bathymetry and bottom elevation. The bathymetry data is expressed in feet and is relative to the elevation of the water level at the time of the survey (1532.9 ft). The elevation data is expressed in meters.

Attached files:

- South Saskatchewan River Survey Area Bottom Elevations – m.xlsx
- South Saskatchewan River Survey Area Bathymetry – feet.xlsx

Closing

We hope that this information meets your requirements for this program. Should you have any questions, please do not hesitate to ask.

We appreciate the opportunity you have provided us to work with you.

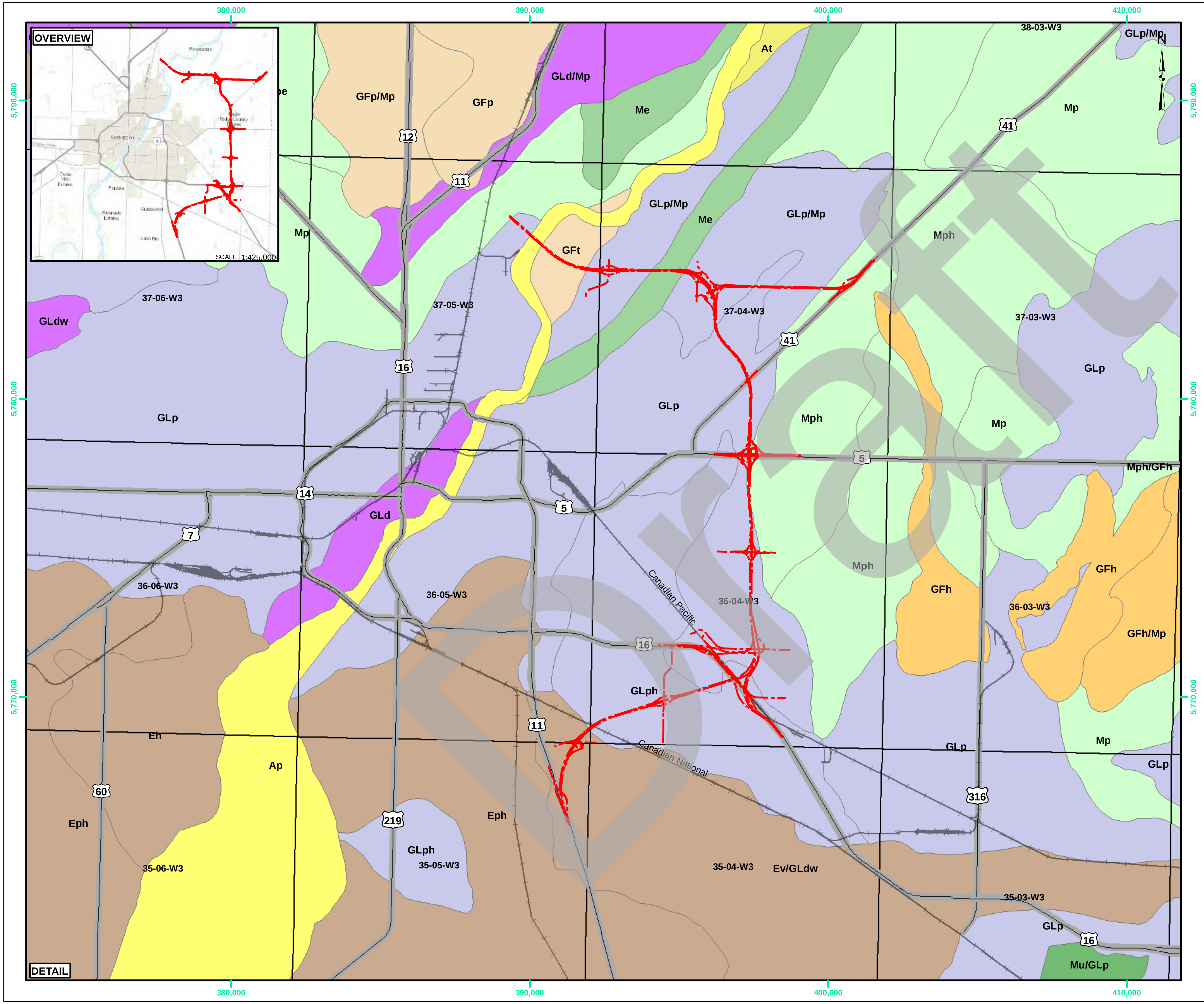
Regards,

Darwin Monita

Darwin Monita
Director

Appendix II

Site Plan with Surficial Geology



LEGEND

- PRELIMINARY FREEWAY ALIGNMENT
- HIGHWAY

SURFICIAL GEOLOGY

- 🟨 ALLUVIAL (A)
- 🟨 ALLUVIAL PLAIN (Ap)
- 🟫 EOLIAN (E)
- 🟫 EOILIAN HUMMOCKY (Eh)
- 🟫 EOILIAN PLAIN (Ep)
- 🟧 GLACIOFLUVIAL HUMMOCKY (GFh)
- 🟫 GLACIOFLUVIAL PLAIN (GFp)
- 🟫 GLACIOFLUVIAL TERRACE (GFt)
- 🟪 GLACIOLACUSTRINE DRUMLINOID (GLd)
- 🟪 GLACIOLACUSTRINE PLAIN (GLp)
- 🟩 MORAINAL ERODED (Me)
- 🟩 MORAINAL PLAIN (Mp)
- 🟩 MORAINAL UNDULATING (Mu)

NOTES

1. COORDINATE SYSTEM: NAD 1983 UTM ZONE 13N.
2. BASE CADASTRAL DATA ADAPTED FROM HER MAJESTY IN RIGHT OF SASKATCHEWAN OR INFORMATION SERVICES CORPORATION OF SASKATCHEWAN, SASKADMIN2016, SASKGRID2016.
3. CADASTRAL BOUNDARIES ARE FOR INFORMATIONAL PURPOSES ONLY AND SHOULD NOT BE CONSIDERED SUITABLE FOR LEGAL, ENGINEERING, OR SURVEYING PURPOSES.
4. HIGHWAYS AND ROADS OBTAINED FROM THE NATIONAL ROAD NETWORK SASKATCHEWAN EDITION 9.0 DATASET, 2017-06-05.
5. PH (PRELININARY HOLES) ARE DRILLED TO 4.57 M (15 FT).
6. SH (STRATIGRAPHIC HOLES) ARE DRILLED TO 13.7 M (45 FT).
7. FH (FOUNDATION HOLES) DEPTH VARIES BUT ARE DRILLED TO A MINIMUM OF 18 M (60 FT).
8. CPT (CONE PENETRATION TESTING HOLES) WERE ATTEMPTED. HOWEVER, GROUND CONDITIONS WERE TO HARD TO PUSH CPT; THEREFORE, THEY WERE CHANGED TO FOUNDATION HOLES.
9. SURFICIAL GEOLOGY 250K SASKATCHEWAN GEOLOGICAL SURVEY, MINISTRY OF ENERGY AND RESOURCES ACCESSED OCT 23, 2020 HTTPS://GEOHUB.SASKATCHEWAN.CA/DATASETS/250K-SURFICIAL-GEOLOGY

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REFERENCE DRAWINGS

DWG No.	DESCRIPTION

REVISIONS

REV	DATE	DESCRIPTION	DES	DRN	CHK	APP
00	2023 03 17	ISSUED FOR INFORMATION	BK	KVG	NB	KD

0 1,000 2,000 4,000 6,000 8,000 METRES

SCALE: 1:125,000

SNC·LAVALIN

CLIENT SASKATCHEWAN MINISTRY OF HIGHWAYS	PROJECT LOCATION SASKATOON FREEWAY

TITLE

PHASE 2 SURFICIAL GEOLOGY OVERVIEW

DATE	2022 06 01	DWG No.	659183-0000-4GDD-0071	FIG No.		REV	00

SIZE 11x17

Path: \\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.1 GIS\Drawings\Geotech\659183-0000-4GDD-0071 Overview.mxd

Appendix III

Aquatic Habitat Protection Permit

SASKATCHEWAN

Water Security Agency

November 4, 2021

(306) 787-1319

Via Email: Geoffrey.Meinert@gov.sk.ca

Ministry of Highways
Attention: Geoffrey Meinert
18-3603 Millar Avenue
SASKATOON, SK S7P 0B2

File number:
2019-SOWE-107-ST1
-AMENDMENT

Dear Geoffrey Meinert:

Re: Aquatic Habitat Protection Permit: Geotechnical Investigation including Borehole Drilling in Various Locations for the Proposed Saskatoon Freeway Project – AMENDMENT

Please find enclosed the amended Aquatic Habitat Protection Permit authorizing the Ministry of Highways (MoH) to proceed with borehole drilling at the following locations insofar as the Aquatic Habitat Protection Program is concerned:

Land Location:	Watercourse/ Water Body:
SE-26-37-05 W3	South Saskatchewan River
SE-34-37-05 W3	Unnamed Wetland
NE-33-37-05 W3	Unnamed Wetland
NE-24-37-05 W3	Small Swale
NW-20-37-04 W3	North East Swale

It is understood from the original application dated June 19, 2019 that a functional planning study will be conducted for the proposed Saskatoon Freeway. Phase 1 of this study is a geotechnical investigation including borehole drilling in the South Saskatchewan River and unnamed wetlands. Within the South Saskatchewan River at SE-26-37-05 W3, two deep (one to a depth of at approximately 100ft) stratigraphic boreholes will be drilled using a rotary drill rig (dual rotary or mud rotary) from a barge. Drill cuttings will be contained in a pit barge tied alongside the drill barge then disposed of in an appropriate facility or location. In the unnamed wetlands at SE-34-37-05 W3 and NE-33-37-05 W3, several boreholes will be drilled using an auger drill rig and cone penetration testing.

The preliminary and stratigraphic boreholes (up to 13m) will be backfilled with the cuttings and/or bentonite chips. A cement/bentonite slurry mixture will be used to backfill deeper stratigraphic boreholes, boreholes with instrumentation installed, and boreholes with groundwater or environmental concerns. Within the river, boreholes will be grouted to the riverbed elevation. Following grouting, the surface casing will be washed to the elevation of the riverbed prior to pulling to avoid mud/grout release into the river. Standpipe piezometers will be installed (if required) at select stratigraphic borehole locations drilled along the general alignment.

…/2

Based on the emails requesting an amendment received October 20, 2021 and October 28, 2021, it is understood that two additional drilling locations at NE-24-37-05 W3 and NW-20-37-04 W3 are required for this project. The drilling process for these additional locations remains consistent with the work originally permitted. The boreholes at the new work locations will be drilled using an auger drill rig. It is anticipated that the boreholes will be deeper than 13m and will therefore be backfilled with a cement/bentonite slurry mixture.

If the project changes in any way from that submitted, or the conditions of the attached permit cannot be met, this permit is no longer valid. Please contact this office so that further review and approvals may be carried out.

Prior to beginning the work associated with this Aquatic Habitat Protection Permit, a Conservation Officer must be notified at the Ministry of Environment district office in Saskatoon. The phone number for this office is (306) 933-6240.

Permit holders are reminded that the discharge of any substance that may cause an adverse effect or is covered by *The Environmental Management and Protection (Saskatchewan Environmental Code Adoption) Regulations, 2010* shall be reported to the Ministry of Environment (MOE) at 1-800-667-7525. Should you require more information on discharges and spills, please check Saskspills (https://www.saskatchewan.ca/business/environmental-protection-and-sustainability/hazardous-materials-and-safe-waste-management) or the MOE website (http://www.environment.gov.sk.ca). You may also contact the MOE Client Service Office at 1-800-567-4224.

This Aquatic Habitat Protection Permit allows you to undertake activities affecting the bed, bank and boundary of a water body or watercourse that are otherwise prohibited under subsection 38(4) of *The Environmental Management and Protection Act, 2010.* The purpose of this permit is to mitigate the environmental impacts of the proposed activities. This permit does not release you from the responsibility of obtaining any other approvals that may be required under federal, provincial or municipal legislation. The permit holder is responsible to obtain the necessary approvals from the local municipality for these improvements. Land control and access are also the responsibility of the permit holder.

If you have any questions, please contact Adam Matichuk at (306) 787-1319 or at Adam.Matichuk@wsask.ca.

Sincerely,

WATER SECURITY AGENCY

Jennifer Grohs
For Adam Matichuk
Aquatic Habitat Protection Specialist
Regulatory Division

cc: Jaret Engele, Ryan Engele, Chris Maier, Cal Schommer, Dave Swiezak, Zach Neudorf, Michelle Baran, Amber Neal, Ministry of Environment, Saskatoon
Cheryl Hanson, Water Security Agency, North Battleford
Alex Blais-Montpetit, Adam Matichuk, Water Security Agency, Regina
Kimberly Doran, Lyndsey MacBride, Brittany Kaszas, Hayden Yip, SNC Lavalin

Water Security Agency

AQUATIC HABITAT PROTECTION PERMIT

Pursuant to Section 6 of *The Environmental Management and Protection (General) Regulations, 2010,* permission is hereby granted to the Ministry of Highways ("Permit Holder"), and any authorized agents acting on behalf of the Ministry of Highways, to proceed with borehole drilling for the proposed Saskatoon Freeway Project at SE-26-37-05 W3, SE-34-37-05 W3, NE-33-37-05 W3, NE-24-37-05 W3 and NW-20-37-04 W3, according to the application and additional plans submitted to the Water Security Agency on June 19, 2019, October 20, 2021 and October 28, 2021.

This permit is issued subject to and restricted to the following conditions:

1. A Conservation Officer shall be contacted at (306) 933-6240 prior to beginning this work so that the appropriate inspections may be conducted.
2. All contractors are to receive copies of all permits before they begin any work. A copy of the permit must be on site at all times and available for review by a Conservation Officer.
3. No in-water work within the South Saskatchewan River is allowed between April 1 – July 15 of any year to protect fish during spawning and incubation periods.
4. Historical records indicate that multiple species-at-risk exist near your planned work locations. It is recommended that all works follow the activity restriction guidelines for timing and setback distances as outlined in Appendix A.
5. Except for drilling activities, no excavation of the water body or watercourse bed, bank or boundary is permitted.
6. Machinery and heavy equipment must arrive at the project site clean and free of fluid leaks, or accumulations of external contaminants that may include, but are not limited to: oil, fuel, grease, other lubricants, soils, mud or plant materials.
7. Machinery and heavy equipment must be cleaned, fuelled, serviced and stored in a manner that will not contaminate the bed, bank or boundary of any water body or watercourse. During winter, machinery and equipment must not be fuelled or serviced on ice or in drainage ditches to prevent hazardous substances from contaminating water bodies or watercourses later in the year.
8. No machinery or heavy equipment is to enter the water under any circumstances. The only exceptions are the use of necessary attached booms, buckets, other tools or implements.

9. Effective measures must be used to minimize any damage to the bed, bank or boundary of any water body or watercourse from the transport and operation of heavy equipment. If there is potential for damage to the bed or banks to occur as a result of the operation of heavy equipment, then appropriate measures must be used to prevent rutting and compaction (e.g., swamp mats).

10. Existing vegetation shall be retained as much as possible.

11. Effective erosion and sedimentation control measures must be installed as per best management practices, monitored, maintained and replaced or upgraded as necessary prior to, during and following project completion to ensure they remain effective until the project site stabilizes and re-vegetates.

12. Excavated and stockpiled materials shall be located above the bank and stabilized so they will not erode into any water body or watercourse.

13. All disturbed project site areas, including road ditches and disturbed slopes adjacent to any water body, shall be stabilized with short and long-term erosion control measures that have been tailored to site conditions.

14. Adequate precautions must be taken to prevent debris and sediment from entering the water. Any project debris entering the water must be removed as soon as practical and disposed of in approved sites. It is unacceptable to bury or burn any debris on site.

15. All temporary structures and debris associated with this project must be satisfactorily removed upon completion of the work.

16. **Drilling mud and cuttings must be fully contained. Drilling mud, cuttings or wash-water shall not enter any water body or watercourse.**

17. Hazardous substances such as fuel, oil, grease, paint and solvents must be stored where they will not contaminate any water body or watercourse and must be disposed of appropriately.

18. All stationary and portable fuel tanks, pumps and engines within 100 metres of a water body or watercourse must have secondary containment (e.g. a water pump and its fuel supply must be placed in a container capable of holding 110% of the total volume of fuel and oils).

19. Appropriately sized spill basins and/or spill kits for clean ups must be on site and accessible at all times. All spills of harmful substances (e.g. petroleum products) must be cleaned up and disposed of properly at approved sites.

20. All spills of any oil, fuel, hydraulic fluids or waste dangerous goods must be immediately contained and reported to a Conservation Officer at (306) 933-6240. All spills meeting or exceeding the quantities specified in the *Environmental Spill Control Regulations* must be reported and handled according to the regulations. The Provincial Spill Control Centre (Spill Line) is 1-800-667-7525.

21. The Permit Holder is solely responsible for all design, safety, and workmanship aspects of all works associated with this permit.

22. The Water Security Agency or the Ministry of Environment may order the Permit Holder to cease any or all work regarding this project if, in the Agency's opinion, the work is or may cause harm to the environment.

23. The Water Security Agency or the Ministry of Environment may order the Permit Holder to do any further work required to rectify any actual or potential problems deemed necessary to protect the environment.

24. The Permit Holder agrees to all conditions and/or orders regarding this permit.

25. This permit does not replace or supersede any approvals, licenses or authorizations, including building permits that may be required from municipal, provincial or federal legislation. The permit holder will maintain in force all such approvals, license or authorizations that may be required.

26. This permit will expire on **<u>March 31, 2022</u>**. Re-application is required if further work is planned.

This permit allows you to undertake activities affecting the bed, bank and boundary of a water body or watercourse that are otherwise prohibited under subsection 38(4) of *The Environmental Management and Protection Act, 2010.* This permit does not replace or supersede any approvals, licenses, or authorizations, including building permits that may be required under municipal, provincial or federal legislation. The permit holder will maintain in force all such approvals, licenses or authorizations that may be required.

WATER SECURITY AGENCY

Jennifer Grohs
For Adam Matichuk
Aquatic Habitat Protection Specialist
Regulatory Division

Appendix A:

Species	Taxon	Work Location	Activity Restriction Period	Setback Distance
Macoun's Gentian *(Gentianopsis virgata ssp. Macounii)*	Plant	SE-26-37-05 W3 & NE-24-37-05 W3	Year-round	30m from any occurrence.
Rocky Mountain Sedge (*Carex saximontana*)	Plant	SE-26-37-05 W3	Year-round	30m from any occurrence.
Sandhills Cinquefoil (*Potentilla lasiodonta*)	Plant	NE-24-37-05 W3	Year-round	30m from any occurrence.
Marsh Felwort (*Lomatogonium rotatum var. fontanum*)	Plant	NE-24-37-05 W3	Year-round	30m from any occurrence.
Plains Rough Fescue (*Festuca hallii*)	Plant	NE-24-37-05 W3	Year-round	30m from any occurrence.
Crawe's Sedge (*Carex crawei)*	Plant	NE-24-37-05 W3	Year-round	30m from any occurrence.
Hairy Germander (*Teucrium canadense var. occidentale*)	Plant	NE-24-37-05 W3	Year-round	30m from any occurrence.
Few-flowered Aster (*Almutaster pauciflorus)*	Plant	NE-24-37-05 W3	Year-round	30m from any occurrence.
Prairie Dunewort (*Botrychium campestre*)	Plant	NE-24-37-05 W3	Year-round	30m from any occurrence.
Northern Leopard Frog (*Lithobates pipiens*)	Amphibian	NE-24-37-05 W3	Year-round	200m from breeding and overwintering habitat.
Wood Lily (*Lilium philadelphicum)*	Plant	NE-24-37-05 W3	Year-round	30m from any occurrence.
Lesser Duckweed (*Lemna minor*)	Plant	NE-24-37-05 W3	Year-round	30m from any occurrence.

Appendix IV

Borehole Logs

BOREHOLE 21-04 (BH1)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2021

5785489.27 N 390037.30 E
NAD 83 ZONE 13 U
SE-26-37-05-W3M

OXIDIZED TILL: Stiff, moist, dark brown, oxidized, silty, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, Fe stains, gypsum crystals, low to medium plastic (till)

- below 1.5 m: hard
- below 3.0 m: brown

SAND: Very dense, moist, brown, oxidized, sand (fine to medium), some silt to silty, trace gravel (fine to coarse), non plastic

- at 13.5 m: sand (fine to coarse)
- at 15.0 m: gravelly (fine to coarse)

OXIDIZED TILL: Hard, moist, mottled brown/grey, oxidized, silt, clayey, some sand to sandy (fine to coarse), some gravel (fine to coarse), highly calcareous, Fe stains, gypsum crystals, medium plastic (till)

SAND: Very dense, wet, brown, oxidized, sand (fine to coarse), silty, trace gravel (fine to coarse), non plastic

- at 21.0 m: some gravel (fine to coarse)

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, clayey, some sandy (fine to coarse), trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

- at 30.0 m: silt lense (0.15 m)

SILT: Hard, moist, grey, unoxidized, silt, clayey, trace sand (fine), non calcareous, gypsum crystals, medium plastic

SAND: Very dense, moist, unoxidized, sand (fine to coarse), silty, non calcareous, non plastic

CLAY: Hard, moist, grey, unoxidized, clay, silty, non calcareous, high plastic

SAND : Very dense, moist, unoxidized, sand (fine to coarse), silty, non calcareous, non plastic

SANDSTONE

- at 78.4 m: cobbles

SAND: Very dense, moist, unoxidized, sand (fine to coarse), silty, non calcareous, non plastic

SILT: Hard, moist, grey, unoxidized, silt, sandy (fine to medium), some clay, non calcareous, gypsum crystals, intermittent sand lenses, medium plastic

CLAY: Hard, moist, grey, unoxidized, clay, silty, non calcareous, fossilization, gypsum crystals, high plastic

SILT: Hard, moist, grey, unoxidized, silt, sandy (fine to medium), some clay, non calcareous, gypsum crystals, medium plastic

CLAY: Hard, moist, mottled grey/light grey, unoxidized, clay, silty, some sand (fine), non calcareous, fossilization, gypsum crystals, high plastic

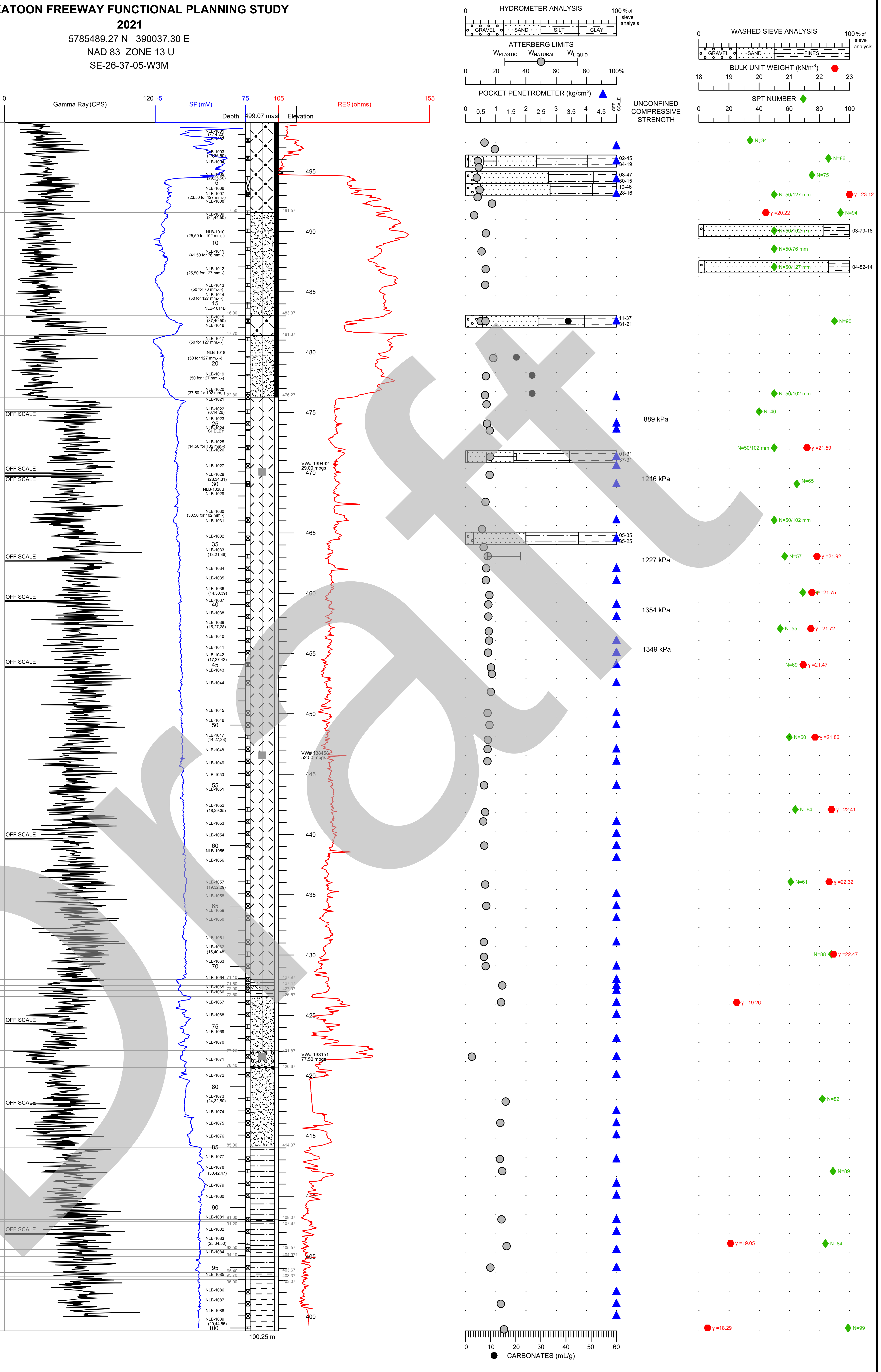
- at 94.0 m: sand lensing

SILT: Hard, moist, grey, unoxidized, silt, sandy (fine to medium), some clay, non calcareous, gypsum crystals, medium plastic

CLAY: Hard, moist, mottled grey/light grey, unoxidized, clay, silty, some sand (fine), non calcareous, fossilization, gypsum crystals, sand lensing, high plastic

SILT: Hard, moist, grey, unoxidized, silt, sandy (fine to medium), some clay, non calcareous, gypsum crystals, medium plastic

CLAY: Hard, moist, mottled grey/light grey, unoxidized, clay, silty, some sand (fine), non calcareous, fossilization, gypsum crystals, high plastic



VW Serial Number	Total Head (masl)
139492	478.17
138458	480.39
138151(8)	N/A

(Recorded 2022-04-01)

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

NOTES

1. Borehole open immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1). specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK survey, 2022).
8. VW138151 malfunctioned after installation and is not providing reliable readings.

CUTTING SAMPLE INTERVAL		COND. WATER	N/A µsiemens/cm	SUPERVISOR	N. BOUEY
TYPE OF DRILL RIG	MUD ROTARY (R408)	COND. MUD	945 µsiemens/cm	LOGGED BY	N. BOUEY
TYPE OF LOGGER	DT2055B VW MULTI CHANNEL LOGGEER	SPECIFIC GRAVITY	1.37	GEOLOGY BY	N/A
ABANDONMENT	VIBRATING WIRE PIEZOMETERS	NG RATE	N/A	CONTRACTOR	FORGED DRILLING Ltd.
BIT SIZE 7" (177.8 mm)	INTERVAL 0.0 m - EOH	LOGGING SPEED	GAMMA 5 m/min	OPERATOR	J. BECK
BIT SIZE N/A	INTERVAL N/A	LOGGING SPEED	RES 5 m/min	DATE DRILLED	2021-11-15

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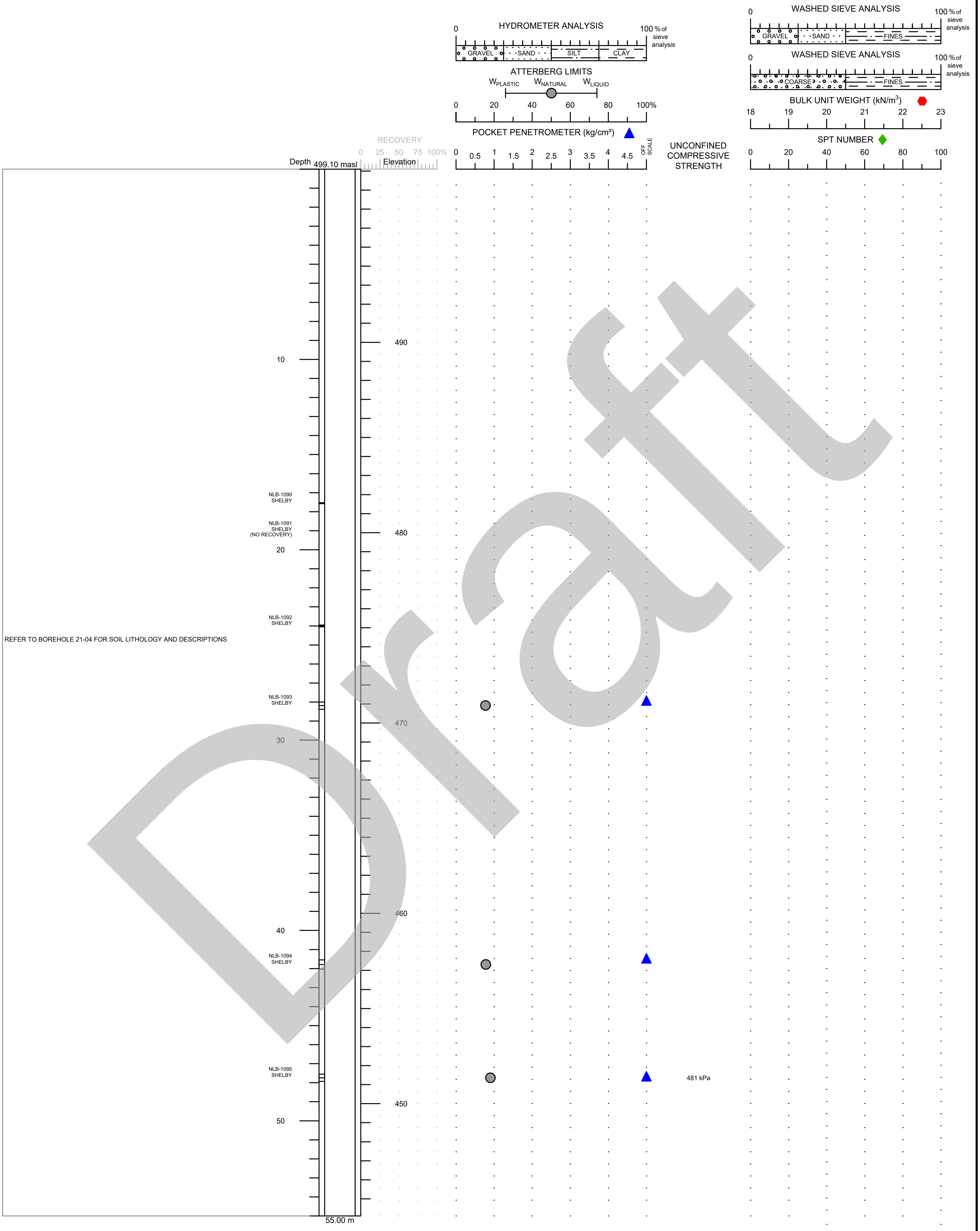
CLIENT SASKATCHEWAN MINISTRY OF HIGHWAYS	PROJECT LOCATION SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng
DRAWN BY	A. COLE, A.Sc.T.
PROJECT No.	659183
SCALE 1:250	DATE 2022-07-26

BOREHOLE 21-05 (BH1-SI)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2021

5785478.12 N   390036.59 E
NAD 83 ZONE 13 U
SE-26-37-05-W3M



REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) Specific gravity 1.36.
3. Depths are in metres (m).
4. Elevations are in metres above sea level (masl).
5. Borehole coordinates and elevations provided by SNC-Lavalin (RTK survey, 2022).

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CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:200	**DATE**	2022-06-16

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	J. BECK	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2021-10-19
ABANDONMENT	-	**INSTALLATION DATE**	2021-10-19

BOREHOLE 21-06 (BH2)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2021

5785139.94 N   390384.44 E
NAD 83 ZONE 13 U
SE-26-37-05-W3M

OXIDIZED TILL: Very stiff, moist, brown, oxidized, silt and sand, clayey, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, low plastic to medium plastic (till)

SAND: Dense, moist, brown, oxidized, sand (fine to coarse), some silt, trace gravel (fine to coarse), non plastic

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium to highly plastic (till)

- at 19.5 m: cobble
- at 22.5 m: silt lense (0.05m)
- at 23.0 m: cobble
- at 70.1 m: cobble
- at 73.0 m: cobble

SAND: Very dense, moist, grey, unoxidized, sand (fine to coarse), some silt, non calcareous, non plastic

SILT: Hard, moist, grey, unoxidized, silt, sandy (fine to medium), some clay, highly calcareous, gypsum crystals, medium plastic

SAND: Very dense, moist, grey, unoxidized, sand (fine to coarse), some gravel (fine to coarse), trace silt, non plastic

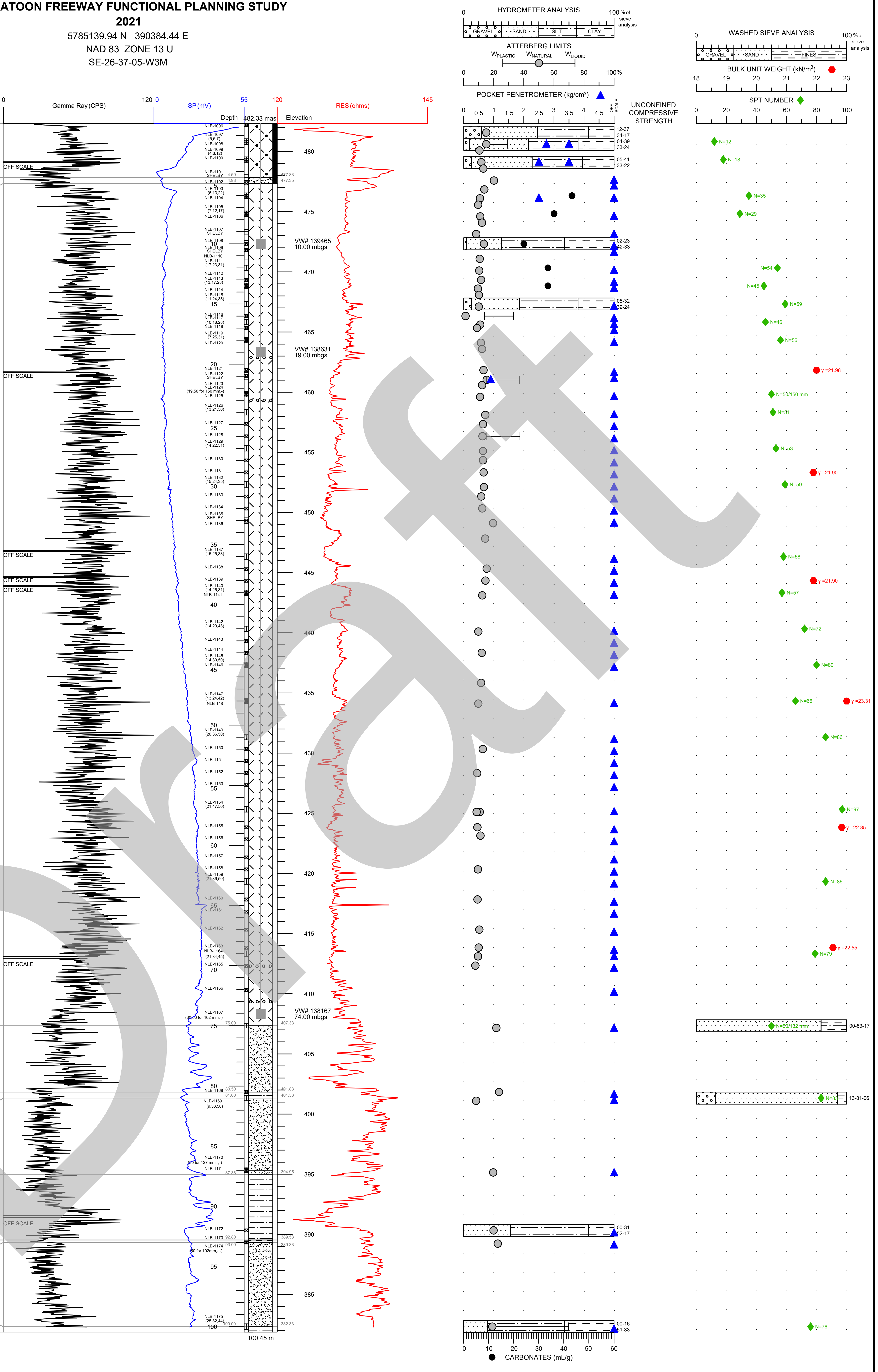
- below 87.0 m: silty, no gravel

SILT: Hard, moist, grey, unoxidized, silt, sandy (fine to medium), some clay, highly calcareous, low plastic

CLAY: Hard, moist, grey, unoxidized, clay, some silt, highly calcareous, gypsum crystals, high plastic

SAND: Very dense, moist, grey, unoxidized, sand (fine to coarse), silty, non plastic

SILT: Hard, moist, mottled grey/light grey, unoxidized, slit, clayey, some sand (fine), non calcareous, gypsum crystals, high plastic



VW Serial Number	Total Head (masl)
139465	477.79
138631	479.82
138167	489.31

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

NOTES

1. Borehole open immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1). specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK survey, 2022).

CUTTING SAMPLE INTERVAL			
TYPE OF DRILL RIG	MUD ROTARY (R408)		
TYPE OF LOGGER	DT2055B VW MULTI CHANNEL LOGGEER		
ABANDONMENT	VIBRATING WIRE PIEZOMETERS		
BIT SIZE	7" (177.8 mm)	INTERVAL	0.0 m - EOH
BIT SIZE	N/A	INTERVAL	N/A

COND. WATER	N/A	µsiemens/cm
COND. MUD	945	
SPECIFIC GRAVITY	1.37	
NG RATE	N/A	
LOGGING SPEED	GAMMA	5 m/min
	RES	5 m/MIN

SUPERVISOR	N. BOUEY
LOGGED BY	N. BOUEY
GEOLOGY BY	N/A
CONTRACTOR	FORGED DRILLING Ltd.
OPERATOR	J. BECK
DATE DRILLED	2021-10-21

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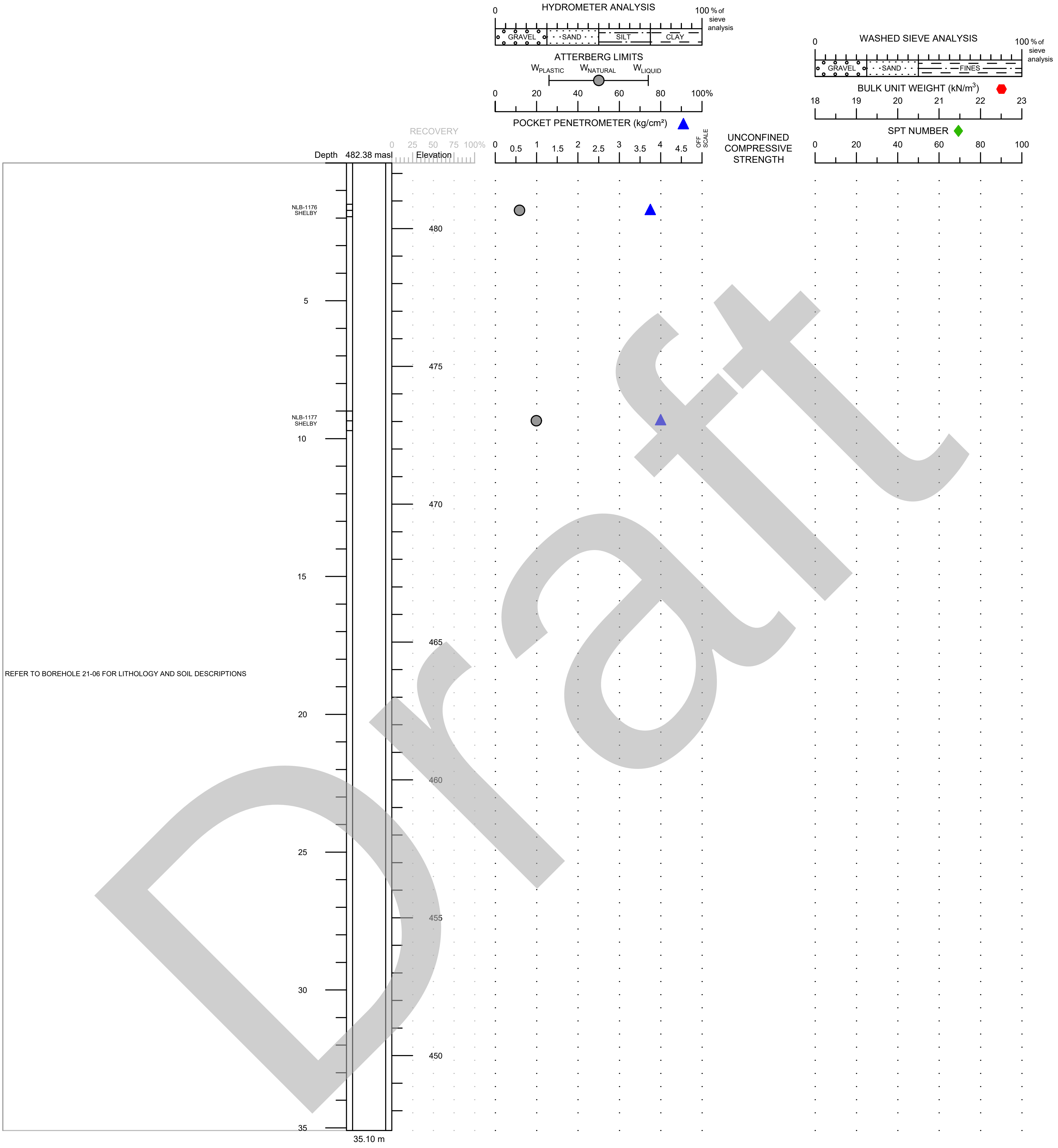
CLIENT SASKATCHEWAN MINISTRY OF HIGHWAYS	PROJECT LOCATION SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng
DRAWN BY	A. COLE, A.Sc.T.
PROJECT No.	659183
SCALE 1:250	DATE 2022-07-27

BOREHOLE 21-07 (BH2-SI)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2021

5785144.33 N 390386.78 E
NAD 83 ZONE 13 U
SE-26-37-05-W3M



REFER TO BOREHOLE 21-06 FOR LITHOLOGY AND SOIL DESCRIPTIONS

REFERENCE DRAWINGS

DWG No	**DESCRIPTION**

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) Specific gravity 1.37.
3. Depths are in metres (m).
4. Elevations are in metres above sea level (masl).
5. Borehole coordinates and elevations provided by SNC-Lavalin (RTK survey, 2022).

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	J. BECK	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-11-26
ABANDONMENT	-	**INSTALLATION DATE**	2022-11-26

SNC·LAVALIN

CLIENT		**PROJECT LOCATION**	
SASKATCHEWAN MINISTRY OF HIGHWAYS		SASKATOON, SASKATCHEWAN	
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:150	**DATE**	2022-06-16

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-01 (SHII 1)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5784351 N   391744 E
NAD 83 ZONE 13 U
NE 06-36-04-W3M

TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

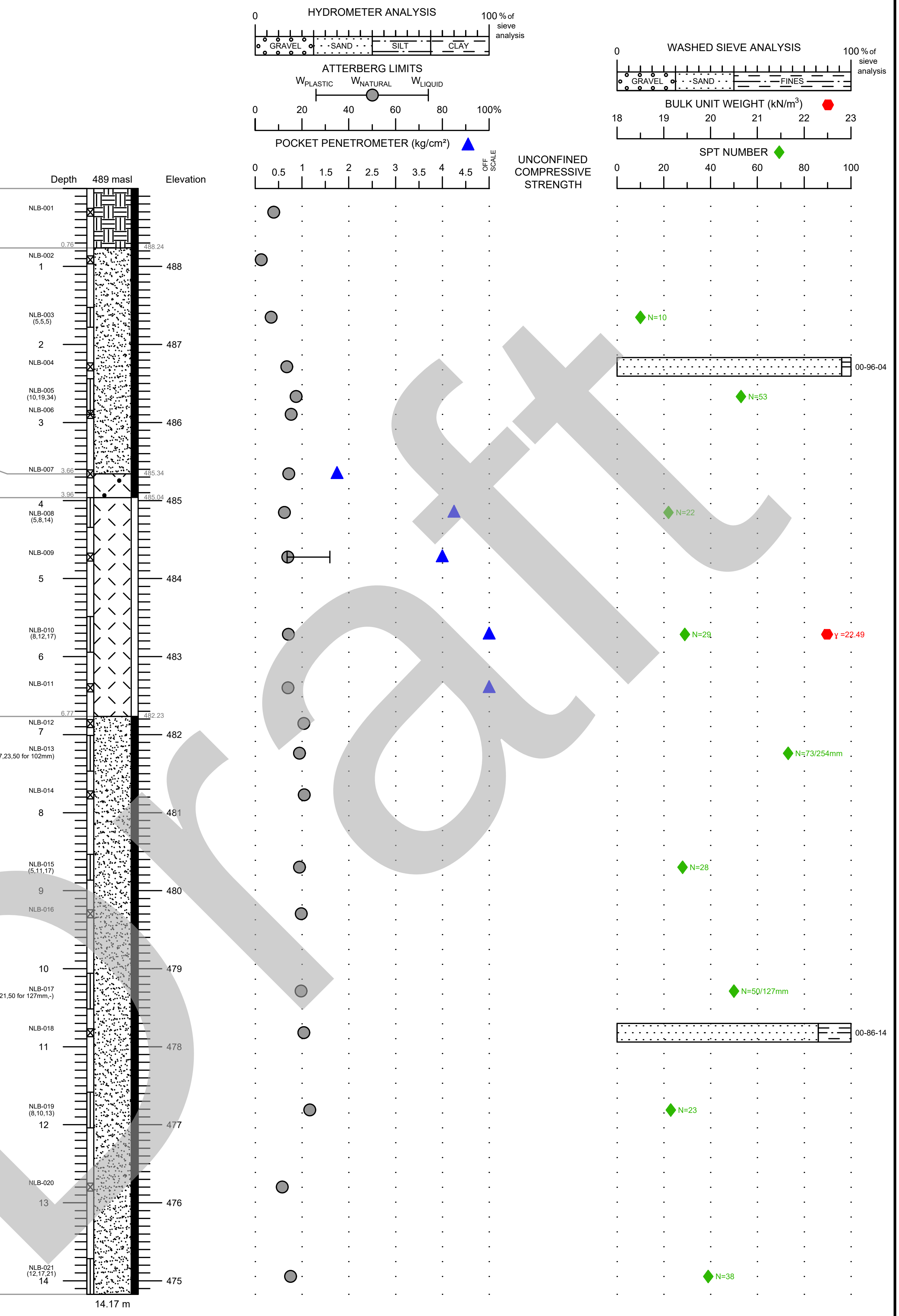
SAND: Compact, wet, brown, oxidized, sand (fine to coarse), trace silt, trace gravel (fine), non plastic

- between 2.44 m and 2.68 m: very dense, sand (fine), silty
- below 2.68 m: some silt, trace gravel (fine to coarse)

OXIDIZED TILL: Very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

UNOXIDIZED TILL: Very stiff, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

SAND: Compact, wet, light brown, oxidized, sand (fine to coarse), some silt, non plastic



REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.40.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S. RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-12
ABANDONMENT	BACKFILLED WITH CUTTINGS	**INSTALLATION DATE**	N/A

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CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:60	**DATE**	2022-07-12

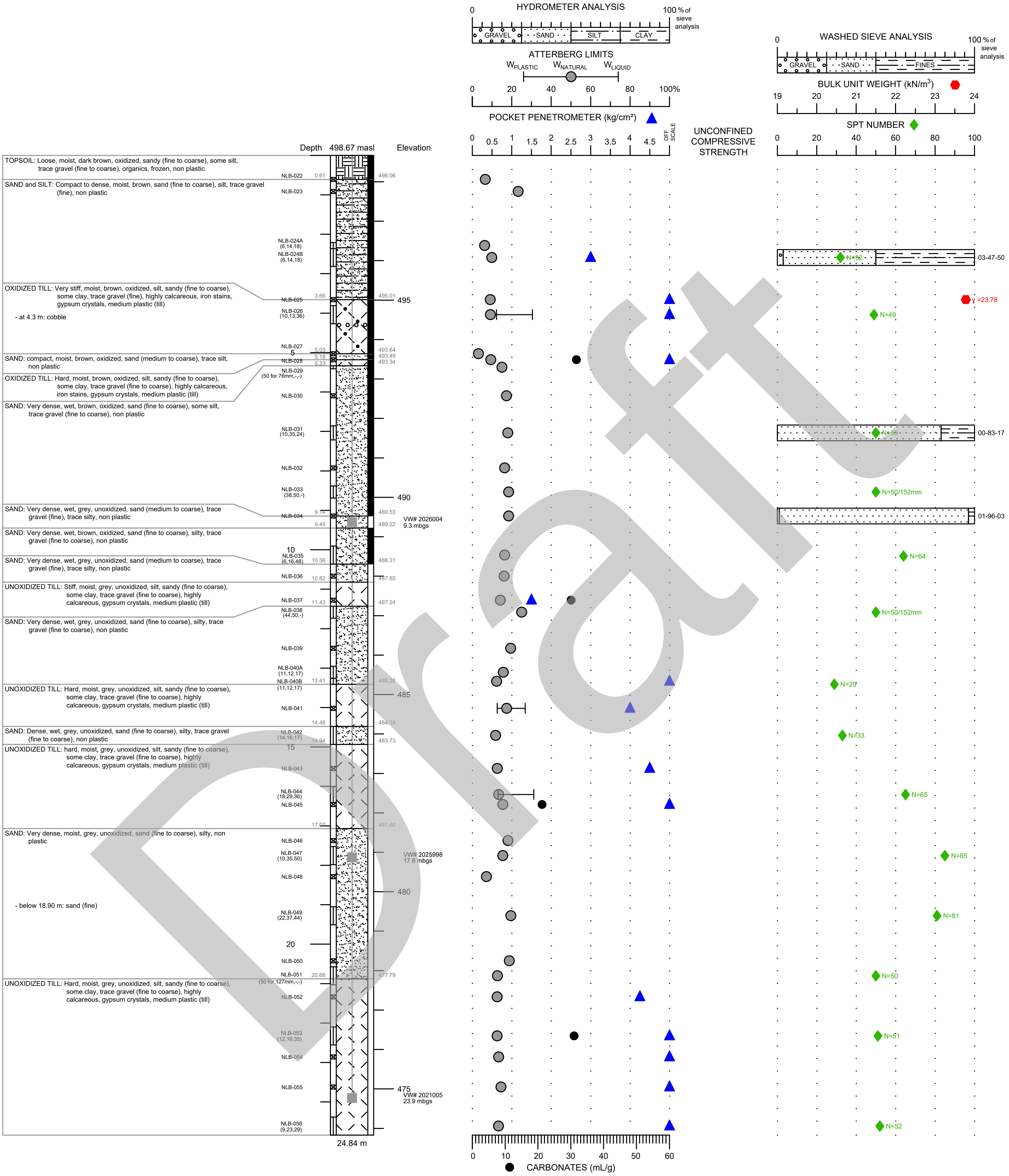
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\BH-659183-BH22-01 (SHII 1).dwg

BOREHOLE 22-02 (FHII 1)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5784355.17 N   392638.41 E
NAD 83 ZONE 13 U
NE 24-37-05-W3M



TOPSOIL: Loose, moist, dark brown, oxidized, sandy (fine to coarse), some silt, trace gravel (fine to coarse), organics, frozen, non plastic

SAND and SILT: Compact to dense, moist, brown, sand (fine to coarse), silt, trace gravel (fine), non plastic

OXIDIZED TILL: Very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- at 4.3 m: cobble

SAND: compact, moist, brown, oxidized, sand (medium to coarse), trace silt, non plastic

OXIDIZED TILL: Hard, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SAND: Very dense, wet, brown, oxidized, sand (fine to coarse), some silt, trace gravel (fine to coarse), non plastic

SAND: Very dense, wet, grey, unoxidized, sand (medium to coarse), trace gravel (fine), trace silty, non plastic

SAND: Very dense, wet, brown, oxidized, sand (fine to coarse), silty, trace gravel (fine to coarse), non plastic

SAND: Very dense, wet, grey, unoxidized, sand (medium to coarse), trace gravel (fine), trace silty, non plastic

UNOXIDIZED TILL: Stiff, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

SAND: Very dense, wet, grey, unoxidized, sand (fine to coarse), silty, trace gravel (fine to coarse), non plastic

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

SAND: Dense, wet, grey, unoxidized, sand (fine to coarse), silty, trace gravel (fine to coarse), non plastic

UNOXIDIZED TILL: hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

SAND: Very dense, moist, grey, unoxidized, sand (fine to coarse), silty, non plastic

- below 18.90 m: sand (fine)

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

VW Serial Number	Total Head (masl)
2026004	491.00
2025998	487.90
2021005	487.70

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

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CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	A. MARLOWE
OPERATOR	E. SERHAN	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-12
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-12

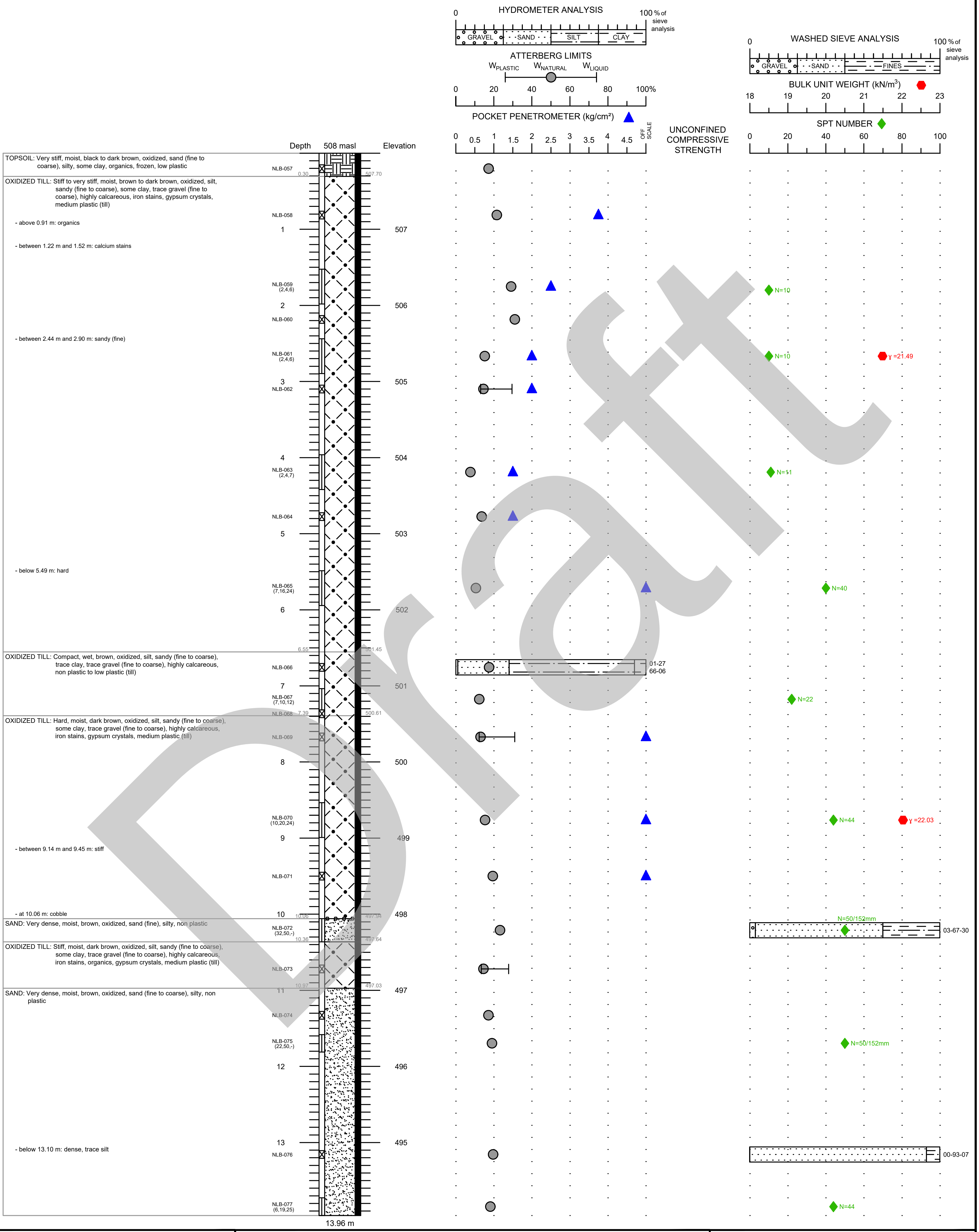
CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-12

LIMITATION

BOREHOLE 22-03 (SHII 4)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5781954 N   396478 E
NAD 83 ZONE 13 U
NE 33-36-04-W3M



TOPSOIL: Very stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

OXIDIZED TILL: Stiff to very stiff, moist, brown to dark brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- above 0.91 m: organics
- between 1.22 m and 1.52 m: calcium stains
- between 2.44 m and 2.90 m: sandy (fine)
- below 5.49 m: hard

OXIDIZED TILL: Compact, wet, brown, oxidized, silt, sandy (fine to coarse), trace clay, trace gravel (fine to coarse), highly calcareous, non plastic to low plastic (till)

OXIDIZED TILL: Hard, moist, dark brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- between 9.14 m and 9.45 m: stiff
- at 10.06 m: cobble

SAND: Very dense, moist, brown, oxidized, sand (fine), silty, non plastic

OXIDIZED TILL: Stiff, moist, dark brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, organics, gypsum crystals, medium plastic (till)

SAND: Very dense, moist, brown, oxidized, sand (fine to coarse), silty, non plastic

- below 13.10 m: dense, trace silt

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:50	**DATE**	2022-07-12

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-06
ABANDONMENT	BACKFILLED WITH CUTTINGS	**INSTALLATION DATE**	N/A

BOREHOLE 22-04 (SHII 7)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5772209 N   397452 E
NAD 83 ZONE 13 U
NE 36-35-05-W3M

TOPSOIL: Very stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SILT: Firm, moist, brown, oxidized, silt, sandy (fine to coarse), trace clay, trace gravel (fine), non plastic to low plastic

OXIDIZED TILL: Very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay to clayey, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium to high plastic (till)

- between 7.01 m and 8.23 m: mottled dark brown and brown
- below 8.23 m: dark brown, no iron staining

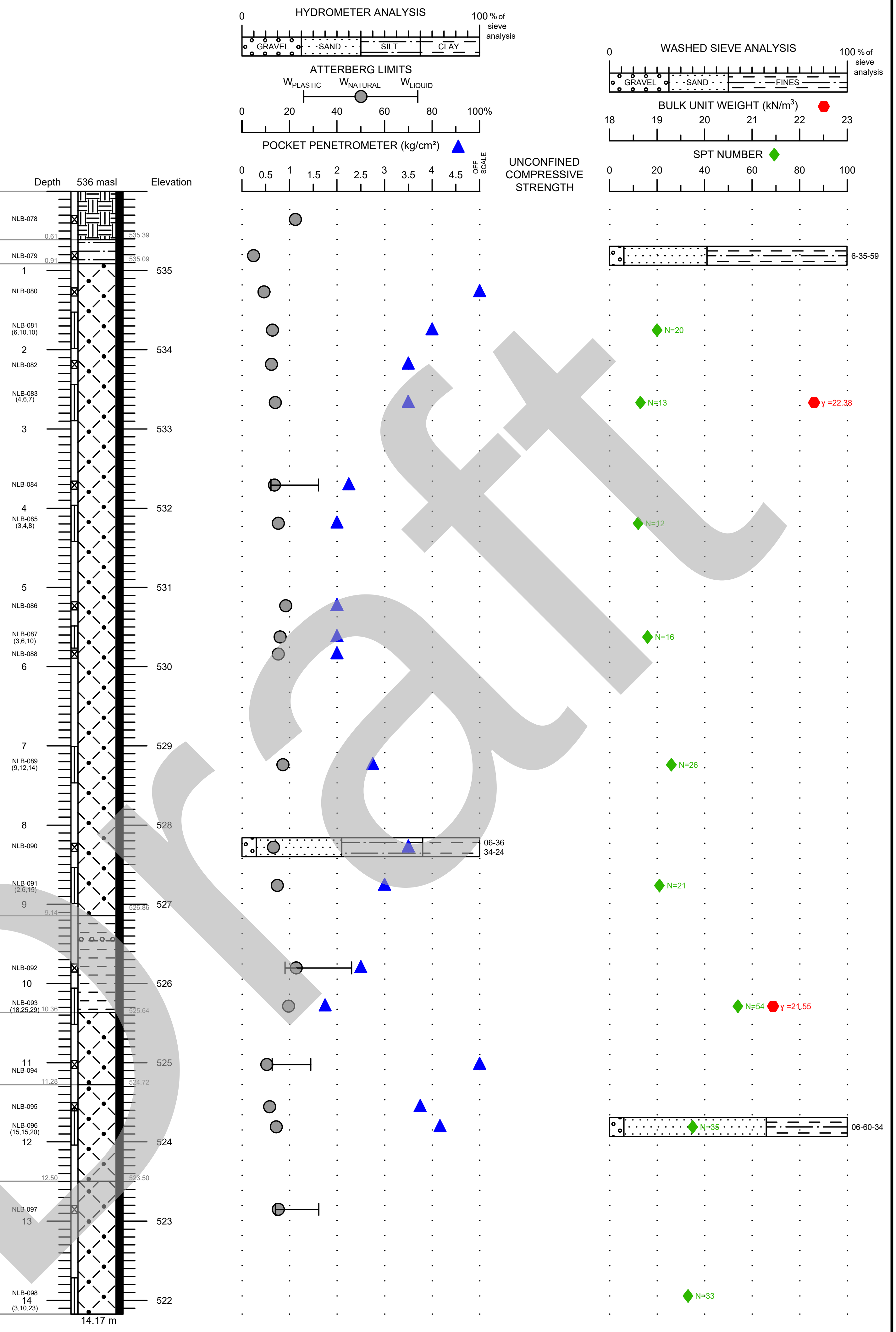
CLAY: Very stiff, moist, dark brown, oxidized, clay, some silt, trace sand, highly calcareous, medium to high plastic

- at 9.45 m: cobble

OXIDIZED TILL: Hard, moist, dark brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

OXIDIZED TILL: Dense, moist, brown, oxidized, sand (fine to coarse), silty, trace clay, trace gravel (fine to coarse), non plastic to low plastic (till)

OXIDIZED TILL: Hard, moist, dark brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)



REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

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CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	A. MARLOWE
OPERATOR	E. SERHAN	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-14
ABANDONMENT	BACKFILLED WITH CUTTINGS	**INSTALLATION DATE**	N/A

CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:60	**DATE**	2022-07-12

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\BH-659183-BH22-04 (SHII 7).dwg

BOREHOLE 22-05 (PHII 6)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5773227 N   397397 E
NAD 83 ZONE 13 U
SW 09-36-04-W3M

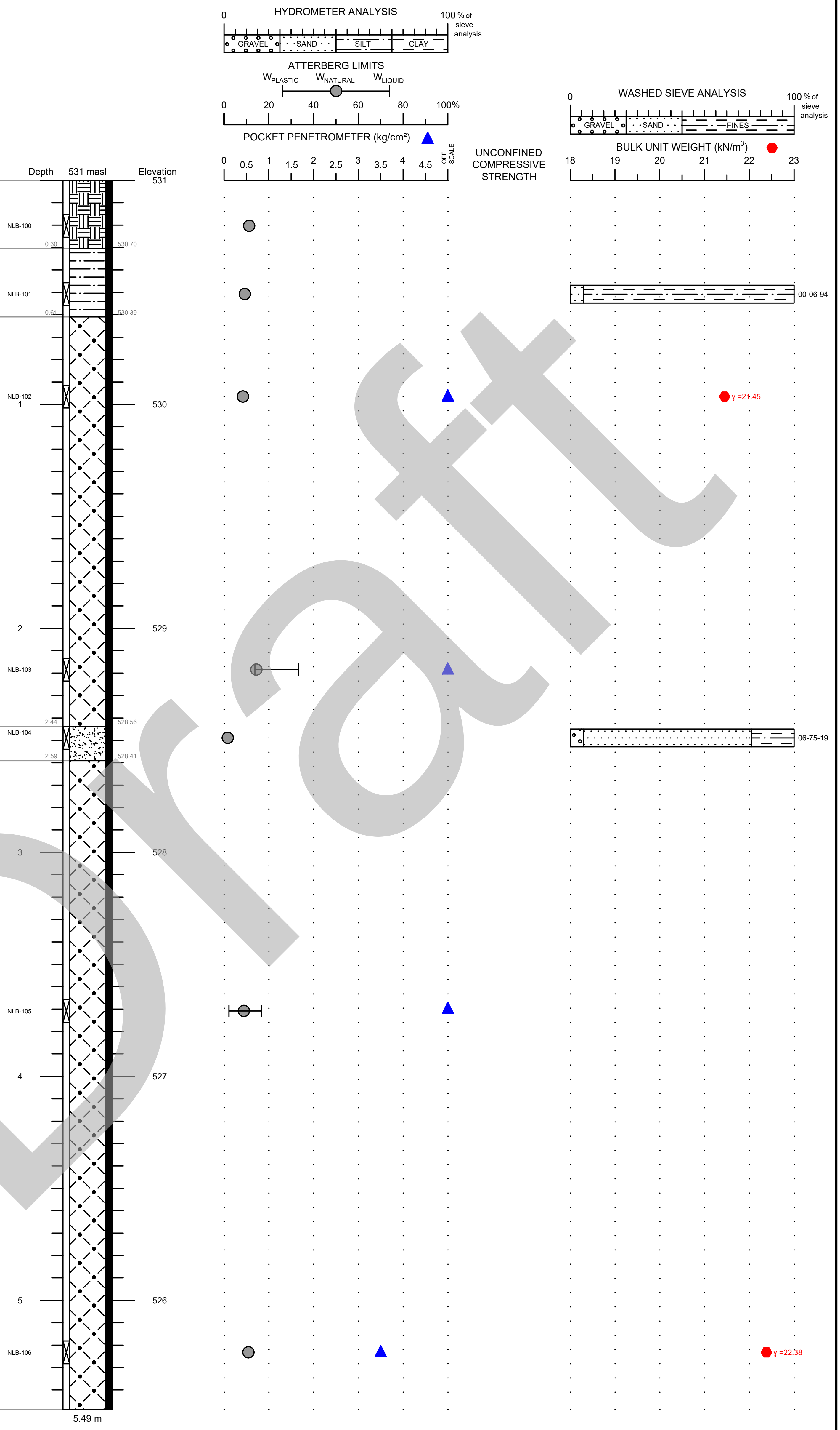
TOPSOIL: firm to stiff, moist, black, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic

SILT: firm, moist, brown, oxidized, silt, trace sand (fine to coarse), trace clay, low to non plastic

OXIDIZED TILL: hard, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SAND: loose to compact, moist, brown, oxidized, sand (fine to coarse), some silt, trace gravel (fine to medium), non plastic

OXIDIZED TILL: hard, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)



REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with cuttings and bentonite chips to surface.
3. Depths are in metres (m).
4. Elevations are in metres above sea level (masl).
5. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	A. MARLOWE
OPERATOR	E. SERHAN	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-14
ABANDONMENT	BACKFILLED WITH CUTTINGS	**INSTALLATION DATE**	N/A

CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

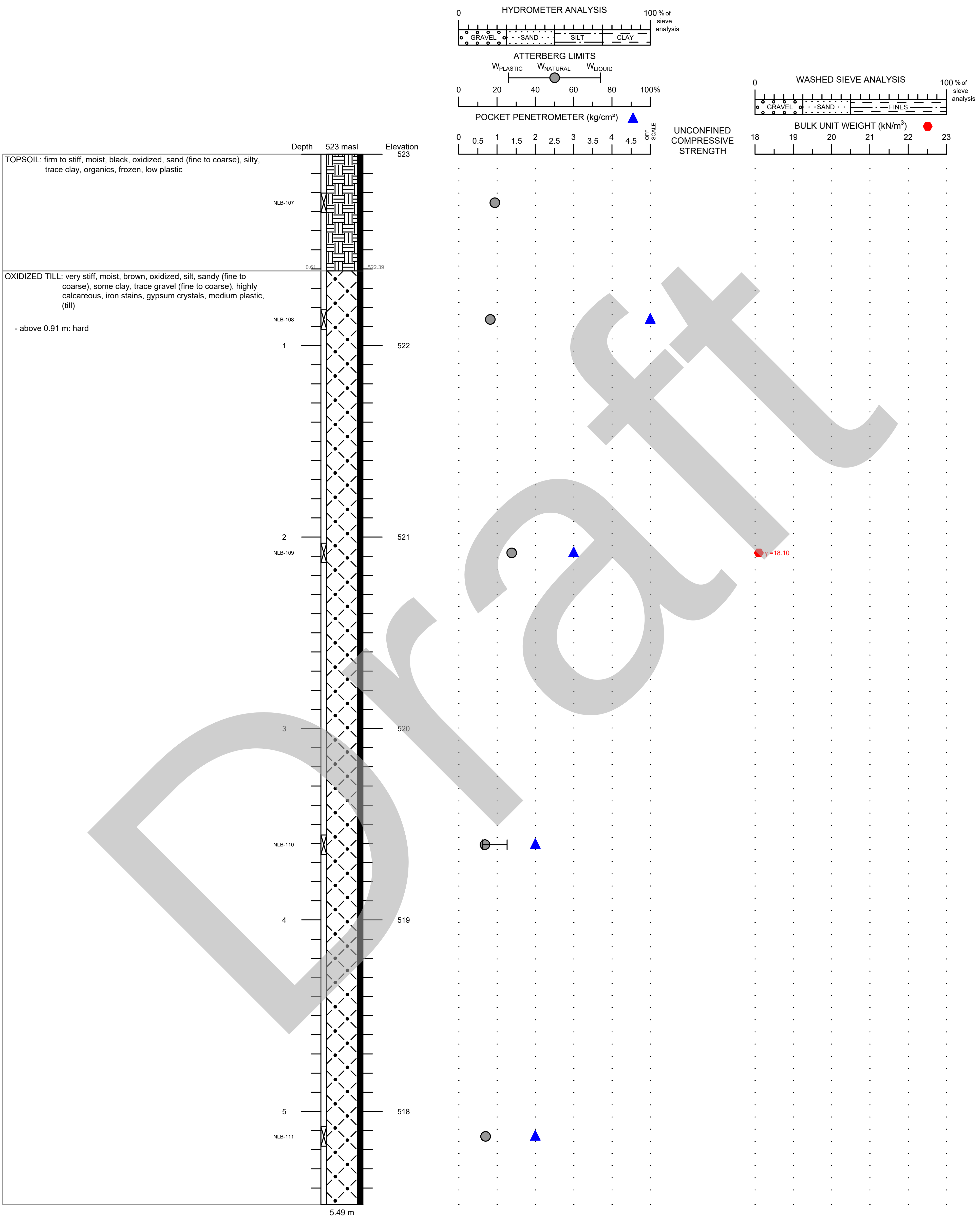
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:20	**DATE**	2022-07-12

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-06 (PHII 5)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5775684 N   397413 E
NAD 83 ZONE 13 U
SW 10-36-04-W3M



TOPSOIL: firm to stiff, moist, black, oxidized, sand (fine to coarse), silty, trace clay, organics, frozen, low plastic

OXIDIZED TILL: very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic, (till)

- above 0.91 m: hard

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with cuttings and bentonite chips to surface.
3. Depths are in metres (m).
4. Elevations are in metres above sea level (masl).
5. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

SNC·LAVALIN

CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:20	**DATE**	2022-07-12

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	A. MARLOWE
OPERATOR	E. SERHAN	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-14
ABANDONMENT	BACKFILLED WITH CUTTINGS	**INSTALLATION DATE**	N/A

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

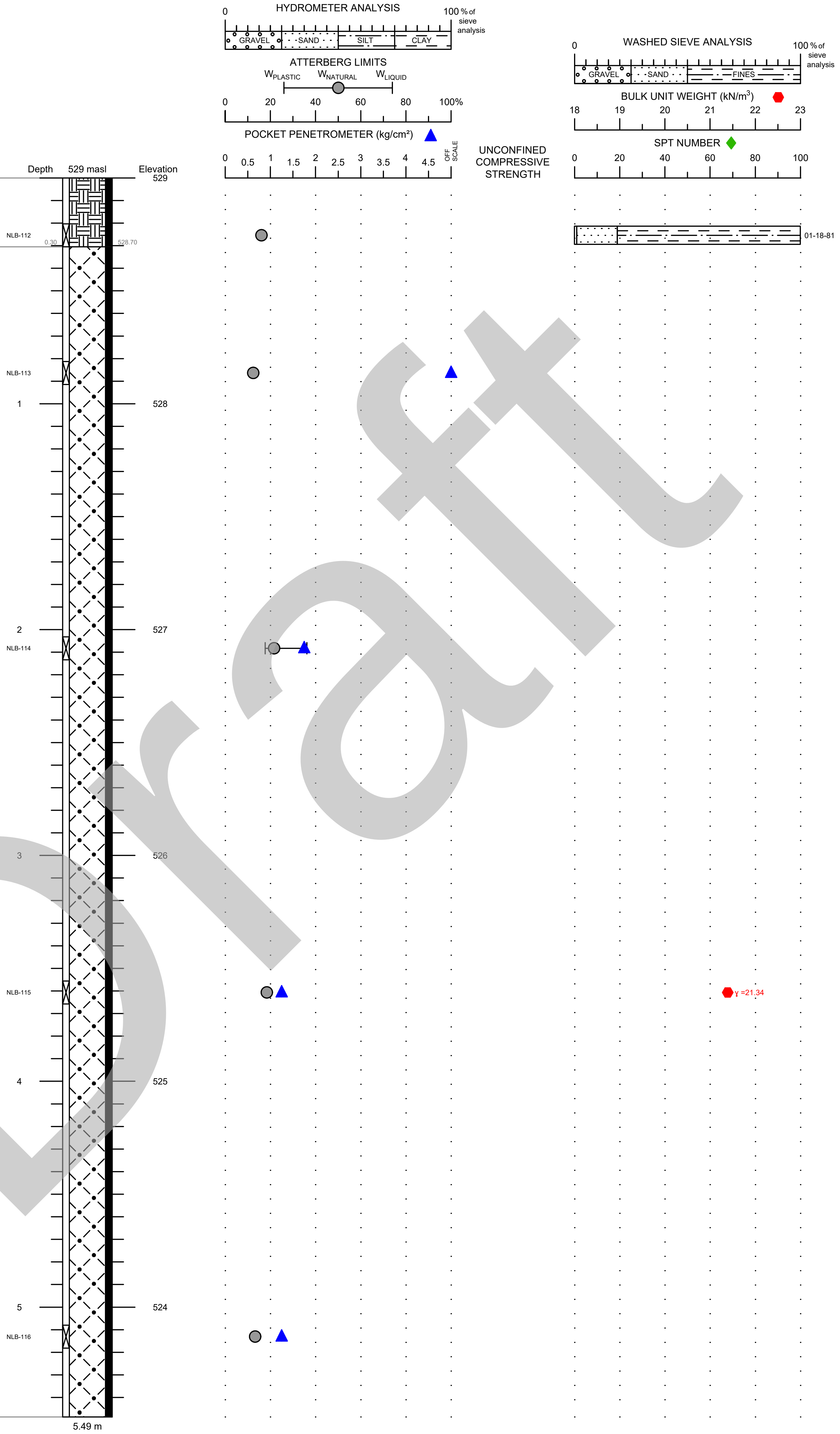
BOREHOLE 22-07 (PHII 4)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5777291 N 397345 E
NAD 83 ZONE 13 U
SW 10-36-04-W3M

TOPSOIL: firm to stiff, moist, black, oxidized, sand (fine to coarse), silty, trace clay, organics, frozen, low plastic

OXIDIZED TILL: stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- above 0.91 m: hard



REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with cuttings and bentonite chips to surface.
3. Depths are in metres (m).
4. Elevations are in metres above sea level (masl).
5. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

SNC·LAVALIN

CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:20	**DATE**	2022-07-12

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

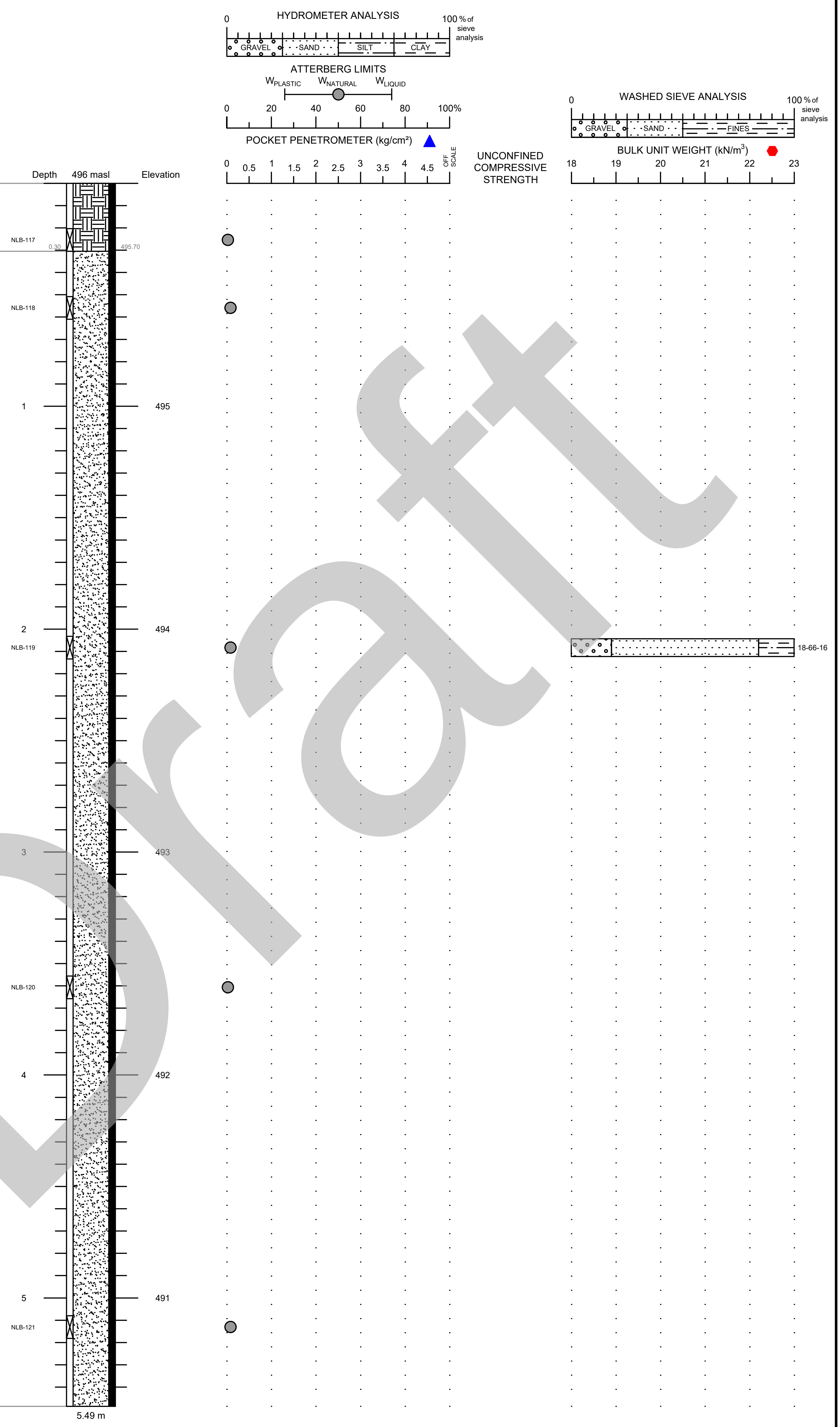
CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	A. MARLOWE
OPERATOR	E. SERHAN	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-14
ABANDONMENT	BACKFILLED WITH CUTTINGS	**INSTALLATION DATE**	N/A

BOREHOLE 22-08 (PHII 1)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5784851 N   390755 E
NAD 83 ZONE 13 U
NW 25-35-05-W3M

TOPSOIL: firm to stiff, moist, black, oxidized, sand (fine to coarse), silty, trace clay, organics, frozen, low plastic

SAND: loose, dry, brown, oxidized, sand (fine to coarse), some silt, some gravel (fine to coarse), non plastic



REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with cuttings and bentonite chips to surface.
3. Depths are in metres (m).
4. Elevations are in metres above sea level (masl).
5. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

SNC·LAVALIN

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	A. MARLOWE
OPERATOR	E. SERHAN	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-15
ABANDONMENT	BACKFILLED WITH CUTTINGS	**INSTALLATION DATE**	N/A

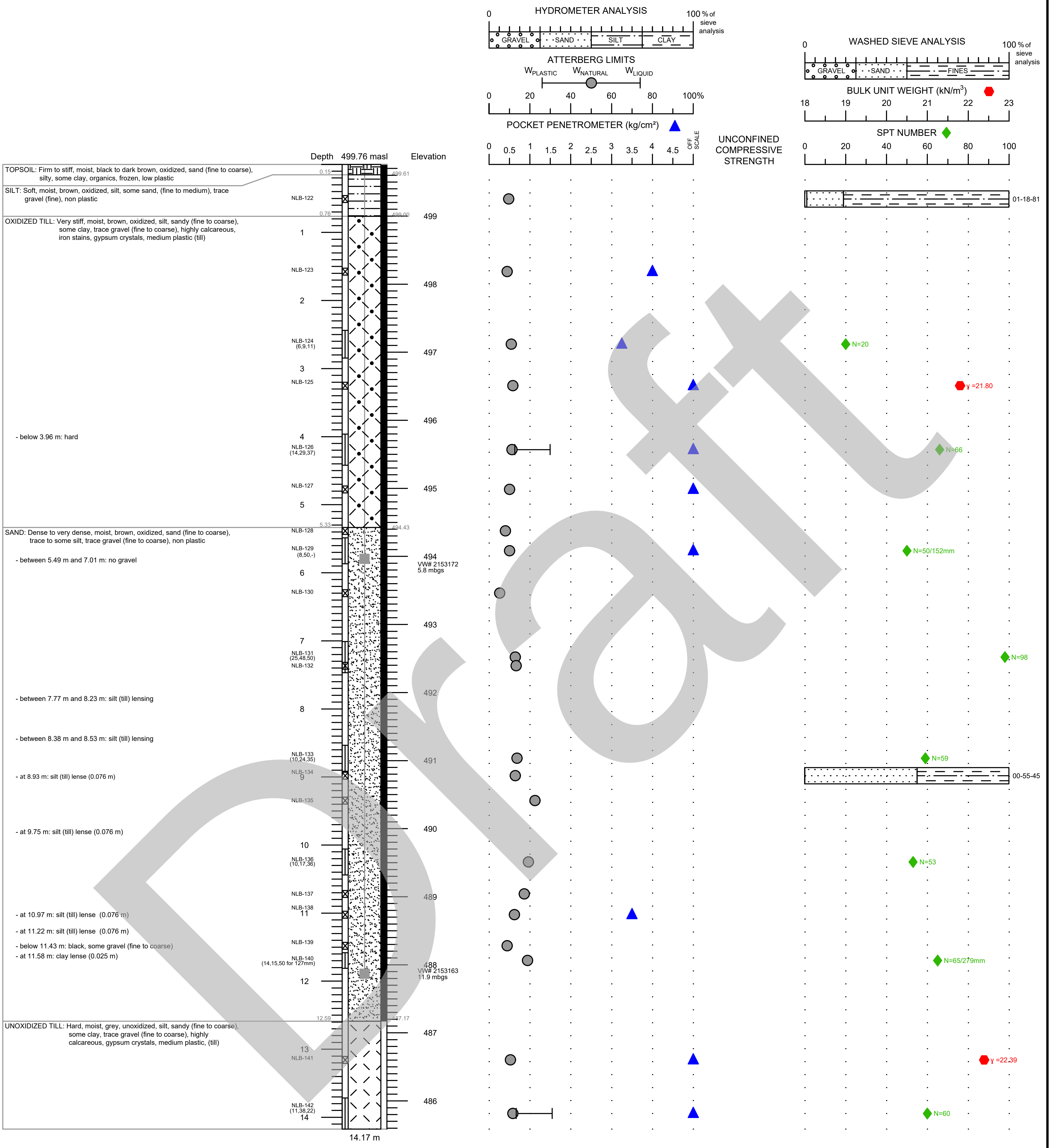
CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:20	**DATE**	2022-07-12

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-09 (SHII 2)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5784131.83 N 392645.44 E
NAD 83 ZONE 13 U
NE 09-36-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SILT: Soft, moist, brown, oxidized, silt, some sand, (fine to medium), trace gravel (fine), non plastic

OXIDIZED TILL: Very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- below 3.96 m: hard

SAND: Dense to very dense, moist, brown, oxidized, sand (fine to coarse), trace to some silt, trace gravel (fine to coarse), non plastic

- between 5.49 m and 7.01 m: no gravel
- between 7.77 m and 8.23 m: silt (till) lensing
- between 8.38 m and 8.53 m: silt (till) lensing
- at 8.93 m: silt (till) lense (0.076 m)
- at 9.75 m: silt (till) lense (0.076 m)
- at 10.97 m: silt (till) lense (0.076 m)
- at 11.22 m: silt (till) lense (0.076 m)
- below 11.43 m: black, some gravel (fine to coarse)
- at 11.58 m: clay lense (0.025 m)

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic, (till)

VW Serial Number	Total Head (masl)
2153172	493.51
2153163	490.86

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

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CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:60	**DATE**	2022-07-12

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S. RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-19
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-19

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\BH-659183-BH22-09 (SHII 2).dwg

BOREHOLE 22-10 (PHII 2)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

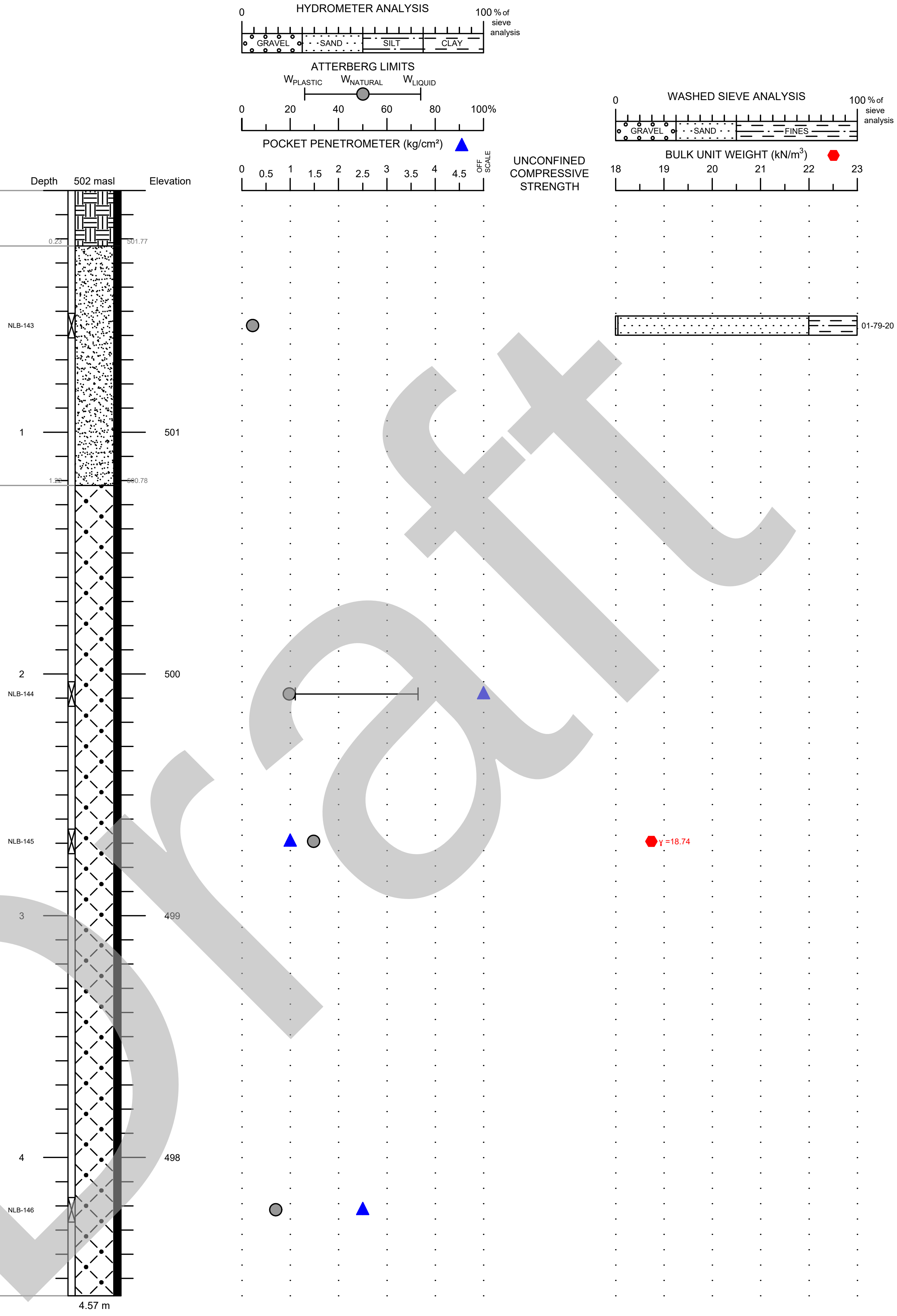
5784292 N   393964 E
NAD 83 ZONE 13 U
NW 25-35-05-W3M

TOPSOIL: firm to stiff, moist, black, oxidized, sand (fine to coarse), silty, trace clay, organics, frozen, low plastic

SAND: loose, moist, brown, oxidized, sand (fine to medium), some silt, trace gravel (fine), organics, non plastic

OXIDIZED TILL: hard, moist, brown, oxidized, silt, some sand to sandy (fine to coarse), some clay to clayey, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, high plastic (till)

- between 2.74 m and 3.96 m: firm to stiff
- below 3.96 m: very stiff



REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with cuttings and bentonite chips to surface.
3. Depths are in metres (m).
4. Elevations are in metres above sea level (masl).
5. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS survey, 2022).

SNC · LAVALIN

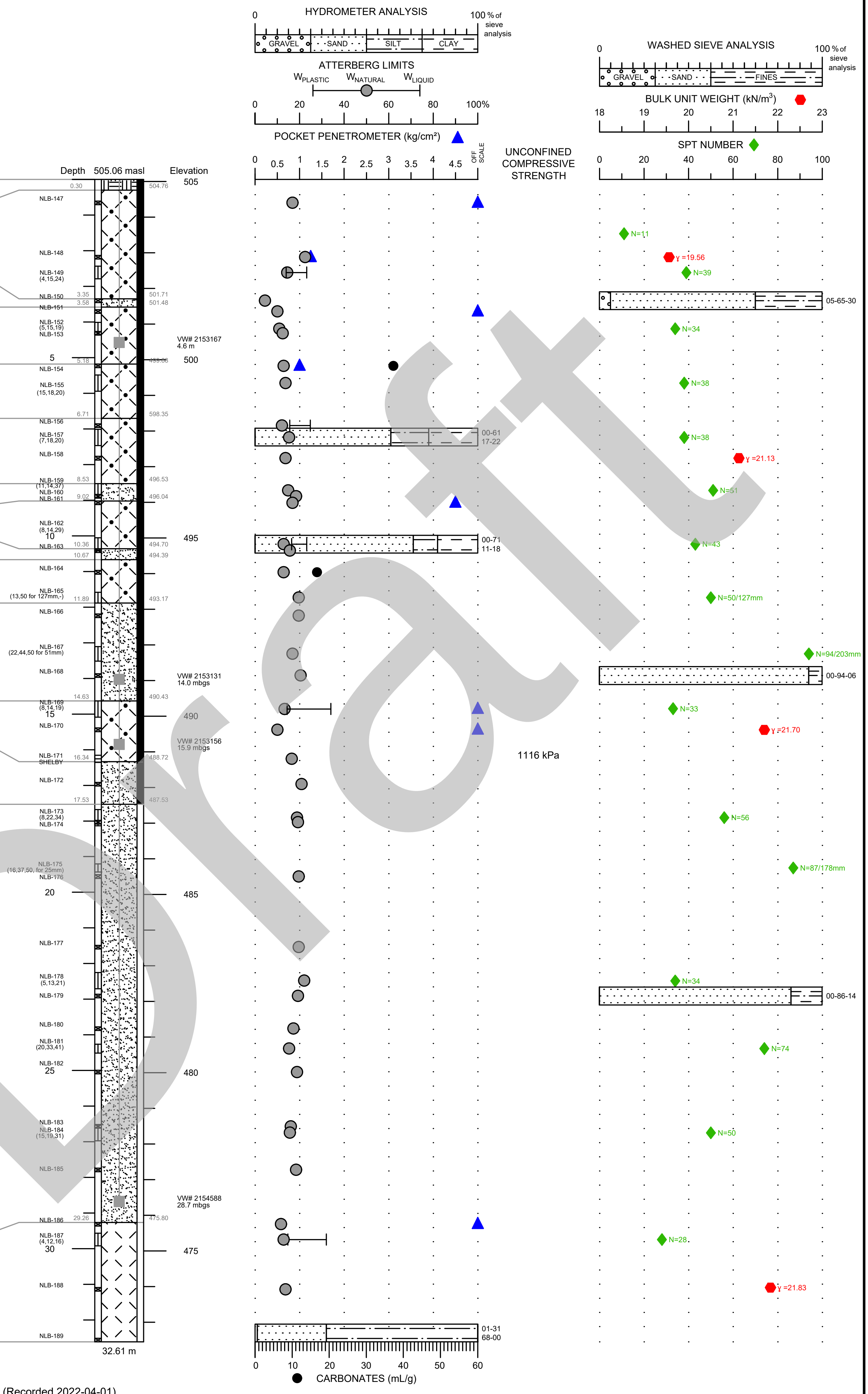
CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:20	**DATE**	2022-07-12

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	R. CANNON
OPERATOR	E. SERHAN	**LOGGED BY**	R. CANNON
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-19
ABANDONMENT	BACKFILLED WITH CUTTINGS	**INSTALLATION DATE**	N/A

BOREHOLE 22-11 (FHII 3)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5783581.89 N   396037.94 E
NAD 83 ZONE 13 U
SE 16-37-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

OXIDIZED TILL: Firm, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to medium), highly calcareous, gypsum crystals, low to medium plastic (till)
- above 0.91 m: hard
- at 0.91 m: sand lense (fine to coarse), white
- below 2.74 m: very stiff, iron stains

SAND: Loose, moist, brown, oxidized, sand (fine to coarse), silty, trace gravel (fine to coarse), non plastic

OXIDIZED TILL: Stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

OXIDIZED TILL: Compact, moist, greyish brown, oxidized, sand (fine to coarse), silty, trace clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, low plastic (till)

OXIDIZED TILL: Dense, moist, brown, oxidized, sand (fine to coarse), some silt, some clay, trace gravel (fine), highly calcareous, gypsum crystals, low plastic (till)

SAND: Very dense, moist, brown, oxidized, sand (fine to coarse), trace silt, trace gravel (fine), non plastic

OXIDIZED TILL: Very dense, moist, mottled brown and grey, oxidized, sand (fine to coarse), some silt, some clay, trace gravel (fine), highly calcareous, iron stains, gypsum crystals, low plastic (till)

SAND: Dense, moist, brown, oxidized, sand (fine to coarse), some silt to silty, trace gravel (fine), non plastic

OXIDIZED TILL: Very dense, moist, mottled brown and grey, oxidized, sand, (fine to coarse), some silt, trace clay, trace gravel (fine), highly calcareous, iron staining, gypsum crystals, low plastic (till)

SAND: Very dense, moist, brown, oxidized, sand (fine to coarse), trace silt, trace gravel (fine), non plastic

OXIDIZED TILL: Hard, moist, grey, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SAND: Very dense, moist, brown, oxidized, sand (fine to coarse), some silt to silty, trace gravel (fine), non plastic
- below 17.07 m: mottled brown and grey

SAND: Very dense, moist, grey, unoxidized, sand (fine to coarse), some silt to silty, trace gravel (fine to coarse), non plastic
- below 26.97 m: no gravel, silt lensing throughout
- at 29.26 m: sand (fine to coarse) and gravel (fine to coarse) lense (0.05 m)

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

VW Serial Number	Total Head (masl)
2153167	501.85
2153131	499.35
2153156	499.22
2154588	497.99

(Recorded 2022-04-01)

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.36.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

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CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	R. CANNON
OPERATOR	E. SERHAN	**LOGGED BY**	R. CANNON
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-20
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-20

CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:125	**DATE**	2022-07-12

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\BH-659183-BH22-11 (FHII 3).dwg

BOREHOLE 22-12 (FHII 4)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5783705.10 N   396236.36 E
NAD 83 ZONE 13 U
SW 15-36-04-W3M

TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Loose, moist, brown, oxidized, sand (fine to medium), some silt, trace gravel (fine), non plastic

OXIDIZED TILL: Stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, some cobble (0.1m to 0.15m), trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- above 1.22 m: organics
- at 1.22 m: cobble
- below 3.66 m: very stiff to hard
- at 3.66 m: cobble
- below 4.27 m: hard
- at 4.88 m: boulder (0.3 m)

OXIDIZED TILL: Hard, moist, brown, oxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- at 6.55 m: cobble (0.13 m)

SAND: Compact, moist, brown, oxidized, sand (fine to coarse), silty, non plastic

- below 7.16 m: some silt

OXIDIZED TILL: Very dense, moist, mottled grey and brown, oxidized, sand (fine to coarse), clayey, some silt, highly calcareous, iron stains, gypsum crystals, low plastic (till)

SAND: Very dense, moist, greyish brown, oxidized, sand (fine to coarse), silty, non plastic

- below 11.58 m: grey

SILT: Hard, moist, grey, unoxidized, silt, some sand (fine to medium), some clay, highly calcareous, organics, gypsum crystals, medium plastic

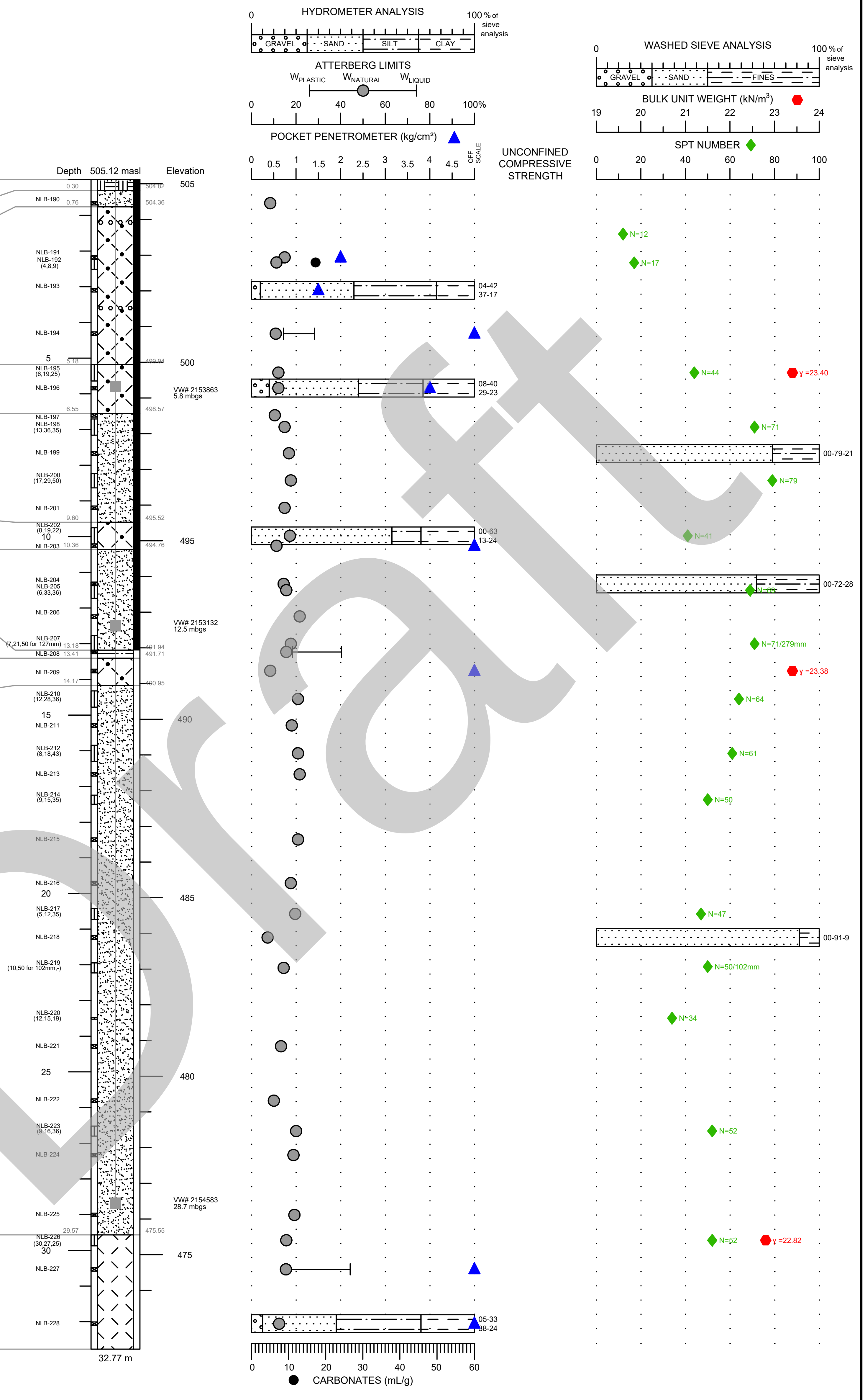
- at 13.34 m: sand seam (fine to coarse)

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, some sand (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

SAND: Very dense, moist, grey, unoxidized, sand (fine to coarse), trace to some silt, non plastic

- between 19.81 m and 20.42 m: light grey
- below 23.47 m: trace gravel (fine to coarse)
- below 28.80 m: silty

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)



VW Serial Number	Total Head (masl)
2153863	499.35
2153132	499.30
2154583	498.30

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.37.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

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CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	R. CANNON
OPERATOR	E. SERHAN	**LOGGED BY**	R. CANNON
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-21
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-07-12

CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY K. DORAN, P.Eng
DRAWN BY A. COLE, A.Sc.T.
PROJECT No. 659183
SCALE 1:125 **DATE** 2022-07-05

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-13 (FHII 5)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5783719.59 N   400439.47 E
NAD 83 ZONE 13 U
NE 15-36-04-W3M

TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SILT: Very soft to firm, moist, light brown, oxidized, silt, sandy (fine to coarse), trace clay, trace gravel (fine to coarse), highly calcareous, iron stains, organics, gypsum crystals, low plastic (till)

OXIDIZED TILL: Firm, moist, mottled grey and brown, oxidized, sand (fine to coarse), silty, some clay, trace gravel (fine to coarse), highly calcareous, iron stains, organics, gypsum crystals, low plastic (till)

SAND: Loose, wet, brown, oxidized, sand (fine to coarse) and gravel (fine to coarse), trace silt, non plastic

OXIDIZED TILL: Very stiff, moist, greyish brown, oxidized, silt, clayey, some sand (fine to coarse), trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium to high plastic (till)

SAND: Loose to compact, moist, brown, oxidized, sand (fine to coarse), trace silt, trace gravel (fine to coarse), non plastic

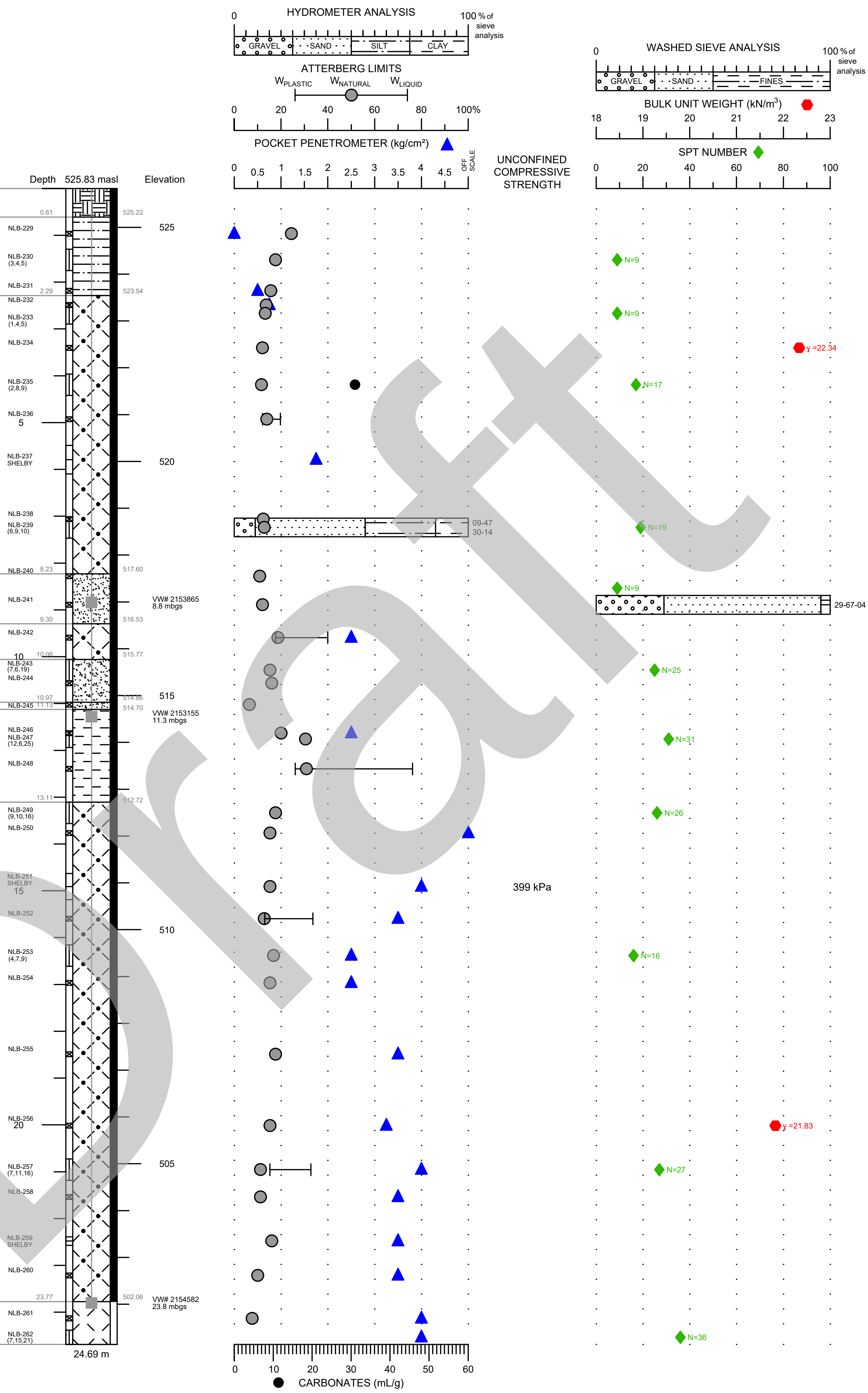
SAND: Loose-compact, moist, brown, oxidized, sand (fine to coarse) and gravel (fine to coarse), trace silt, non plastic

CLAY: Very stiff, moist, greyish brown, oxidized, clay, silty, trace sand, highly calcareous, gypsum crystals, high plastic

OXIDIZED TILL: Very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- below 16.15 m: grey

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)



VW Serial Number	Total Head (masl)
2153865	526.57
2153155	521.15
2154582	515.02

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

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CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-22
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-22

CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-12

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-14 (FHII 2)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5784010.09 N   395686.34 E
NAD 83 ZONE 13 U
NW 19-37-04-W3M

TOPSOIL: Stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Loose, moist, brown, oxidized, sand (fine to medium), some silt to silty, trace gravel (fine), non plastic
- at 1.2 m: cobble 254mm
- at 1.47 m: Silt till lense 51mm

SAND: Dense, moist, brown, oxidized, sand (fine to coarse), some silt, non plastic
- below 1.83 m: Intermittent sand till lensing

OXIDIZED TILL: Very stiff to hard, moist, brown, oxidized, sand (fine to coarse), some silt, trace clay, trace gravel (fine), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SAND: Dense, moist, brown, oxidized, sand (fine to coarse), some silt, trace gravel (fine), non plastic

OXIDIZED TILL: Hard, moist, mottled brown and grey, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SAND: Very dense, moist, brown, oxidized, sand (fine to coarse), trace silt, non plastic
- below 7.0 m: trace to some silt
- at 8.8 m: silt till seam 76mm
- below 9.2 m: grey and brown
- at 9.45 m: gravel seam (fine to coarse)

OXIDIZED TILL: Hard, moist, mottled brown and grey, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

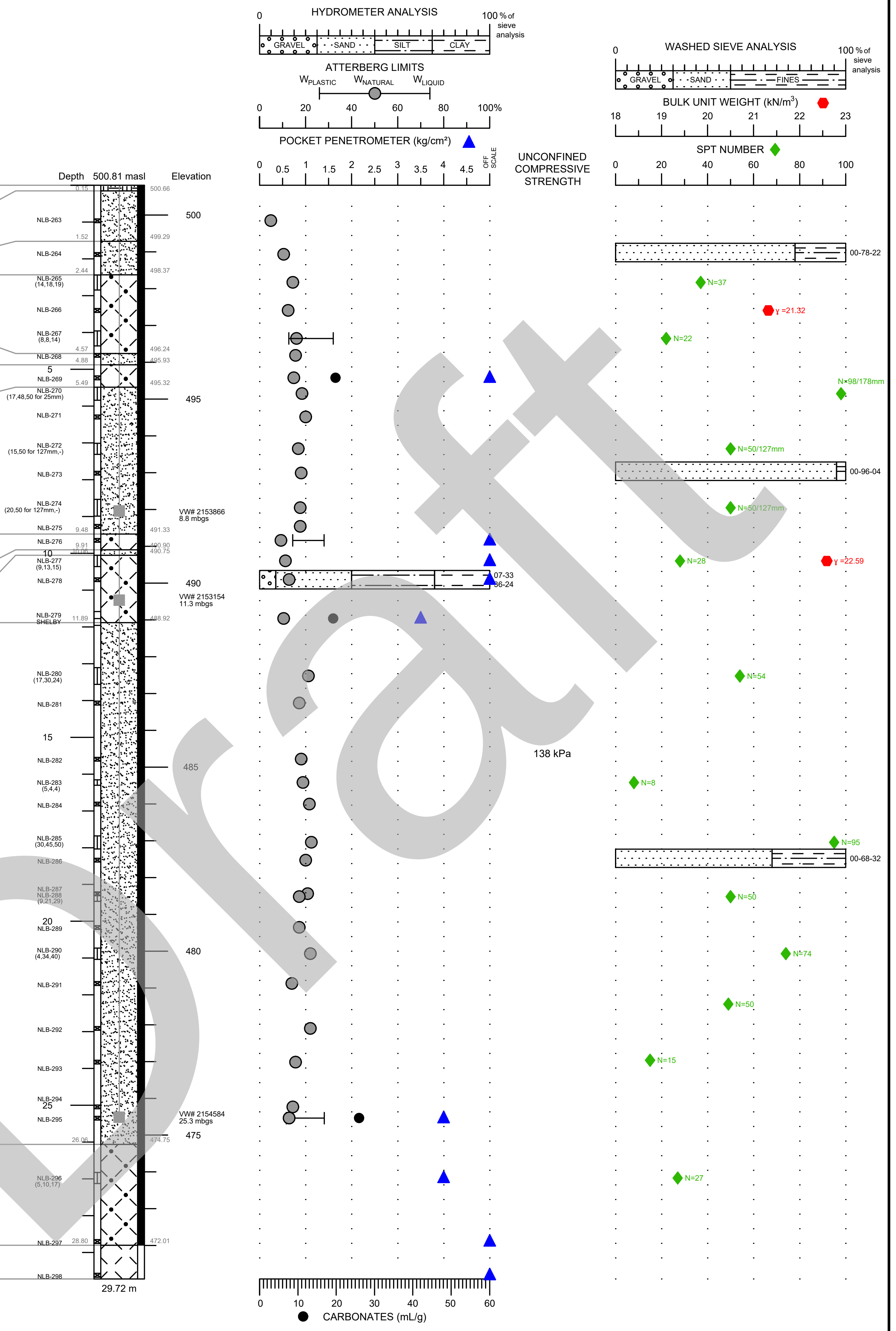
SAND: Compact, moist, brown, oxidized, sand (fine to coarse), some silt, trace gravel (fine), non plastic

OXIDIZED TILL: Hard, moist, mottled brown and grey, oxidized, silt, sandy (fine to coarse), clayey, trace to some gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SAND: Compact, moist, brown, oxidized, sand (fine to coarse), some silt, trace clay, trace gravel (fine), non plastic
- between 14 m and 17.3 m: loose, wet
- between 17.3 m and 18.6 m: silty, dense
- below 18.6 m: trace silt

OXIDIZED TILL: Hard, moist, grey, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)



VW Serial Number	Total Head (masl)
2153866	497.41
2153154	497.15
2154584	495.83

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.38.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

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CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng
DRAWN BY	A. COLE, A.Sc.T.
PROJECT No.	659183
SCALE	1:125
DATE	2022-07-12

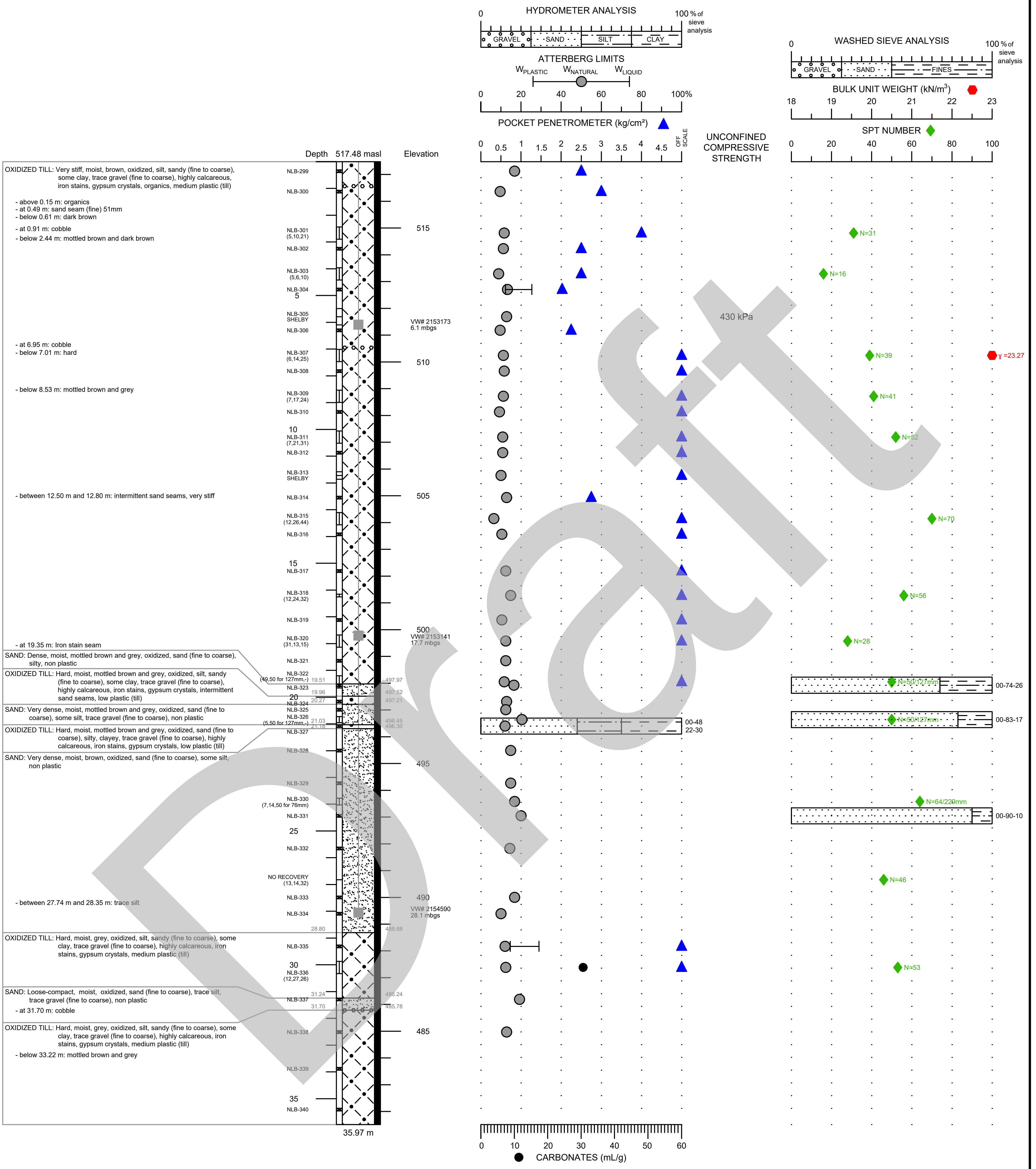
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S. RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-22
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-22

BOREHOLE 22-15 (FHII 6)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5780587.75 N 397296.46 E
NAD 83 ZONE 13 U
NW 27-36-04-W3M



OXIDIZED TILL: Very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, organics, medium plastic (till)

- above 0.15 m: organics
- at 0.49 m: sand seam (fine) 51mm
- below 0.61 m: dark brown
- at 0.91 m: cobble
- below 2.44 m: mottled brown and dark brown
- at 6.95 m: cobble
- below 7.01 m: hard
- below 8.53 m: mottled brown and grey
- between 12.50 m and 12.80 m: intermittent sand seams, very stiff
- at 19.35 m: Iron stain seam

SAND: Dense, moist, mottled brown and grey, oxidized, sand (fine to coarse), silty, non plastic

OXIDIZED TILL: Hard, moist, mottled brown and grey, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, intermittent sand seams, low plastic (till)

SAND: Very dense, moist, mottled brown and grey, oxidized, sand (fine to coarse), some silt, trace gravel (fine to coarse), non plastic

OXIDIZED TILL: Hard, moist, mottled brown and grey, oxidized, sand (fine to coarse), silty, clayey, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, low plastic (till)

SAND: Very dense, moist, brown, oxidized, sand (fine to coarse), some silt, non plastic

- between 27.74 m and 28.35 m: trace silt

OXIDIZED TILL: Hard, moist, grey, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SAND: Loose-compact, moist, oxidized, sand (fine to coarse), trace silt, trace gravel (fine to coarse), non plastic

- at 31.70 m: cobble

OXIDIZED TILL: Hard, moist, grey, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- below 33.22 m: mottled brown and grey

VW Serial Number	Total Head (masl)
2153173	511.11
2153141	521.82
2154590	504.65

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.36.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:150	**DATE**	2022-07-12

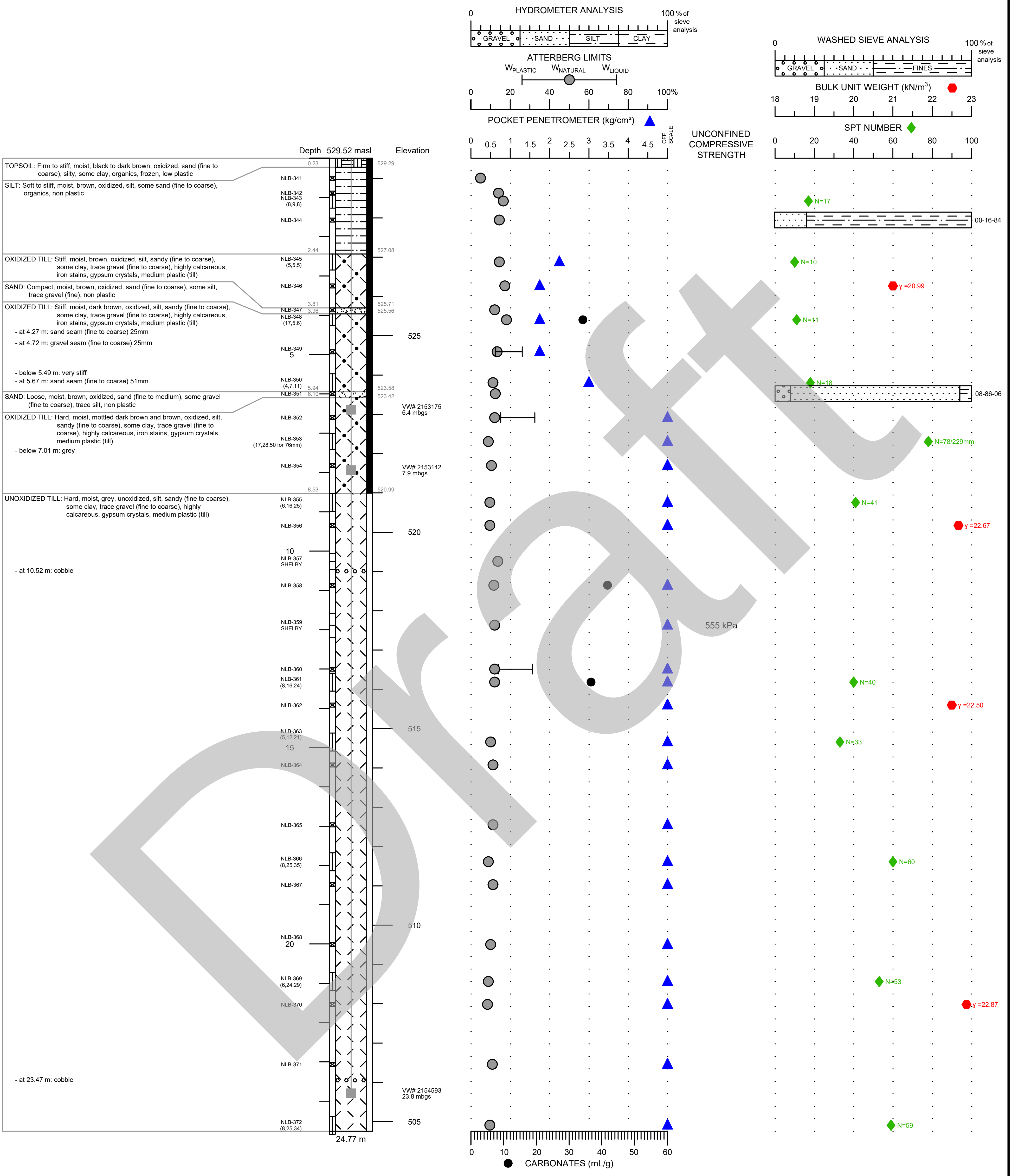
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-23
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-23

BOREHOLE 22-16 (FHII 9)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5778077.49 N   397387.02 E
NAD 83 ZONE 13 U
NW 19-37-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SILT: Soft to stiff, moist, brown, oxidized, silt, some sand (fine to coarse), organics, non plastic

OXIDIZED TILL: Stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SAND: Compact, moist, brown, oxidized, sand (fine to coarse), some silt, trace gravel (fine), non plastic

OXIDIZED TILL: Stiff, moist, dark brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)
- at 4.27 m: sand seam (fine to coarse) 25mm
- at 4.72 m: gravel seam (fine to coarse) 25mm
- below 5.49 m: very stiff
- at 5.67 m: sand seam (fine to coarse) 51mm

SAND: Loose, moist, brown, oxidized, sand (fine to medium), some gravel (fine to coarse), trace silt, non plastic

OXIDIZED TILL: Hard, moist, mottled dark brown and brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)
- below 7.01 m: grey

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)
- at 10.52 m: cobble
- at 23.47 m: cobble

VW Serial Number	Total Head (masl)
2153175	520.34
2153142	523.47
2154593	521.55

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.40.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

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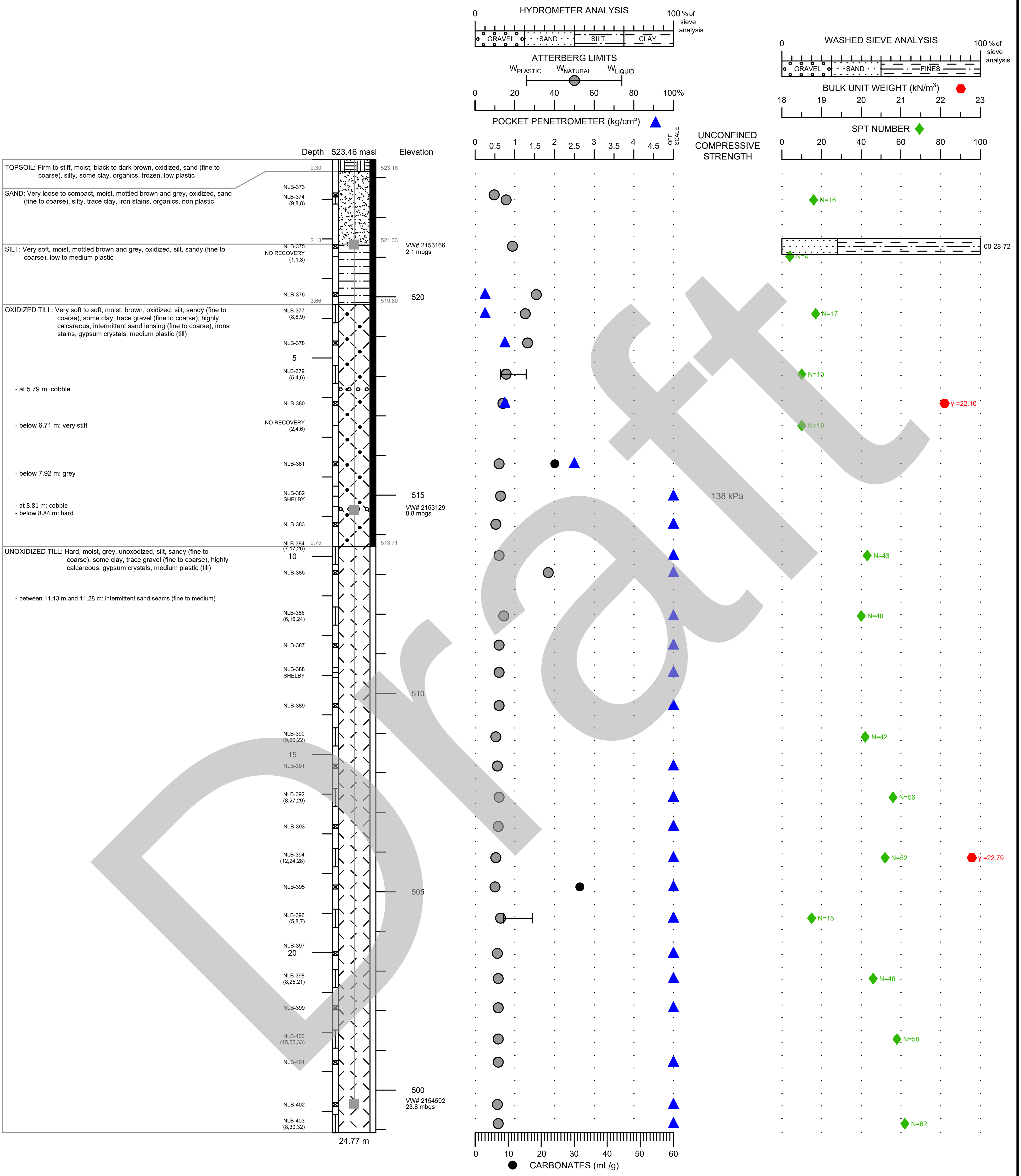
CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-24
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-24

CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-12

LIMITATION

BOREHOLE 22-17 (FHII 10)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5777926.99 N   397085.68 E
NAD 83 ZONE 13 U
NE 19-37-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Very loose to compact, moist, mottled brown and grey, oxidized, sand (fine to coarse), silty, trace clay, iron stains, organics, non plastic

SILT: Very soft, moist, mottled brown and grey, oxidized, silt, sandy (fine to coarse), low to medium plastic

OXIDIZED TILL: Very soft to soft, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, intermittent sand lensing (fine to coarse), irons stains, gypsum crystals, medium plastic (till)

- at 5.79 m: cobble
- below 6.71 m: very stiff
- below 7.92 m: grey
- at 8.81 m: cobble
- below 8.84 m: hard

UNOXIDIZED TILL: Hard, moist, grey, unoxodized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

- between 11.13 m and 11.28 m: intermittent sand seams (fine to medium)

VW Serial Number	Total Head (masl)
2153166	521.18
2153129	520.94
2154592	520.42

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

SNC·LAVALIN

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	R. CANNON
OPERATOR	E.SERHAN	**LOGGED BY**	R. CANNON
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-24
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-24

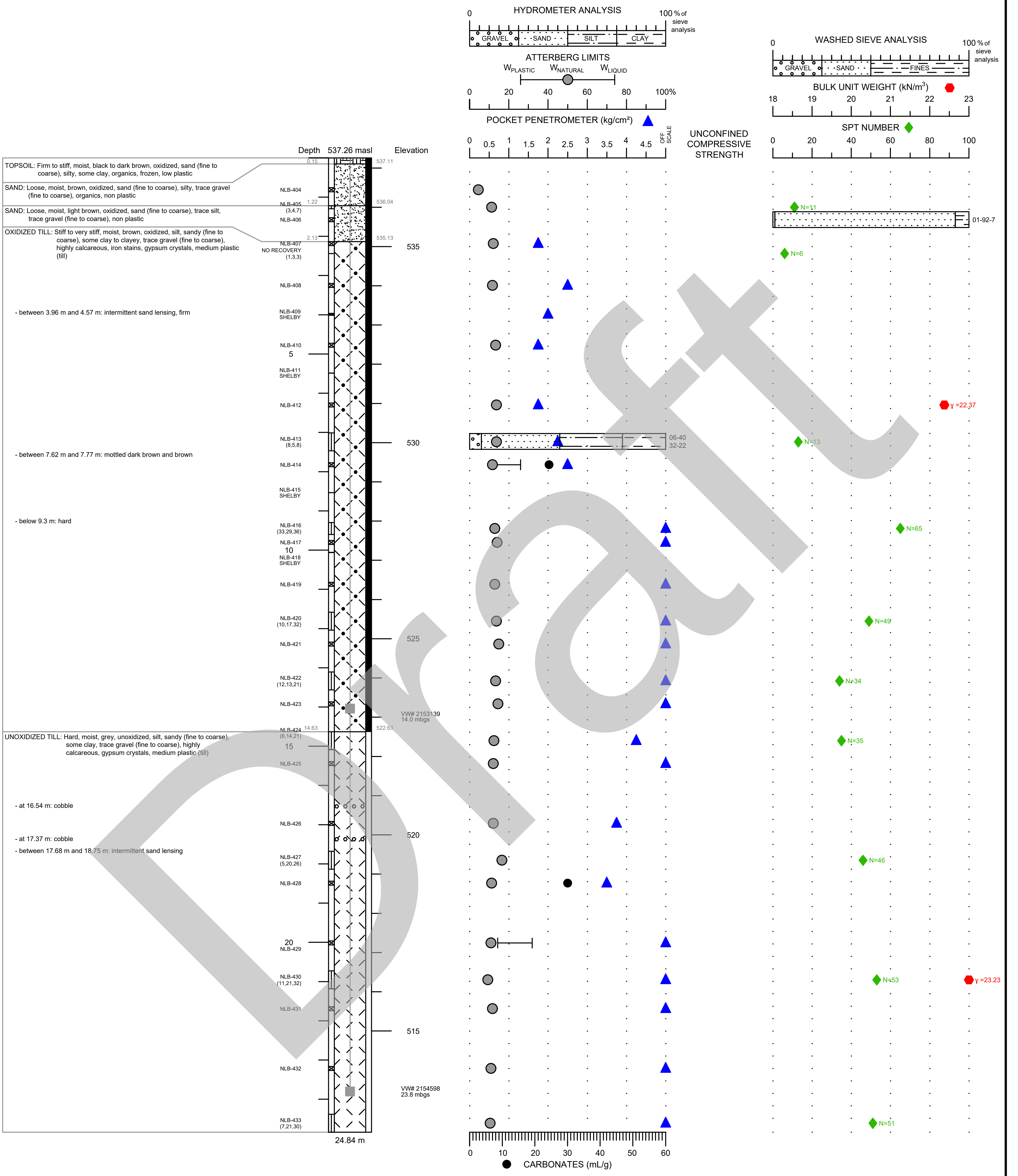
CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-05

LIMITATION

BOREHOLE 22-18 (FHII 7)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5778311.54 N   397626.55 E
NAD 83 ZONE 13 U
NW 34-36-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Loose, moist, brown, oxidized, sand (fine to coarse), silty, trace gravel (fine to coarse), organics, non plastic

SAND: Loose, moist, light brown, oxidized, sand (fine to coarse), trace silt, trace gravel (fine to coarse), non plastic

OXIDIZED TILL: Stiff to very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay to clayey, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- between 3.96 m and 4.57 m: intermittent sand lensing, firm
- between 7.62 m and 7.77 m: mottled dark brown and brown
- below 9.3 m: hard

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

- at 16.54 m: cobble
- at 17.37 m: cobble
- between 17.68 m and 18.75 m: intermittent sand lensing

VW Serial Number	Total Head (masl)
2153139	531.71
2154598	530.75

(Recorded 2022-04-01)

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.37.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	R. CANNON
OPERATOR	E.SERHAN	**LOGGED BY**	R. CANNON
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-25
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-25

SNC • LAVALIN

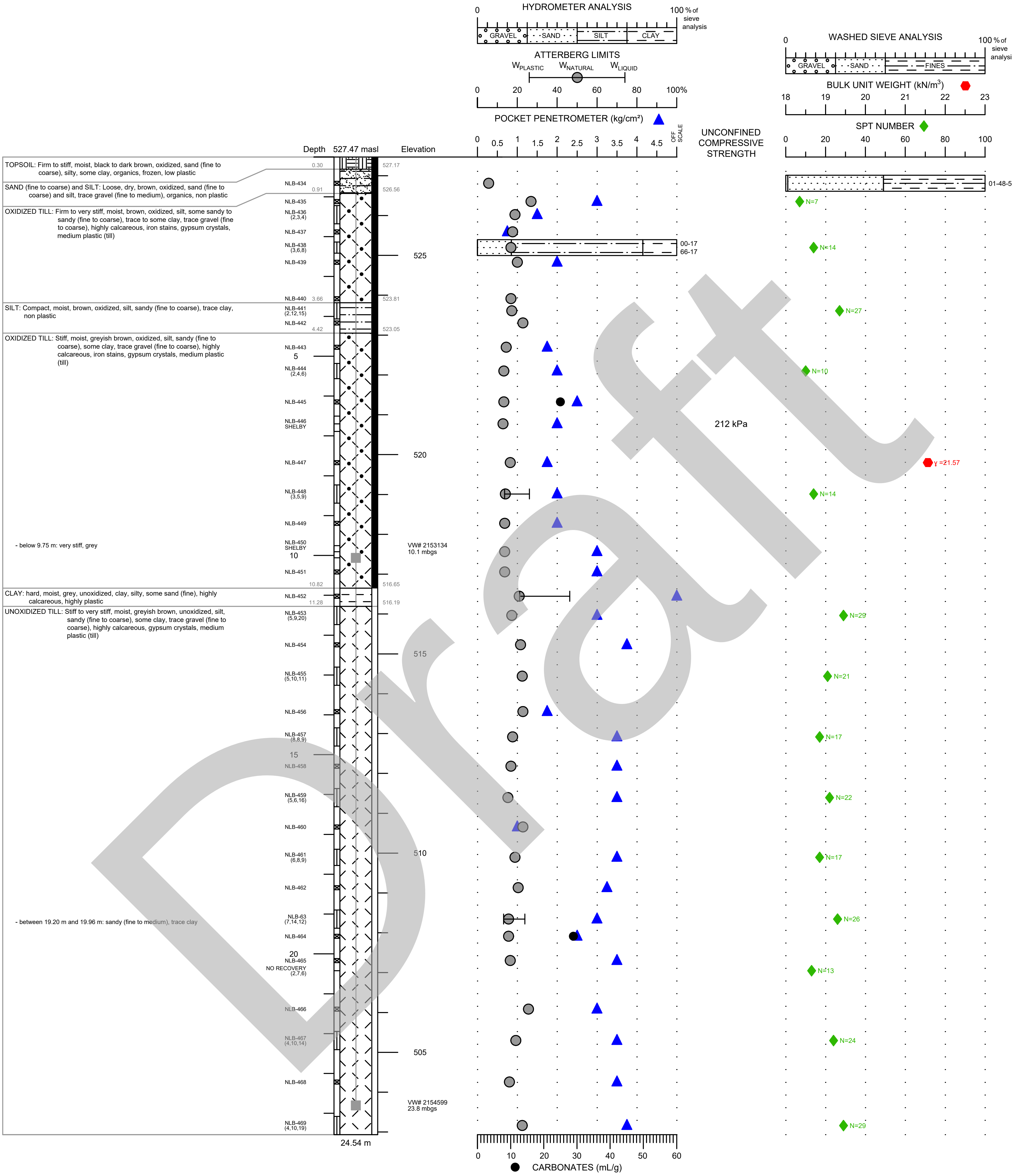
CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-05

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-19 (FHII 11)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5774878.19 N 397437.57 E
NAD 83 ZONE 13 U
SW 21-37-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND (fine to coarse) and SILT: Loose, dry, brown, oxidized, sand (fine to coarse) and silt, trace gravel (fine to medium), organics, non plastic

OXIDIZED TILL: Firm to very stiff, moist, brown, oxidized, silt, some sandy to sandy (fine to coarse), trace to some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SILT: Compact, moist, brown, oxidized, silt, sandy (fine to coarse), trace clay, non plastic

OXIDIZED TILL: Stiff, moist, greyish brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- below 9.75 m: very stiff, grey

CLAY: hard, moist, grey, unoxidized, clay, silty, some sand (fine), highly calcareous, highly plastic

UNOXIDIZED TILL: Stiff to very stiff, moist, greyish brown, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

- between 19.20 m and 19.96 m: sandy (fine to medium), trace clay

VW Serial Number	Total Head (masl)
2153134	525.89
2154599	522.67

(Recorded 2022-04-01)

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.39.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	R. CANNON
OPERATOR	E.SERHAN	**LOGGED BY**	R. CANNON
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-25
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-25

SNC • LAVALIN

CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-12

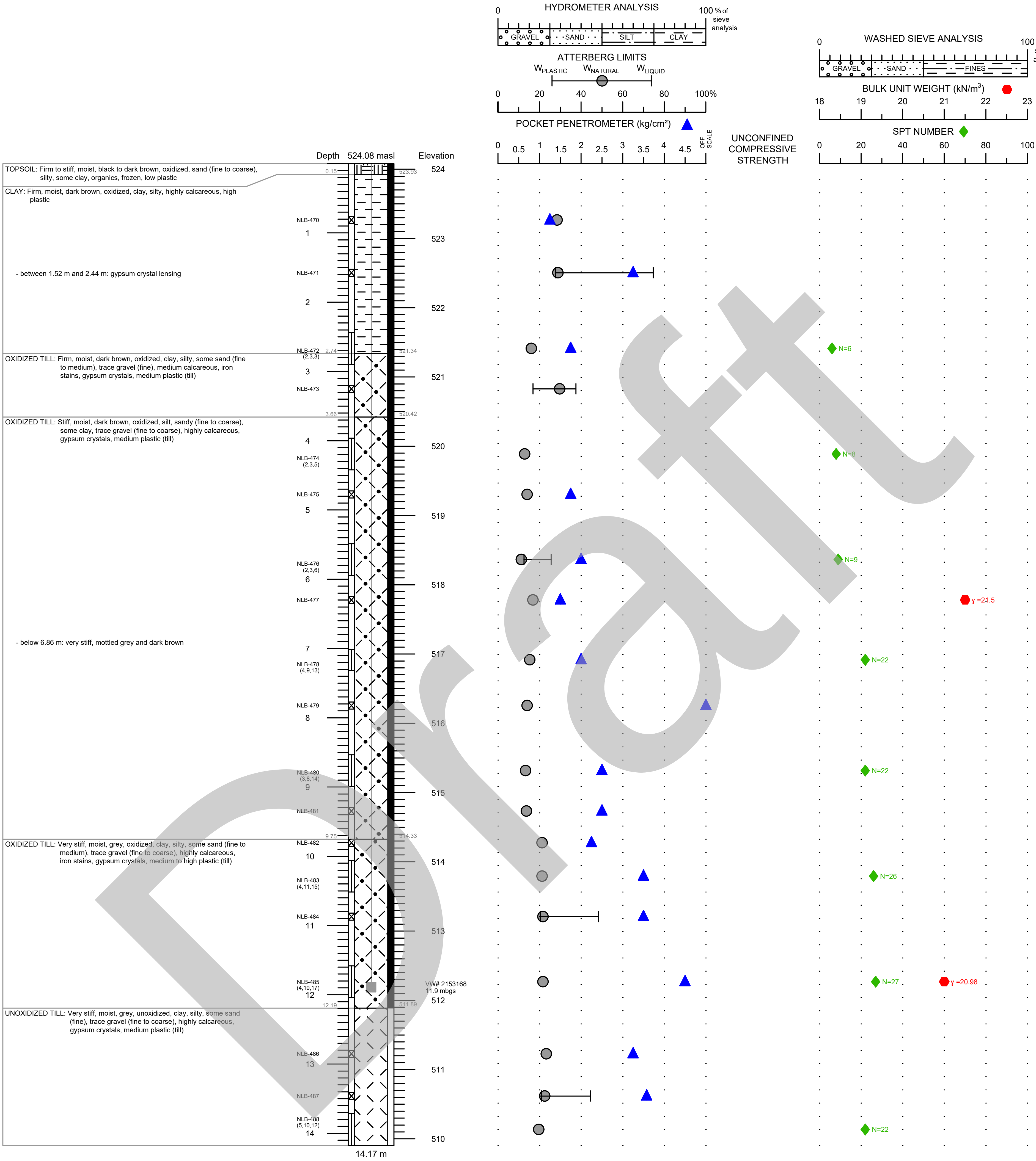
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\BH-659183-BH22-19 (FHII 11).dwg

BOREHOLE 22-20 (SHII 6)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5774872.76 N   397276.94 E
NAD 83 ZONE 13 U
NE 36-35-05-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

CLAY: Firm, moist, dark brown, oxidized, clay, silty, highly calcareous, high plastic

- between 1.52 m and 2.44 m: gypsum crystal lensing

OXIDIZED TILL: Firm, moist, dark brown, oxidized, clay, silty, some sand (fine to medium), trace gravel (fine), medium calcareous, iron stains, gypsum crystals, medium plastic (till)

OXIDIZED TILL: Stiff, moist, dark brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

- below 6.86 m: very stiff, mottled grey and dark brown

OXIDIZED TILL: Very stiff, moist, grey, oxidized, clay, silty, some sand (fine to medium), trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium to high plastic (till)

UNOXIDIZED TILL: Very stiff, moist, grey, unoxidized, clay, silty, some sand (fine), trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

VW Serial Number	Total Head (masl)
2153168	521.28

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.40.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK Survey, 2022).

SNC·LAVALIN

CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:60	**DATE**	2022-07-05

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S. RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-26
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-26

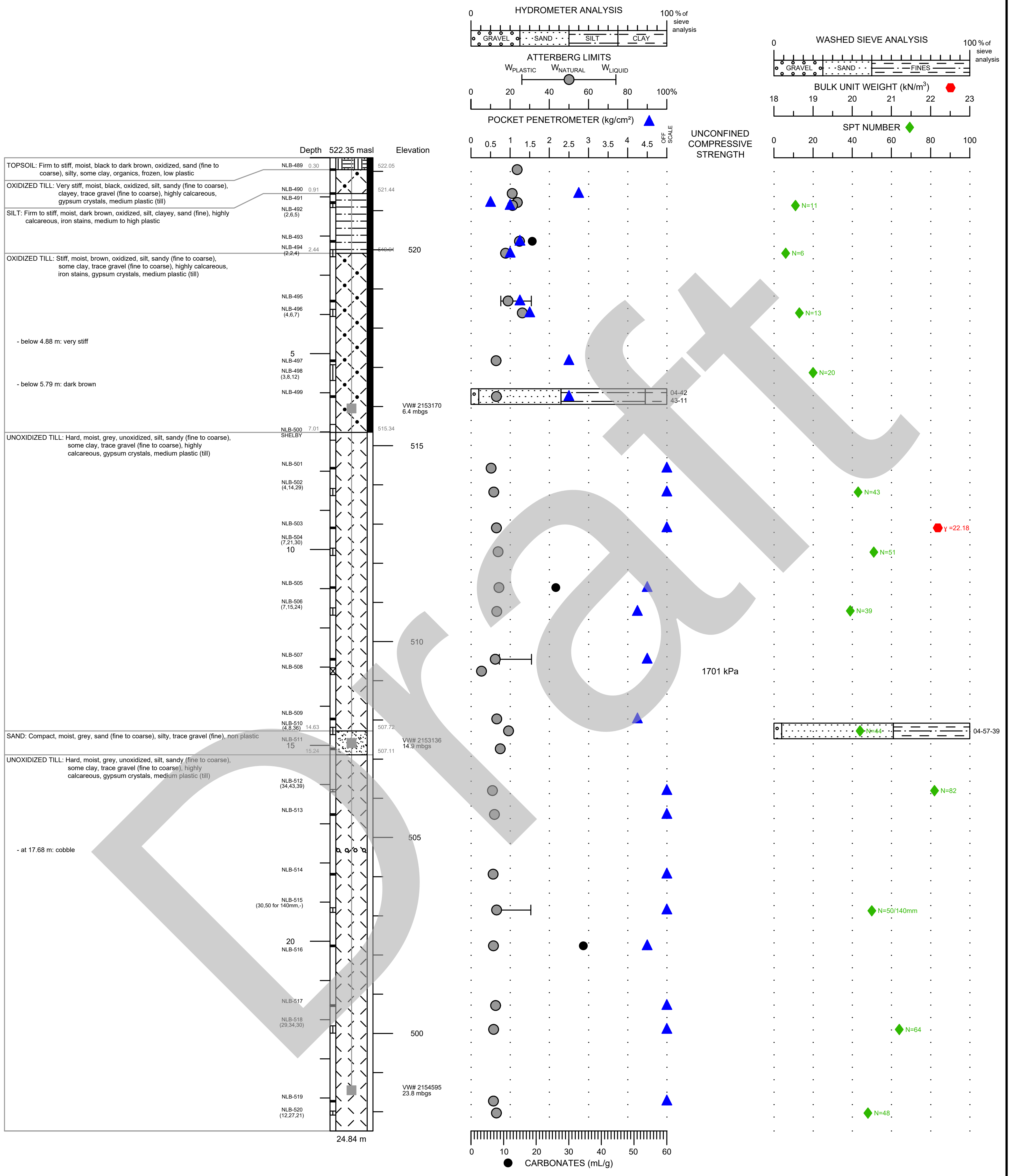
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\BH-659183-BH22-20 (SHII 6).dwg

BOREHOLE 22-21 (FHII 8)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5778062.63 N   397141.05 E
NAD 83 ZONE 13 U
SW 25-37-05-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

OXIDIZED TILL: Very stiff, moist, black, oxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

SILT: Firm to stiff, moist, dark brown, oxidized, silt, clayey, sand (fine), highly calcareous, iron stains, medium to high plastic

OXIDIZED TILL: Stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- below 4.88 m: very stiff
- below 5.79 m: dark brown

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

SAND: Compact, moist, grey, sand (fine to coarse), silty, trace gravel (fine), non plastic

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

- at 17.68 m: cobble

VW Serial Number	Total Head (masl)
2153170	519.43
2153136	518.99
2154595	518.71

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.36.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	E.SERHAN	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-26
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-26

SNC·LAVALIN

CLIENT SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION** SASKATOON, SASKATCHEWAN

APPROVED BY K. DORAN, P.Eng
DRAWN BY A. COLE, A.Sc.T.
PROJECT No. 659183
SCALE 1:100 **DATE** 2022-07-05

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-22 (FHII 12)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5771676.13 N 395942.28 E
NAD 83 ZONE 13 U
SW 16-36-04-W3M

TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

OXIDIZED TILL: Stiff, moist, dark brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, organics, frozen, gypsum crystals, low plastic (till)

OXIDIZED TILL: Very soft, moist, brown, oxidized, silt, clayey, trace sand (fine to coarse), trace gravel (fine to coarse), highly calcareous, irons stains, gypsum crystals, medium to high plastic (till)

CLAY: Firm, moist, brown, oxidized, clay, silty, some sand (fine to medium), highly calcareous, iron stains, gypsum crystals, high plastic

- below 3.96 m: mottled dark brown and brown

CLAY: Firm, moist, grey, unoxidized, clay, some silt to silty, trace sand (fine), highly calcareous, high plastic

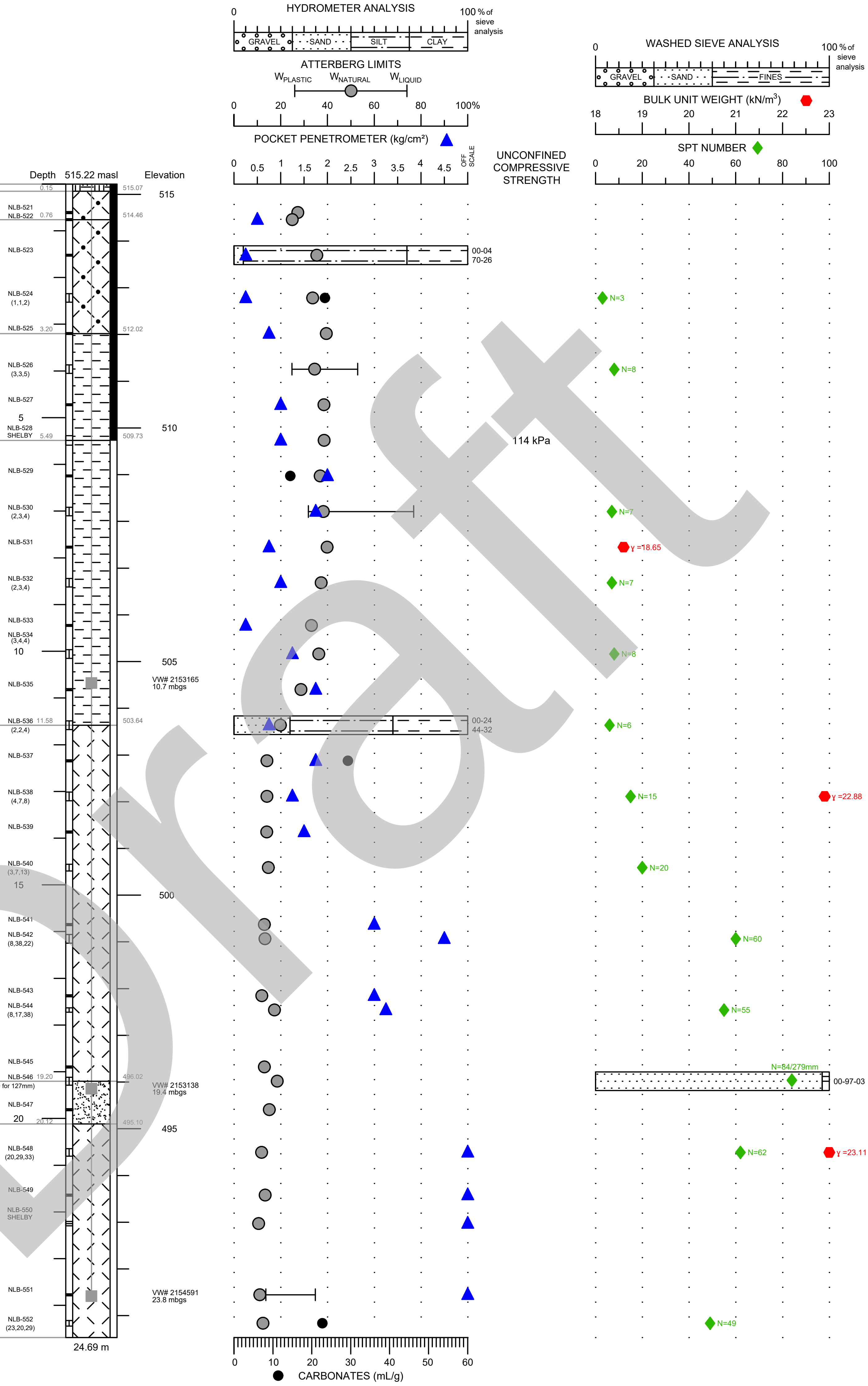
- below 9.30 m: some sand (fine to medium)

UNOXIDIZED TILL: Stiff, moist, grey, unoxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

- below 13.10 m: very stiff

SAND: Very dense, moist, grey, unoxidized, sand (fine to medium), trace silt, non plastic

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium to high plastic (till)



VW Serial Number	Total Head (masl)
2353165	507.82
2153138 / 2154602*	512.58
2154591	514.13

*spliced with SN:2154602

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.36.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

SNC • LAVALIN

CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-05

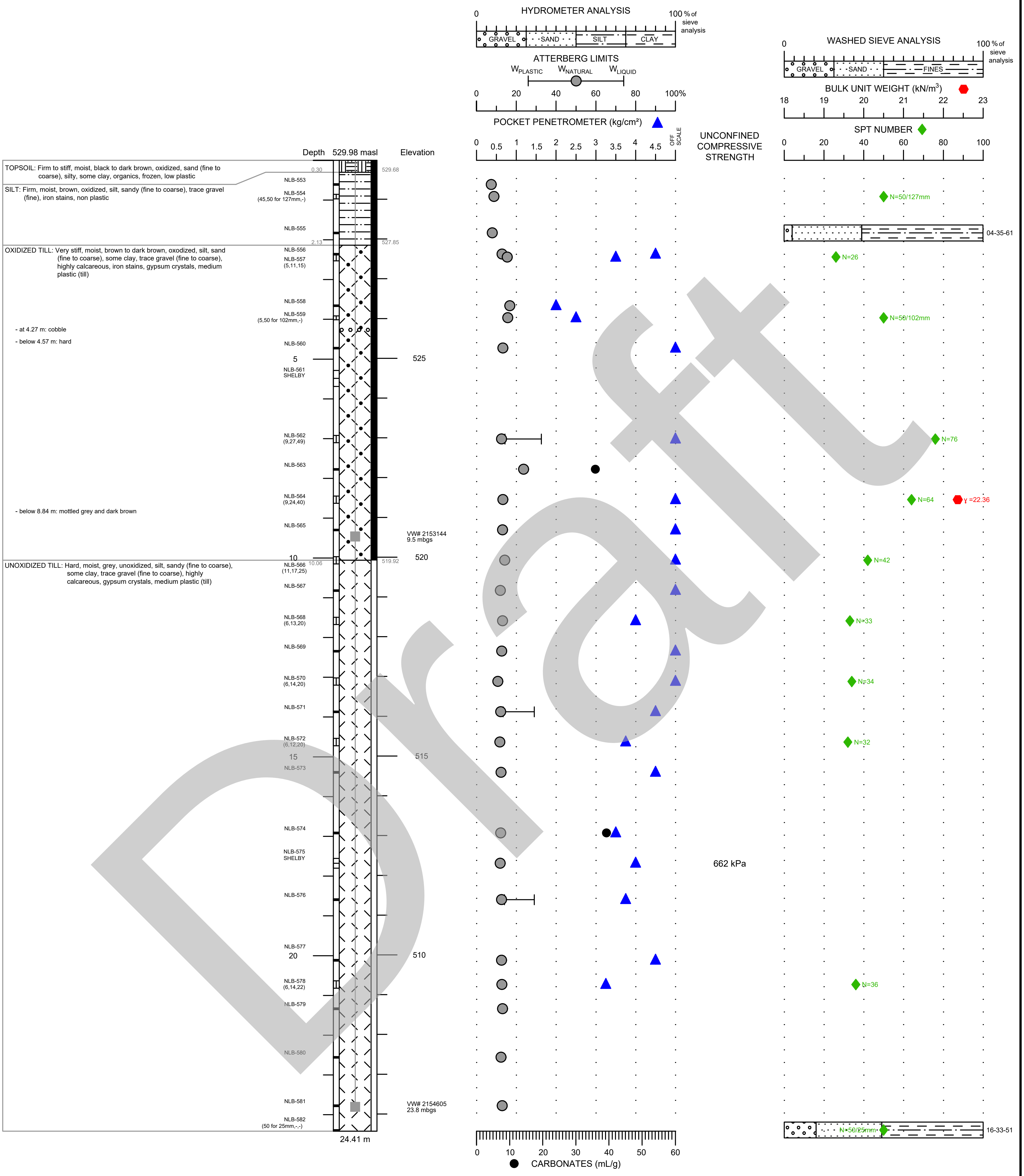
CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-27
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-27

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-23 (FHII 14)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5771595.48 N   397323.53 E
NAD 83 ZONE 13 U
NW 10-36-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SILT: Firm, moist, brown, oxidized, silt, sandy (fine to coarse), trace gravel (fine), iron stains, non plastic

OXIDIZED TILL: Very stiff, moist, brown to dark brown, oxodized, silt, sand (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- at 4.27 m: cobble
- below 4.57 m: hard
- below 8.84 m: mottled grey and dark brown

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

VW Serial Number	Total Head (masl)
2153144	524.25
2154605	522.91

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.37.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

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CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-28
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-28

CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-05

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-24 (FHII 19)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5770026.22 N   397270.48 E
NAD 83 ZONE 13 U
SW 27-36-04-W3M

TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

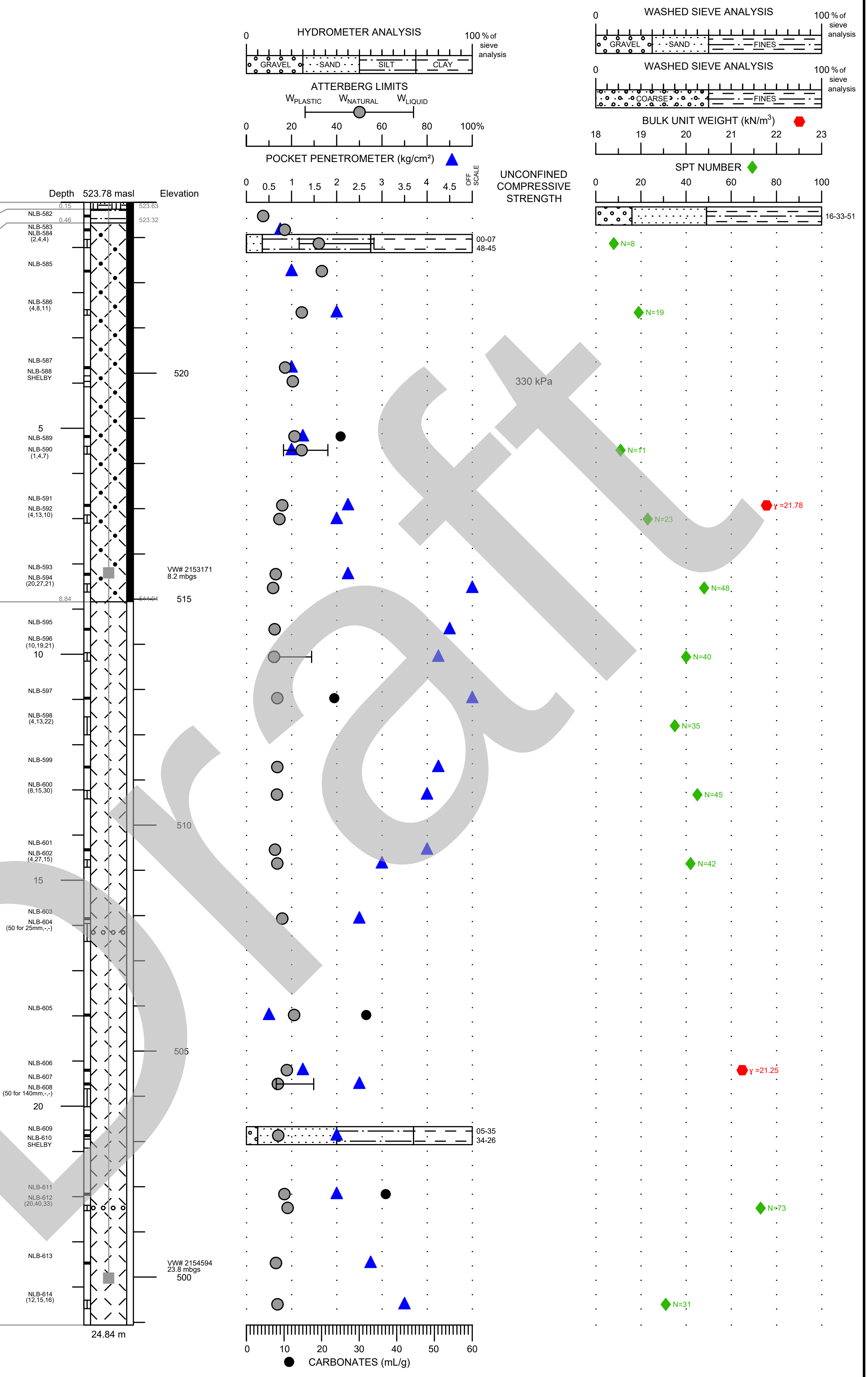
SILT: Firm, moist, brown, oxidized, silt, sandy (fine to coarse), some gravel, iron stains, organics, gypsum crystals, low plastic

OXIDIZED TILL: Firm to stiff, moist, dark brown to brown, oxidized, silt and clay, trace sand (fine to coarse), trace gravel (fine to coarse), medium to highly calcareous, iron stains, organics, gypsum crystals, high plastic (till)

- below 1.52 m: some sand to sandy (fine to coarse), some clay to clayey, medium plastic
- below 5.79 m: very stiff, mottled dark brown to brown

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, intermittent sand seams, gypsum crystals, medium plastic (till)

- below 11.58 m: no sand lenses
- below 14.63 m: very stiff
- at 16.15 m: cobble
- between 17.68 m and 19.51: firm to stiff
- below 19.51 m: stiff to very stiff
- at 22.25 m: cobble



VW Serial Number	Total Head (masl)
2153171	504.86
2154594	518.28

(Recorded 2022-04-01)

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.36.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

SNC-LAVALIN

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	E.SHERAN	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-28
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-02-29

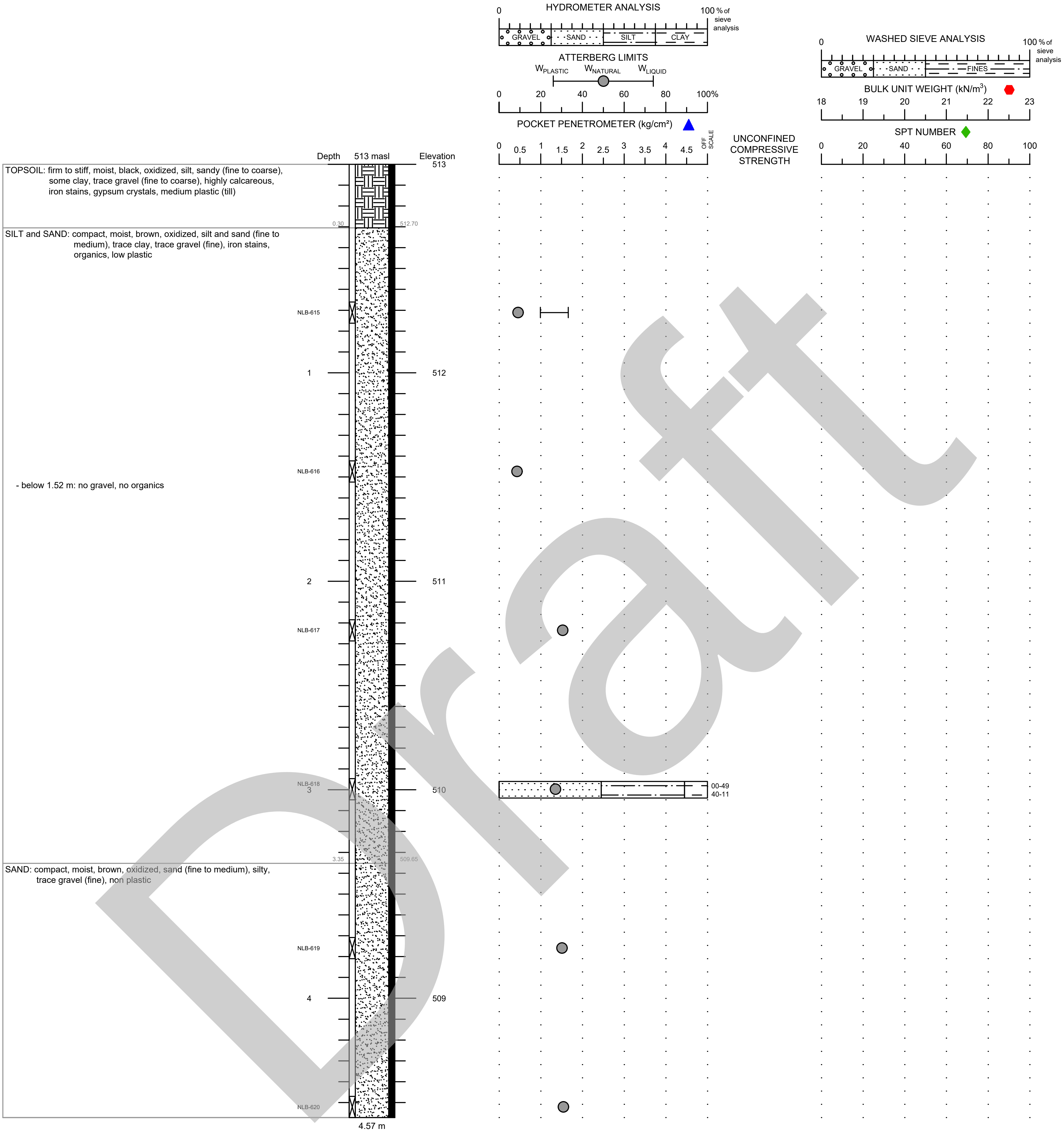
CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-05

LIMITATION

BOREHOLE 22-25 (PHII 8)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5769614 N   393657 E
NAD 83 ZONE 13 U
NE 06-36-04-W3M



TOPSOIL: firm to stiff, moist, black, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SILT and SAND: compact, moist, brown, oxidized, silt and sand (fine to medium), trace clay, trace gravel (fine), iron stains, organics, low plastic

- below 1.52 m: no gravel, no organics

SAND: compact, moist, brown, oxidized, sand (fine to medium), silty, trace gravel (fine), non plastic

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with cuttings and bentonite chips to surface.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

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CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:20	**DATE**	2022-07-05

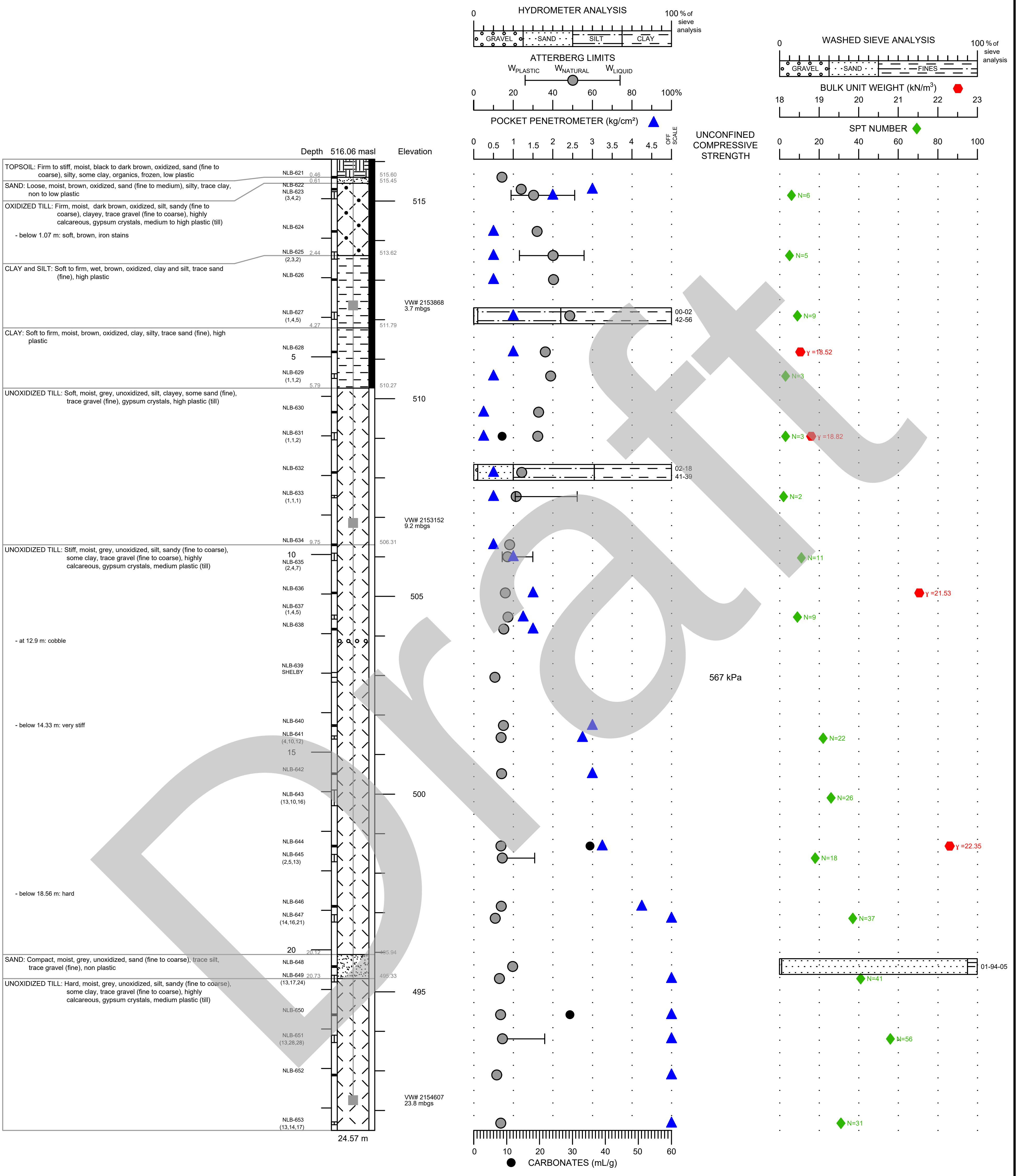
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S. RANDAL	**LOGGED BY**	B. LANG
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-27
ABANDONMENT	BACKFILLED WITH CUTTINGS	**INSTALLATION DATE**	N/A

BOREHOLE 22-26 (FHII 13)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5771431.49 N   396250.68 E
NAD 83 ZONE 13 U
NE 09-36-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Loose, moist, brown, oxidized, sand (fine to medium), silty, trace clay, non to low plastic

OXIDIZED TILL: Firm, moist, dark brown, oxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium to high plastic (till)

- below 1.07 m: soft, brown, iron stains

CLAY and SILT: Soft to firm, wet, brown, oxidized, clay and silt, trace sand (fine), high plastic

CLAY: Soft to firm, moist, brown, oxidized, clay, silty, trace sand (fine), high plastic

UNOXIDIZED TILL: Soft, moist, grey, unoxidized, silt, clayey, some sand (fine), trace gravel (fine), gypsum crystals, high plastic (till)

UNOXIDIZED TILL: Stiff, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

- at 12.9 m: cobble

- below 14.33 m: very stiff

- below 18.56 m: hard

SAND: Compact, moist, grey, unoxidized, sand (fine to coarse), trace silt, trace gravel (fine), non plastic

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

VW Serial Number	Total Head (masl)
2153868	514.86
2153152	514.81
2154607	515.93

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

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CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-05

LIMITATION

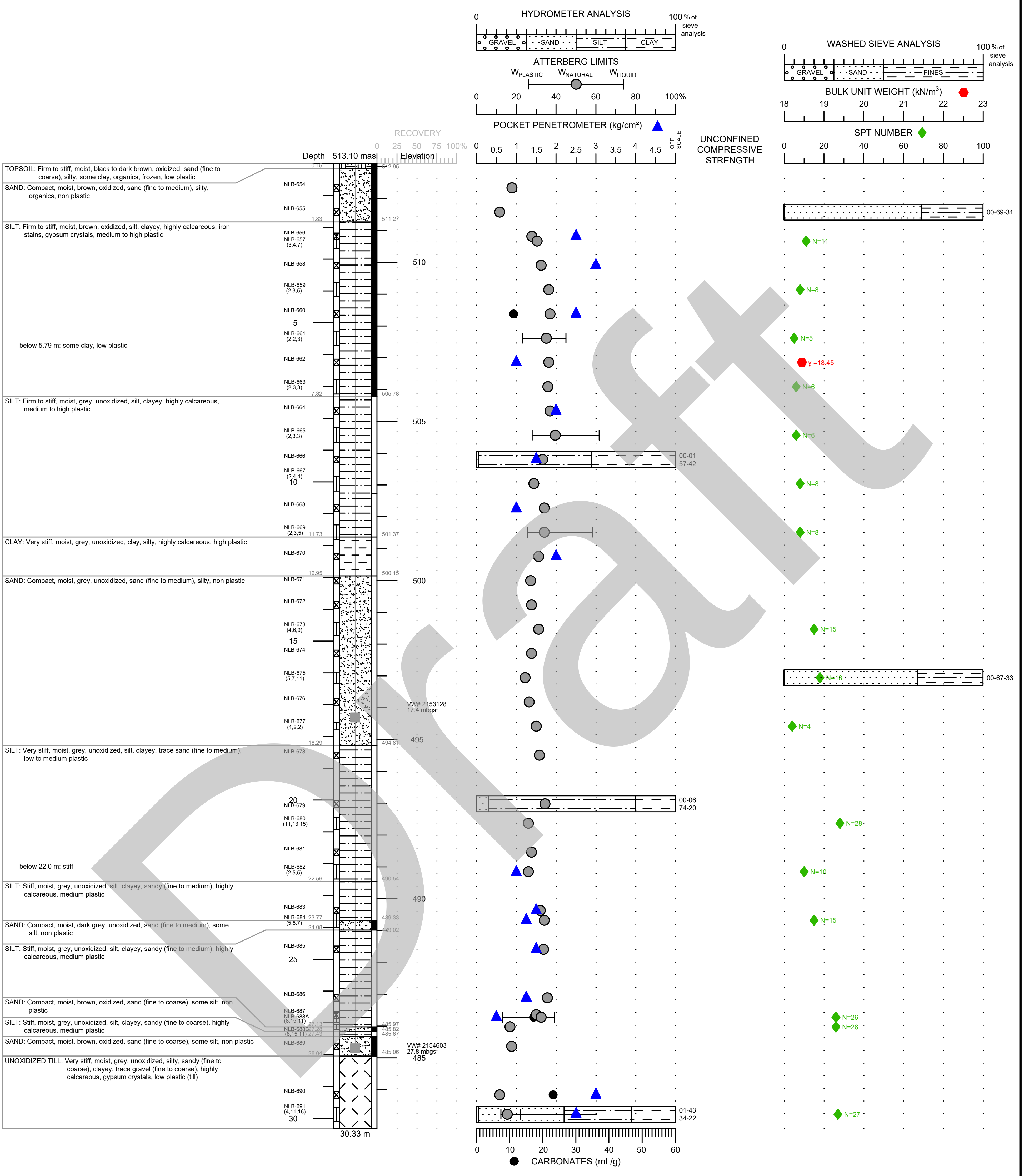
This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	B. LANG
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-29
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-29

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\BH-659183-BH22-26 (FHII 13).dwg

BOREHOLE 22-27 (FHII 21)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5768977.46 N   392037.41 E
NAD 83 ZONE 13 U
SW 06-36-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Compact, moist, brown, oxidized, sand (fine to medium), silty, organics, non plastic

SILT: Firm to stiff, moist, brown, oxidized, silt, clayey, highly calcareous, iron stains, gypsum crystals, medium to high plastic

- below 5.79 m: some clay, low plastic

SILT: Firm to stiff, moist, grey, unoxidized, silt, clayey, highly calcareous, medium to high plastic

CLAY: Very stiff, moist, grey, unoxidized, clay, silty, highly calcareous, high plastic

SAND: Compact, moist, grey, unoxidized, sand (fine to medium), silty, non plastic

SILT: Very stiff, moist, grey, unoxidized, silt, clayey, trace sand (fine to medium), low to medium plastic

- below 22.0 m: stiff

SILT: Stiff, moist, grey, unoxidized, silt, clayey, sandy (fine to medium), highly calcareous, medium plastic

SAND: Compact, moist, dark grey, unoxidized, sand (fine to medium), some silt, non plastic

SILT: Stiff, moist, grey, unoxidized, silt, clayey, sandy (fine to medium), highly calcareous, medium plastic

SAND: Compact, moist, brown, oxidized, sand (fine to coarse), some silt, non plastic

SILT: Stiff, moist, grey, unoxidized, silt, clayey, sandy (fine to coarse), highly calcareous, medium plastic

SAND: Compact, moist, brown, oxidized, sand (fine to coarse), some silt, non plastic

UNOXIDIZED TILL: Very stiff, moist, grey, unoxidized, silty, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, low plastic (till)

VW Serial Number	Total Head (masl)
2153128	508.53
2154603	508.37

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

SNC·LAVALIN

CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:125	**DATE**	2022-07-05

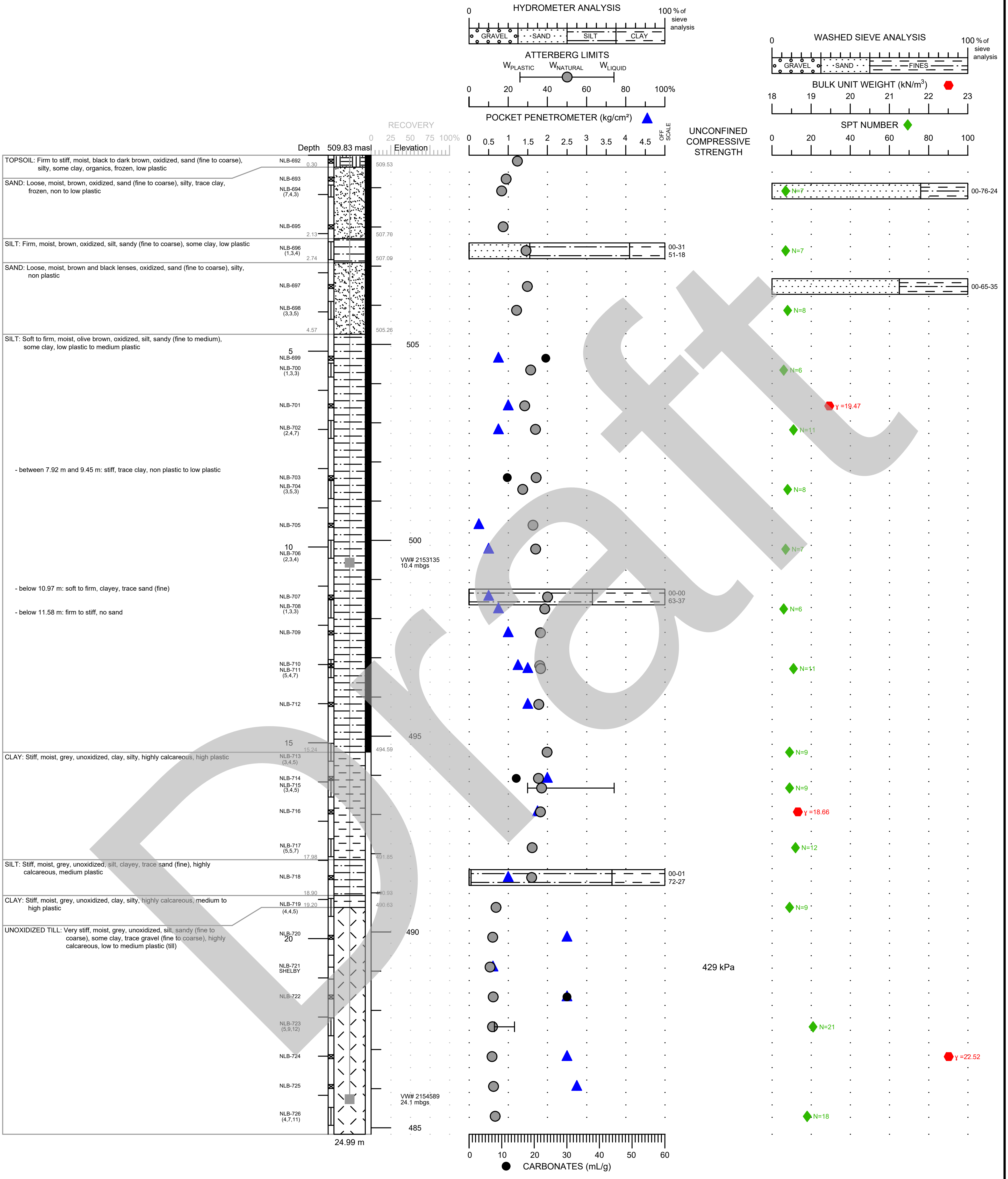
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S. RANDAL	**LOGGED BY**	B. LANG
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-30
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-30

BOREHOLE 22-28 (FHII 22)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5768454.18 N   391484.62 E
NAD 83 ZONE 13 U
SW 16-36-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Loose, moist, brown, oxidized, sand (fine to coarse), silty, trace clay, frozen, non to low plastic

SILT: Firm, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, low plastic

SAND: Loose, moist, brown and black lenses, oxidized, sand (fine to coarse), silty, non plastic

SILT: Soft to firm, moist, olive brown, oxidized, silt, sandy (fine to medium), some clay, low plastic to medium plastic

- between 7.92 m and 9.45 m: stiff, trace clay, non plastic to low plastic
- below 10.97 m: soft to firm, clayey, trace sand (fine)
- below 11.58 m: firm to stiff, no sand

CLAY: Stiff, moist, grey, unoxidized, clay, silty, highly calcareous, high plastic

SILT: Stiff, moist, grey, unoxidized, silt, clayey, trace sand (fine), highly calcareous, medium plastic

CLAY: Stiff, moist, grey, unoxidized, clay, silty, highly calcareous, medium to high plastic

UNOXIDIZED TILL: Very stiff, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, low to medium plastic (till)

VW Serial Number	Total Head (masl)
2153135	507.75
2154589	507.64

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.37.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

SNC·LAVALIN

CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-05

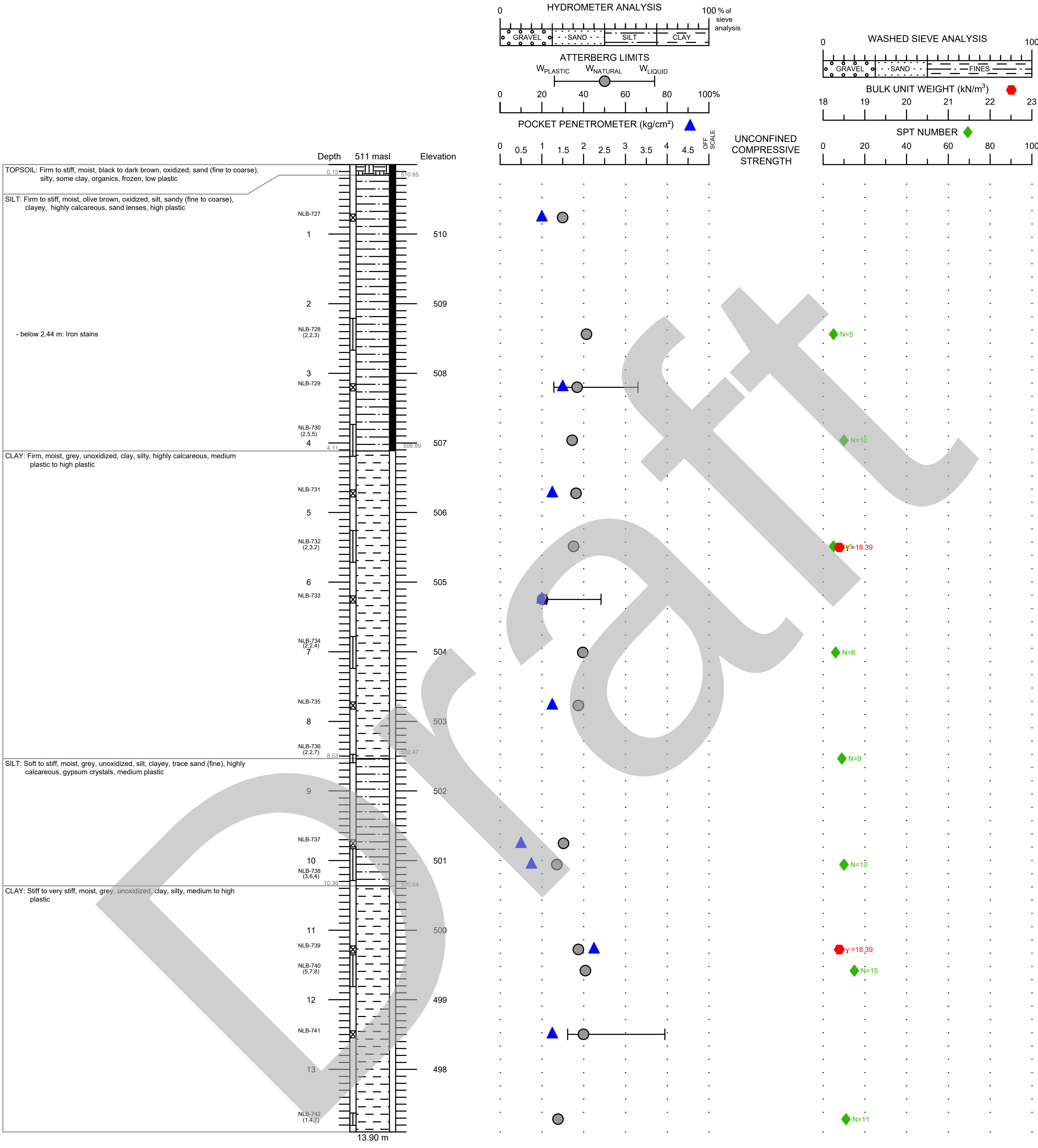
CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	A. MARLOWE
OPERATOR	E. SERHAN	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-31
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-01-31

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-29 (SHII 9)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5768431 N   391659 E
NAD 83 ZONE 13 U
NW 05-36-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SILT: Firm to stiff, moist, olive brown, oxidized, silt, sandy (fine to coarse), clayey, highly calcareous, sand lenses, high plastic

- below 2.44 m: Iron stains

CLAY: Firm, moist, grey, unoxidized, clay, silty, highly calcareous, medium plastic to high plastic

SILT: Soft to stiff, moist, grey, unoxidized, silt, clayey, trace sand (fine), highly calcareous, gypsum crystals, medium plastic

CLAY: Stiff to very stiff, moist, grey, unoxidized, clay, silty, medium to high plastic

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.37.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:60	**DATE**	2022-07-05

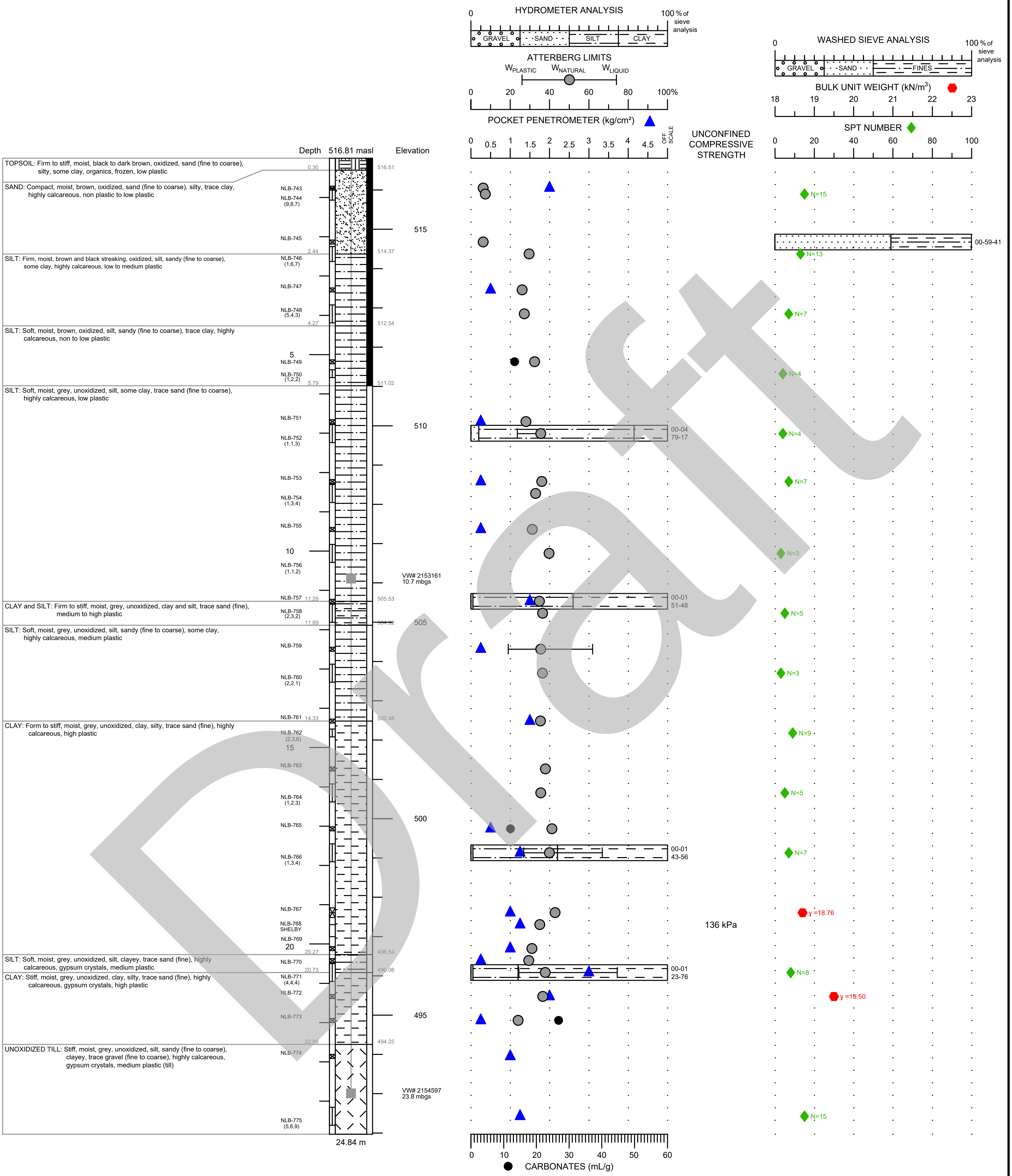
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	B. LANG
OPERATOR	S. RANDAL	**LOGGED BY**	B. LANG
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-01-31
ABANDONMENT	-	**INSTALLATION DATE**	N/A

BOREHOLE 22-30 (FHII 20)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5769922.78 N   394480.90 E
NAD 83 ZONE 13 U
SW 27-36-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Compact, moist, brown, oxidized, sand (fine to coarse), silty, trace clay, highly calcareous, non plastic to low plastic

SILT: Firm, moist, brown and black streaking, oxidized, silt, sandy (fine to coarse), some clay, highly calcareous, low to medium plastic

SILT: Soft, moist, brown, oxidized, silt, sandy (fine to coarse), trace clay, highly calcareous, non to low plastic

SILT: Soft, moist, grey, unoxidized, silt, some clay, trace sand (fine to coarse), highly calcareous, low plastic

CLAY and SILT: Firm to stiff, moist, grey, unoxidized, clay and silt, trace sand (fine), medium to high plastic

SILT: Soft, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, highly calcareous, medium plastic

CLAY: Form to stiff, moist, grey, unoxidized, clay, silty, trace sand (fine), highly calcareous, high plastic

SILT: Soft, moist, grey, unoxidized, silt, clayey, trace sand (fine), highly calcareous, gypsum crystals, medium plastic

CLAY: Stiff, moist, grey, unoxidized, clay, silty, trace sand (fine), highly calcareous, gypsum crystals, high plastic

UNOXIDIZED TILL: Stiff, moist, grey, unoxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

VW Serial Number	Total Head (masl)
2153161	512.75
2154597	513.02

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.37.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

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CLIENT SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION** SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-05

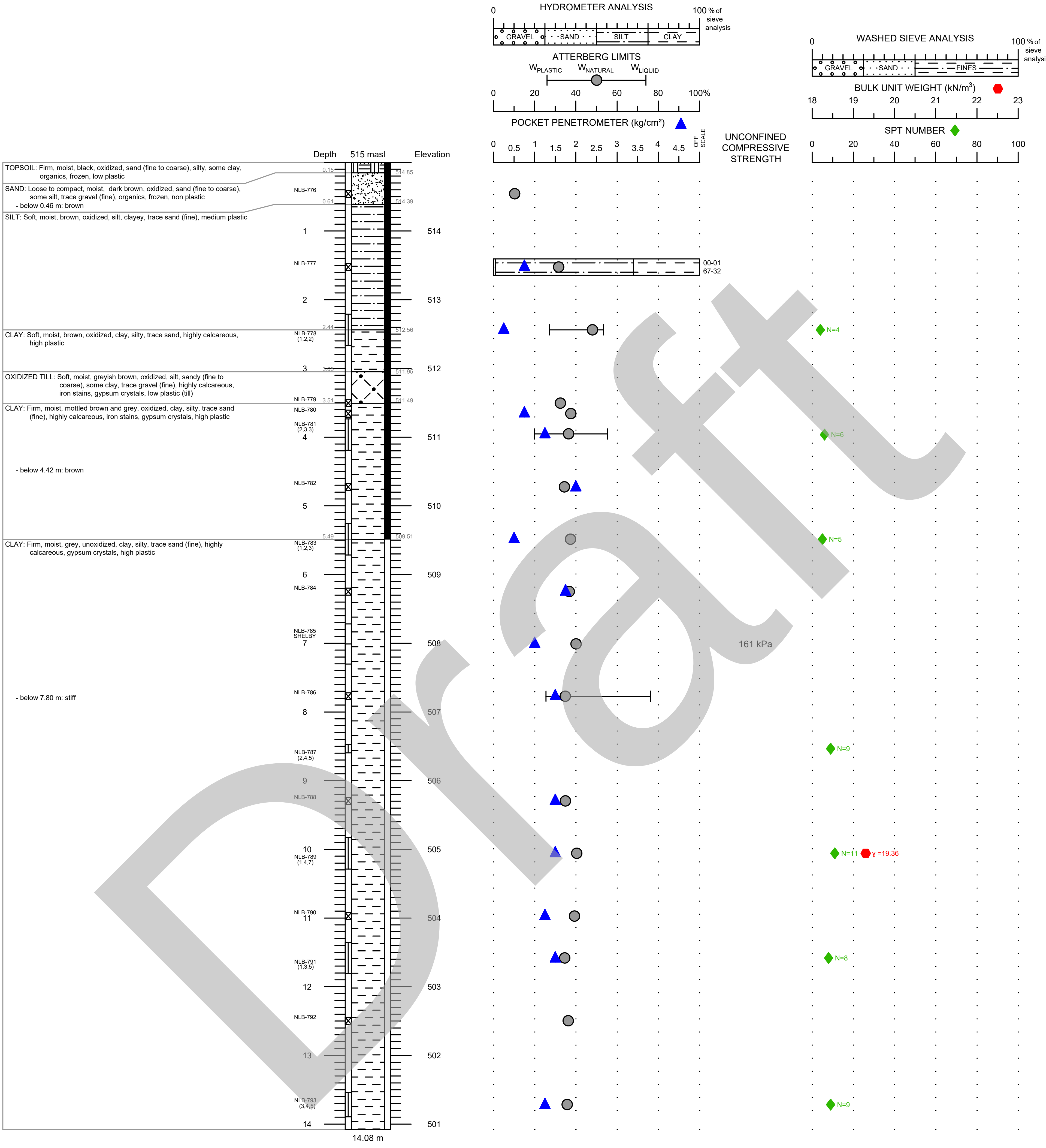
CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	A. MARLOWE
OPERATOR	E. SERHAN	**LOGGED BY**	A. MARLOW
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-02
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-02-02

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-31 (SHII 8)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5769695 N 394479 E
NAD 83 ZONE 13 U
NW 05-36-04-W3M



TOPSOIL: Firm, moist, black, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Loose to compact, moist, dark brown, oxidized, sand (fine to coarse), some silt, trace gravel (fine), organics, frozen, non plastic
- below 0.46 m: brown

SILT: Soft, moist, brown, oxidized, silt, clayey, trace sand (fine), medium plastic

CLAY: Soft, moist, brown, oxidized, clay, silty, trace sand, highly calcareous, high plastic

OXIDIZED TILL: Soft, moist, greyish brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine), highly calcareous, iron stains, gypsum crystals, low plastic (till)

CLAY: Firm, moist, mottled brown and grey, oxidized, clay, silty, trace sand (fine), highly calcareous, iron stains, gypsum crystals, high plastic
- below 4.42 m: brown

CLAY: Firm, moist, grey, unoxidized, clay, silty, trace sand (fine), highly calcareous, gypsum crystals, high plastic
- below 7.80 m: stiff

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:60	**DATE**	2022-07-06

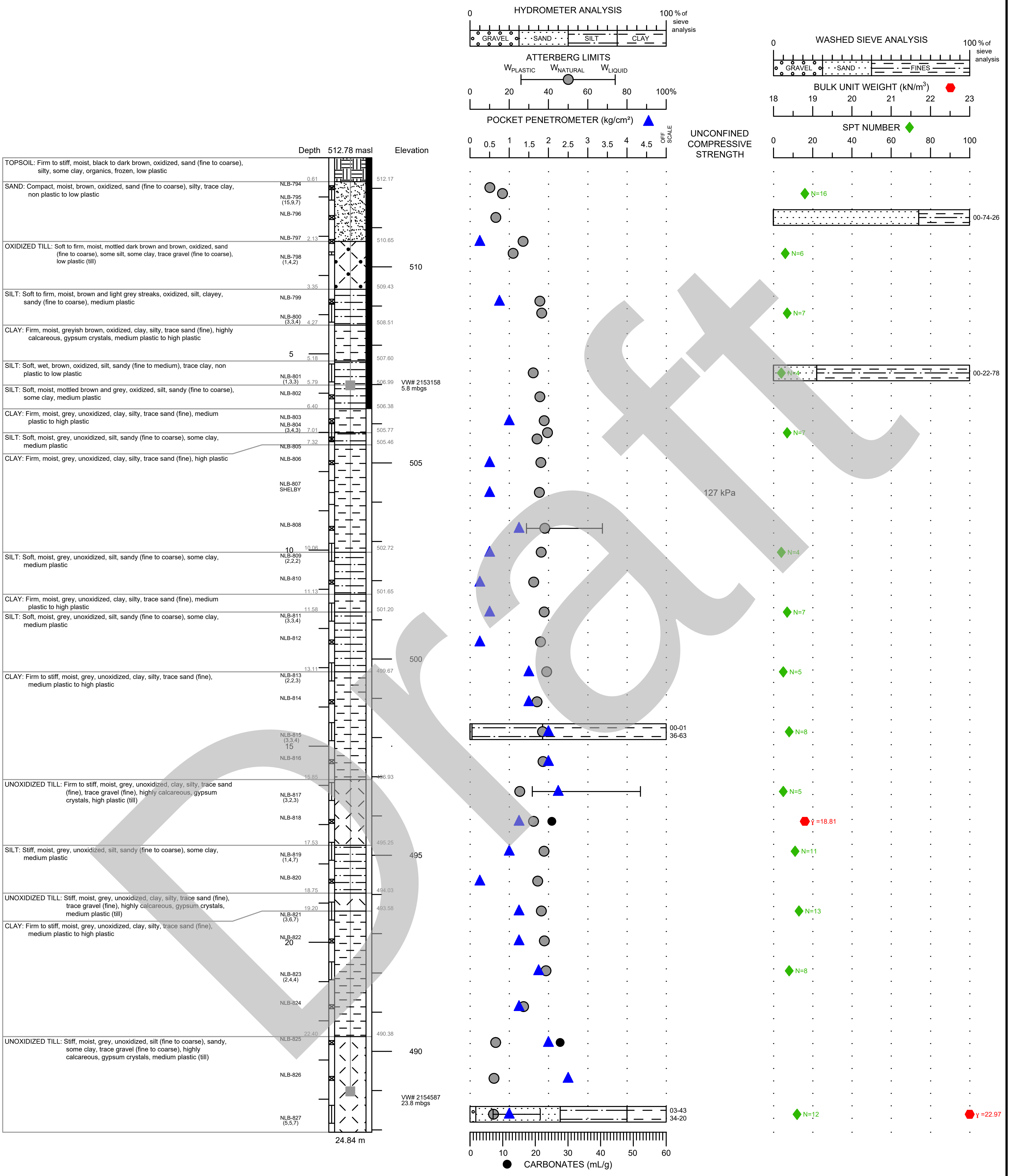
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S. RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-02
ABANDONMENT	-	**INSTALLATION DATE**	N/A

BOREHOLE 22-32 (FHII 24)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5766758.86 N 391083.42 E
NAD 83 ZONE 13 U
NW 25-35-05-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SAND: Compact, moist, brown, oxidized, sand (fine to coarse), silty, trace clay, non plastic to low plastic

OXIDIZED TILL: Soft to firm, moist, mottled dark brown and brown, oxidized, sand (fine to coarse), some silt, some clay, trace gravel (fine to coarse), low plastic (till)

SILT: Soft to firm, moist, brown and light grey streaks, oxidized, silt, clayey, sandy (fine to coarse), medium plastic

CLAY: Firm, moist, greyish brown, oxidized, clay, silty, trace sand (fine), highly calcareous, gypsum crystals, medium plastic to high plastic

SILT: Soft, wet, brown, oxidized, silt, sandy (fine to medium), trace clay, non plastic to low plastic

SILT: Soft, moist, mottled brown and grey, oxidized, silt, sandy (fine to coarse), some clay, medium plastic

CLAY: Firm, moist, grey, unoxidized, clay, silty, trace sand (fine), medium plastic to high plastic

SILT: Soft, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, medium plastic

CLAY: Firm, moist, grey, unoxidized, clay, silty, trace sand (fine), high plastic

SILT: Soft, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, medium plastic

CLAY: Firm, moist, grey, unoxidized, clay, silty, trace sand (fine), medium plastic to high plastic

SILT: Soft, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, medium plastic

CLAY: Firm to stiff, moist, grey, unoxidized, clay, silty, trace sand (fine), medium plastic to high plastic

UNOXIDIZED TILL: Firm to stiff, moist, grey, unoxidized, clay, silty, trace sand (fine), trace gravel (fine), highly calcareous, gypsum crystals, high plastic (till)

SILT: Stiff, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, medium plastic

UNOXIDIZED TILL: Stiff, moist, grey, unoxidized, clay, silty, trace sand (fine), trace gravel (fine), highly calcareous, gypsum crystals, medium plastic (till)

CLAY: Firm to stiff, moist, grey, unoxidized, clay, silty, trace sand (fine), medium plastic to high plastic

UNOXIDIZED TILL: Stiff, moist, grey, unoxidized, silt (fine to coarse), sandy, some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

VW Serial Number	Total Head (masl)
2153158	511.27
2154587	510.84

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.36.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S. RANDAL	**LOGGED BY**	A. MARLOWE
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-03
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-02-03

SNC • LAVALIN

CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-06

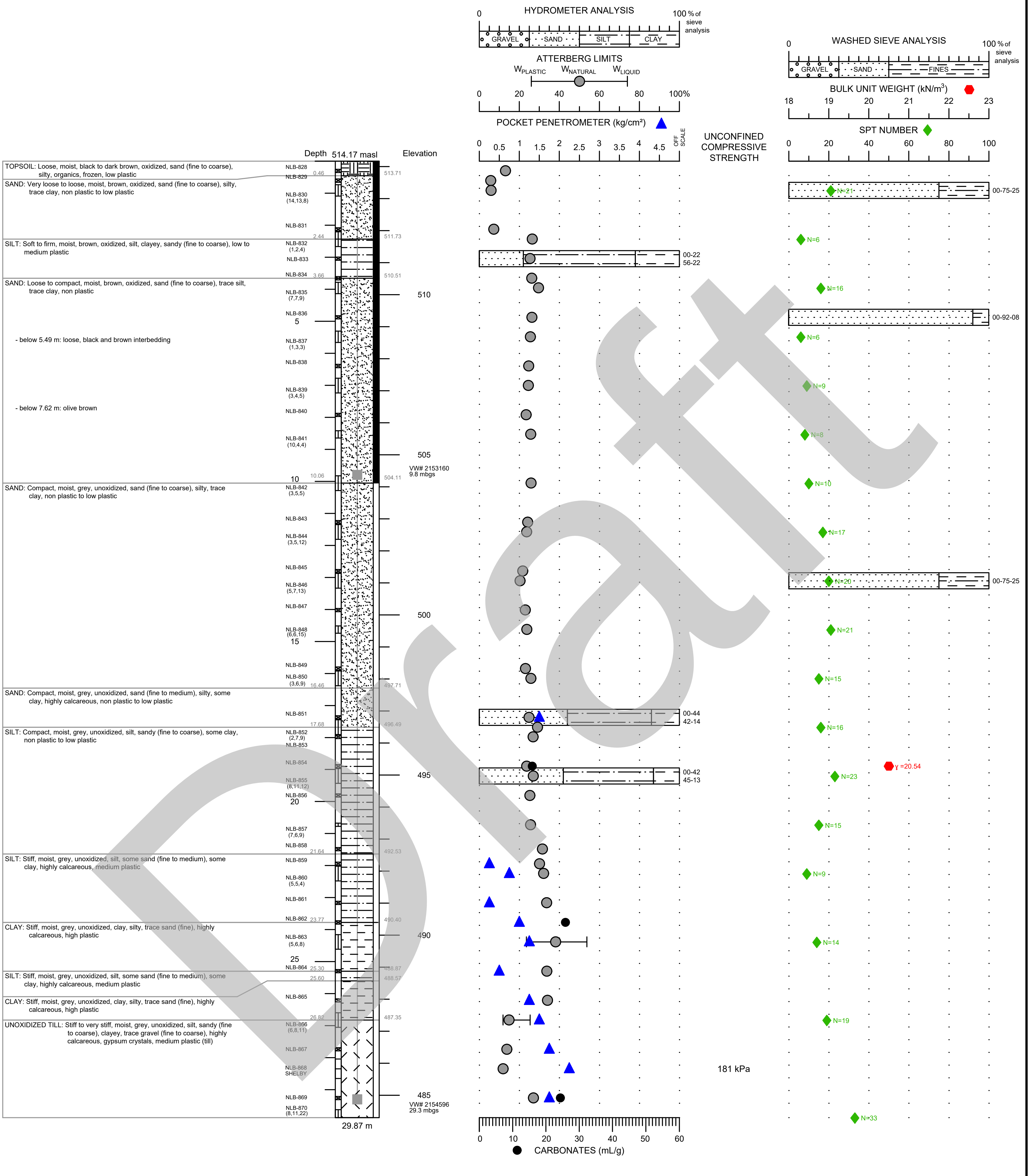
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\BH-659183-BH22-32 (FHII 24).dwg

BOREHOLE 22-33 (FHII 23)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5766875.09 N 390989.72 E
NAD 83 ZONE 13 U
NW 25-35-05-W3M



TOPSOIL: Loose, moist, black to dark brown, oxidized, sand (fine to coarse), silty, organics, frozen, low plastic

SAND: Very loose to loose, moist, brown, oxidized, sand (fine to coarse), silty, trace clay, non plastic to low plastic

SILT: Soft to firm, moist, brown, oxidized, silt, clayey, sandy (fine to coarse), low to medium plastic

SAND: Loose to compact, moist, brown, oxidized, sand (fine to coarse), trace silt, trace clay, non plastic

- below 5.49 m: loose, black and brown interbedding

- below 7.62 m: olive brown

SAND: Compact, moist, grey, unoxidized, sand (fine to coarse), silty, trace clay, non plastic to low plastic

SAND: Compact, moist, grey, unoxidized, sand (fine to medium), silty, some clay, highly calcareous, non plastic to low plastic

SILT: Compact, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, non plastic to low plastic

SILT: Stiff, moist, grey, unoxidized, silt, some sand (fine to medium), some clay, highly calcareous, medium plastic

CLAY: Stiff, moist, grey, unoxidized, clay, silty, trace sand (fine), highly calcareous, high plastic

SILT: Stiff, moist, grey, unoxidized, silt, some sand (fine to medium), some clay, highly calcareous, medium plastic

CLAY: Stiff, moist, grey, unoxidized, clay, silty, trace sand (fine), highly calcareous, high plastic

UNOXIDIZED TILL: Stiff to very stiff, moist, grey, unoxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

VW Serial Number	Total Head (masl)
2153160	510.64
2154596	510.35

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.37.
3. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
4. Depths are in metres (m).
5. Elevations are in metres above sea level (masl).
6. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

SNC·LAVALIN

CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:125	**DATE**	2022-07-06

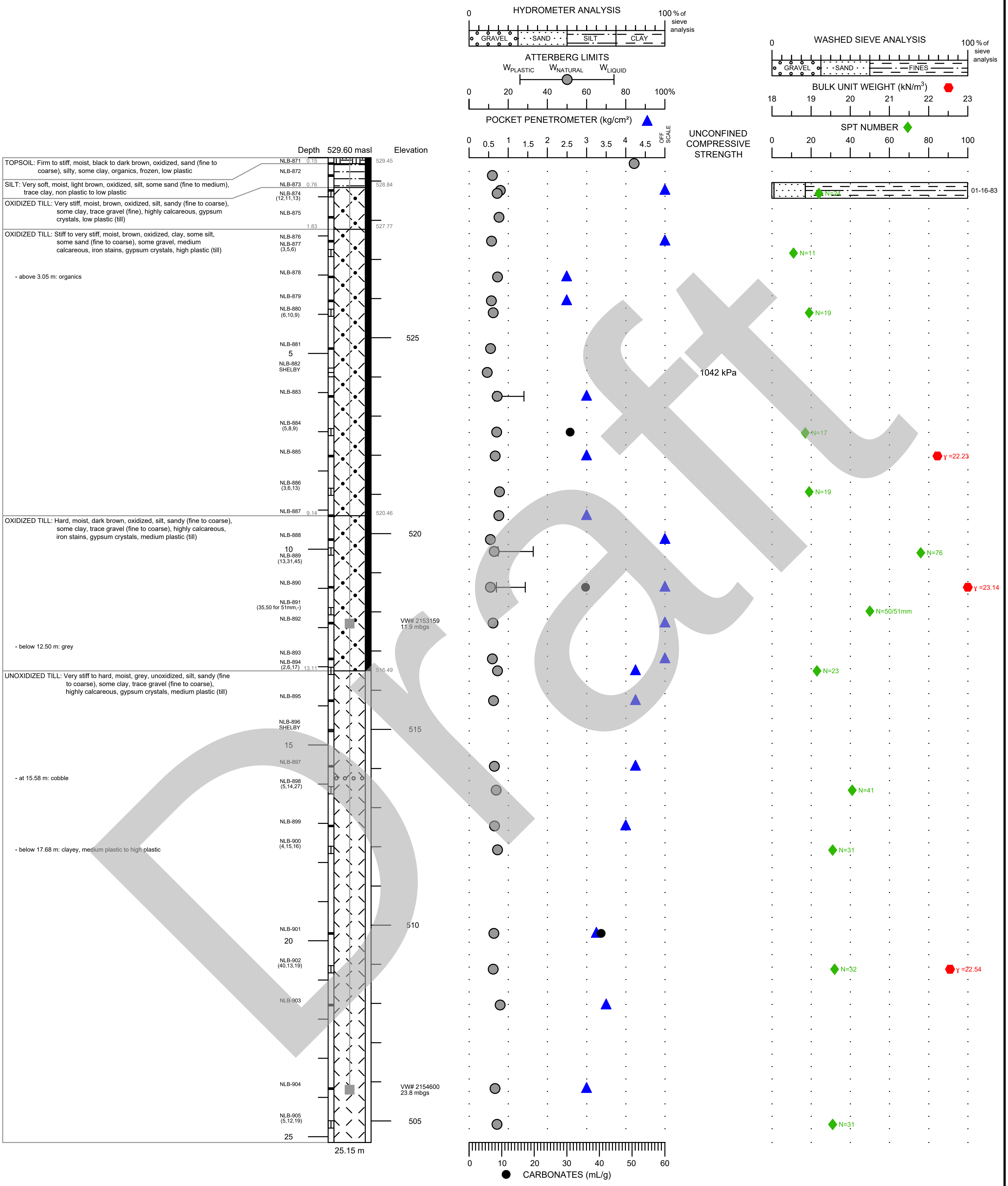
CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	E. SERHAN	**LOGGED BY**	G. KELLY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-03
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-02-04

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

BOREHOLE 22-34 (FHII 16)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5770779.96 N   397353.59 E
NAD 83 ZONE 13 U
SW 10-36-04-W3M


TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SILT: Very soft, moist, light brown, oxidized, silt, some sand (fine to medium), trace clay, non plastic to low plastic

OXIDIZED TILL: Very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine), highly calcareous, gypsum crystals, low plastic (till)

OXIDIZED TILL: Stiff to very stiff, moist, brown, oxidized, clay, some silt, some sand (fine to coarse), some gravel, medium calcareous, iron stains, gypsum crystals, high plastic (till)

- above 3.05 m: organics

OXIDIZED TILL: Hard, moist, dark brown, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- below 12.50 m: grey

UNOXIDIZED TILL: Very stiff to hard, moist, grey, unoxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

- at 15.58 m: cobble
- below 17.68 m: clayey, medium plastic to high plastic

VW Serial Number	Total Head (masl)
2153159	522.95
2154600	528.40

(Recorded 2022-04-01)

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.36.
3. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
4. Depths are in metres (m).
5. Elevations are in metres above sea level (masl).
6. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

SNC · LAVALIN

CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-06

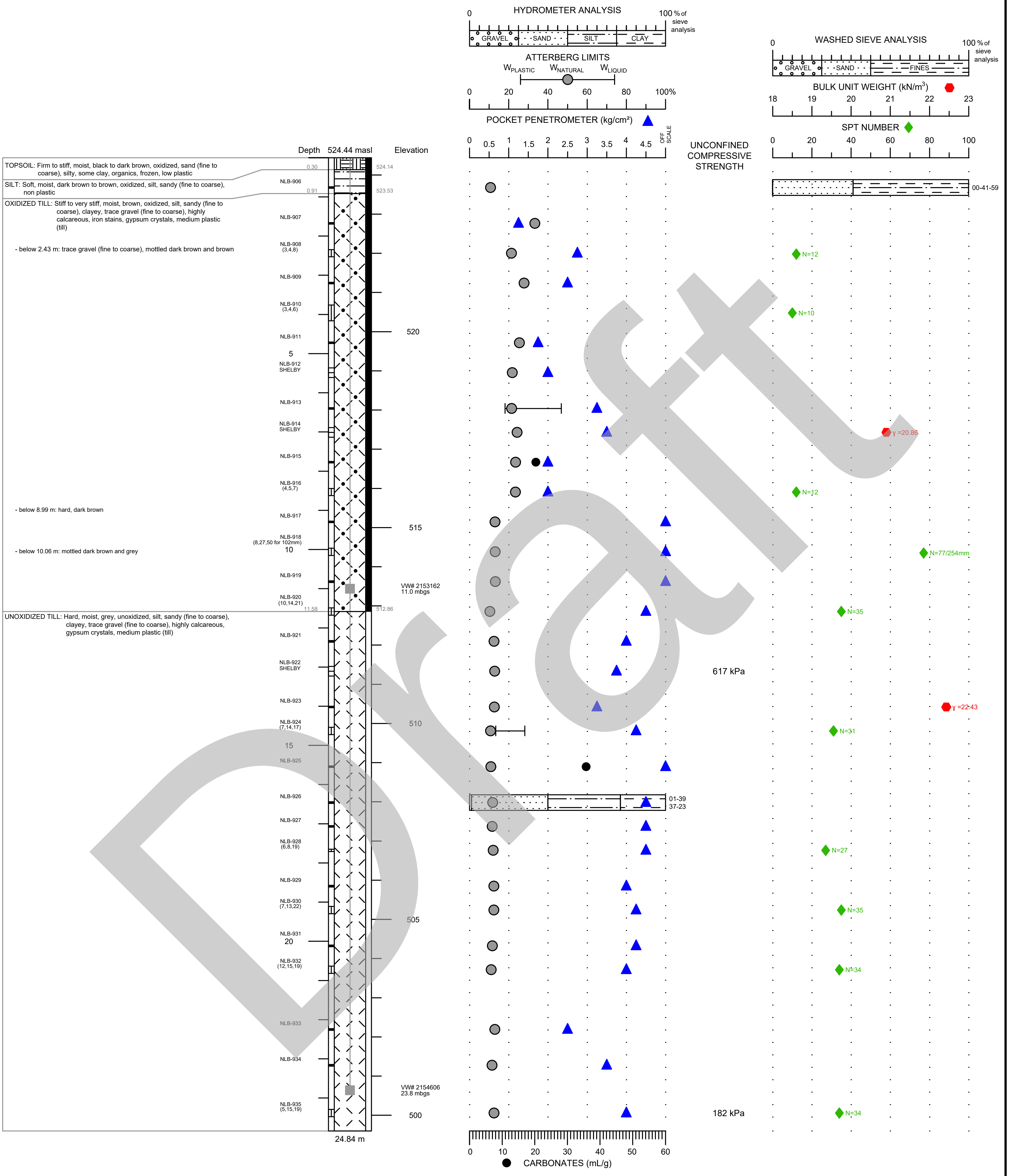
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	G.KELLY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-04
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-02-04

BOREHOLE 22-35 (FHII 18)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5770298.27 N   397187.79 E
NAD 83 ZONE 13 U
SW 10-36-04-W3M



TOPSOIL: Firm to stiff, moist, black to dark brown, oxidized, sand (fine to coarse), silty, some clay, organics, frozen, low plastic

SILT: Soft, moist, dark brown to brown, oxidized, silt, sandy (fine to coarse), non plastic

OXIDIZED TILL: Stiff to very stiff, moist, brown, oxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

- below 2.43 m: trace gravel (fine to coarse), mottled dark brown and brown
- below 8.99 m: hard, dark brown
- below 10.06 m: mottled dark brown and grey

UNOXIDIZED TILL: Hard, moist, grey, unoxidized, silt, sandy (fine to coarse), clayey, trace gravel (fine to coarse), highly calcareous, gypsum crystals, medium plastic (till)

VW Serial Number	Total Head (masl)
2153162	519.94
2154606	519.26

(Recorded 2022-04-01)

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.37.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

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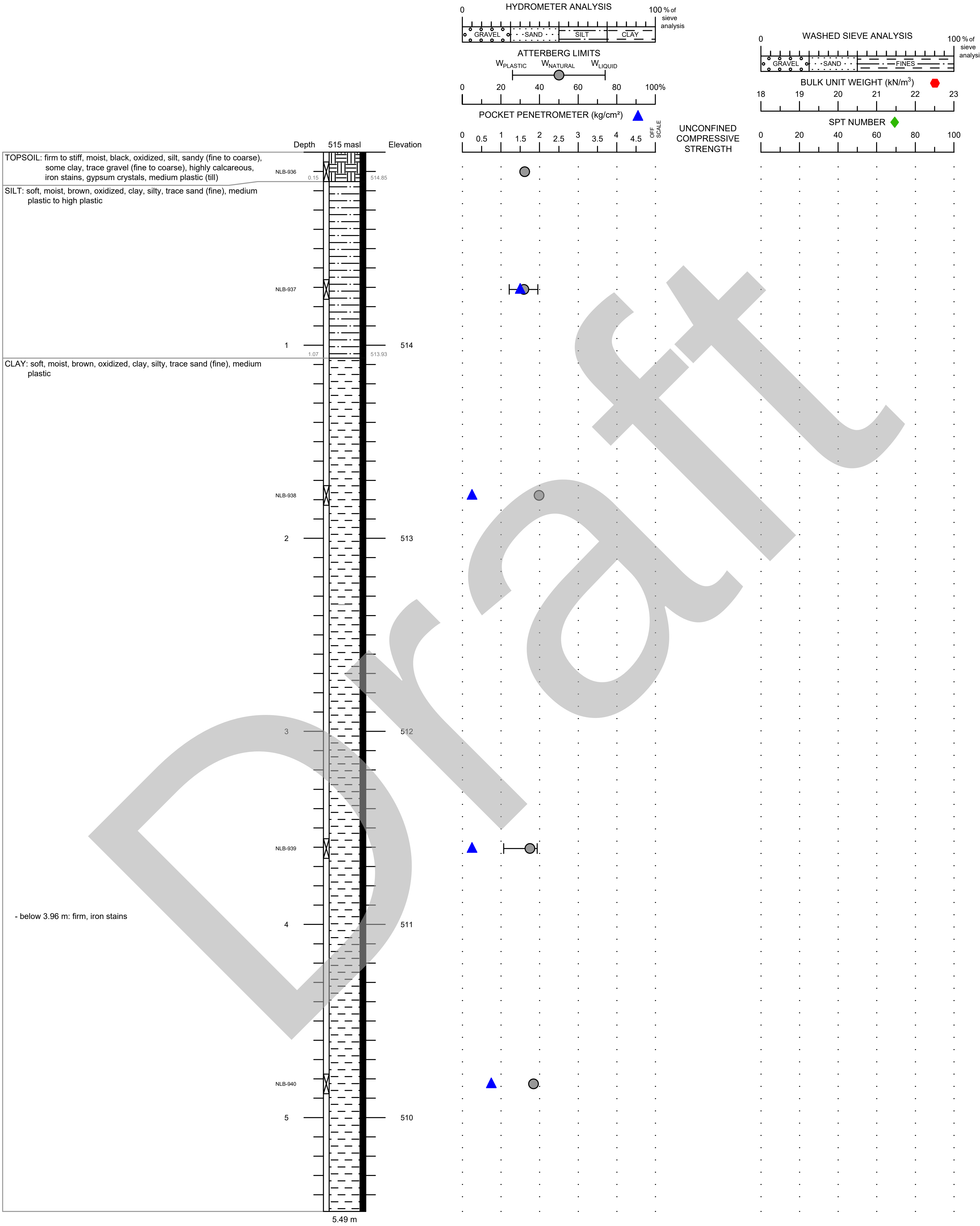
CLIENT	SASKATCHEWAN MINISTRY OF HIGHWAYS	**PROJECT LOCATION**	SASKATOON, SASKATCHEWAN
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-07-06

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-05
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-02-05

LIMITATION

BOREHOLE 22-36 (PHII 7)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5770159 N 395321 E
NAD 83 ZONE 13
SW 09-36-04-W3M



TOPSOIL: firm to stiff, moist, black, oxidized, silt, sandy (fine to coarse), some clay, trace gravel (fine to coarse), highly calcareous, iron stains, gypsum crystals, medium plastic (till)

SILT: soft, moist, brown, oxidized, clay, silty, trace sand (fine), medium plastic to high plastic

CLAY: soft, moist, brown, oxidized, clay, silty, trace sand (fine), medium plastic

- below 3.96 m: firm, iron stains

REFERENCE DRAWINGS	
DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with cuttings and bentonite chips to surface.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (Handheld GPS Survey, 2022).

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CLIENT	PROJECT LOCATION
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:20	**DATE**	2022-07-06

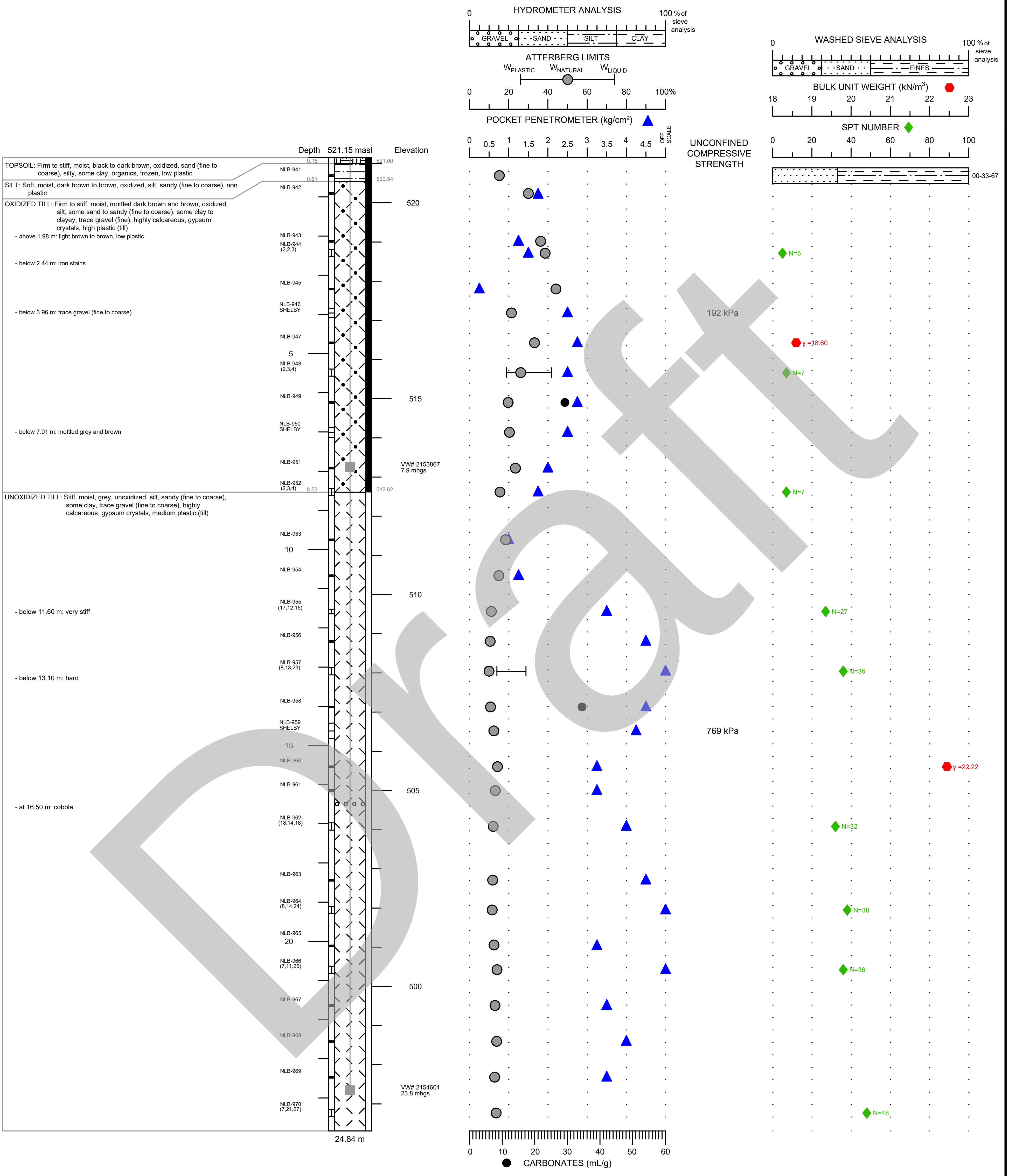
LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S. RANDAL	**LOGGED BY**	G. KELLY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-05
ABANDONMENT	-	**INSTALLATION DATE**	N/A

BOREHOLE 22-37 (FHII 17)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5770543.15 N   396750.85 E
NAD 83 ZONE 13 U
SE 09-36-04-W3M



VW Serial Number	Total Head (masl)
2153867	516.08
2154601	516.55

(Recorded 2022-04-01)

REFERENCE DRAWINGS

DWG No	DESCRIPTION

NOTES

1. Borehole open and dry immediately after drilling (I.A.D.).
2. Borehole backfilled with water:cement:bentonite mixture (4.5:1:0.1) specific gravity 1.35.
3. Standard Penetration Tests (SPT) conducted with 63.5 kg (140 lb) automatic trip hammer falling 762 mm (30 inches).
4. (#,#,#) denotes SPT blows per 152 mm (6.0 inches).
5. Depths are in metres (m).
6. Elevations are in metres above sea level (masl).
7. Borehole coordinates and elevations provided by SNC-Lavalin (RTK GPS Survey, 2022).

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CONTRACTOR	FORGED DRILLING Ltd.	**SUPERVISOR**	N. BOUEY
OPERATOR	S.RANDAL	**LOGGED BY**	N. BOUEY
TYPE OF DRILL RIG	R702	**DRILLED DATE**	2022-02-06
ABANDONMENT	GROUTED VIBRATING WIRE PIEZOMETERS	**INSTALLATION DATE**	2022-02-06

CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	A. COLE, A.Sc.T.		
PROJECT No.	659183		
SCALE	1:100	**DATE**	2022-04-11

LIMITATION

This drill log is a summary of the conditions estimated by the field personnel at the specific location at the time of drilling. The conditions and properties described above will vary between locations and may vary with time.

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\BH-659183-BH22-37 (FHII 17).dwg

Appendix V

Vibrating Wire Calibration Records

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	SNC LAVALIN INC., ENVIRONMENT & WATER
Sales Order:	229808
Customer ID:	
Model:	VW2100-2.0
Serial Number:	VW138151
Mfg Number:	P138151
Range:	2.0 MPa
Cable Length:	89 meters
Cable Marking:	7704 m to 7793 m
Cable Type:	EL380004K
Cable Colour Code:	Red/Black (Coil) Green/White (Thermistor)
Thermistor Type:	3K

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (%FS)	Calculated Polynomial (MPa)	Polynomial Error (%FS)
0.000	9212	9214	9213	0.003	0.13	0.000	0.00
0.400	8524	8524	8524	0.399	-0.03	0.400	0.00
0.800	7833	7833	7833	0.798	-0.12	0.800	-0.01
1.200	7138	7138	7138	1.198	-0.11	1.200	-0.00
1.600	6440	6441	6441	1.600	-0.01	1.600	0.02
2.000	5741	5742	5742	2.002	0.12	2.000	-0.01
Max Error (%)					0.13		0.02

Linear Calibration Factor: **CF = 5.7614e-04 MPa/B unit**
Temperature Correction Factor: **Tk = 1.6348e-04 MPa/°C rise**

Polynomial Gauge Factor:
A = -1.6347e-09 MPa/(B unit)² **B = -5.5169e-04 MPa/B unit** **C = calculate (see below) MPa**

Users must establish site zero readings for calculation purposes
Polynomial C = -[A(L_0^2) + B(L_0)]

Pressure is calculated with the following equations:
Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$
Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0, L = initial (installation) and current readings, in B units
T_0, T = initial (installation) and current temperature, in °C
S_0, S = initial (installation) and current barometric pressure readings, in MPa
B units = Hz²/1000 ie: 1700 Hz = 2890 B units

Shipped Zero Readings:	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
	27 Oct 2021	9208	21.4	1018.1

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician:	Kailah Toews	**Date:**	27/10/2021
Approved:	Ora Nygren	**Date:**	27/10/2021

Calibration Record

Monitor with Confidence
RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer: SNC LAVALIN INC., ENVIRONMENT & WATER
Sales Order: 229808
Customer ID:
Model: VW2100-2.0
Serial Number: VW138167
Mfg Number: P138167
Range: 2.0 MPa
Cable Length: 95 meters
Cable Marking: 7608 m to 7703 m
Cable Type: EL380004K
Cable Colour Code: Red/Black (Coil) Green/White (Thermistor)
Thermistor Type: 3K

Applied Pressure (MPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (MPa)	Linearity Error (%FS)	Calculated Polynomial (MPa)	Polynomial Error (%FS)
0.000	9483	9485	9484	0.003	0.13	0.000	0.00
0.400	8806	8806	8806	0.400	-0.02	0.400	0.00
0.800	8125	8126	8125	0.798	-0.10	0.800	-0.00
1.200	7442	7442	7442	1.198	-0.10	1.200	-0.00
1.600	6756	6756	6756	1.600	-0.02	1.600	0.01
2.000	6068	6068	6068	2.002	0.12	2.000	-0.00
Max Error (%)					0.13		0.01

Linear Calibration Factor: **CF = 5.8542e-04 MPa/B unit**
Temperature Correction Factor: **Tk = 1.2733e-04 MPa/°C rise**

Polynomial Gauge Factor:
A = -1.6064e-09 MPa/(B unit)² **B = -5.6044e-04 MPa/B unit** **C = calculate (see below) MPa**

Users must establish site zero readings for calculation purposes
Polynomial C = $-[A(L_0^2) + B(L_0)]$

Pressure is calculated with the following equations:
Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$
Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0, L = initial (installation) and current readings, in B units
T_0, T = initial (installation) and current temperature, in °C
S_0, S = initial (installation) and current barometric pressure readings, in MPa
B units = Hz²/1000 ie: 1700 Hz = 2890 B units

	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
Shipped Zero Readings:	27 Oct 2021	9489	21.4	1017.1

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician: Kailah Toews **Date:** 27/10/2021

Approved: Ora Nygren **Date:** 27/10/2021

Monitor with Confidence

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	SNC LAVALIN INC., ENVIRONMENT & WATER
Sales Order:	229808
Customer ID:	
Model:	VW2100-0.7
Serial Number:	VW138458
Mfg Number:	P138458
Range:	700 kPa
Cable Length:	55 meters
Cable Marking:	7483 m to 7538 m
Cable Type:	EL380004K
Cable Colour Code:	Red/Black (Coil) Green/White (Thermistor)
Thermistor Type:	3K

Applied Pressure (kPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (kPa)	Linearity Error (%FS)	Calculated Polynomial (kPa)	Polynomial Error (%FS)
0.0	9506	9507	9506	0.9	0.13	0.0	0.00
140.0	8897	8897	8897	139.8	-0.03	140.0	-0.01
280.0	8284	8285	8285	279.3	-0.11	280.0	-0.00
420.0	7670	7670	7670	419.3	-0.10	420.0	0.00
560.0	7053	7053	7053	559.9	-0.02	560.0	0.01
700.0	6434	6434	6434	700.9	0.13	700.0	-0.00
Max Error (%)					0.13		0.01

Linear Calibration Factor: **CF = 2.2781e-01 kPa/B unit**
Temperature Correction Factor: **Tk = 2.6597e-01 kPa/°C rise**

Polynomial Gauge Factor:
A = -7.2922e-07 kPa/(B unit)² **B = -2.1618e-01 kPa/B unit** **C = calculate (see below) kPa**

Users must establish site zero readings for calculation purposes
Polynomial C = -[A(L_0^2) + B(L_0)]

Pressure is calculated with the following equations:
Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$
Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0, L = initial (installation) and current readings, in B units
T_0, T = initial (installation) and current temperature, in °C
S_0, S = initial (installation) and current barometric pressure readings, in kPa
B units = Hz²/1000 ie: 1700 Hz = 2890 B units

Shipped Zero Readings:	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
	27 Oct 2021	9480	21.0	1018.1

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician: Kailah Toews **Date:** 27/10/2021

Approved: Ora Nygren **Date:** 27/10/2021

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Monitor with Confidence

Vibrating Wire Piezometer

Customer:	SNC LAVALIN INC., ENVIRONMENT & WATER
Sales Order:	229808
Customer ID:	
Model:	VW2100-0.7
Serial Number:	VW138631
Mfg Number:	P138631
Range:	700 kPa
Cable Length:	46 meters
Cable Marking:	7436 m to 7482 m
Cable Type:	EL380004K
Cable Colour Code:	Red/Black (Coil) Green/White (Thermistor)
Thermistor Type:	3K

Applied Pressure (kPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (kPa)	Linearity Error (%FS)	Calculated Polynomial (kPa)	Polynomial Error (%FS)
0.0	9114	9114	9114	0.4	0.05	0.0	0.00
140.0	8523	8524	8523	139.9	-0.01	140.0	-0.00
280.0	7931	7931	7931	279.7	-0.04	280.0	-0.00
420.0	7338	7338	7338	419.7	-0.04	420.0	-0.00
560.0	6743	6744	6744	560.1	0.01	560.1	0.02
700.0	6150	6150	6150	700.3	0.04	699.9	-0.01
Max Error (%)					0.05		0.02

Linear Calibration Factor: **CF = 2.3611e-01 kPa/B unit**
Temperature Correction Factor: **Tk = 3.0104e-02 kPa/°C rise**

Polynomial Gauge Factor:
A = -2.8063e-07 kPa/(B unit)² **B = -2.3183e-01 kPa/B unit** **C = calculate (see below) kPa**

Users must establish site zero readings for calculation purposes
Polynomial C = $-[A(L_0^2) + B(L_0)]$

Pressure is calculated with the following equations:
Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$
Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0, L = initial (installation) and current readings, in B units
T_0, T = initial (installation) and current temperature, in °C
S_0, S = initial (installation) and current barometric pressure readings, in kPa
B units = Hz²/1000 ie: 1700 Hz = 2890 B units

	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
Shipped Zero Readings:	27 Oct 2021	9121	21.7	1018.1

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician: Kailah Toews **Date:** 27/10/2021

Approved: Ora Nygren **Date:** 27/10/2021

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	SNC LAVALIN INC., ENVIRONMENT & WATER
Sales Order:	229808
Customer ID:	
Model:	VW2100-0.35
Serial Number:	VW139465
Mfg Number:	P139465
Range:	350 kPa
Cable Length:	29 meters
Cable Marking:	7577 m to 7606 m
Cable Type:	EL380004K
Cable Colour Code:	Red/Black (Coil) Green/White (Thermistor)
Thermistor Type:	3K

Applied Pressure (kPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (kPa)	Linearity Error (%FS)	Calculated Polynomial (kPa)	Polynomial Error (%FS)
0.0	8983	8984	8983	-0.1	-0.03	0.0	0.00
70.0	8382	8382	8382	70.0	0.01	70.0	0.00
140.0	7780	7780	7780	140.1	0.02	140.0	-0.01
210.0	7179	7179	7179	210.1	0.03	210.0	0.01
280.0	6579	6579	6579	280.0	0.01	280.0	0.00
350.0	5979	5979	5979	349.9	-0.03	350.0	-0.00
Max Error (%)					0.03		0.01

Linear Calibration Factor: **CF = 1.1650e-01 kPa/B unit**
Temperature Correction Factor: **Tk = -3.8737e-02 kPa/°C rise**

Polynomial Gauge Factor:
A = 9.2212e-08 kPa/$(B\ unit)^2$ **B = -1.1788e-01 kPa/B unit** **C = calculate (see below) kPa**

Users must establish site zero readings for calculation purposes
Polynomial C = $-[A(L_0^2) + B(L_0)]$

Pressure is calculated with the following equations:
Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$
Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0, L = initial (installation) and current readings, in B units
T_0, T = initial (installation) and current temperature, in °C
S_0, S = initial (installation) and current barometric pressure readings, in kPa
B units = $Hz^2/1000$ ie: 1700 Hz = 2890 B units

Shipped Zero Readings:	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
	27 Oct 2021	8981	21.1	1018.1

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician:	Kailah Toews	**Date:**	27/10/2021
Approved:	Ora Nygren	**Date:**	27/10/2021

rst INSTRUMENTS Monitor with Confidence

Calibration Record

RST Instruments Ltd., 11545 Kingston St., Maple Ridge, British Columbia, Canada V2X 0Z5
Tel: 604 540 1100 • Fax: 604 540 1005 • Toll Free: 1 800 665 5599 (North America only)
e-mail: info@rstinstruments.com • Website: www.rstinstruments.com

Vibrating Wire Piezometer

Customer:	SNC LAVALIN INC., ENVIRONMENT & WATER
Sales Order:	229808
Customer ID:	
Model:	VW2100-0.35
Serial Number:	VW139492
Mfg Number:	P139492
Range:	350 kPa
Cable Length:	36 meters
Cable Marking:	7540 m to 7575 m
Cable Type:	EL380004K
Cable Colour Code:	Red/Black (Coil) Green/White (Thermistor)
Thermistor Type:	3K

Applied Pressure (kPa)	First Reading (B units)	Second Reading (B units)	Average Reading (B units)	Calculated Linear (kPa)	Linearity Error (%FS)	Calculated Polynomial (kPa)	Polynomial Error (%FS)
0.0	9517	9518	9518	-0.2	-0.07	0.1	0.03
70.0	8823	8824	8824	69.9	-0.02	69.9	-0.04
140.0	8129	8129	8129	140.2	0.05	139.9	-0.03
210.0	7434	7434	7434	210.4	0.12	210.1	0.04
280.0	6744	6744	6744	280.2	0.05	280.1	0.03
350.0	6058	6058	6058	349.6	-0.12	349.9	-0.02
Max Error (%)					0.12		0.04

Linear Calibration Factor: **CF = 1.0111e-01 kPa/B unit**
Temperature Correction Factor: **Tk = -7.7851e-02 kPa/°C rise**

Polynomial Gauge Factor:
A = 2.1624e-07 kPa/(B unit)² **B = -1.0447e-01 kPa/B unit** **C = calculate (see below) kPa**

Users must establish site zero readings for calculation purposes
Polynomial C = $-[A(L_0^2) + B(L_0)]$

Pressure is calculated with the following equations:
Linear: $P = CF(L_0 - L) - Tk(T_0 - T) + (S_0 - S)$
Polynomial: $P = A(L^2) + B(L) + C - Tk(T_0 - T) + (S_0 - S)$

L_0, L = initial (installation) and current readings, in B units
T_0, T = initial (installation) and current temperature, in °C
S_0, S = initial (installation) and current barometric pressure readings, in kPa
B units = Hz²/1000 ie: 1700 Hz = 2890 B units

	Date	VW Reading (B Units)	Temperature (°C)	Baro (mbar)
Shipped Zero Readings:	27 Oct 2021	9530	21.8	1018.1

This instrument has been calibrated using standards traceable to the NIST in compliance with ANSI Z540-1

Technician: Kailah Toews **Date:** 27/10/2021

Approved: Ora Nygren **Date:** 27/10/2021

GEOKON.

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: April 27, 2020

This calibration has been verified/validated as of 08/07/2020

Serial Number: 2021005

Temperature: 23.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.6 mbar

Cable Length: 30 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8994	8995	8995	1.189	0.17	-0.020	0.00
140.0	8237	8237	8237	139.7	-0.04	140.1	0.01
280.0	7476	7477	7477	278.8	-0.17	280.0	-0.01
420.0	6710	6711	6711	418.9	-0.16	420.1	0.00
560.1	5941	5941	5941	559.7	-0.05	560.0	0.00
700.0	5167	5167	5167	701.3	0.17	700.0	0.00

(kPa) Linear Gauge Factor (G): **-0.1829** **(kPa/ digit)**

Polynomial Gauge factors: **A: -6.63E-07** **B: -0.1735** **C:**

Thermal Factor (K): 0.05192 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.02653** **(psi/ digit)**

Polynomial Gauge Factors: **A: -9.616E-08** **B: -0.02517** **C:**

Thermal Factor (K): 0.007530 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9004 **Temperature: 22.8 °C** **Barometer: 993.5 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

3004.2 21.1°C

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Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: June 25, 2020

This calibration has been verified/validated as of 08/07/2020

Serial Number: 2025998

Temperature: 22.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 992.3 mbar

Cable Length: 20 meters

Technician: Kathy Rogers

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9074	9075	9075	0.274	0.08	-0.047	-0.01
70.0	8438	8438	8438	70.03	0.01	70.11	0.03
140.0	7802	7803	7803	139.7	-0.08	140.0	0.00
210.0	7164	7165	7165	209.6	-0.10	209.9	-0.02
279.9	6523	6523	6523	279.9	-0.01	280.0	0.01
349.9	5881	5881	5881	350.3	0.09	349.9	0.00

(kPa) Linear Gauge Factor (G): -0.1096 **(kPa/ digit)**

Polynomial Gauge factors: **A:** -2.469E-07 **B:** -0.1059 **C:**

Thermal Factor (K): -0.1160 **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01590 **(psi/ digit)**

Polynomial Gauge Factors: **A:** -3.581E-08 **B:** -0.01536 **C:**

Thermal Factor (K): -0.01682 **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9083 **Temperature:** 21.9 **°C** **Barometer:** 993.3 **mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

3619.6 22.7

GEOKON.

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: June 25, 2020

This calibration has been verified/validated as of 08/07/2020

Serial Number: 2026004

Temperature: 22.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 992.3 mbar

Cable Length: 12 meters

Technician: Kathy Rogers

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9008	9008	9008	0.228	0.07	0.141	0.04
70.0	8398	8398	8398	69.65	-0.10	69.73	-0.08
140.0	7781	7781	7781	139.9	-0.03	140.0	0.02
210.0	7165	7166	7166	209.9	-0.01	210.1	0.04
279.9	6551	6551	6551	279.9	-0.02	279.9	0.00
349.9	5935	5935	5935	350.0	0.01	349.9	-0.01

(kPa) Linear Gauge Factor (G): -0.1138 (kPa/ digit)

Polynomial Gauge factors: A: -1.07E-07 B: -0.1122 C: ________

Thermal Factor (K): -0.1276 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01651 (psi/ digit)

Polynomial Gauge Factors: A: -1.551E-08 B: -0.01628 C: ________

Thermal Factor (K): -0.01851 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9010 Temperature: 21.8 °C Barometer: 993.3 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

3009.3 23

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Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153128

Temperature: 20.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.8 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdrey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8720	8721	8721	0.464	0.13	0.026	0.01
70.0	8197	8197	8197	69.88	-0.04	70.01	0.00
140.0	7671	7672	7672	139.6	-0.13	140.0	-0.01
210.0	7144	7144	7144	209.5	-0.13	209.9	-0.01
280.0	6612	6612	6612	280.0	0.00	280.2	0.04
349.9	6082	6082	6082	350.3	0.11	349.9	-0.02

(kPa) Linear Gauge Factor (G): -0.1326 (kPa/ digit)

Polynomial Gauge factors: A: -5.147E-07 B: -0.1250 C: ________

Thermal Factor (K): -0.02481 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01923 (psi/ digit)

Polynomial Gauge Factors: A: -7.465E-08 B: -0.01813 C: ________

Thermal Factor (K): -0.003599 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8736 Temperature: 21.7 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number:	4500S-350 kPa	Date of Calibration:	November 18, 2021
Serial Number:	2153129	Temperature:	20.90 °C
Calibration Instruction:	CI-Pressure Transducers 7 kPa~3.5 MPa	Barometric Pressure:	993.8 mbar
Cable Length:	20 meters	Technician:	Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9098	9098	9098	0.516	0.15	-0.028	-0.01
70.0	8559	8560	8560	69.92	-0.02	70.04	0.01
140.0	8019	8019	8019	139.6	-0.13	140.0	0.01
210.0	7476	7476	7476	209.6	-0.11	210.0	0.02
280.0	6931	6932	6932	279.7	-0.08	279.9	-0.04
349.9	6382	6382	6382	350.5	0.18	350.0	0.02

(kPa) Linear Gauge Factor (G): -0.1289 (kPa/ digit)

Polynomial Gauge factors: A: -5.706E-07 B: -0.1200 C: ________

Thermal Factor (K): -0.03618 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01869 (psi/ digit)

Polynomial Gauge Factors: A: -8.276E-08 B: -0.01741 C: ________

Thermal Factor (K): -0.005247 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9113 Temperature: 21.7 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153131

Temperature: 20.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.8 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9187	9188	9188	0.564	0.16	0.057	0.02
70.0	8634	8634	8634	69.89	-0.03	70.00	0.00
140.0	8079	8079	8079	139.4	-0.17	139.8	-0.05
210.0	7518	7519	7519	209.6	-0.10	210.0	0.02
280.0	6956	6956	6956	280.1	0.01	280.2	0.05
349.9	6395	6395	6395	350.3	0.11	349.8	-0.03

(kPa) Linear Gauge Factor (G): -0.1253 (kPa/ digit)

Polynomial Gauge factors: A: -4.992E-07 B: -0.1175 C: ________

Thermal Factor (K): -0.04921 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01817 (psi/ digit)

Polynomial Gauge Factors: A: -7.241E-08 B: -0.01704 C: ________

Thermal Factor (K): -0.007137 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9203 Temperature: 36.5 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

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Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153132

Temperature: 20.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.8 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdrey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8826	8827	8827	0.568	0.16	0.068	0.02
70.0	8277	8278	8278	69.92	-0.02	69.98	-0.01
140.0	7727	7727	7727	139.5	-0.16	139.8	-0.06
210.0	7170	7170	7170	209.8	-0.04	210.2	0.06
280.0	6614	6615	6615	280.0	-0.01	280.1	0.01
349.9	6057	6058	6058	350.4	0.12	349.9	-0.02

(kPa) Linear Gauge Factor (G): -0.1263 (kPa/ digit)

Polynomial Gauge factors: A: -4.568E-07 B: -0.1195 C: ________

Thermal Factor (K): -0.04656 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01832 (psi/ digit)

Polynomial Gauge Factors: A: -6.625E-08 B: -0.01734 C: ________

Thermal Factor (K): -0.006753 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8836 Temperature: 21.8 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number:	4500S-350 kPa	Date of Calibration:	November 18, 2021
Serial Number:	2153134	Temperature:	20.90 °C
Calibration Instruction:	CI-Pressure Transducers 7 kPa~3.5 MPa	Barometric Pressure:	993.8 mbar
Cable Length:	20 meters	Technician:	Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8582	8583	8583	0.406	0.12	0.058	0.02
70.0	7984	7985	7985	69.85	-0.04	69.90	-0.03
140.0	7382	7382	7382	139.8	-0.05	140.1	0.01
210.0	6780	6780	6780	209.7	-0.06	210.0	0.01
280.0	6175	6175	6175	280.0	-0.01	280.0	0.01
349.9	5570	5570	5570	350.3	0.09	349.9	-0.01

(kPa) Linear Gauge Factor (G): -0.1161 (kPa/ digit)

Polynomial Gauge factors: A: -2.702E-07 B: -0.1123 C: ________

Thermal Factor (K): -0.03868 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01684 (psi/ digit)

Polynomial Gauge Factors: A: -3.92E-08 B: -0.01629 C: ________

Thermal Factor (K): -0.005611 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8600 Temperature: 21.5 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number:	4500S-350 kPa	Date of Calibration:	November 18, 2021
Serial Number:	2153135	Temperature:	20.90 °C
Calibration Instruction:	CI-Pressure Transducers 7 kPa~3.5 MPa	Barometric Pressure:	993.8 mbar
Cable Length:	20 meters	Technician:	Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9010	9011	9011	0.558	0.16	0.025	0.01
70.0	8451	8451	8451	69.88	-0.03	70.01	0.00
140.0	7889	7889	7889	139.5	-0.14	140.0	-0.01
210.0	7324	7325	7325	209.5	-0.14	209.9	-0.01
280.0	6755	6755	6755	280.0	0.00	280.2	0.04
349.9	6187	6187	6187	350.4	0.13	349.9	-0.02

(kPa) Linear Gauge Factor (G): **-0.1239** **(kPa/ digit)**

Polynomial Gauge factors: **A: -5.181E-07** **B: -0.1160** **C:** ______

Thermal Factor (K): -0.05464 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.01797** **(psi/ digit)**

Polynomial Gauge Factors: **A: -7.514E-08** **B: -0.01683** **C:** ______

Thermal Factor (K): -0.007926 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9026 **Temperature: 21.8 °C** **Barometer: 980.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153136

Temperature: 20.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.8 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdrey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9022	9023	9023	0.441	0.13	0.013	0.00
70.0	8471	8472	8472	69.91	-0.03	70.02	0.01
140.0	7919	7919	7919	139.6	-0.13	139.9	-0.02
210.0	7363	7363	7363	209.7	-0.08	210.0	0.03
280.0	6806	6806	6806	279.9	-0.04	280.0	-0.01
349.9	6247	6247	6247	350.4	0.12	349.9	0.00

(kPa) Linear Gauge Factor (G): -0.1261 (kPa/ digit)

Polynomial Gauge factors: A: -4.394E-07 B: -0.1194 C:

Thermal Factor (K): -0.008836 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01829 (psi/ digit)

Polynomial Gauge Factors: A: -6.373E-08 B: -0.01731 C:

Thermal Factor (K): -0.001282 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9039 Temperature: 21.8 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153138

Temperature: 20.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.8 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8808	8809	8809	0.439	0.13	0.076	0.02
70.0	8256	8256	8256	69.80	-0.06	69.94	-0.02
140.0	7701	7701	7701	139.5	-0.16	139.9	-0.04
210.0	7141	7141	7141	209.8	-0.05	210.2	0.06
280.0	6582	6583	6583	279.9	-0.04	280.0	0.00
349.9	6022	6022	6022	350.2	0.09	349.9	-0.01

(kPa) Linear Gauge Factor (G): -0.1255 (kPa/ digit)

Polynomial Gauge factors: A: -4.051E-07 B: -0.1195 C:

Thermal Factor (K): -0.01216 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01821 (psi/ digit)

Polynomial Gauge Factors: A: -5.875E-08 B: -0.01734 C:

Thermal Factor (K): -0.001764 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8820 Temperature: 21.7 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number:	4500S-350 kPa	Date of Calibration:	November 18, 2021
Serial Number:	2153139	Temperature:	20.90 °C
Calibration Instruction:	CI-Pressure Transducers 7 kPa~3.5 MPa	Barometric Pressure:	993.8 mbar
Cable Length:	20 meters	Technician:	Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9059	9060	9060	0.455	0.13	0.007	0.00
70.0	8525	8526	8526	69.91	-0.03	70.02	0.01
140.0	7990	7990	7990	139.6	-0.13	140.0	-0.02
210.0	7451	7451	7451	209.7	-0.08	210.1	0.03
280.0	6911	6912	6912	279.8	-0.05	280.0	-0.02
349.9	6369	6369	6369	350.4	0.13	349.9	0.00

(kPa) Linear Gauge Factor (G): **-0.1301** **(kPa/ digit)**

Polynomial Gauge factors: **A:** **-4.86E-07** **B:** **-0.1226** **C:** ______

Thermal Factor (K): **-0.01476** **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.01886** **(psi/ digit)**

Polynomial Gauge Factors: **A:** **-7.049E-08** **B:** **-0.01778** **C:** ______

Thermal Factor (K): **-0.002141** **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: **9074** **Temperature:** **21.6** **°C** **Barometer:** **980.7** **mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa
Date of Calibration: November 18, 2021

Serial Number: 2153141
Temperature: 20.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa
Barometric Pressure: 993.8 mbar

Cable Length: 20 meters
Technician: Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8987	8988	8988	0.197	0.06	-0.076	-0.02
70.0	8454	8455	8455	70.04	0.01	70.17	0.05
140.0	7923	7924	7924	139.6	-0.11	140.0	-0.02
210.0	7389	7389	7389	209.7	-0.08	210.0	0.01
280.0	6854	6854	6854	279.8	-0.07	279.9	-0.03
349.9	6316	6316	6316	350.3	0.10	350.0	0.02

(kPa) Linear Gauge Factor (G): -0.1310 (kPa/ digit)

Polynomial Gauge factors: A: -3.532E-07 B: -0.1256 C: ______

Thermal Factor (K): 0.01093 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01901 (psi/ digit)

Polynomial Gauge Factors: A: -5.123E-08 B: -0.01822 C: ______

Thermal Factor (K): 0.001585 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9000 Temperature: 22.0 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153142

Temperature: 20.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.8 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8995	8995	8995	0.521	0.15	0.063	0.02
70.0	8462	8463	8463	69.87	-0.04	69.90	-0.03
140.0	7926	7926	7926	139.7	-0.08	140.0	0.00
210.0	7388	7388	7388	209.8	-0.04	210.1	0.04
280.0	6849	6850	6850	279.9	-0.02	280.0	-0.02
349.9	6308	6309	6309	350.4	0.13	349.9	0.00

(kPa) Linear Gauge Factor (G): -0.1302 (kPa/ digit)

Polynomial Gauge factors: A: -4.234E-07 B: -0.1238 C: ______

Thermal Factor (K): -0.01601 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01889 (psi/ digit)

Polynomial Gauge Factors: A: -6.14E-08 B: -0.01795 C: ______

Thermal Factor (K): -0.002323 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9005 Temperature: 21.7 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153144

Temperature: 20.90 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.8 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8936	8937	8937	0.461	0.13	0.054	0.02
70.0	8410	8410	8410	69.83	-0.05	69.93	-0.02
140.0	7880	7881	7881	139.6	-0.12	140.0	-0.02
210.0	7348	7348	7348	209.8	-0.06	210.1	0.05
280.0	6816	6816	6816	279.8	-0.05	280.0	-0.02
349.9	6281	6281	6281	350.3	0.12	349.9	0.00

(kPa) Linear Gauge Factor (G): -0.1318 (kPa/ digit)

Polynomial Gauge factors: A: -4.549E-07 B: -0.1248 C: ________

Thermal Factor (K): -0.06409 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01911 (psi/ digit)

Polynomial Gauge Factors: A: -6.598E-08 B: -0.01811 C: ________

Thermal Factor (K): -0.009296 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8949 Temperature: 21.7 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153152

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8809	8810	8810	0.414	0.12	0.023	0.01
70.0	8222	8223	8223	69.86	-0.04	70.00	0.00
140.0	7633	7634	7634	139.6	-0.13	140.0	-0.02
210.0	7042	7042	7042	209.5	-0.12	209.9	0.00
280.0	6446	6447	6447	280.0	-0.01	280.1	0.03
349.9	5852	5853	5853	350.3	0.10	349.9	-0.02

(kPa) Linear Gauge Factor (G): -0.1183 (kPa/ digit)

Polynomial Gauge factors: **A: -3.791E-07** **B: -0.1128** **C:**

Thermal Factor (K): -0.03183 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01716 (psi/ digit)

Polynomial Gauge Factors: **A: -5.499E-08** **B: -0.01635** **C:**

Thermal Factor (K): -0.004616 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8811 **Temperature: 21.0 °C** **Barometer: 997.1 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153154

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9006	9007	9007	0.181	0.05	0.037	0.01
70.0	8430	8430	8430	69.88	-0.03	69.97	-0.01
140.0	7852	7852	7852	139.8	-0.07	140.0	-0.01
210.0	7273	7273	7273	209.8	-0.05	210.0	0.01
280.0	6692	6692	6692	280.0	0.00	280.1	0.02
349.9	6113	6113	6113	350.0	0.03	349.9	-0.01

(kPa) Linear Gauge Factor (G): -0.1209 (kPa/ digit)

Polynomial Gauge factors: A: -1.691E-07 B: -0.1184 C: ________

Thermal Factor (K): -0.09727 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01754 (psi/ digit)

Polynomial Gauge Factors: A: -2.453E-08 B: -0.01717 C: ________

Thermal Factor (K): -0.01411 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9006 Temperature: 21.3 °C Barometer: 997.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153155

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8826	8826	8826	0.360	0.10	0.074	0.02
70.0	8246	8246	8246	69.86	-0.04	69.91	-0.02
140.0	7663	7663	7663	139.7	-0.08	139.9	-0.02
210.0	7078	7078	7078	209.8	-0.03	210.0	0.03
280.0	6492	6492	6492	280.1	0.01	280.1	0.02
349.9	5907	5907	5907	350.2	0.06	349.9	-0.02

(kPa) Linear Gauge Factor (G): -0.1198 (kPa/ digit)

Polynomial Gauge factors: A: -2.431E-07 B: -0.1163 C: ________

Thermal Factor (K): -0.03781 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01738 (psi/ digit)

Polynomial Gauge Factors: A: -3.526E-08 B: -0.01686 C: ________

Thermal Factor (K): -0.005483 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8825 Temperature: 21.1 °C Barometer: 997.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153156

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 20 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8552	8553	8553	0.409	0.12	0.033	0.01
70.0	7959	7959	7959	69.80	-0.05	69.91	-0.02
140.0	7361	7361	7361	139.7	-0.09	140.1	0.02
210.0	6763	6763	6763	209.6	-0.09	210.0	0.01
280.0	6162	6163	6163	279.8	-0.05	280.0	-0.02
349.9	5559	5560	5560	350.3	0.11	350.0	0.01

(kPa) Linear Gauge Factor (G): -0.1169 (kPa/ digit)

Polynomial Gauge factors: A: -3.454E-07 B: -0.1120 C:

Thermal Factor (K): -0.01868 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01696 (psi/ digit)

Polynomial Gauge Factors: A: -5.01E-08 B: -0.01625 C:

Thermal Factor (K): -0.002709 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8552 Temperature: 21.3 °C Barometer: 997.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153158

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8672	8673	8673	0.536	0.15	0.024	0.01
70.0	8091	8091	8091	69.85	-0.04	70.00	0.00
140.0	7507	7507	7507	139.5	-0.16	140.0	-0.02
210.0	6920	6920	6920	209.4	-0.15	209.9	-0.01
280.0	6328	6328	6328	280.0	-0.01	280.2	0.04
349.9	5737	5738	5738	350.4	0.13	349.9	-0.02

(kPa) Linear Gauge Factor (G): **-0.1192** **(kPa/ digit)**

Polynomial Gauge factors: **A:** **-4.864E-07** **B:** **-0.1122** **C:** ______

Thermal Factor (K): **0.03131** **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.01729** **(psi/ digit)**

Polynomial Gauge Factors: **A:** **-7.055E-08** **B:** **-0.01627** **C:** ______

Thermal Factor (K): **0.004541** **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: **8672** **Temperature:** **21.2** **°C** **Barometer:** **997.1** **mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number:	4500S-350 kPa	Date of Calibration:	November 18, 2021
Serial Number:	2153159	Temperature:	21.30 °C
Calibration Instruction:	CI-Pressure Transducers 7 kPa~3.5 MPa	Barometric Pressure:	993.3 mbar
Cable Length:	15 meters	Technician:	Dean O. Cowdrey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	7998	7999	7999	0.398	0.11	0.060	0.02
70.0	7387	7387	7387	69.89	-0.03	69.99	0.00
140.0	6774	6775	6775	139.5	-0.15	139.8	-0.06
210.0	6157	6157	6157	209.7	-0.08	210.0	0.02
280.0	5537	5537	5537	280.1	0.03	280.2	0.06
349.9	4921	4921	4921	350.1	0.06	349.8	-0.04

(kPa) Linear Gauge Factor (G): -0.1136 **(kPa/ digit)**

Polynomial Gauge factors: **A:** -2.911E-07 **B:** -0.1099 **C:** ____

Thermal Factor (K): -0.06996 **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01648 **(psi/ digit)**

Polynomial Gauge Factors: **A:** -4.221E-08 **B:** -0.01594 **C:** ____

Thermal Factor (K): -0.01015 **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 7996 **Temperature:** 22.0 **°C** **Barometer:** 997.9 **mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153160

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8991	8992	8992	0.304	0.09	0.025	0.01
70.0	8418	8419	8419	69.92	-0.02	69.98	0.00
140.0	7844	7844	7844	139.7	-0.09	140.0	-0.02
210.0	7267	7267	7267	209.8	-0.04	210.1	0.03
280.0	6690	6690	6690	279.9	-0.03	280.0	-0.01
349.9	6111	6112	6112	350.2	0.08	349.9	0.00

(kPa) Linear Gauge Factor (G): -0.1215 (kPa/ digit)

Polynomial Gauge factors: **A: -2.565E-07** **B: -0.1176** **C:**

Thermal Factor (K): -0.05350 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01762 (psi/ digit)

Polynomial Gauge Factors: **A: -3.72E-08** **B: -0.01706** **C:**

Thermal Factor (K): -0.007760 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8976 **Temperature: 21.2 °C** **Barometer: 997.1 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153161

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdrey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8847	8848	8848	0.550	0.16	0.057	0.02
70.0	8280	8280	8280	69.87	-0.03	69.99	0.00
140.0	7711	7711	7711	139.4	-0.18	139.8	-0.06
210.0	7135	7136	7136	209.7	-0.08	210.1	0.05
280.0	6560	6560	6560	280.0	-0.01	280.1	0.02
349.9	5984	5984	5984	350.3	0.12	349.9	-0.02

(kPa) Linear Gauge Factor (G): -0.1222 (kPa/ digit)

Polynomial Gauge factors: A: -4.667E-07 B: -0.1152 C: ________

Thermal Factor (K): 0.1442 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01772 (psi/ digit)

Polynomial Gauge Factors: A: -6.769E-08 B: -0.01671 C: ________

Thermal Factor (K): 0.02092 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8850 Temperature: 21.7 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153162

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8713	8714	8714	0.405	0.12	0.007	0.00
70.0	8113	8113	8113	69.94	-0.01	70.00	0.00
140.0	7510	7511	7511	139.7	-0.09	140.0	-0.01
210.0	6906	6906	6906	209.7	-0.07	210.0	0.01
280.0	6299	6300	6300	279.9	-0.03	280.0	-0.01
349.9	5691	5692	5692	350.3	0.12	349.9	0.00

(kPa) Linear Gauge Factor (G): -0.1158 (kPa/ digit)

Polynomial Gauge factors: A: -3.131E-07 B: -0.1113 C: ________

Thermal Factor (K): 0.04139 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01679 (psi/ digit)

Polynomial Gauge Factors: A: -4.541E-08 B: -0.01614 C: ________

Thermal Factor (K): 0.006003 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8715 Temperature: 21.3 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153163

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8768	8769	8769	0.299	0.09	-0.012	0.00
70.0	8186	8186	8186	69.99	0.00	70.07	0.02
140.0	7604	7604	7604	139.6	-0.12	139.9	-0.03
210.0	7018	7018	7018	209.7	-0.07	210.0	0.02
280.0	6431	6431	6431	279.9	-0.02	280.0	0.00
349.9	5843	5844	5844	350.2	0.08	349.9	0.00

(kPa) Linear Gauge Factor (G): -0.1196 (kPa/ digit)

Polynomial Gauge factors: A: -2.918E-07 B: -0.1154 C:

Thermal Factor (K): 0.02560 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01735 (psi/ digit)

Polynomial Gauge Factors: A: -4.233E-08 B: -0.01673 C:

Thermal Factor (K): 0.003713 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8771 Temperature: 21.1 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number:	4500S-350 kPa	Date of Calibration:	November 18, 2021
Serial Number:	2153165	Temperature:	21.30 °C
Calibration Instruction:	CI-Pressure Transducers 7 kPa~3.5 MPa	Barometric Pressure:	993.3 mbar
Cable Length:	15 meters	Technician:	Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9023	9023	9023	0.235	0.07	-0.025	-0.01
70.0	8428	8428	8428	70.02	0.01	70.06	0.02
140.0	7833	7833	7833	139.8	-0.06	140.0	-0.01
210.0	7236	7237	7237	209.8	-0.05	210.0	0.00
280.0	6638	6638	6638	280.0	-0.02	280.0	-0.01
349.9	6039	6039	6039	350.2	0.08	350.0	0.00

(kPa) Linear Gauge Factor (G): -0.1173 (kPa/ digit)

Polynomial Gauge factors: A: -2.105E-07 B: -0.1141 C: ________

Thermal Factor (K): -0.008359 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01701 (psi/ digit)

Polynomial Gauge Factors: A: -3.053E-08 B: -0.01655 C: ________

Thermal Factor (K): -0.001212 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9024 Temperature: 22.6 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153166

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdrey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8857	8858	8858	0.546	0.16	0.022	0.01
70.0	8286	8286	8286	69.83	-0.05	69.91	-0.02
140.0	7709	7709	7709	139.8	-0.07	140.2	0.04
210.0	7134	7134	7134	209.5	-0.13	209.9	-0.02
280.0	6553	6553	6553	279.9	-0.03	280.0	0.00
349.9	5971	5971	5971	350.5	0.15	350.0	0.00

(kPa) Linear Gauge Factor (G): -0.1212 (kPa/ digit)

Polynomial Gauge factors: **A: -4.561E-07** **B: -0.1145** **C:**

Thermal Factor (K): -0.03405 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01758 (psi/ digit)

Polynomial Gauge Factors: **A: -6.616E-08** **B: -0.01660** **C:**

Thermal Factor (K): -0.004939 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8860 **Temperature: 21.6 °C** **Barometer: 997.9 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153167

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8850	8850	8850	0.393	0.11	0.034	0.01
70.0	8319	8319	8319	69.87	-0.03	70.00	0.00
140.0	7787	7787	7787	139.5	-0.15	139.9	-0.05
210.0	7250	7250	7250	209.7	-0.06	210.1	0.05
280.0	6714	6714	6714	279.9	-0.04	280.0	0.00
349.9	6176	6176	6176	350.3	0.09	349.9	-0.01

(kPa) Linear Gauge Factor (G): -0.1308 (kPa/ digit)

Polynomial Gauge factors: A: -4.296E-07 B: -0.1244 C:

Thermal Factor (K): -0.01371 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01898 (psi/ digit)

Polynomial Gauge Factors: A: -6.231E-08 B: -0.01804 C:

Thermal Factor (K): -0.001988 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8848 Temperature: 21.4 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153168

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8928	8929	8929	0.423	0.12	0.068	0.02
70.0	8355	8354	8355	69.76	-0.06	69.81	-0.05
140.0	7774	7774	7774	139.9	-0.04	140.1	0.04
210.0	7195	7196	7196	209.8	-0.05	210.0	0.02
280.0	6615	6616	6616	279.8	-0.05	279.9	-0.04
349.9	6032	6032	6032	350.3	0.11	350.0	0.01

(kPa) Linear Gauge Factor (G): -0.1208 (kPa/ digit)

Polynomial Gauge factors: A: -3.035E-07 B: -0.1163 C:

Thermal Factor (K): -0.04069 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01752 (psi/ digit)

Polynomial Gauge Factors: A: -4.402E-08 B: -0.01686 C:

Thermal Factor (K): -0.005901 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

$$\text{Linear, } P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$$

$$\text{Polynomial, } P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8930 Temperature: 21.1 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153170

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdery

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8755	8755	8755	0.472	0.13	0.044	0.01
70.0	8166	8167	8167	69.93	-0.02	69.97	-0.01
140.0	7576	7576	7576	139.6	-0.11	139.9	-0.04
210.0	6981	6981	6981	209.8	-0.03	210.1	0.05
280.0	6387	6387	6387	279.9	-0.02	280.0	-0.01
349.9	5790	5791	5791	350.3	0.12	349.9	-0.01

(kPa) Linear Gauge Factor (G): -0.1180 (kPa/ digit)

Polynomial Gauge factors: A: -3.343E-07 B: -0.1132 C: ________

Thermal Factor (K): 0.07381 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01712 (psi/ digit)

Polynomial Gauge Factors: A: -4.849E-08 B: -0.01641 C: ________

Thermal Factor (K): 0.01070 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

$$\text{Linear, } P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$$

$$\text{Polynomial, } P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8757 Temperature: 22.2 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153171

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8689	8689	8689	0.359	0.10	-0.036	-0.01
70.0	8107	8107	8107	70.06	0.02	70.08	0.03
140.0	7525	7525	7525	139.8	-0.08	140.0	-0.01
210.0	6941	6941	6941	209.7	-0.07	209.9	-0.01
280.0	6354	6354	6354	280.0	-0.01	280.0	0.00
349.9	5766	5767	5767	350.3	0.12	349.9	0.00

(kPa) Linear Gauge Factor (G): -0.1198 (kPa/ digit)

Polynomial Gauge factors: A: -3.084E-07 B: -0.1153 C:

Thermal Factor (K): -0.02021 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01737 (psi/ digit)

Polynomial Gauge Factors: A: -4.472E-08 B: -0.01672 C:

Thermal Factor (K): -0.002932 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8691 Temperature: 21.9 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153172

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8665	8666	8666	0.185	0.05	-0.053	-0.02
70.0	8099	8099	8099	70.03	0.01	70.11	0.03
140.0	7533	7534	7534	139.8	-0.08	140.0	-0.01
210.0	6966	6966	6966	209.7	-0.07	210.0	0.00
280.0	6397	6397	6397	279.9	-0.04	280.0	-0.02
349.9	5826	5827	5827	350.2	0.08	350.0	0.01

(kPa) Linear Gauge Factor (G): -0.1233 (kPa/ digit)

Polynomial Gauge factors: A: -2.439E-07 B: -0.1198 C: ________

Thermal Factor (K): 0.006923 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01788 (psi/ digit)

Polynomial Gauge Factors: A: -3.537E-08 B: -0.01737 C: ________

Thermal Factor (K): 0.001004 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

$$\text{Linear, } P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$$

$$\text{Polynomial, } P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8663 Temperature: 21.3 °C Barometer: 997.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153173

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8957	8957	8957	0.464	0.13	0.014	0.00
70.0	8359	8359	8359	69.83	-0.04	69.95	-0.01
140.0	7757	7757	7757	139.7	-0.10	140.1	0.01
210.0	7154	7154	7154	209.6	-0.10	210.0	0.02
280.0	6549	6549	6549	279.8	-0.07	279.9	-0.03
349.9	5940	5940	5940	350.4	0.14	350.0	0.01

(kPa) Linear Gauge Factor (G): -0.1160 (kPa/ digit)

Polynomial Gauge factors: A: -3.916E-07 B: -0.1102 C: ________

Thermal Factor (K): -0.03262 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01682 (psi/ digit)

Polynomial Gauge Factors: A: -5.679E-08 B: -0.01598 C: ________

Thermal Factor (K): -0.004731 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8960 Temperature: 21.5 °C Barometer: 997.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: November 18, 2021

Serial Number: 2153175

Temperature: 21.30 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 993.3 mbar

Cable Length: 15 meters

Technician: Dean O. Cowdey

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8042	8043	8043	0.432	0.12	-0.061	-0.02
70.0	7478	7479	7479	70.09	0.03	70.12	0.04
140.0	6915	6915	6915	139.7	-0.10	140.0	-0.01
210.0	6348	6348	6348	209.7	-0.07	210.0	0.02
280.0	5780	5780	5780	279.9	-0.05	279.9	-0.04
349.9	5208	5208	5208	350.5	0.16	350.0	0.02

(kPa) Linear Gauge Factor (G): -0.1235 (kPa/ digit)

Polynomial Gauge factors: A: -4.1E-07 B: -0.1181 C: ________

Thermal Factor (K): 0.08800 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01791 (psi/ digit)

Polynomial Gauge Factors: A: -5.946E-08 B: -0.01712 C: ________

Thermal Factor (K): 0.01276 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8039 Temperature: 20.9 °C Barometer: 997.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: December 01, 2021

Serial Number: 2153863

Temperature: 21.70 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 992.8 mbar

Cable Length: 15 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9131	9131	9131	0.515	0.15	-0.038	-0.01
70.0	8592	8592	8592	69.97	0.00	70.03	0.02
140.0	8051	8051	8051	139.7	-0.08	140.1	0.02
209.9	7509	7509	7509	209.5	-0.12	209.9	-0.01
279.9	6964	6963	6964	279.8	-0.03	279.9	-0.01
349.9	6415	6415	6415	350.5	0.17	350.0	0.01

(kPa) Linear Gauge Factor (G): -0.1289 (kPa/ digit)

Polynomial Gauge factors: A: -5.177E-07 B: -0.1208 C:

Thermal Factor (K): -0.1128 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01869 (psi/ digit)

Polynomial Gauge Factors: A: -7.508E-08 B: -0.01752 C:

Thermal Factor (K): -0.01636 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9132 Temperature: 20.9 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: December 01, 2021

Serial Number: 2153865

Temperature: 21.70 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 992.8 mbar

Cable Length: 15 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9089	9090	9090	0.433	0.12	0.066	0.02
70.0	8529	8529	8529	69.77	-0.06	69.91	-0.02
140.0	7965	7966	7966	139.5	-0.14	139.9	-0.03
209.9	7398	7398	7398	209.7	-0.07	210.1	0.04
279.9	6831	6831	6831	279.8	-0.03	280.0	0.01
349.9	6262	6262	6262	350.2	0.09	349.9	-0.02

(kPa) Linear Gauge Factor (G): -0.1237 (kPa/ digit)

Polynomial Gauge factors: A: -3.962E-07 B: -0.1176 C:

Thermal Factor (K): -0.1031 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01794 (psi/ digit)

Polynomial Gauge Factors: A: -5.746E-08 B: -0.01706 C:

Thermal Factor (K): -0.01495 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9092 Temperature: 21.1 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: December 01, 2021

Serial Number: 2153866

Temperature: 21.70 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 992.8 mbar

Cable Length: 15 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9144	9145	9145	0.332	0.09	-0.059	-0.02
70.0	8619	8619	8619	70.04	0.02	70.10	0.04
140.0	8094	8094	8094	139.7	-0.09	140.0	0.00
209.9	7567	7567	7567	209.6	-0.10	209.9	-0.02
279.9	7037	7037	7037	279.9	-0.01	280.0	0.01
349.9	6506	6506	6506	350.3	0.11	349.9	0.00

(kPa) Linear Gauge Factor (G): -0.1326 (kPa/ digit)

Polynomial Gauge factors: A: -4.112E-07 B: -0.1262 C:

Thermal Factor (K): -0.05772 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01924 (psi/ digit)

Polynomial Gauge Factors: A: -5.964E-08 B: -0.01831 C:

Thermal Factor (K): -0.008372 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9146 Temperature: 21.0 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-350 kPa

Date of Calibration: December 01, 2021

Serial Number: 2153867

Temperature: 21.70 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 992.8 mbar

Cable Length: 15 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9130	9129	9130	0.442	0.13	0.003	0.00
70.0	8579	8579	8579	69.93	-0.01	70.06	0.03
140.0	8028	8028	8028	139.5	-0.14	139.9	-0.02
209.9	7474	7475	7475	209.3	-0.17	209.8	-0.05
279.9	6913	6914	6914	280.2	0.06	280.3	0.10
349.9	6358	6359	6359	350.2	0.08	349.8	-0.04

(kPa) Linear Gauge Factor (G): -0.1262 (kPa/ digit)

Polynomial Gauge factors: A: -4.653E-07 B: -0.1190 C:

Thermal Factor (K): -0.03956 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01831 (psi/ digit)

Polynomial Gauge Factors: A: -6.748E-08 B: -0.01726 C:

Thermal Factor (K): -0.005738 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9130 Temperature: 21.2 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number:	4500S-350 kPa	Date of Calibration:	December 01, 2021
Serial Number:	2153868	Temperature:	21.70 °C
Calibration Instruction:	CI-Pressure Transducers 7 kPa~3.5 MPa	Barometric Pressure:	992.8 mbar
Cable Length:	15 meters	Technician:	

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8396	8397	8397	0.563	0.16	0.069	0.02
70.0	7843	7843	7843	69.87	-0.03	69.92	-0.01
140.0	7287	7287	7287	139.5	-0.14	139.8	-0.05
209.9	6725	6726	6726	209.8	-0.04	210.1	0.05
279.9	6165	6166	6166	279.9	0.00	280.0	0.01
349.9	5603	5603	5603	350.4	0.12	349.9	-0.02

(kPa) Linear Gauge Factor (G): -0.1252 (kPa/ digit)

Polynomial Gauge factors: A: -4.429E-07 B: -0.1190 C: ________

Thermal Factor (K): -0.05571 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.01816 (psi/ digit)

Polynomial Gauge Factors: A: -6.424E-08 B: -0.01726 C: ________

Thermal Factor (K): -0.008080 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8399 Temperature: 21.7 °C Barometer: 997.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: November 24, 2021

Serial Number: 2154582

Temperature: 23.20 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 1002.4 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8826	8827	8827	1.403	0.20	0.009	0.00
140.0	7988	7988	7988	139.8	-0.03	140.0	0.00
280.0	7145	7145	7145	279.0	-0.15	280.0	0.00
420.0	6297	6297	6297	418.9	-0.15	420.0	0.00
559.9	5444	5444	5444	559.7	-0.04	560.0	0.00
700.1	4585	4586	4586	701.4	0.19	700.0	0.00

(kPa) Linear Gauge Factor (G): -0.1651 (kPa/ digit)

Polynomial Gauge factors: A: -5.649E-07 B: -0.1575 C: ________

Thermal Factor (K): 0.07067 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02394 (psi/ digit)

Polynomial Gauge Factors: A: -8.194E-08 B: -0.02284 C: ________

Thermal Factor (K): 0.01025 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8854 Temperature: 26.0 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: November 24, 2021

Serial Number: 2154583

Temperature: 23.20 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 1002.4 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8597	8597	8597	1.356	0.19	0.166	0.02
140.0	7781	7781	7781	139.7	-0.05	139.8	-0.03
280.0	6959	6959	6959	279.0	-0.14	279.8	-0.02
420.0	6131	6132	6132	419.2	-0.11	420.1	0.02
559.9	5300	5301	5301	560.1	0.01	560.2	0.04
700.1	4468	4469	4469	701.1	0.14	699.9	-0.03

(kPa) Linear Gauge Factor (G): **-0.1695** **(kPa/ digit)**

Polynomial Gauge factors: **A: -5.054E-07** **B: -0.1629** **C:**

Thermal Factor (K): **0.06091** **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.02458** **(psi/ digit)**

Polynomial Gauge Factors: **A: -7.33E-08** **B: -0.02362** **C:**

Thermal Factor (K): **0.008834** **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: **8614** **Temperature:** **23.8** **°C** **Barometer:** **980.7** **mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: November 24, 2021

Serial Number: 2154584

Temperature: 23.20 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 1002.4 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8454	8455	8455	0.939	0.13	-0.051	-0.01
140.0	7640	7641	7641	140.0	-0.01	140.1	0.02
280.0	6824	6826	6825	279.3	-0.10	280.0	0.00
420.0	6006	6006	6006	419.2	-0.12	419.9	-0.01
559.9	5182	5183	5183	559.8	-0.03	560.0	0.00
700.1	4355	4356	4356	701.1	0.14	700.1	0.00

(kPa) Linear Gauge Factor (G): -0.1708 (kPa/ digit)

Polynomial Gauge factors: A: -4.311E-07 B: -0.1653 C:

Thermal Factor (K): -0.01945 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02477 (psi/ digit)

Polynomial Gauge Factors: A: -6.252E-08 B: -0.02397 C:

Thermal Factor (K): -0.002822 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8468 Temperature: 21.9 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154587

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8670	8671	8671	1.068	0.15	0.128	0.02
140.0	7828	7828	7828	139.5	-0.07	139.8	-0.03
279.9	6979	6979	6979	279.1	-0.12	279.9	-0.01
419.9	6126	6126	6126	419.3	-0.09	420.1	0.02
560.0	5270	5271	5271	559.9	-0.03	560.1	0.01
700.1	4412	4412	4412	701.0	0.13	700.0	-0.01

(kPa) Linear Gauge Factor (G): **-0.1643** **(kPa/ digit)**

Polynomial Gauge factors: **A:** **-4.042E-07** **B:** **-0.1591** **C:** ______

Thermal Factor (K): **0.1973** **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.02384** **(psi/ digit)**

Polynomial Gauge Factors: **A:** **-5.863E-08** **B:** **-0.02307** **C:** ______

Thermal Factor (K): **0.02861** **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: **8688** **Temperature:** **25.2** **°C** **Barometer:** **981.1** **mbar**

The above instrument was found to be in tolerance in all operating ranges.

The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154588

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8729	8729	8729	1.344	0.19	0.085	0.01
140.0	7906	7907	7907	139.5	-0.07	139.7	-0.04
279.9	7075	7076	7076	279.0	-0.13	280.1	0.02
419.9	6242	6242	6242	419.0	-0.13	420.1	0.02
560.0	5405	5405	5405	559.6	-0.07	559.9	-0.03
700.1	4560	4561	4561	701.4	0.19	700.1	0.01

(kPa) Linear Gauge Factor (G): -0.1679 (kPa/ digit)

Polynomial Gauge factors: A: -5.527E-07 B: -0.1606 C: ________

Thermal Factor (K): 0.1881 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02436 (psi/ digit)

Polynomial Gauge Factors: A: -8.016E-08 B: -0.02329 C: ________

Thermal Factor (K): 0.02728 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8734 Temperature: 21.0 °C Barometer: 981.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154589

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8963	8964	8964	0.943	0.13	0.015	0.00
140.0	8154	8155	8155	139.7	-0.05	139.9	-0.02
279.9	7341	7340	7341	279.3	-0.10	280.1	0.02
419.9	6525	6525	6525	419.1	-0.11	419.9	0.00
560.0	5705	5705	5705	559.7	-0.04	560.0	-0.01
700.1	4881	4881	4881	701.1	0.14	700.1	0.01

(kPa) Linear Gauge Factor (G): -0.1715 (kPa/ digit)

Polynomial Gauge factors: A: -4.283E-07 B: -0.1656 C: ______

Thermal Factor (K): 0.06960 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02487 (psi/ digit)

Polynomial Gauge Factors: A: -6.212E-08 B: -0.02401 C: ______

Thermal Factor (K): 0.01009 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8973 Temperature: 25.8 °C Barometer: 980.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154590

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8731	8732	8732	1.438	0.21	0.049	0.01
140.0	7914	7915	7915	139.7	-0.04	139.9	-0.01
279.9	7092	7092	7092	278.9	-0.15	279.9	-0.01
419.9	6264	6264	6264	419.0	-0.13	420.0	0.02
560.0	5432	5432	5432	559.8	-0.03	560.0	0.00
700.1	4594	4596	4595	701.5	0.20	700.1	0.00

(kPa) Linear Gauge Factor (G): -0.1692 (kPa/ digit)

Polynomial Gauge factors: **A: -5.834E-07** **B: -0.1615** **C:**

Thermal Factor (K): 0.1579 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02454 (psi/ digit)

Polynomial Gauge Factors: **A: -8.462E-08** **B: -0.02342** **C:**

Thermal Factor (K): 0.02290 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8747 **Temperature: 23.6 °C** **Barometer: 980.7 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154591

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8975	8976	8976	1.282	0.18	0.056	0.01
140.0	8166	8166	8166	139.6	-0.05	140.0	-0.01
279.9	7353	7353	7353	278.6	-0.19	279.7	-0.04
419.9	6531	6531	6531	419.1	-0.12	420.2	0.04
560.0	5708	5709	5709	559.7	-0.05	560.0	-0.01
700.1	4880	4880	4880	701.3	0.17	700.0	0.00

(kPa) Linear Gauge Factor (G): **-0.1709** **(kPa/ digit)**

Polynomial Gauge factors: **A:** **-5.786E-07** **B:** **-0.1629** **C:**

Thermal Factor (K): **-0.03506** **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.02479** **(psi/ digit)**

Polynomial Gauge Factors: **A:** **-8.391E-08** **B:** **-0.02363** **C:**

Thermal Factor (K): **-0.005085** **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: **8983** **Temperature:** **25.3** **°C** **Barometer:** **981** **mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154592

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8506	8506	8506	1.337	0.19	0.103	0.01
140.0	7679	7680	7680	139.4	-0.08	139.7	-0.04
279.9	6843	6844	6844	279.1	-0.12	280.1	0.03
419.9	6007	6007	6007	418.9	-0.15	419.9	0.00
560.0	5164	5164	5164	559.7	-0.05	560.0	0.00
700.1	4316	4317	4317	701.3	0.18	700.1	0.00

(kPa) Linear Gauge Factor (G): -0.1671 (kPa/ digit)

Polynomial Gauge factors: A: -5.398E-07 B: -0.1602 C: ________

Thermal Factor (K): 0.1331 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02423 (psi/ digit)

Polynomial Gauge Factors: A: -7.829E-08 B: -0.02323 C: ________

Thermal Factor (K): 0.01930 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8518 Temperature: 21.4 °C Barometer: 981.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154593

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8654	8654	8654	1.190	0.17	0.081	0.01
140.0	7840	7840	7840	139.6	-0.06	139.8	-0.03
279.9	7019	7019	7019	279.1	-0.11	280.0	0.01
419.9	6196	6196	6196	419.1	-0.12	419.9	0.00
560.0	5368	5368	5368	559.8	-0.03	560.0	0.00
700.1	4536	4537	4537	701.2	0.16	700.1	0.00

(kPa) Linear Gauge Factor (G): -0.1700 (kPa/ digit)

Polynomial Gauge factors: A: -4.908E-07 B: -0.1635 C:

Thermal Factor (K): 0.08498 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02466 (psi/ digit)

Polynomial Gauge Factors: A: -7.119E-08 B: -0.02372 C:

Thermal Factor (K): 0.01232 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8670 Temperature: 22.8 °C Barometer: 981.1 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154594

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8954	8954	8954	1.185	0.17	0.007	0.00
140.0	8136	8136	8136	139.7	-0.04	139.9	-0.02
279.9	7312	7312	7312	279.3	-0.10	280.1	0.02
419.9	6487	6487	6487	419.0	-0.13	419.8	-0.01
560.0	5655	5656	5656	559.8	-0.03	560.0	-0.01
700.1	4820	4820	4820	701.3	0.18	700.1	0.01

(kPa) Linear Gauge Factor (G): -0.1694 (kPa/ digit)

Polynomial Gauge factors: A: -4.94E-07 B: -0.1626 C:

Thermal Factor (K): -0.006893 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02456 (psi/ digit)

Polynomial Gauge Factors: A: -7.165E-08 B: -0.02358 C:

Thermal Factor (K): -0.0009997 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8947 Temperature: 20.9 °C Barometer: 997.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154595

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8734	8734	8734	0.987	0.14	0.009	0.00
140.0	7890	7890	7890	139.8	-0.02	140.0	0.00
279.9	7043	7043	7043	279.2	-0.10	279.9	-0.01
419.9	6191	6192	6192	419.3	-0.09	420.0	0.01
560.0	5337	5337	5337	559.9	-0.02	560.0	0.00
700.1	4479	4479	4479	701.1	0.14	700.1	0.00

(kPa) Linear Gauge Factor (G): -0.1645 (kPa/ digit)

Polynomial Gauge factors: A: -3.813E-07 B: -0.1595 C: ________

Thermal Factor (K): 0.09412 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02386 (psi/ digit)

Polynomial Gauge Factors: A: -5.53E-08 B: -0.02313 C: ________

Thermal Factor (K): 0.01365 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8747 Temperature: 25.4 °C Barometer: 981.9 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154596

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8957	8960	8959	1.276	0.18	0.079	0.01
140.0	8146	8146	8146	139.6	-0.06	139.8	-0.02
279.9	7327	7328	7328	278.8	-0.16	279.9	-0.01
419.9	6504	6504	6504	419.0	-0.13	420.0	0.02
560.0	5677	5677	5677	559.7	-0.04	560.0	0.00
700.1	4845	4846	4846	701.2	0.17	700.0	0.00

(kPa) Linear Gauge Factor (G): -0.1702 (kPa/ digit)

Polynomial Gauge factors: **A: -5.531E-07** **B: -0.1625** **C:**

Thermal Factor (K): -0.01044 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02468 (psi/ digit)

Polynomial Gauge Factors: **A: -8.021E-08** **B: -0.02358** **C:**

Thermal Factor (K): -0.001515 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8963 **Temperature: 24.3 °C** **Barometer: 981.1 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154597

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8783	8783	8783	1.035	0.15	0.106	0.02
140.0	7981	7980	7981	139.5	-0.07	139.8	-0.03
279.9	7172	7172	7172	279.0	-0.13	279.9	0.00
419.9	6360	6360	6360	419.2	-0.11	420.0	0.02
560.0	5545	5545	5545	559.8	-0.03	560.1	0.01
700.1	4727	4727	4727	701.0	0.13	700.0	-0.01

(kPa) Linear Gauge Factor (G): -0.1726 (kPa/ digit)

Polynomial Gauge factors: A: -4.576E-07 B: -0.1664 C:

Thermal Factor (K): 0.2885 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02503 (psi/ digit)

Polynomial Gauge Factors: A: -6.637E-08 B: -0.02413 C:

Thermal Factor (K): 0.04185 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8787 Temperature: 21.4 °C Barometer: 997.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154598

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8849	8850	8850	0.926	0.13	0.178	0.03
140.0	8026	8027	8027	139.5	-0.07	139.7	-0.05
279.9	7196	7196	7196	279.3	-0.09	279.9	0.00
419.9	6364	6365	6365	419.3	-0.09	419.9	0.00
560.0	5528	5528	5528	560.1	0.01	560.3	0.04
700.1	4693	4693	4693	700.7	0.09	699.9	-0.02

(kPa) Linear Gauge Factor (G): -0.1684 (kPa/ digit)

Polynomial Gauge factors: A: -3.395E-07 B: -0.1638 C: ________

Thermal Factor (K): 0.1345 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02442 (psi/ digit)

Polynomial Gauge Factors: A: -4.924E-08 B: -0.02375 C: ________

Thermal Factor (K): 0.01951 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8846 Temperature: 20.8 °C Barometer: 997.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154599

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9068	9069	9069	1.309	0.19	0.065	0.01
140.0	8276	8276	8276	139.7	-0.05	139.8	-0.02
279.9	7477	7478	7478	279.1	-0.12	280.0	0.00
419.9	6675	6675	6675	419.2	-0.10	420.1	0.02
560.0	5870	5870	5870	559.8	-0.04	559.9	-0.02
700.1	5059	5059	5059	701.4	0.18	700.1	0.01

(kPa) Linear Gauge Factor (G): -0.1746 (kPa/ digit)

Polynomial Gauge factors: A: -5.47E-07 B: -0.1669 C:

Thermal Factor (K): 0.1511 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02532 (psi/ digit)

Polynomial Gauge Factors: A: -7.934E-08 B: -0.02420 C:

Thermal Factor (K): 0.02192 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9061 Temperature: 21.1 °C Barometer: 997.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154600

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8827	8828	8828	1.579	0.23	-0.030	0.00
140.0	7996	7997	7997	139.7	-0.04	140.0	0.00
279.9	7160	7161	7161	278.7	-0.18	279.9	0.00
419.9	6318	6318	6318	418.8	-0.17	420.0	0.01
560.0	5471	5471	5471	559.6	-0.07	559.9	-0.02
700.1	4615	4616	4616	701.8	0.24	700.2	0.01

(kPa) Linear Gauge Factor (G): **-0.1662** **(kPa/ digit)**

Polynomial Gauge factors: **A:** **-6.719E-07** **B:** **-0.1572** **C:**

Thermal Factor (K): **0.1099** **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.02411** **(psi/ digit)**

Polynomial Gauge Factors: **A:** **-9.745E-08** **B:** **-0.02280** **C:**

Thermal Factor (K): **0.01595** **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: **8825** **Temperature:** **21.4** **°C** **Barometer:** **997.7** **mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154601

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9093	9093	9093	1.392	0.20	-0.055	-0.01
140.0	8298	8298	8298	139.7	-0.04	140.1	0.01
279.9	7500	7500	7500	278.6	-0.19	279.9	-0.01
419.9	6695	6695	6695	418.6	-0.18	420.0	0.00
560.0	5885	5885	5885	559.6	-0.07	560.0	-0.01
700.1	5069	5069	5069	701.6	0.21	700.1	0.01

(kPa) Linear Gauge Factor (G): -0.1740 (kPa/ digit)

Polynomial Gauge factors: A: -7.069E-07 B: -0.1640 C:

Thermal Factor (K): 0.03174 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02524 (psi/ digit)

Polynomial Gauge Factors: A: -1.025E-07 B: -0.02378 C:

Thermal Factor (K): 0.004604 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9088 Temperature: 20.4 °C Barometer: 997.7 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154603

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8642	8643	8643	1.438	0.21	0.056	0.01
140.0	7826	7826	7826	139.6	-0.06	139.8	-0.02
279.9	7002	7002	7002	279.0	-0.14	280.1	0.02
419.9	6175	6176	6176	418.8	-0.16	419.9	0.00
560.0	5342	5342	5342	559.8	-0.04	560.1	0.00
700.1	4504	4505	4505	701.5	0.20	700.1	0.00

(kPa) Linear Gauge Factor (G): -0.1692 (kPa/ digit)

Polynomial Gauge factors: **A: -6.048E-07** **B: -0.1612** **C:**

Thermal Factor (K): -0.001386 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02454 (psi/ digit)

Polynomial Gauge Factors: **A: -8.772E-08** **B: -0.02338** **C:**

Thermal Factor (K): -0.0002010 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8651 **Temperature: 24.3 °C** **Barometer: 982.1 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154605

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8749	8749	8749	1.164	0.17	-0.015	0.00
140.0	7916	7916	7916	139.7	-0.04	140.0	0.00
279.9	7079	7080	7080	278.8	-0.16	279.9	-0.01
419.9	6238	6238	6238	418.8	-0.17	419.9	-0.01
560.0	5390	5390	5390	559.8	-0.04	560.1	0.01
700.1	4539	4540	4540	701.2	0.17	700.1	0.00

(kPa) Linear Gauge Factor (G): **-0.1663** **(kPa/ digit)**

Polynomial Gauge factors: **A: -5.344E-07** **B: -0.1592** **C:**

Thermal Factor (K): 0.1236 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.02412** **(psi/ digit)**

Polynomial Gauge Factors: **A: -7.751E-08** **B: -0.02309** **C:**

Thermal Factor (K): 0.01793 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 8757 **Temperature: 23.8 °C** **Barometer: 981.5 mbar**

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number: 4500S-700 kPa

Date of Calibration: December 01, 2021

Serial Number: 2154606

Temperature: 23.40 °C

Calibration Instruction: CI-Pressure Transducers 7 kPa~3.5 MPa

Barometric Pressure: 995.9 mbar

Cable Length: 35 meters

Technician:

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	9149	9150	9150	1.219	0.17	-0.056	-0.01
140.0	8296	8296	8296	139.9	-0.01	140.1	0.01
279.9	7440	7440	7440	279.0	-0.14	279.9	-0.01
419.9	6578	6578	6578	419.0	-0.13	420.0	0.01
560.0	5712	5712	5712	559.7	-0.04	559.9	-0.01
700.1	4840	4840	4840	701.4	0.19	700.1	0.01

(kPa) Linear Gauge Factor (G): -0.1625 (kPa/ digit)

Polynomial Gauge factors: A: -4.939E-07 B: -0.1556 C: ________

Thermal Factor (K): -0.001915 (kPa/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): -0.02357 (psi/ digit)

Polynomial Gauge Factors: A: -7.163E-08 B: -0.02256 C: ________

Thermal Factor (K): -0.0002778 (psi/ °C)

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)$*

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)$*

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: 9166 Temperature: 24.6 °C Barometer: 981.5 mbar

The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

GEOKON®

Vibrating Wire Pressure Transducer Calibration Report

Model Number:	4500S-700 kPa	Date of Calibration:	December 01, 2021
Serial Number:	2154607	Temperature:	23.40 °C
Calibration Instruction:	CI-Pressure Transducers 7 kPa~3.5 MPa	Barometric Pressure:	995.9 mbar
Cable Length:	35 meters	Technician:	

Applied Pressure (kPa)	Gauge Reading 1st Cycle	Gauge Reading 2nd Cycle	Average Gauge Reading	Calculated Pressure (Linear)	Error Linear (%FS)	Calculated Pressure (Polynomial)	Error Polynomial (%FS)
0.0	8755	8755	8755	1.516	0.22	-0.012	0.00
140.0	7935	7936	7936	139.6	-0.06	140.0	0.00
279.9	7111	7111	7111	278.5	-0.20	279.9	0.00
419.9	6280	6280	6280	418.5	-0.20	419.9	0.00
560.0	5443	5443	5443	559.6	-0.07	560.0	0.00
700.1	4600	4600	4600	701.6	0.22	700.1	0.00

(kPa) Linear Gauge Factor (G): **-0.1685** **(kPa/ digit)**

Polynomial Gauge factors: **A: -7.043E-07** **B: -0.1591** **C:** ______

Thermal Factor (K): **0.2551** **(kPa/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

(psi) Linear Gauge Factor (G): **-0.02444** **(psi/ digit)**

Polynomial Gauge Factors: **A: -1.022E-07** **B: -0.02307** **C:** ______

Thermal Factor (K): **0.03700** **(psi/ °C)**

Calculate C by setting P=0 and R_1 = initial field zero reading into the polynomial equation

Calculated Pressures:

Linear, $P = G(R_1 - R_0) + K(T_1 - T_0) - (S_1 - S_0)^*$

Polynomial, $P = AR_1^2 + BR_1 + C + K(T_1 - T_0) - (S_1 - S_0)^*$

*Barometric pressures expressed in kPa or psi. Barometric compensation is not required with vented transducers.

Factory Zero Reading: **8775** **Temperature:** **21.3** **°C** **Barometer:** **981.9** **mbar**

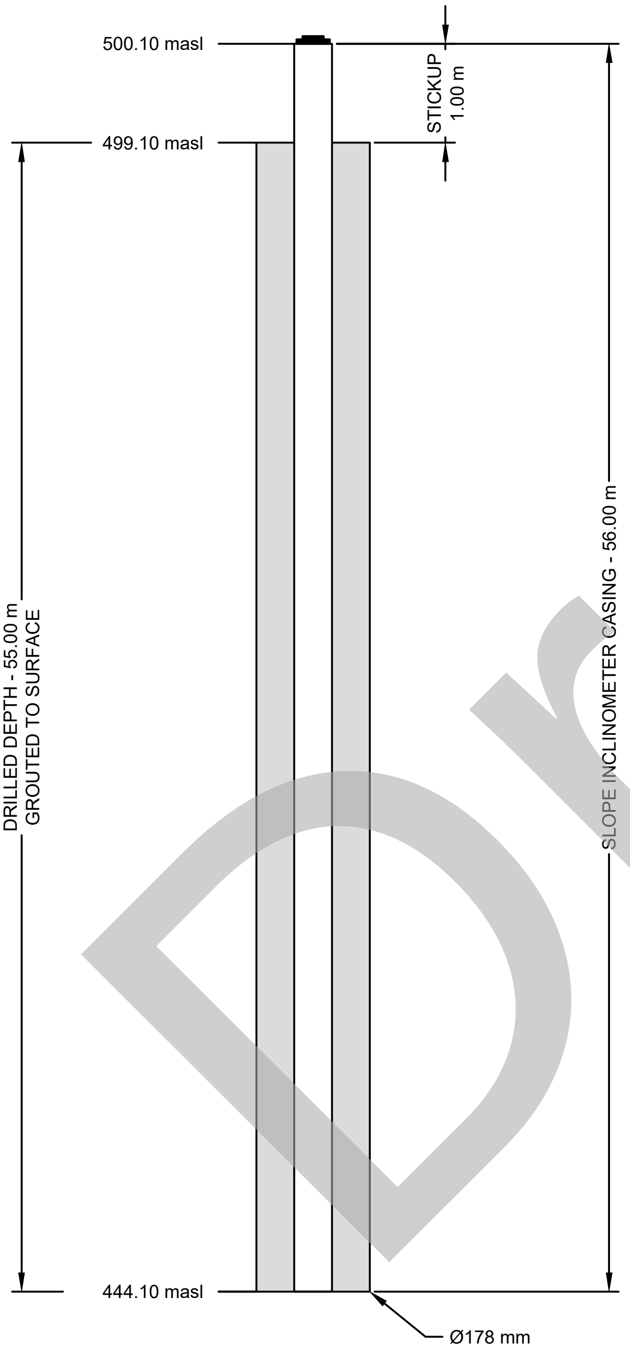
The above instrument was found to be in tolerance in all operating ranges.
The above named instrument has been calibrated by comparison with standards traceable to the NIST, in compliance with ANSI Z540-1.

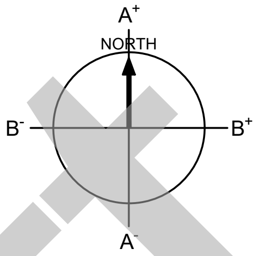
Appendix VI

Slope Inclinometer Details

SLOPE INCLINOMETER 21-05 (BH1-SI)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5785478.12 N   390036.59 E
NAD 83 ZONE 13 U
SE-26-37-05-W3M





A+ AXIS NOTCHED

SLOPE INCLINOMETER SPECIFICATIONS:
- North 0° of A+ axis notched

SLOPE INCLINOMETER CASING SPECIFICATIONS:
- Geo-Lok (85 mm) casing
- threaded with o-ring seals

GROUT SPECIFICATIONS:
- cement-bentonite (water:cement:bentonite at 4.5:1:0.1 by weight)
- mixed to specific gravity of approximately 1.36

NOTES

1. Depths are in metres (m).
2. Elevations are in metres above sea level (masl).
3. Borehole coordinates and elevations provided by SNC-Lavalin (RTK survey, 2022).

SUPERVISOR	N. BOUEY
CONTRACTOR	FORGED DRILL Ltd.
OPERATOR	J. BECK
DRILL RIG TYPE	R408
DATE INSTALLED	2021-11-20
APPROVED BY	K. DORAN, P.Eng
DRAWN BY	E. OVCINA
PROJECT No.	659183
SCALE	NOT TO SCALE
DATE	2022-07-21

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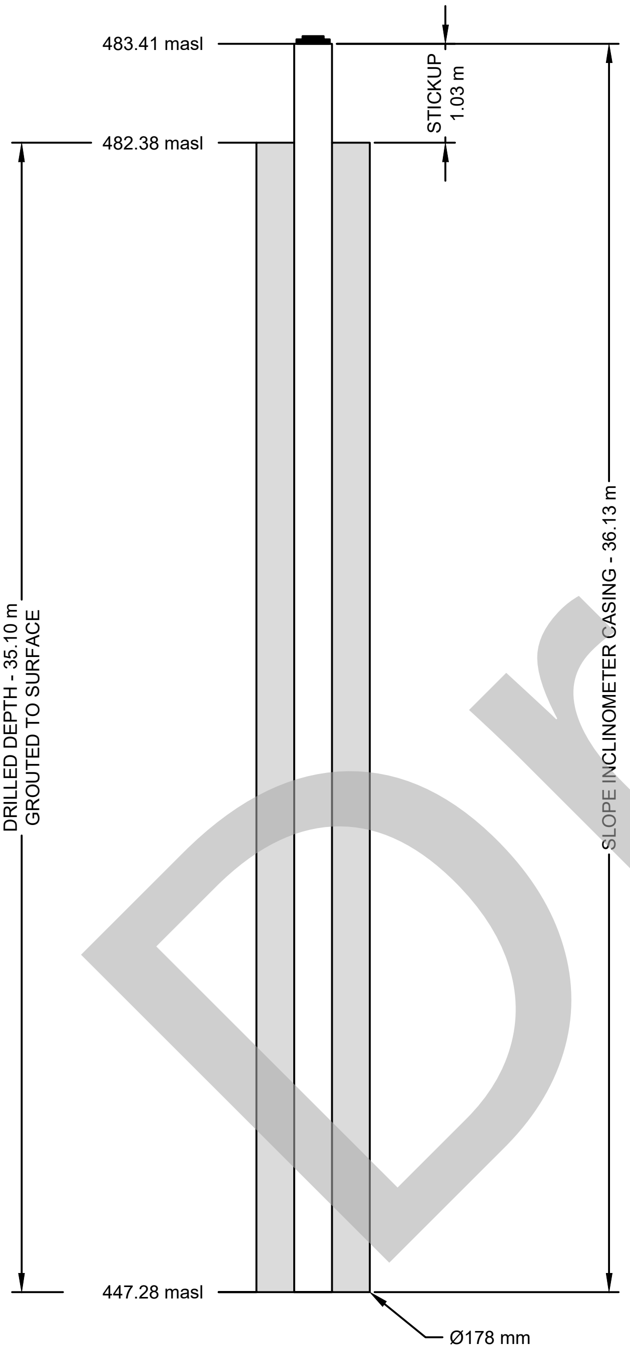
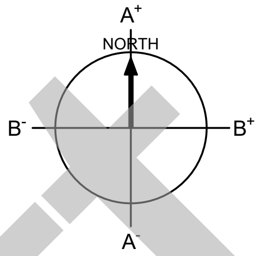
CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

SLOPE INCLINOMETER 21-07 (BH2-SI)
SASKATCHEWAN MINISTRY OF HIGHWAYS
SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY
2022

5785144.33 N   390386.78 E
NAD 83 ZONE 13 U
SE-26-37-05-W3M





A^+ AXIS NOTCHED

SLOPE INCLINOMETER SPECIFICATIONS:
- North 0° of A+ axis notched

SLOPE INCLINOMETER CASING SPECIFICATIONS:
- Geo-Lok (85 mm) casing
- threaded with o-ring seals

GROUT SPECIFICATIONS:
- cement-bentonite (water:cement:bentonite at 4.5:1:0.1 by weight)
- mixed to specific gravity of approximately 1.37

NOTES

1. Depths are in metres (m).
2. Elevations are in metres above sea level (masl).
3. Borehole coordinates and elevations provided by SNC-Lavalin (RTK survey, 2022).

SUPERVISOR	N. BOUEY		
CONTRACTOR	FORGED DRILL Ltd.		
OPERATOR	J. BECK		
DRILL RIG TYPE	R408		
DATE INSTALLED	2021-11-26		
APPROVED BY	K. DORAN, P.Eng		
DRAWN BY	E. OVCINA		
PROJECT No.	659183		
SCALE	NOT TO SCALE	**DATE**	2022-07-21

SNC • LAVALIN

CLIENT	**PROJECT LOCATION**
SASKATCHEWAN MINISTRY OF HIGHWAYS	SASKATOON, SASKATCHEWAN

\\sli1653\Projects QMS\SMHI\659183_Saskatoon Freeway Functional Planning Study\40_Execution\45_GIS_Dwgs\4.5.2 CAD\BOREHOLES\River Logs\SI-659183-BH21-07 (BH2-SI).dwg

Appendix VII

Laboratory Testing Results

Appendix VII (A)

Natural Water Content

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

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MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(m)	M/C %
NLB-1001	BH01	1.5 - 1.9	**12.4**
NLB-1002	BH01	1.5 - 3	**19.3**
NLB-1003	BH01	3 - 3.45	**8.0**
NLB-1004	BH01	3 - 4.5	**8.7**
NLB-1005	BH01	4.5 - 4.95	**7.3**
NLB-1006	BH01	4.5 - 6	**9.2**
NLB-1007	BH01	6 - 6.45	**7.9**
NLB-1008	BH01	6 - 7.5	**17.4**
NLB-1009	BH01	7.5 - 7.95	**5.6**
NLB-1010	BH01	9 - 9.45	**13.4**
NLB-1011	BH01	10.5 - 10.95	**10.5**
NLB-1012	BH01	12 - 12.4	**13.2**
NLB-1013	BH01	13.5 - 13.95	**12.9**
NLB-1015	BH01	16.5 - 16.95	**10.0**
NLB-1016	BH01	17.5 - 18	**13.1**
NLB-1018	BH01	19.5 - 19.65	**18.3**
NLB-1019	BH01	21 - 21.15	**13.4**
NLB-1020	BH01	22.5 - 22.8	**12.8**
NLB-1021	BH01	22.8 - 24	**13.8**
NLB-1023	BH01	25	**14.1**
NLB-1025	BH01	25.5-25.65	**15.9**
NLB-1026	BH01	27 - 28.5	**16.3**
NLB-1027	BH01	28.5 - 30	**15.8**
NLB-1029	BH01	30 - 33	**13.2**
NLB-1031	BH01	33 - 34.5	**10.9**
NLB-1032	BH01	34.5 - 36	**11.8**
NLB-1033	BH01	36 - 36.45	**14.6**
NLB-1034	BH01	37	**13.6**
NLB-1035	BH01	38	**13.4**
NLB-1036	BH01	39 - 39.45	**15.7**
NLB-1037	BH01	40	**15.0**
NLB-1038	BH01	41	**15.0**
NLB-1039	BH01	42 - 42.45	**15.3**
NLB-1040	BH01	43	**15.5**
NLB-1041	BH01	44	**14.9**
NLB-1042	BH01	45 - 45.45	**16.8**
NLB-1043	BH01	45 - 46.5	**17.4**
NLB-1044	BH01	46.5 - 48	**16.7**
NLB-1045	BH01	49.0	**14.4**
NLB-1046	BH01	50.0	**15.8**
NLB-1047	BH01	51 - 51.45	**14.6**
NLB-1048	BH01	52.0	**14.5**
NLB-1049	BH01	53.0	**14.4**
NLB-1051	BH01	55.0	**12.2**
NLB-1052	BH01	57-57.45	**12.9**
NLB-1053	BH01	58.0	**11.6**
NLB-1055	BH01	60.0	**12.3**
NLB-1057	BH01	63 - 63.45	**12.9**
NLB-1059	BH01	65.0	**13.6**
NLB-1061	BH01	68.0	**12.1**
NLB-1062	BH01	69-69.45	**12.1**
NLB-1063	BH01	70.0	**13.2**
NLB-1065	BH01	71.6	**24.3**
NLB-1067	BH01	73.0	**23.5**
NLB-1069	BH01	75.0	**No Sample**
NLB-1071	BH01	77.5	**4.1**
NLB-1073	BH01	81-81.45	**26.5**
NLB-1075	BH01	83.0	**23.0**
NLB-1077	BH01	86.0	**22.7**
NLB-1079	BH01	88.0	**24.2**
NLB-1081	BH01	91.0	**23.7**
NLB-1083	BH01	93-93.15	**27.1**
NLB-1085	BH01	95.0	**16.4**
NLB-1087	BH01	98.0	**23.3**
NLB-1089	BH01	100-100.25	**25.4**
NLB-1093	BH01	28-28.38	**15.4**
NLB-1094	BH01	41.55-42.03	**15.6**
NLB-1095	BH01	47.55-47.93	**18.0**
NLB-1096	BH02	0 - 1.5	**14.9**
NLB-1097	BH02	1.5 - 1.95	**15.0**

Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional
Project #:	659183
Date:	2021-01-27

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

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MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(m)	M/C %	Sample #	Test Hole	Depth(m)	M/C %
NLB-1098	BH02	1.5 - 3	**10.4**	NLB-1133	BH02	31.0	**11.7**
NLB-1099	BH02	3 - 3.45	**11.7**	NLB-1134	BH02	32.0	**12.3**
NLB-1100	BH02	3 - 4.5	**13.0**	NLB-1135	BH02	33 - 33.45	**19.5**
NLB-1101	BH02	4.5 - 4.98	**20.1**	NLB-1136	BH02	33-36	**14.2**
NLB-1102	BH02	4.98 - 6	**13.7**	NLB-1138	BH02	37.0	**15.2**
NLB-1103	BH02	6 - 6.45	**10.8**	NLB-1139	BH02	38.0	**14.4**
NLB-1104	BH02	6 - 7.5	**9.6**	NLB-1140	BH02	39-39.45	**12.3**
NLB-1105	BH02	7.5 - 7.95	**10.9**	NLB-1142	BH02	42-42.45	**9.7**
NLB-1106	BH02	7.5 - 9	**12.1**	NLB-1144	BH02	44.0	**12.0**
NLB-1107	BH02	9 - 9.38	**8.3**	NLB-1146	BH02	45-48	**11.5**
NLB-1108	BH02	10.0	**13.4**	NLB-1147	BH02	48-48.45	**9.7**
NLB-1109	BH02	10.5 - 10.5	**No Sample**	NLB-1148	BH02	52.0	**12.7**
NLB-1110	BH02	10.5 - 12	**10.6**	NLB-1150	BH02	54.0	**8.9**
NLB-1111	BH02	12 - 12.45	**10.3**	NLB-1152	BH02	57-57.45	**10.6**
NLB-1112	BH02	13.0	**11.6**	NLB-1154	BH02	57-57.45	**8.6**
NLB-1113	BH02	13.5 - 13.95	**9.4**	NLB-1155	BH02	58.5	**9.1**
NLB-1114	BH02	13.5 - 15	**10.1**	NLB-1156	BH02	59.5	**11.1**
NLB-1115	BH02	15 - 15.45	**10.0**	NLB-1158	BH02	62.0	**9.5**
NLB-1116	BH02	16.0	**1.2**	NLB-1160	BH02	64.5	**9.1**
NLB-1117	BH02	16.5 - 16.95	**10.9**	NLB-1162	BH02	67.0	**10.4**
NLB-1118	BH02	17.0	**8.8**	NLB-1163	BH02	68.5	**9.9**
NLB-1119	BH02	18 - 18.45	**11.4**	NLB-1164	BH02	69-69.45	**9.5**
NLB-1120	BH02	18 - 19.5	**12.2**	NLB-1166	BH02	70.0	**7.8**
NLB-1121	BH02	20.5	**13.2**	NLB-1167	BH02	75-75.35	**21.7**
NLB-1122	BH02	21 - 21.61	**15.3**	NLB-1168	BH02	80.5	**23.5**
NLB-1123	BH02	21 - 22.5	**12.2**	NLB-1169	BH02	81-81.45	**8.2**
NLB-1124	BH02	22.5 - 22.95	**10.8**	NLB-1170	BH02	87-87.38	**19.6**
NLB-1125	BH02	22.5 - 24	**12.1**	NLB-1172	BH02	92.0	**19.8**
NLB-1126	BH02	24 - 24.45	**14.3**	NLB-1174	BH02	93-93.2	**22.6**
NLB-1127	BH02	25.0	**12.8**	NLB-1175	BH02	100-100.45	**19.0**
NLB-1128	BH02	26.0	**12.5**	NLB-1176	BH02	1.5-1.95	**11.7**
NLB-1129	BH02	27 - 27.45	**12.8**	NLB-1177	BH02	9-9.71	**19.8**
NLB-1130	BH02	28.0	**12.8**				
NLB-1131	BH02	29.0	**13.2**				
NLB-1132	BH02	30 - 30.45	**13.4**				

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2021-01-27

Geoscience & Materials

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

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MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-117	PHII 1	1.0	**0.6**	NLB-131	SHII 2	23.0 - 24.0	**13.0**
NLB-118	PHII 1	2.0	**1.6**	NLB-132	SHII 2	24.0	**13.4**
NLB-119	PHII 1	7.0	**1.6**	NLB-133	SHII 2	28.0 - 29.25	**13.5**
NLB-120	PHII 1	12.0	**0.5**	NLB-134	SHII 2	29.3	**12.6**
NLB-121	PHII 1	17.0	**1.4**	NLB-135	SHII 2	30.5	**22.4**
NLB-001	SHII 1	1.0	**7.9**	NLB-136	SHII 2	33.0 - 34.25	**19.3**
NLB-002	SHII 1	3.0	**2.5**	NLB-137	SHII 2	35.0	**17.1**
NLB-003	SHII 1	5.0 - 5.8	**6.8**	NLB-138	SHII 2	36.0	**12.4**
NLB-004	SHII 1	7.5	**13.4**	NLB-139	SHII 2	37.5	**8.8**
NLB-005	SHII 1	8.0 - 9.5	**17.4**	NLB-140	SHII 2	38.0 - 38.75	**18.7**
NLB-006	SHII 1	9.5	**15.3**	NLB-141	SHII 2	43.0	**10.5**
NLB-007	SHII 1	12.0	**14.3**	NLB-142	SHII 2	45.0 - 46.5	**11.7**
NLB-008	SHII 1	13.0 - 14.25	**12.5**	NLB-143	PHII 2	2.0	**4.2**
NLB-009	SHII 1	15.5	**13.9**	NLB-144	PHII 2	7.0	**19.4**
NLB-010	SHII 1	18.0 - 19.5	**14.2**	NLB-145	PHII 2	9.0	**29.6**
NLB-011	SHII 1	21.0	**14.0**	NLB-146	PHII 2	14.0	**14.0**
NLB-012	SHII 1	22.5	**20.7**	NLB-022	FHII 1	2.0	**6.5**
NLB-013	SHII 1	23.0 - 24.5	**18.9**	NLB-023	FHII 1	3.0	**23.2**
NLB-014	SHII 1	25.5	**20.9**	NLB-024A	FHII 1	7.5 - 8.0	**6.2**
NLB-015	SHII 1	28.0 - 29.1	**18.8**	NLB-024B	FHII 1	8.0 - 9.0	**9.8**
NLB-016	SHII 1	30.5	**19.7**	NLB-025	FHII 1	12.0	**9.0**
NLB-017	SHII 1	33.0 - 34.5	**19.5**	NLB-026	FHII 1	12.5 - 14.0	**9.1**
NLB-018	SHII 1	35.5	**20.8**	NLB-027	FHII 1	16.5	**3.0**
NLB-019	SHII 1	38.0 - 38.8	**23.3**	NLB-028	FHII 1	17.0	**9.3**
NLB-020	SHII 1	40.0	**11.5**	NLB-029	FHII 1	17.5 - 17.75	**15.0**
NLB-021	SHII1	45.0 - 46.5	**15.1**	NLB-030	FHII 1	20.0	**17.3**
NLB-122	SHII 2	1.5	**9.6**	NLB-031	FHII 1	22.5 - 23.7	**17.9**
NLB-123	SHII 2	5.0	**8.9**	NLB-032	FHII 1	26.0	**16.3**
NLB-124	SHII 2	8.0 - 9.3	**10.7**	NLB-033	FHII 1	27.5 - 28.5	**18.4**
NLB-125	SHII 2	10.5	**11.4**	NLB-034	FHII 1	30.0	**18.4**
NLB-126	SHII 2	13.0 - 14.5	**11.1**	NLB-035	FHII 1	32.5 - 34	**16.3**
NLB-127	SHII 2	15.5	**9.9**	NLB-036	FHII 1	35.0	**16.1**
NLB-128	SHII 2	17.5	**8.0**	NLB-037	FHII 1	37.0	**14.1**
NLB-129	SHII 2	18.0 - 19.25	**10.0**	NLB-038	FHII 1	37.5 - 38.5	**25.0**
NLB-130	SHII 2	20.5	**5.4**	NLB-039	FHII 1	41.0	**19.4**

Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional
Project #:	659183
Date:	2022-04-11

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

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MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-040A	FHII 1	42.5 - 43.5	**15.6**	NLB-281	FHII 2	46.0	**17.2**
NLB-041	FHII 1	46.0	**12.3**	NLB-282	FHII 2	51.0	**18.1**
NLB-042	FHII 1	47.5 - 49.0	**17.4**	NLB-283	FHII 2	53.0 - 53.5	**18.7**
NLB-043	FHII 1	51.0	**11.8**	NLB-284	FHII 2	55.0	**21.5**
NLB-044	FHII 1	52.5 - 53.8	**12.6**	NLB-285	FHII 2	58.0 - 59.2	**22.4**
NLB-045	FHII 1	54.0	**13.3**	NLB-286	FHII 2	60.0	**20.1**
NLB-046	FHII 1	57.0	**15.4**	NLB-287	FHII 2	63.0	**20.7**
NLB-047	FHII 1	57.5 - 59.0	**18.0**	NLB-288	FHII 2	63.0 - 63.8	**17.1**
NLB-048	FHII 1	60.0	**15.4**	NLB-289	FHII 2	66.0	**17.4**
NLB-049	FHII 1	62.5 - 64.0	**7.1**	NLB-290	FHII 2	68.0 - 69.0	**22.1**
NLB-050	FHII 1	67.0	**19.5**	NLB-291	FHII 2	71.0	**13.9**
NLB-051	FHII 1	67.5 - 69.0	**18.7**	NLB-292	FHII 2	75.0	**21.9**
NLB-052	FHII 1	70.0	**12.7**	NLB-293	FHII 2	78.0	**15.5**
NLB-053	FHII 1	72.5 - 74.0	**12.6**	NLB-294	FHII 2	82.0	**14.5**
NLB-054	FHII 1	75.0	**13.3**	NLB-295	FHII 2	86.0	**12.8**
NLB-055	FHII 1	77.5	**14.5**	NLB-147	FHII 3	2.0	**16.6**
NLB-056	FHII 1	80.0 - 81.5	**13.2**	NLB-148	FHII 3	7.0	**22.4**
NLB-263	FHII 2	3.0	**5.0**	NLB-149	FHII 3	8.0 - 9.17	**14.5**
NLB-264	FHII 2	6.0	**10.5**	NLB-150	FHII 3	11.0	**4.3**
NLB-265	FHII 2	8.0 - 9.3	**14.2**	NLB-151	FHII 3	12.0	**10.1**
NLB-266	FHII 2	11.0	**12.5**	NLB-152	FHII 3	13.0 - 14.5	**10.8**
NLB-267	FHII 2	13.0 - 14.3	**16.2**	NLB-153	FHII 3	14.0	**12.5**
NLB-268	FHII 2	15.0	**15.6**	NLB-154	FHII 3	17.0	**12.6**
NLB-269	FHII 2	17.0	**14.7**	NLB-155	FHII 3	18.0 - 19.5	**13.7**
NLB-270	FHII 2	18.0 - 19.2	**18.3**	NLB-156	FHII 3	22.5	**12.2**
NLB-271	FHII 2	20.5	**20.2**	NLB-157	FHII 3	23.0 - 24.5	**15.3**
NLB-272	FHII 2	23.0 - 24.0	**16.9**	NLB-158	FHII 3	25.5	**13.7**
NLB-273	FHII 2	25.5	**17.9**	NLB-159	FHII 3	28 - 29.25	**14.9**
NLB-274	FHII 2	28.0 - 29.5	**17.5**	NLB-160	FHII 3	29.0	**18.3**
NLB-275	FHII 2	30.3	**17.6**	NLB-161	FHII 3	29.5	**16.8**
NLB-276	FHII 2	31.5	**9.1**	NLB-162	FHII 3	33 - 34.2	**12.8**
NLB-277	FHII 2	33.0 - 34.0	**11.4**	NLB-163	FHII 3	34.0	**15.6**
NLB-278	FHII 2	35.0	**12.9**	NLB-164	FHII 3	36.0	**12.7**
NLB-279	FHII 2	38.0 - 39.25	**10.5**	NLB-165	FHII 3	38 - 39	**19.6**
NLB-280	FHII 2	43.0 - 44.5	**21.1**				

Checker: Don [illegible] **Reviewer:** Don [illegible]

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-11

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

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MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-166	FHII 3	40.0	**19.8**	NLB-205	FHII 4	37.0 - 38.5	**15.5**
NLB-167	FHII 3	43 - 44.3	**16.8**	NLB-206	FHII 4	40.0	**21.6**
NLB-168	FHII 3	45.5	**20.4**	NLB-207	FHII 4	42.0 - 43.5	**17.8**
NLB-169	FHII 3	48 - 49.5	**13.1**	NLB-208	FHII 4	43.3	**15.8**
NLB-170	FHII 3	50.5	**10.0**	NLB-209	FHII 4	45.0	**8.2**
NLB-171	FHII 3	53 - 53.6	**16.5**	NLB-210	FHII 4	47.0 - 48.5	**20.7**
NLB-172	FHII 3	55.5	**20.9**	NLB-211	FHII 4	50.0	**17.9**
NLB-173	FHII 3	58.0 - 59.5	**18.8**	NLB-212	FHII 4	52.0 - 53.5	**20.8**
NLB-174	FHII 3	59.0	**19.2**	NLB-213	FHII 4	54.5	**21.8**
NLB-176	FHII 3	64.0	**19.6**	NLB-215	FHII 4	60.5	**20.8**
NLB-177	FHII 3	70.5	**21.8**	NLB-216	FHII 4	64.5	**17.5**
NLB-178	FHII 3	73.0 - 74.5	**19.2**	NLB-217	FHII 4	67.0 - 68.0	**19.8**
NLB-179	FHII 3	75.0	**17.3**	NLB-218	FHII 4	69.5	**7.0**
NLB-180	FHII 3	78.0	**15.4**	NLB-219	FHII 4	72.0 - 72.9	**14.2**
NLB-182	FHII 3	82.0	**18.8**	NLB-221	FHII 4	79.5	**13.0**
NLB-183	FHII 3	87.0	**16.2**	NLB-222	FHII 4	84.5	**10.1**
NLB-184	FHII 3	87.0 - 88.5	**15.7**	NLB-223	FHII 4	87.0 - 87.9	**19.9**
NLB-185	FHII 3	91.0	**18.4**	NLB-224	FHII 4	89.5	**18.9**
NLB-186	FHII 3	96.0	**11.6**	NLB-225	FHII 4	95.0	**19.4**
NLB-187	FHII 3	97.0 - 98.2	**12.8**	NLB-226	FHII 4	97.0 - 98.0	**15.4**
NLB-188	FHII 3	102.0	**13.5**	NLB-227	FHII 4	100.0	**15.4**
NLB-190	FHII 4	2.0	**8.5**	NLB-228	FHII 4	103.0	**12.5**
NLB-191	FHII 4	7.0	**14.8**	NLB-229	FHII 5	3.0	**24.3**
NLB-192	FHII 4	7.0 - 8.2	**11.1**	NLB-230	FHII 5	5.0 - 6.5	**17.6**
NLB-194	FHII 4	14.0	**10.9**	NLB-231	FHII 5	7.0	**15.5**
NLB-195	FHII 4	17.0 - 18.5	**11.9**	NLB-232	FHII 5	8.0	**13.7**
NLB-196	FHII 4	19.0	**11.9**	NLB-233	FHII 5	8.0 - 9.5	**13.3**
NLB-197	FHII 4	21.5	**10.5**	NLB-234	FHII 5	11.0	**11.9**
NLB-198	FHII 4	22.0 - 23.5	**14.8**	NLB-235	FHII 5	13.0 - 14.5	**11.7**
NLB-199	FHII 4	25.0	**16.6**				
NLB-200	FHII 4	27.0 - 28.3	**17.4**				
NLB-201	FHII 4	30.0	**14.8**				
NLB-202	FHII 4	32.0 - 33.5	**17.3**				
NLB-203	FHII 4	33.5	**11.3**				
NLB-204	FHII 4	37.0	**14.4**				

Checker: **Reviewer:**

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Geoscience & Materials

MOISTURE CONTENT TEST REPORT

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MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-236	FHII 5	16.0	**13.9**	NLB-067	SHII 4	23.0 - 24.1	**12.3**
NLB-238	FHII 5	23.0	**12.2**	NLB-069	SHII 4	25.0	**12.9**
NLB-239	FHII 5	23.0 - 24.5	**12.7**	NLB-070	SHII 4	28.0 - 29.5	**15.3**
NLB-240	FHII 5	27.0	**11.0**	NLB-071	SHII 4	31.0	**19.4**
NLB-241	FHII 5	29.0	**12.1**	NLB-072	SHII 4	33.0 - 34.0	**23.2**
NLB-242	FHII 5	31.5	**18.6**	NLB-073	SHII 4	35.0	**14.5**
NLB-243	FHII 5	33.0 - 34.5	**15.2**	NLB-074	SHII 4	37.0	**17.1**
NLB-244	FHII 5	34.5	**16.1**	NLB-075	SHII 4	38.0 - 38.75	**19.0**
NLB-245	FHII 5	36.0	**6.5**	NLB-076	SHII 4	43.0	**19.5**
NLB-246	FHII 5	38.0	**20.0**	NLB-077	SHII 4	45.0 - 45.8	**18.1**
NLB-247	FHII 5	38.0 - 39.2	**30.4**	NLB-299	FHII 6	1.0	**16.8**
NLB-248	FHII 5	40.5	**30.8**	NLB-300	FHII 6	3.5	**9.7**
NLB-249	FHII 5	43.0 - 44.5	**17.5**	NLB-301	FHII 6	8.0 - 9.5	**11.7**
NLB-250	FHII 5	45.0	**15.4**	NLB-302	FHII 6	10.5	**11.1**
NLB-251	FHII 5	48.0 - 49.8	**15.0**	NLB-303	FHII 6	13.0 - 14.5	**8.6**
NLB-252	FHII 5	51.0	**12.8**	NLB-304	FHII 6	15.5	**13.1**
NLB-253	FHII 5	53.0 - 54.5	**16.8**	NLB-305	FHII 6	15.0 - 20.0	**12.9**
NLB-254	FHII 5	55.5	**15.3**	NLB-306	FHII 6	20.5	**9.4**
NLB-255	FHII 5	60.5	**17.6**	NLB-307	FHII 6	23.0 - 24.5	**11.3**
NLB-256	FHII 5	65.5	**15.3**	NLB-308	FHII 6	25.5	**11.4**
NLB-257	FHII 5	68.0 - 69.5	**11.0**	NLB-309	FHII 6	28.0 - 29.5	**11.4**
NLB-258	FHII 5	70.5	**11.1**	NLB-310	FHII 6	30.5	**9.2**
NLB-259	FHII 5	73.0 - 74.5	**15.8**	NLB-311	FHII 6	33.0 - 34.5	**10.6**
NLB-260	FHII 5	76.0	**10.1**	NLB-312	FHII 6	35.5	**10.9**
NLB-261	FHII 5	79.0	**7.8**	NLB-313	FHII 6	38.0 - 38.9	**10.1**
NLB-057	SHII 4	0.5	**17.2**	NLB-314	FHII 6	41.0	**12.8**
NLB-058	SHII 4	2.5	**21.5**	NLB-315	FHII 6	43.0 - 44.5	**6.2**
NLB-059	SHII 4	5.0 - 6.5	**29.1**	NLB-316	FHII 6	45.5	**10.4**
NLB-060	SHII 4	7.0	**31.0**	NLB-317	FHII 6	50.0	**12.3**
NLB-061	SHII 4	8.0 - 9.5	**15.1**	NLB-318	FHII 6	53.0 - 53.3	**14.7**
NLB-062	SHII 4	10.0	**14.5**	NLB-319	FHII 6	56.0	**10.5**
NLB-063	SHII 4	13.0 - 14.5	**7.6**	NLB-320	FHII 6	58.0 - 59.5	**12.5**
NLB-064	SHII 4	15.5	**13.5**	NLB-321	FHII 6	61.0	**12.2**
NLB-065	SHII 4	18.0 - 19.5	**10.5**				
NLB-066	SHII 4	22.0	**17.5**				

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-11

Geoscience & Materials

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

SNC·LAVALIN

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-322	FHII 6	63.0 - 63.5	**11.5**	NLB-427	FHII 7	58.0 - 59.5	**16.3**
NLB-323	FHII 6	64.0	**16.4**	NLB-428	FHII 7	60.5	**11.1**
NLB-324	FHII 6	66.0	**12.8**	NLB-429	FHII 7	65.5	**11.0**
NLB-325	FHII 6	67.0	**12.6**	NLB-430	FHII 7	68.0 - 69.5	**9.4**
NLB-326	FHII 6	68.0 - 68.75	**20.3**	NLB-431	FHII 7	71.0	**11.5**
NLB-327	FHII 6	69.0	**11.8**	NLB-432	FHII 7	76.0	**10.7**
NLB-328	FHII 6	72.0	**14.8**	NLB-433	FHII 7	80.0 - 81.5	**10.4**
NLB-329	FHII 6	76.0	**14.6**	NLB-489	FHII 8	1.0	**23.5**
NLB-330	FHII 6	78.0 - 78.8	**16.9**	NLB-490	FHII 8	3.0	**21.0**
NLB-331	FHII 6	80.0	**20.1**	NLB-491	FHII 8	4.0	**23.6**
NLB-332	FHII 6	84.0	**14.5**	NLB-492	FHII 8	4.0 - 4.8	**21.2**
NLB-333	FHII 6	90.0	**16.6**	NLB-493	FHII 8	7.0	**24.7**
NLB-334	FHII 6	92.0	**9.9**	NLB-494	FHII 8	8.0 - 9.5	**17.6**
NLB-335	FHII 6	96.0	**12.1**	NLB-495	FHII 8	12.0	**18.9**
NLB-336	FHII 6	98.0 - 99.5	**12.4**	NLB-496	FHII 8	13.0 - 14.5	**26.1**
NLB-337	FHII 6	-	**19.3**	NLB-497	FHII 8	17.0	**12.8**
NLB-338	FHII 6	102.5	**13.0**	NLB-499	FHII 8	20.0	**13.0**
NLB-404	FHII 7	2.5	**4.5**	NLB-501	FHII 8	26.0	**10.2**
NLB-405	FHII 7	4.0 - 4.25	**11.3**	NLB-502	FHII 8	28.0 - 29.5	**11.6**
NLB-407	FHII 7	7.0	**12.0**	NLB-503	FHII 8	31.0	**13.0**
NLB-408	FHII 7	10.5	**11.6**	NLB-504	FHII 8	33.0 - 34.5	**13.8**
NLB-410	FHII 7	15.5	**13.1**	NLB-505	FHII 8	36.0	**14.2**
NLB-412	FHII 7	20.5	**13.6**	NLB-506	FHII 8	38.0 - 39.5	**13.1**
NLB-413	FHII 7	23.0 - 24.5	**13.8**	NLB-507	FHII 8	42.0	**12.4**
NLB-414	FHII 7	25.5	**11.7**	NLB-508	FHII 8	43.0 - 44.5	**5.3**
NLB-416	FHII 7	30.5 - 31.5	**12.8**	NLB-509	FHII 8	47.0	**13.2**
NLB-417	FHII 7	32.0	**13.8**	NLB-510	FHII 8	48.0 - 49.3	**19.1**
NLB-419	FHII 7	35.5	**12.7**	NLB-511	FHII 8	49.5	**14.9**
NLB-420	FHII 7	38.0 - 39.5	**13.8**				
NLB-421	FHII 7	40.5	**14.8**				
NLB-422	FHII 7	43.0 - 44.5	**13.2**				
NLB-423	FHII 7	45.5	**14.5**				
NLB-424	FHII 7	48.0 - 49.5	**12.3**				
NLB-425	FHII 7	50.5	**11.8**				
NLB-426	FHII 7	55.5	**12.0**				

Checker:

Reviewer:

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Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-11

Geoscience & Materials

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

SNC·LAVALIN

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-512	FHII 8	53.0 - 53.5	**10.9**	NLB-368	FHII 9	65.5	**9.9**
NLB-513	FHII 8	55.0	**12.0**	NLB-369	FHII 9	68.0 - 69.5	**9.0**
NLB-514	FHII 8	60.0	**11.3**	NLB-370	FHII 9	70.5	**8.5**
NLB-515	FHII 8	63 - 64	**13.0**	NLB-371	FHII 9	75.5	**10.7**
NLB-516	FHII 8	66.0	**11.4**	NLB-372	FHII 9	80.0 - 81.25	**9.7**
NLB-517	FHII 8	71.0	**12.6**				
NLB-518	FHII 8	73.0 - 74.5	**11.5**				
NLB-519	FHII 8	79.0	**11.4**				
NLB-520	FHII 8	80.0	**13.0**				
NLB-341	FHII 9	1.5	**4.7**				
NLB-342	FHII 9	3.0	**14.2**				
NLB-343	FHII 9	3.0 - 4.2	**16.4**				
NLB-344	FHII 9	5.0	**14.3**				
NLB-345	FHII 9	8.0 - 9.3	**14.5**				
NLB-346	FHII 9	10.5	**17.1**				
NLB-347	FHII 9	12.5	**12.0**				
NLB-348	FHII 9	13.0 - 14.0	**18.0**				
NLB-349	FHII 9	16.0	**13.2**				
NLB-350	FHII 9	18.0 - 19.5	**11.1**				
NLB-351	FHII 9	19.5	**12.6**				
NLB-352	FHII 9	21.5	**11.9**				
NLB-353	FHII 9	23.0 - 24.3	**8.8**				
NLB-354	FHII 9	25.5	**10.5**				
NLB-355	FHII 9	28.0 - 29.5	**9.7**				
NLB-356	FHII 9	30.5	**9.8**				
NLB-357	FHII 9	33.0 - 34.3	**13.7**				
NLB-358	FHII 9	35.5	**11.8**				
NLB-359	FHII 9	38.0 - 40.0	**11.8**				
NLB-360	FHII 9	42.5	**12.0**				
NLB-361	FHII 9	43.0 - 44.5	**11.9**				
NLB-363	FHII 9	48.0 - 49.5	**9.8**				
NLB-364	FHII 9	50.5	**11.1**				
NLB-365	FHII 9	55.5	**11.1**				
NLB-366	FHII 9	58.0 - 59.5	**8.6**				
NLB-367	FHII 9	60.5	**11.1**				

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Project #: 659183
Date: 2022-04-11

Geoscience & Materials

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

SNC·LAVALIN

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %
NLB-373	FHII 10	3.0	**9.5**
NLB-374	FHII 10	3.0 - 3.7	**15.6**
NLB-375	FHII 10	7.0	**18.9**
NLB-376	FHII 10	11.0	**31.0**
NLB-377	FHII 10	12.0 - 13.5	**25.1**
NLB-378	FHII 10	15.0	**26.5**
NLB-379	FHII 10	17.0 - 18.5	**15.5**
NLB-380	FHII 10	20.0	**14.2**
NLB-381	FHII 10	25.0	**12.2**
NLB-382	FHII 10	27.0 - 28.7	**13.0**
NLB-383	FHII 10	30.0	**10.4**
NLB-384	FHII 10	32.0 - 33.5	**11.9**
NLB-385	FHII 10	34.0	**36.7**
NLB-386	FHII 10	37.0 - 38.5	**14.3**
NLB-387	FHII 10	40.0	**11.9**
NLB-388	FHII 10	42.0 - 42.8	**12.1**
NLB-389	FHII 10	45.0	**12.0**
NLB-390	FHII 10	47.0 - 48.5	**10.5**
NLB-391	FHII 10	50.0	**11.2**
NLB-392	FHII 10	52.0 - 53.5	**11.9**
NLB-393	FHII 10	55.0	**11.4**
NLB-394	FHII 10	57.0 - 58.5	**10.5**
NLB-395	FHII 10	60.0	**9.9**
NLB-396	FHII 10	62.0 - 63.5	**12.8**
NLB-397	FHII 10	65.5	**11.1**
NLB-398	FHII 10	67.0 - 68.3	**11.6**
NLB-399	FHII 10	70.0	**11.8**
NLB-400	FHII 10	72.0 - 73.5	**11.6**
NLB-401	FHII 10	74.5	**11.6**
NLB-402	FHII 10	78.0	**11.4**
NLB-403	FHII 10	79.0 - 80.5	**11.4**
NLB-112	PHII 4	1.0	**15.9**
NLB-113	PHII 4	3.0	**12.5**
NLB-114	PHII 4	7.0	**21.7**
NLB-115	PHII 4	12.0	**18.3**
NLB-116	PHII 4	17.0	**13.3**
NLB-107	PHII 5	1.0	**18.8**
NLB-108	PHII 5	3.0	**16.6**
NLB-109	PHII 5	7.0	**27.5**
NLB-110	PHII 5	12.0	**13.5**
NLB-111	PHII 5	17.0	**13.9**
NLB-470	SHII 6	2.5	**28.6**
NLB-471	SHII 6	5.0	**28.7**
NLB-472	SHII 6	8.0 - 9.5	**16.1**
NLB-473	SHII 6	10.5	**29.7**
NLB-474	SHII 6	13.0 - 14.5	**13.0**
NLB-475	SHII 6	15.5	**14.1**
NLB-476	SHII 6	18.0 - 19.5	**11.2**
NLB-477	SHII 6	20.5	**16.7**
NLB-478	SHII 6	23.0 - 24.0	**15.2**
NLB-479	SHII 6	25.5	**14.0**
NLB-480	SHII 6	28.0 - 29.5	**13.3**
NLB-481	SHII 6	30.5	**13.7**
NLB-482	SHII 6	32.0	**21.1**
NLB-483	SHII 6	33.0 - 34.5	**21.0**
NLB-484	SHII 6	35.5	**21.7**
NLB-485	SHII 6	38.0 - 39.5	**21.8**
NLB-486	SHII 6	42.0	**23.4**
NLB-487	SHII 6	44.0	**22.2**
NLB-488	SHII 6	45.0 - 46.5	**19.5**
NLB-434	FHII 11	2.0	**5.6**
NLB-435	FHII 11	3.5	**26.8**
NLB-436	FHII 11	4.0 - 5.5	**18.9**
NLB-437	FHII 11	6.0	**17.8**
NLB-438	FHII 11	7.0 - 7.9	**17.0**
NLB-439	FHII 11	8.5	**20.0**
NLB-440	FHII 11	11.5	**16.6**
NLB-441	FHII 11	12.0 - 13.3	**17.1**
NLB-442	FHII 11	13.5	**22.6**
NLB-443	FHII 11	15.5	**14.6**

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Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-11

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

SNC·LAVALIN

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-444	FHII 11	17.0 - 18.25	**13.4**	NLB-080	SHII 7	4.0	**9.2**
NLB-445	FHII 11	20.0	**13.2**	NLB-081	SHII 7	5.0 - 6.5	**12.8**
NLB-446	FHII 11	22.0 - 23.25	**12.6**	NLB-082	SHII 7	7.0	**12.3**
NLB-447	FHII 11	25.0	**16.6**	NLB-083	SHII 7	8.0 - 9.5	**13.8**
NLB-448	FHII 11	27.0 - 28.5	**14.1**	NLB-084	SHII 7	12.0	**13.7**
NLB-449	FHII 11	30.0	**13.5**	NLB-085	SHII 7	13.0 - 14.5	**15.4**
NLB-450	FHII 11	32.0 - 33	**13.5**	NLB-086	SHII 7	17.0	**18.3**
NLB-451	FHII 11	34.0	**13.6**	NLB-087	SHII 7	18.0 - 18.9	**16.1**
NLB-452	FHII 11	36.0	**20.9**	NLB-088	SHII 7	19.0	**15.4**
NLB-453	FHII 11	37.0 - 38.5	**17.4**	NLB-089	SHII 7	23.0 - 24.5	**17.4**
NLB-454	FHII 11	40.0	**21.8**	NLB-090	SHII 7	27.0	**13.4**
NLB-455	FHII 11	42.0 - 43.5	**22.4**	NLB-091	SHII 7	28.0 - 29.5	**14.6**
NLB-456	FHII 11	45.5	**22.9**	NLB-092	SHII 7	32.0	**23.0**
NLB-457	FHII 11	47.0 - 48.5	**17.6**	NLB-093	SHII 7	33.0 - 34.5	**19.7**
NLB-458	FHII 11	50.0	**16.8**	NLB-094	SHII 7	36.0	**10.2**
NLB-459	FHII 11	52.0 - 53.3	**15.0**	NLB-095	SHII 7	38.0	**11.7**
NLB-460	FHII 11	55.0	**22.9**	NLB-096	SHII 7	38.0 - 39.5	**14.4**
NLB-461	FHII 11	57.0 - 58.5	**18.6**	NLB-097	SHII 7	42.0	**15.1**
NLB-462	FHII 11	60.0	**20.5**	NLB-553	FHII 14	2.0	**7.4**
NLB-463	FHII 11	62.0 - 63.5	**15.6**	NLB-554	FHII 14	3.0 - 3.9	**8.7**
NLB-464	FHII 11	64.0	**15.7**	NLB-555	FHII 14	6.0	**7.9**
NLB-465	FHII 11	66.0	**16.3**	NLB-556	FHII 14	8.0	**12.8**
NLB-466	FHII 11	70.0	**25.5**	NLB-557	FHII 14	8.0 - 9.5	**15.4**
NLB-467	FHII 11	72.0 - 73.5	**19.0**	NLB-558	FHII 14	12.0	**16.7**
NLB-468	FHII 11	76.0	**15.9**	NLB-559	FHII 14	13.0	**15.6**
NLB-469	FHII 11	79.0 - 80.5	**22.5**	NLB-560	FHII 14	15.5	**13.2**
NLB-100	PHII 6	0.5	**11.0**	NLB-562	FHII 14	23.0 - 24.5	**12.5**
NLB-101	PHII 6	1.5	**9.2**	NLB-563	FHII 14	25.5	**23.6**
NLB-102	PHII 6	3.0	**8.5**	NLB-564	FHII 14	28.0 - 29.5	**13.2**
NLB-103	PHII 6	7.0	**14.5**	NLB-565	FHII 14	30.5	**13.0**
NLB-104	PHII 6	8.0	**1.7**	NLB-566	FHII 14	33.0 - 34.5	**14.1**
NLB-105	PHII 6	12.0	**8.9**	NLB-567	FHII 14	35.5	**11.9**
NLB-106	PHII 6	17.0	**10.9**	NLB-568	FHII 14	38.0 - 39.5	**13.0**
NLB-078	SHII 7	1.0	**22.3**	NLB-569	FHII 14	40.5	**12.6**
NLB-079	SHII 7	2.5	**4.7**				

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Geoscience & Materials

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

SNC·LAVALIN

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-570	FHII 14	43.0 - 44.5	**10.6**	NLB-897	FHII 16	51.0	**12.8**
NLB-571	FHII 14	45.5	**12.1**	NLB-898	FHII 16	53.0 - 54.5	**13.8**
NLB-572	FHII 14	48.0 - 49.5	**11.7**	NLB-899	FHII 16	56.0	**12.9**
NLB-573	FHII 14	50.5	**12.3**	NLB-900	FHII 16	58.0 - 59.5	**14.4**
NLB-574	FHII 14	55.5	**12.1**	NLB-901	FHII 16	65.0	**12.6**
NLB-575	FHII 14	58.0 - 60.0	**11.8**	NLB-902	FHII 16	68.0 - 69.5	**12.3**
NLB-576	FHII 14	61.0	**12.5**	NLB-903	FHII 16	71.0	**15.8**
NLB-577	FHII 14	66.0	**12.5**	NLB-904	FHII 16	78.0	**13.2**
NLB-578	FHII 14	68.0 - 69.5	**12.7**	NLB-905	FHII 16	81.0 - 82.5	**14.2**
NLB-579	FHII 14	70.0	**13.1**	NLB-521	FHII 12	2.0	**27.3**
NLB-580	FHII 14	74.0	**12.3**	NLB-522	FHII 12	2.5	**24.9**
NLB-581	FHII 14	78.0	**12.8**	NLB-523	FHII 12	5.0	**35.4**
NLB-871	FHII 16	0.5	**84.3**	NLB-524	FHII 12	8.0 - 9.5	**33.6**
NLB-872	FHII 16	1.5	**11.9**	NLB-525	FHII 12	10.5	**39.5**
NLB-873	FHII 16	3.0	**16.0**	NLB-526	FHII 12	13.0 - 14.5	**34.5**
NLB-874	FHII 16	3.0 - 4.5	**14.3**	NLB-527	FHII 12	15.5	**38.4**
NLB-875	FHII 16	5.0	**15.2**	NLB-528	FHII 12	18.0 - 19.6	**38.5**
NLB-876	FHII 16	7.0	**11.4**	NLB-529	FHII 12	20.5	**36.8**
NLB-878	FHII 16	10.0	**14.4**	NLB-530	FHII 12	23.0 - 24.5	**38.2**
NLB-879	FHII 16	12.0	**11.4**	NLB-531	FHII 12	25.5	**39.8**
NLB-880	FHII 16	13.0 - 14.5	**12.3**	NLB-532	FHII 12	28.0 - 29.5	**37.3**
NLB-881	FHII 16	16.0	**10.9**	NLB-533	FHII 12	31.0	**33.1**
NLB-882	FHII 16	18.0 - 19.7	**9.2**	NLB-534	FHII 12	33.0 - 34.5	**36.3**
NLB-883	FHII 16	20.0	**14.3**	NLB-535	FHII 12	35.5	**28.6**
NLB-884	FHII 16	23 - 24.5	**14.1**	NLB-536	FHII 12	38.0 - 39.5	**19.8**
NLB-885	FHII 16	25.0	**13.3**	NLB-537	FHII 12	40.5	**14.0**
NLB-886	FHII 16	28.0 - 29.5	**15.5**	NLB-538	FHII 12	43.0 - 44.5	**14.0**
NLB-887	FHII 16	30.0	**15.1**	NLB-539	FHII 12	45.5	**14.0**
NLB-888	FHII 16	32.0	**10.9**	NLB-540	FHII 12	48.0 - 49.2	**14.6**
NLB-889	FHII 16	33.0 - 34.5	**12.8**	NLB-541	FHII 12	52.0	**13.0**
NLB-890	FHII 16	36.0	**10.8**				
NLB-892	FHII 16	39.0	**12.2**				
NLB-893	FHII 16	42.0	**11.9**				
NLB-894	FHII 16	43.0 - 44.5	**14.4**				
NLB-895	FHII 16	45.5	**12.5**				

Checker: **Reviewer:**

Client:	SMHI
Project:	Saskatoon Freeway Functional
Project #:	659183
Date:	2022-04-11

Geoscience & Materials

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-542	FHII 12	53.0 - 54.5	**13.2**	NLB-646	FHII 13	62.0	**13.9**
NLB-543	FHII 12	57.0	**11.8**	NLB-647	FHII 13	63.0 - 64.5	**10.8**
NLB-544	FHII 12	58.0 - 58.8	**17.3**	NLB-648	FHII 13	67.0	**19.6**
NLB-545	FHII 12	62.0	**13.0**	NLB-649	FHII 13	68.0 - 69.4	**12.9**
NLB-546	FHII 12	63.0 - 64.4	**18.5**	NLB-650	FHII 13	71.0	**13.5**
NLB-547	FHII 12	65.0	**15.0**	NLB-651	FHII 13	73.0 - 74.5	**14.4**
NLB-548	FHII 12	68.0 - 69.3	**11.8**	NLB-652	FHII 13	76.0	**11.5**
NLB-549	FHII 12	71.0	**13.3**	NLB-653	FHII 13	80.0 - 80.6	**13.6**
NLB-550	FHII 12	73.0 - 73.8	**10.5**	NLB-941	FHII 17	1.5	**15.1**
NLB-551	FHII 12	78.0	**11.0**	NLB-942	FHII 17	3.0	**30.0**
NLB-552	FHII 12	80.0 - 81.0	**12.3**	NLB-943	FHII 17	7.0	**36.2**
NLB-621	FHII 13	1.5	**14.2**	NLB-944	FHII 17	8.0 - 9.5	**38.5**
NLB-622	FHII 13	2.5	**24.0**	NLB-945	FHII 17	11.0	**44.1**
NLB-623	FHII 13	3.0 - 4.5	**30.2**	NLB-946	FHII 17	13.0 - 15.0	**21.4**
NLB-624	FHII 13	6.0	**32.0**	NLB-947	FHII 17	15.5	**33.1**
NLB-625	FHII 13	8.0 - 9.5	**40.1**	NLB-948	FHII 17	18.0 - 19.5	**26.1**
NLB-626	FHII 13	10.0	**40.3**	NLB-949	FHII 17	20.5	**19.6**
NLB-627	FHII 13	13.0 - 14.5	**48.5**	NLB-950	FHII 17	23.0 - 25.0	**20.4**
NLB-628	FHII 13	16.0	**36.1**	NLB-951	FHII 17	26.0	**23.4**
NLB-629	FHII 13	18.0 - 19.0	**38.8**	NLB-952	FHII 17	28.0 - 29.5	**15.5**
NLB-630	FHII 13	21.0	**32.8**	NLB-953	FHII 17	32.0	**18.4**
NLB-631	FHII 13	23.0 - 24.3	**32.3**	NLB-954	FHII 17	35.0	**14.9**
NLB-632	FHII 13	26.0	**24.2**	NLB-955	FHII 17	38.0 - 39.0	**11.1**
NLB-633	FHII 13	28.0 - 28.5	**21.3**	NLB-956	FHII 17	40.5	**10.5**
NLB-634	FHII 13	32.0	**18.1**	NLB-957	FHII 17	43.0 - 44.5	**9.9**
NLB-635	FHII 13	33.0 - 34.5	**17.1**	NLB-958	FHII 17	46.0	**10.6**
NLB-636	FHII 13	36.0	**15.9**	NLB-959	FHII 17	48.0 - 49.25	**12.4**
NLB-637	FHII 13	38.0 - 38.8	**17.2**	NLB-960	FHII 17	51.0	**14.2**
NLB-638	FHII 13	39.0	**15.2**	NLB-961	FHII 17	53.0	**13.1**
NLB-639	FHII 13	43.0 - 45.0	**10.7**	NLB-962	FHII 17	58.0 - 59.5	**12.0**
NLB-640	FHII 13	47.0	**15.0**	NLB-963	FHII 17	60.5	**11.8**
NLB-641	FHII 13	48.0 - 48.7	**13.7**	NLB-964	FHII 17	63.0 - 64.5	**11.5**
NLB-642	FHII 13	51.0	**14.1**	NLB-965	FHII 17	66.0	**12.5**
NLB-644	FHII 13	57.0	**13.7**	NLB-966	FHII 17	68.0 - 69.5	**14.0**
NLB-645	FHII 13	58.0 - 59.5	**14.4**				

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-11

Geoscience & Materials

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

SNC·LAVALIN

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-967	FHII 17	71.0	**12.9**	NLB-584	FHII 19	3.0 - 4.5	**32.0**
NLB-968	FHII 17	74.0	**13.8**	NLB-585	FHII 19	5.0	**33.3**
NLB-969	FHII 17	77.0	**12.7**	NLB-586	FHII 19	8.0 - 9.0	**24.4**
NLB-970	FHII 17	80.0 - 81.5	**13.5**	NLB-587	FHII 19	12.0	**17.1**
NLB-906	FHII 18	2.5	**10.7**	NLB-588	FHII 19	13.0 - 15.0	**20.5**
NLB-907	FHII 18	5.5	**33.3**	NLB-589	FHII 19	17.0	**21.3**
NLB-908	FHII 18	8.0 - 9.5	**21.4**	NLB-590	FHII 19	18.0 - 19.4	**24.4**
NLB-909	FHII 18	10.5	**27.8**	NLB-591	FHII 19	22.0	**15.8**
NLB-911	FHII 18	15.5	**25.4**	NLB-592	FHII 19	23.0 - 24.5	**14.5**
NLB-912	FHII 18	18.0 - 20.0	**21.8**	NLB-593	FHII 19	27.0	**15.8**
NLB-913	FHII 18	21.0	**21.4**	NLB-594	FHII 19	28.0 - 29.5	**12.9**
NLB-914	FHII 18	23.0 - 25.0	**24.2**	NLB-595	FHII 19	31.0	**11.8**
NLB-915	FHII 18	25.5	**23.5**	NLB-596	FHII 19	33.0 - 34.5	**12.5**
NLB-916	FHII 18	28.0 - 29.5	**23.4**	NLB-597	FHII 19	36.0	**12.2**
NLB-917	FHII 18	30.5	**12.9**	NLB-599	FHII 19	41.0	**13.6**
NLB-918	FHII 18	33.0 - 34.5	**13.0**	NLB-600	FHII 19	43.0 - 44.5	**13.5**
NLB-919	FHII 18	35.5	**13.1**	NLB-601	FHII 19	47.0	**12.6**
NLB-920	FHII 18	38.0 - 39.5	**10.4**	NLB-602	FHII 19	48.0 - 49.3	**13.6**
NLB-921	FHII 18	40.5	**12.5**	NLB-603	FHII 19	52.0	**15.8**
NLB-922	FHII 18	43.0 - 45.0	**12.8**	NLB-605	FHII 19	58.0	**21.1**
NLB-923	FHII 18	46.0	**12.6**	NLB-606	FHII 19	63.0	**17.9**
NLB-924	FHII 18	48.0 - 49.5	**10.7**	NLB-607	FHII 19	64.0	**13.9**
NLB-925	FHII 18	51.0	**10.8**	NLB-609	FHII 19	68.0	**14.1**
NLB-926	FHII 18	54.0	**11.8**	NLB-611	FHII 19	72.0	**16.8**
NLB-927	FHII 18	56.0	**11.5**	NLB-612	FHII 19	73.0 - 74.0	**18.2**
NLB-928	FHII 18	58.0 - 58.5	**12.0**	NLB-613	FHII 19	77.0	**13.0**
NLB-929	FHII 18	61.0	**12.4**	NLB-614	FHII 19	80.0 - 81.5	**13.7**
NLB-930	FHII 18	63.0 - 64.5	**12.4**	NLB-936	PHII 7	0.5	**32.2**
NLB-931	FHII 18	66.0	**11.6**	NLB-937	PHII 7	2.5	**31.8**
NLB-932	FHII 18	68.0 - 69.5	**11.0**	NLB-938	PHII 7	6.0	**39.7**
NLB-933	FHII 18	73.0	**12.9**				
NLB-934	FHII 18	76.0	**11.4**				
NLB-935	FHII 18	80.0 - 81.5	**12.5**				
NLB-582	FHII 19	1.0	**7.4**				
NLB-583	FHII 19	2.0	**16.9**				

Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional
Project #:	659183
Date:	2022-04-11

Geoscience & Materials

MOISTURE CONTENT TEST REPORT

SNC·LAVALIN

(Test Reference: ASTM D 2216)

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-939	PHII 7	12.0	**35.0**	NLB-778	SHII 8	8.0 - 9.5	**48.0**
NLB-940	PHII 7	16.0	**36.8**	NLB-779	SHII 8	11.5	**32.5**
NLB-743	FHII 20	2.5	**6.2**	NLB-780	SHII 8	12.0	**37.5**
NLB-744	FHII 20	3 - 4	**7.3**	NLB-781	SHII 8	13.0 - 14.5	**36.4**
NLB-745	FHII 20	7.0	**6.2**	NLB-782	SHII 8	15.5	**34.4**
NLB-746	FHII 20	8.0 - 9.25	**29.5**	NLB-783	SHII 8	18.0 - 19.5	**37.3**
NLB-747	FHII 20	11.0	**26.0**	NLB-784	SHII 8	20.5	**36.7**
NLB-748	FHII 20	13.0 - 14.5	**27.1**	NLB-785	SHII 8	23.0 - 24.9	**40.1**
NLB-749	FHII 20	17.0	**32.3**	NLB-786	SHII 8	25.5	**34.8**
NLB-751	FHII 20	22.0	**28.0**	NLB-788	SHII 8	30.5	**34.9**
NLB-752	FHII 20	23.0 - 24.5	**35.5**	NLB-789	SHII 8	33.0 - 34.5	**40.4**
NLB-753	FHII 20	27.0	**36.0**	NLB-790	SHII 8	36.0	**39.3**
NLB-754	FHII 20	28.0 - 29.5	**32.9**	NLB-791	SHII 8	38.0 - 39.5	**34.5**
NLB-755	FHII 20	31.0	**31.2**	NLB-792	SHII 8	41.0	**36.2**
NLB-756	FHII 20	33.0 - 34.5	**39.7**	NLB-793	SHII 8	45.0 - 46.2	**35.8**
NLB-757	FHII 20	37.0	**34.8**	NLB-615	PHII 8	2.5	**9.0**
NLB-758	FHII 20	38.0 - 39.5	**36.4**	NLB-616	PHII 8	5.0	**8.5**
NLB-759	FHII 20	41.0	**35.5**	NLB-617	PHII 8	7.5	**30.5**
NLB-760	FHII 20	43.0 - 44.5	**36.4**	NLB-618	PHII 8	10.0	**27.0**
NLB-761	FHII 20	47.0	**35.3**	NLB-619	PHII 8	12.5	**30.2**
				NLB-620	PHII 8	15.0	**30.8**
NLB-763	FHII 20	51.0	**37.8**				
NLB-764	FHII 20	53.0 - 54.5	**35.5**				
NLB-765	FHII 20	56.0	**41.1**				
NLB-766	FHII 20	58.0 - 59.5	**39.8**				
NLB-767	FHII 20	63.0	**42.7**				
NLB-768	FHII 20	64.0 - 66.0	**35.0**				
NLB-769	FHII 20	66.0	**31.0**				
NLB-770	FHII 20	67.0	**29.4**				
NLB-771	FHII 20	68.0 - 69.5	**37.7**				
NLB-772	FHII 20	70.0	**36.5**				
NLB-773	FHII 20	72.0	**24.0**				
NLB-776	SHII 8	1.5	**10.3**				
NLB-777	SHII 8	5.0	**31.5**				

Checker: **Reviewer:**

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-11

Geoscience & Materials

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

SNC·LAVALIN

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-654	FHII 21	2.5	**17.8**	NLB-688B	FHII 21	89.0 - 89.5	**17.0**
NLB-655	FHII 21	5.0	**11.6**	NLB-689	FHII 21	91.0	**17.6**
NLB-656	FHII 21	7.5	**27.8**	NLB-690	FHII 21	96.0	**11.8**
NLB-657	FHII 21	8.0 - 9.5	**30.4**	NLB-691	FHII 21	98.0 - 99.5	**15.4**
NLB-658	FHII 21	10.5	**32.4**	NLB-692	FHII 22	0.5	**24.6**
NLB-659	FHII 21	13.0 - 14.5	**36.2**	NLB-693	FHII 22	2.0	**18.9**
NLB-660	FHII 21	15.5	**36.9**	NLB-694	FHII 22	3.0 - 4.0	**16.5**
NLB-661	FHII 21	18.0 - 19.5	**35.0**	NLB-695	FHII 22	6.0	**17.3**
NLB-662	FHII 21	20.5	**36.2**	NLB-696	FHII 22	8.0 - 9.5	**29.1**
NLB-663	FHII 21	23.0 - 24.5	**35.8**	NLB-697	FHII 22	11.0	**29.7**
NLB-664	FHII 21	25.5	**36.9**	NLB-698	FHII 22	13.0 - 14.5	**24.2**
NLB-665	FHII 21	28.0 - 29.6	**39.4**	NLB-700	FHII 22	18.0 - 19.2	**31.5**
NLB-666	FHII 21	30.5	**33.1**	NLB-701	FHII 22	21.0	**28.3**
NLB-667	FHII 21	33.0 - 34.5	**28.9**	NLB-702	FHII 22	23.0 - 24.5	**33.8**
NLB-668	FHII 21	35.5	**33.8**	NLB-703	FHII 22	27.0	**34.2**
NLB-669	FHII 21	38.0 - 39.5	**34.0**	NLB-704	FHII 22	28.0 - 29.5	**27.4**
NLB-670	FHII 21	40.5	**31.2**	NLB-705	FHII 22	31.0	**32.6**
NLB-671	FHII 21	43.0	**27.1**	NLB-706	FHII 22	33.0 - 34.5	**33.9**
NLB-672	FHII 21	45.5	**27.5**	NLB-707	FHII 22	37.0	**40.1**
NLB-673	FHII 21	48.0 - 49.3	**31.2**	NLB-708	FHII 22	38.0 - 39.5	**38.6**
NLB-674	FHII 21	50.5	**27.5**	NLB-709	FHII 22	40.0	**36.4**
NLB-675	FHII 21	53.0 - 54.2	**24.4**	NLB-710	FHII 22	43.0	**36.1**
NLB-676	FHII 21	55.5	**26.4**	NLB-711	FHII 22	43.0 - 44.5	**36.5**
NLB-677	FHII 21	58.0 - 59.5	**29.9**	NLB-712	FHII 22	46.0	**35.6**
NLB-678	FHII 21	61.0	**31.8**	NLB-713	FHII 22	50.0 - 51.5	**39.8**
NLB-679	FHII 21	66.0	**34.5**	NLB-714	FHII 22	52.2	**35.4**
NLB-680	FHII 21	68.0 - 69.25	**26.0**	NLB-715	FHII 22	53.0 - 54.7	**37.0**
NLB-681	FHII 21	71.0	**27.6**	NLB-716	FHII 22	55.5	**36.4**
NLB-682	FHII 21	73.0 - 74.5	**26.0**	NLB-717	FHII 22	58.0 - 60.0	**32.2**
NLB-683	FHII 21	77.0	**31.8**	NLB-718	FHII 22	60.5	**31.9**
NLB-684	FHII 21	78.0 - 79.5	**34.1**	NLB-719	FHII 22	63.0 - 64.8	**13.7**
NLB-685	FHII 21	81.0	**33.4**	NLB-720	FHII 22	65.5	**12.0**
NLB-686	FHII 21	86.0	**35.6**	NLB-721	FHII 22	68.0 - 70.3	**10.7**
NLB-687	FHII 21	78.0	**30.2**	NLB-722	FHII 22	70.5	**12.3**
NLB-688A	FHII 21	88.0 - 89	**32.5**				

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-11

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

SNC·LAVALIN

MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-723	FHII 22	73.0 - 74.7	**11.9**	NLB-844	FHII 23	38 - 39.5	**23.6**
NLB-724	FHII 22	75.5	**11.7**	NLB-845	FHII 23	42.0	**21.6**
NLB-725	FHII 22	78.0	**12.5**	NLB-846	FHII 23	43 - 44.5	**20.4**
NLB-726	FHII 22	80.5 - 82.0	**13.3**	NLB-847	FHII 23	46.0	**22.9**
NLB-727	SHII 9	2.5	**29.9**	NLB-848	FHII 23	48 - 48.75	**23.7**
NLB-728	SHII 9	8.0 - 9.7	**41.3**	NLB-849	FHII 23	52.0	**23.1**
NLB-729	SHII 9	10.5	**36.9**	NLB-850	FHII 23	53 - 54.5	**25.7**
NLB-730	SHII 9	13.0 - 14.5	**34.5**	NLB-851	FHII 23	57.0	**24.8**
NLB-731	SHII 9	15.5	**36.3**	NLB-852	FHII 23	58 - 59.5	**29.0**
NLB-732	SHII 9	18.0 - 19.5	**35.1**	NLB-853	FHII 23	59.0	**26.9**
NLB-733	SHII 9	20.5	**20.4**	NLB-854	FHII 23	62.0	**23.7**
NLB-734	SHII 9	23.0 - 24.5	**39.5**	NLB-855	FHII 23	63 - 64.5	**27.0**
NLB-735	SHII 9	25.5	**37.4**	NLB-856	FHII 23	65.0	**25.2**
NLB-737	SHII 9	32.0	**30.3**	NLB-857	FHII 23	68 - 68.3	**25.6**
NLB-738	SHII 9	33 - 34.5	**27.1**	NLB-858	FHII 23	70.5	**31.5**
NLB-739	SHII 9	37.0	**37.4**	NLB-859	FHII 23	72.0	**30.1**
NLB-740	SHII 9	38 - 39.5	**40.8**	NLB-860	FHII 23	73 - 74.5	**32.1**
NLB-741	SHII 9	41.0	**39.8**	NLB-861	FHII 23	76.0	**33.6**
NLB-742	SHII 9	45 - 46.5	**27.7**	NLB-863	FHII 23	80 - 81.5	**38.1**
NLB-828	FHII 23	1.0	**13.1**	NLB-864	FHII 23	83.0	**33.6**
NLB-829	FHII 23	2.0	**5.6**	NLB-865	FHII 23	86.0	**34.0**
NLB-830	FHII 23	3 - 4.2	**5.8**	NLB-866	FHII 23	88 - 89.5	**14.8**
NLB-831	FHII 23	7.0	**7.3**	NLB-867	FHII 23	91.0	**13.7**
NLB-832	FHII 23	8 - 9.5	**26.5**	NLB-868	FHII 23	93 - 95	**11.8**
NLB-833	FHII 23	10.0	**25.3**	NLB-869	FHII 23	96.0	**27.1**
NLB-834	FHII 23	12.0	**26.2**	NLB-794	FHII 24	2.5	**10.1**
NLB-835	FHII 23	13 - 14.2	**29.5**	NLB-795	FHII 24	3.0 - 4.1	**16.5**
NLB-836	FHII 23	16.0	**26.1**	NLB-796	FHII 24	5.0	**13.1**
NLB-837	FHII 23	18 - 19.2	**25.5**	NLB-797	FHII 24	7.0	**27.0**
NLB-838	FHII 23	21.0	**24.6**	NLB-798	FHII 24	8.0 - 8.25	**21.9**
NLB-839	FHII 23	23 - 24.5	**24.4**	NLB-799	FHII 24	12.0	**35.6**
NLB-840	FHII 23	26.0	**23.4**	NLB-800	FHII 24	13.0 - 14.5	**36.5**
NLB-841	FHII 23	28 - 28.75	**25.7**				
NLB-842	FHII 23	33 - 34.5	**25.9**				
NLB-843	FHII 23	37.0	**24.1**				

Checker:

Reviewer:

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Project: Saskatoon Freeway Functional
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Geoscience & Materials

MOISTURE CONTENT TEST REPORT

(Test Reference: ASTM D 2216)

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MOISTURE CONTENT RESULTS

Sample #	Test Hole	Depth(ft)	M/C %	Sample #	Test Hole	Depth(ft)	M/C %
NLB-801	FHII 24	18.0 - 19.5	**32.2**				
NLB-802	FHII 24	20.0	**36.3**				
NLB-803	FHII 24	22.0	**37.8**				
NLB-804	FHII 24	23.0 - 24.5	**39.5**				
NLB-805	FHII 24	23.5	**34.1**				
NLB-806	FHII 24	25.5	**36.0**				
NLB-807	FHII 24	28.0 - 30.0	**35.3**				
NLB-808	FHII 24	31.0	**38.1**				
NLB-809	FHII 24	33.0 - 34.5	**36.2**				
NLB-810	FHII 24	35.5	**32.4**				
NLB-811	FHII 24	38.0 - 39.5	**37.7**				
NLB-812	FHII 24	40.5	**35.9**				
NLB-813	FHII 24	43.0 - 44.5	**39.0**				
NLB-814	FHII 24	45.5	**34.1**				
NLB-815	FHII 24	48.0 - 49.5	**36.9**				
NLB-816	FHII 24	50.5	**37.2**				
NLB-817	FHII 24	53.0 - 54.5	**25.3**				
NLB-818	FHII 24	55.5	**32.3**				
NLB-819	FHII 24	58.0 - 59.5	**37.6**				
NLB-820	FHII 24	60.5	**34.5**				
NLB-821	FHII 24	63.0 - 64.5	**36.4**				
NLB-822	FHII 24	65.5	**37.9**				
NLB-823	FHII 24	68.0 - 69.5	**38.7**				
NLB-824	FHII 24	71.0	**27.3**				
NLB-825	FHII 24	74.0	**13.0**				
NLB-826	FHII 24	77.0	**12.2**				
NLB-827	FHII 24	80.0 - 81.5	**11.9**				

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-11

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Appendix VII (B)

Atterberg Limits

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

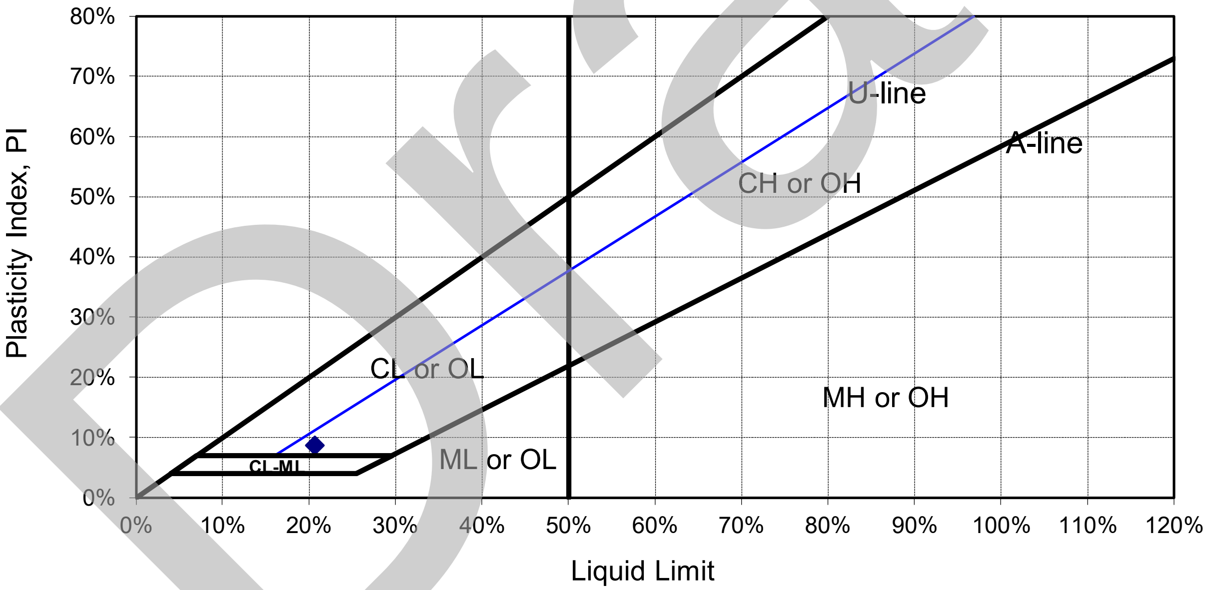
CERTIFIED BY CCIL

SNC · LAVALIN

Sample: NLB-1004 BH1 at 3-4.5m (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	20	22	
Tare Wt, g	12.42	Tare Wt, g	14.23	14.19	
Wet + Tare, g	23.79	Wet + tare, g	32.59	40.86	
Dry + Tare, g	22.57	Dry + tare, g	29.35	36.25	
M%	12.0%	Water content	21.4%	20.9%	AVERAGE
		Adjusted W/C	20.8%	20.6%	20.7%

SUMMARY		COMMENTS
Plastic Limit:	**12.0%**	-
Liquid Limit:	**20.7%**	
Plasticity Index:	**8.7%**	
Classification:	**CL**	
Natural Water Content:	**8.7%**	



Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-Feb-2022

ATTERBERG LIMITS TEST REPORT

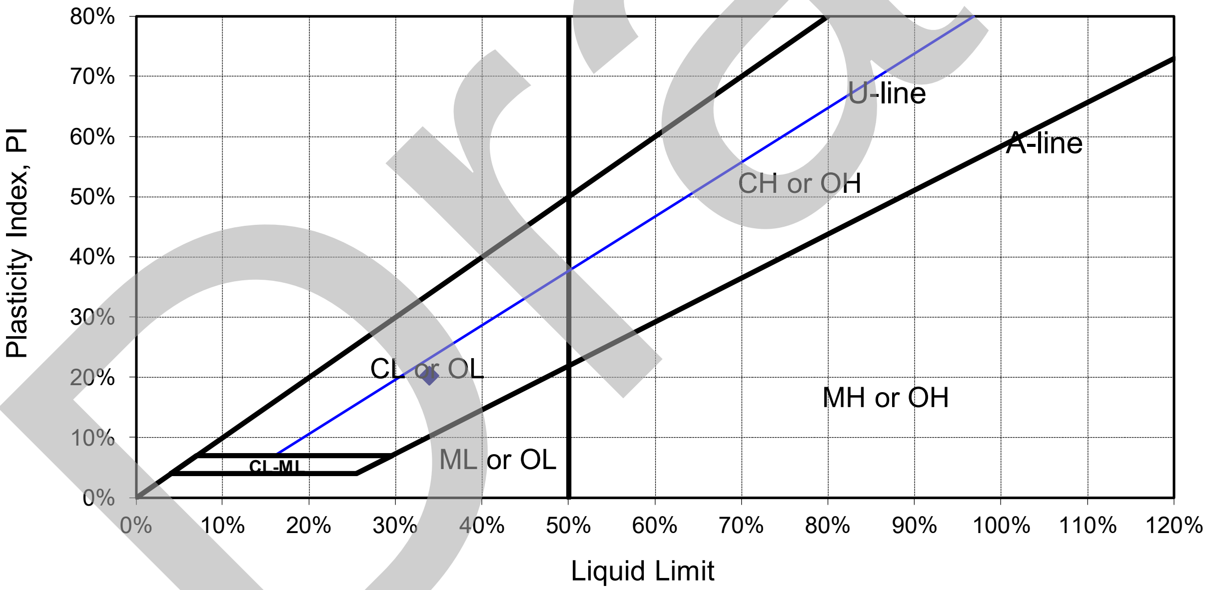
(Test Reference: ASTM D 4318)

SNC · LAVALIN

Sample: NLB-1026 BH1 at 27-28.5m (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	20	19	
Tare Wt, g	13.68	Tare Wt, g	14.00	14.35	
Wet + Tare, g	26.73	Wet + tare, g	35.42	37.62	
Dry + Tare, g	25.16	Dry + tare, g	29.85	31.60	
M%	13.7%	Water content	35.1%	34.9%	AVERAGE
		Adjusted W/C	34.2%	33.7%	33.9%

SUMMARY		COMMENTS
Plastic Limit:	**13.7%**	-
Liquid Limit:	**33.9%**	
Plasticity Index:	**20.3%**	
Classification:	**CL**	
Natural Water Content:	**16.3%**	



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Project #: 659183
Date: 10-Feb-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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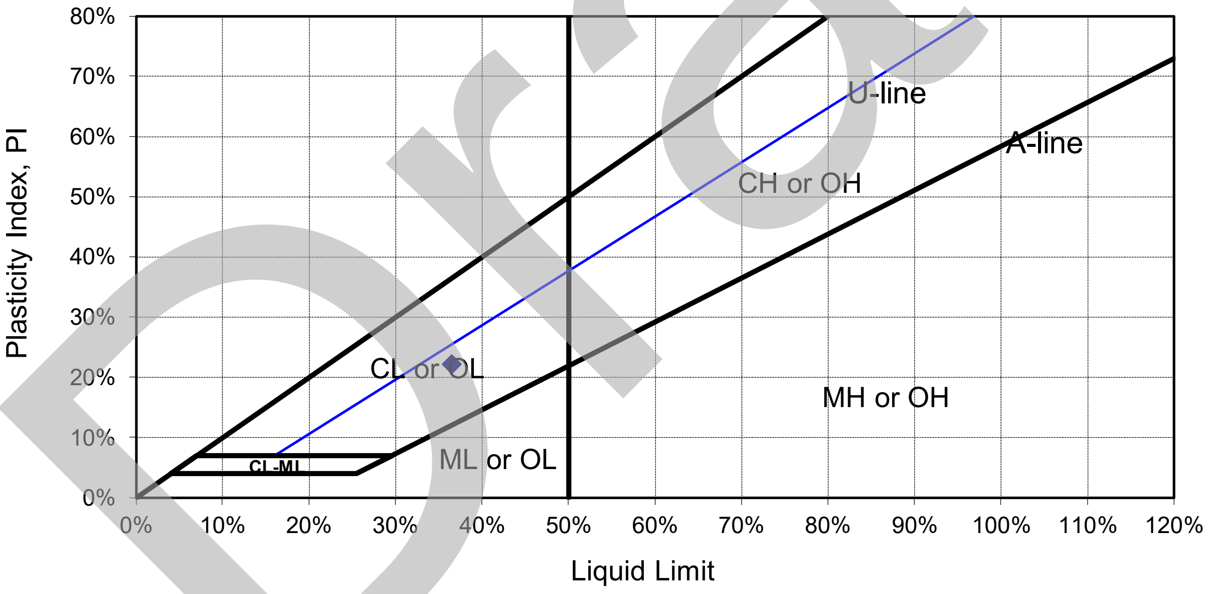
SNC·LAVALIN

Sample: NLB-1033 BH1 at 36-36.45m (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	22	20	
Tare Wt, g	14.15	Tare Wt, g	13.59	13.70	
Wet + Tare, g	27.23	Wet + tare, g	31.50	33.74	
Dry + Tare, g	25.59	Dry + tare, g	26.64	28.28	
M%	14.3%	Water content	37.2%	37.4%	AVERAGE
		Adjusted W/C	36.6%	36.4%	36.5%

SUMMARY		COMMENTS
Plastic Limit:	**14.3%**	-
Liquid Limit:	**36.5%**	
Plasticity Index:	**22.2%**	
Classification:	**CL**	
Natural Water Content:	**14.6%**	



Checker: **Reviewer:**

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Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-Feb-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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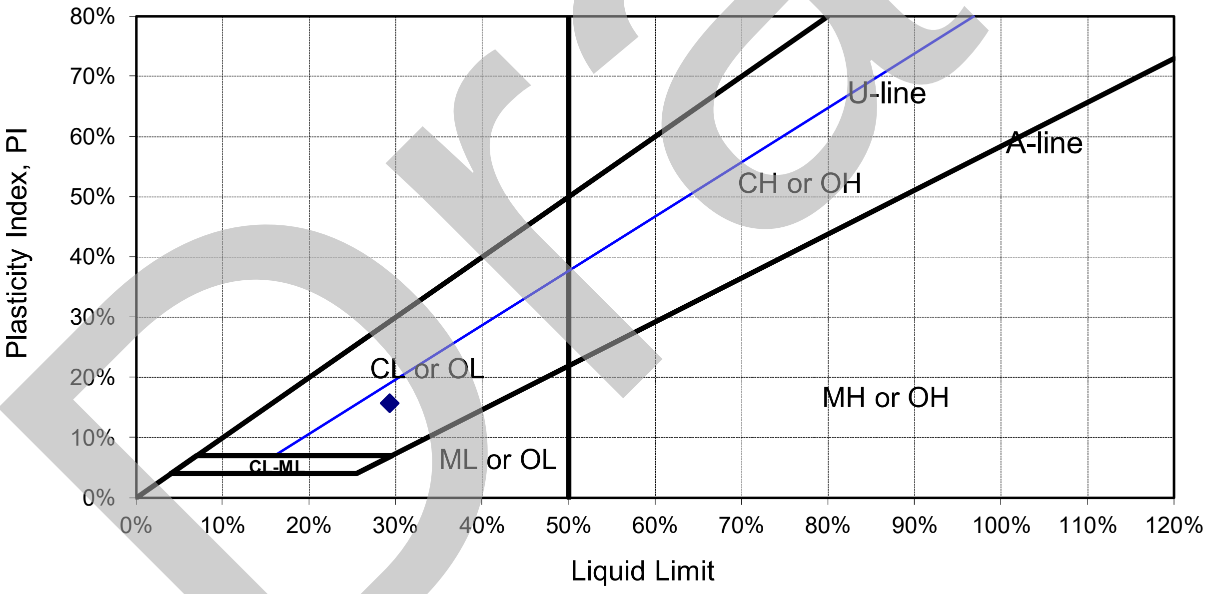
SNC·LAVALIN

Sample: NLB-1098 BH2 at 1.5-3m (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	20	21	
Tare Wt, g	12.46	Tare Wt, g	14.24	14.19	
Wet + Tare, g	23.07	Wet + tare, g	36.29	37.15	
Dry + Tare, g	21.80	Dry + tare, g	31.18	31.86	
M%	13.6%	Water content	30.2%	29.9%	AVERAGE
		Adjusted W/C	29.3%	29.3%	29.3%

SUMMARY		COMMENTS
Plastic Limit:	**13.6%**	-
Liquid Limit:	**29.3%**	
Plasticity Index:	**15.7%**	
Classification:	**CL**	
Natural Water Content:	**10.4%**	



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Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-Feb-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

Sample: NLB-1116 BH2 at 16m (air-dried)

PLASTIC LIMIT	
Tare Wt, g	13.66
Wet + Tare, g	26.25
Dry + Tare, g	24.72
M%	13.8%

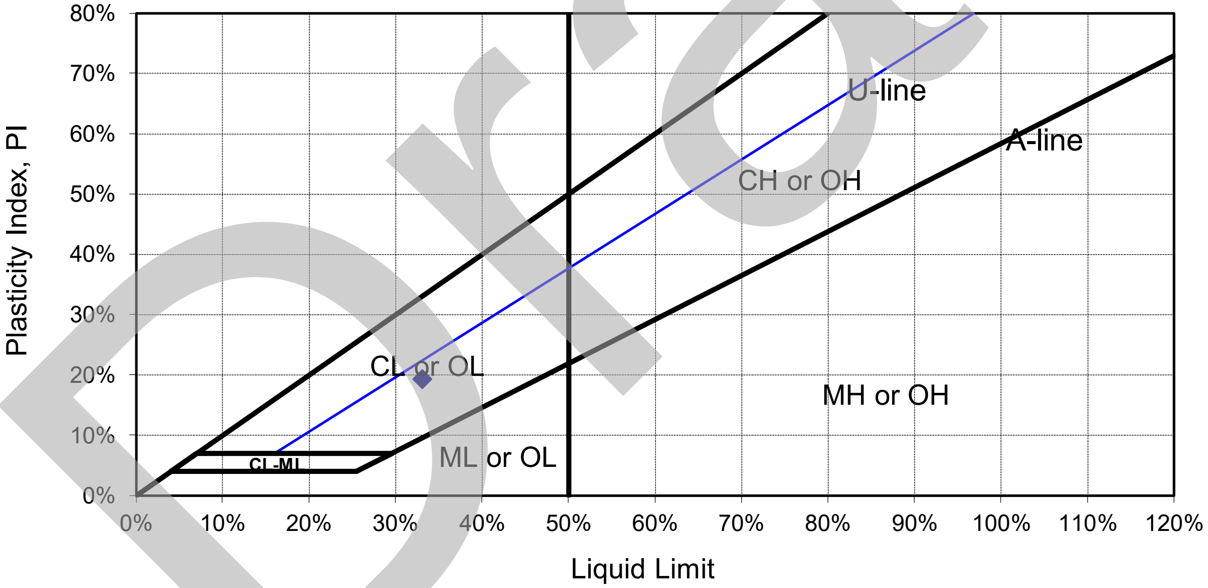
LIQUID LIMIT (METHOD B)			
# of Blows	20	21	
Tare Wt, g	14.00	14.34	
Wet + tare, g	36.65	37.35	
Dry + tare, g	30.89	31.54	
Water content	34.1%	33.8%	AVERAGE
Adjusted W/C	33.2%	33.0%	33.1%

SUMMARY	
Plastic Limit:	**13.8%**
Liquid Limit:	**33.1%**
Plasticity Index:	**19.3%**
Classification:	**CL**

COMMENTS

-

Natural Water Content: **1.2%**



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Reviewer:

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Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-Feb-2022

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ATTERBERG LIMITS TEST REPORT

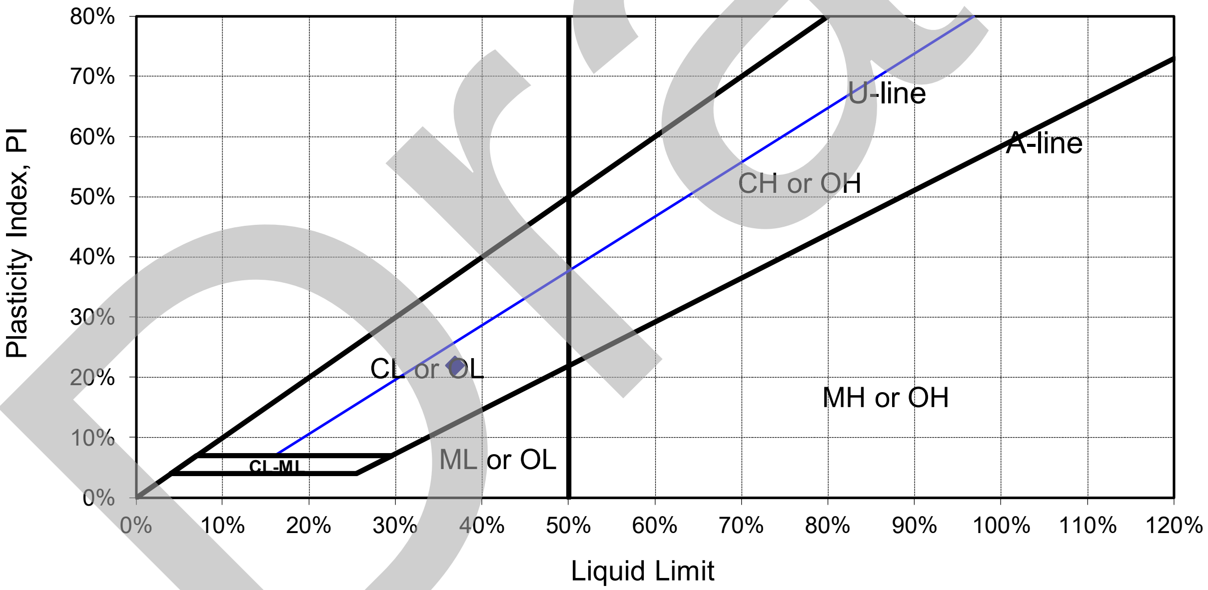
(Test Reference: ASTM D 4318)

Sample: NLB-1123 BH2 at 21-22.5m (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	27	25	
Tare Wt, g	13.59	Tare Wt, g	14.12	13.68	
Wet + Tare, g	23.47	Wet + tare, g	34.74	37.06	
Dry + Tare, g	22.19	Dry + tare, g	29.19	30.81	
M%	14.9%	Water content	36.8%	36.5%	AVERAGE
		Adjusted W/C	37.2%	36.5%	36.9%

SUMMARY		COMMENTS
Plastic Limit:	**14.9%**	-
Liquid Limit:	**36.9%**	
Plasticity Index:	**22.0%**	
Classification:	**CL**	

Natural Water Content: **12.2%**



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Reviewer:

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Project #: 659183
Date: 10-Feb-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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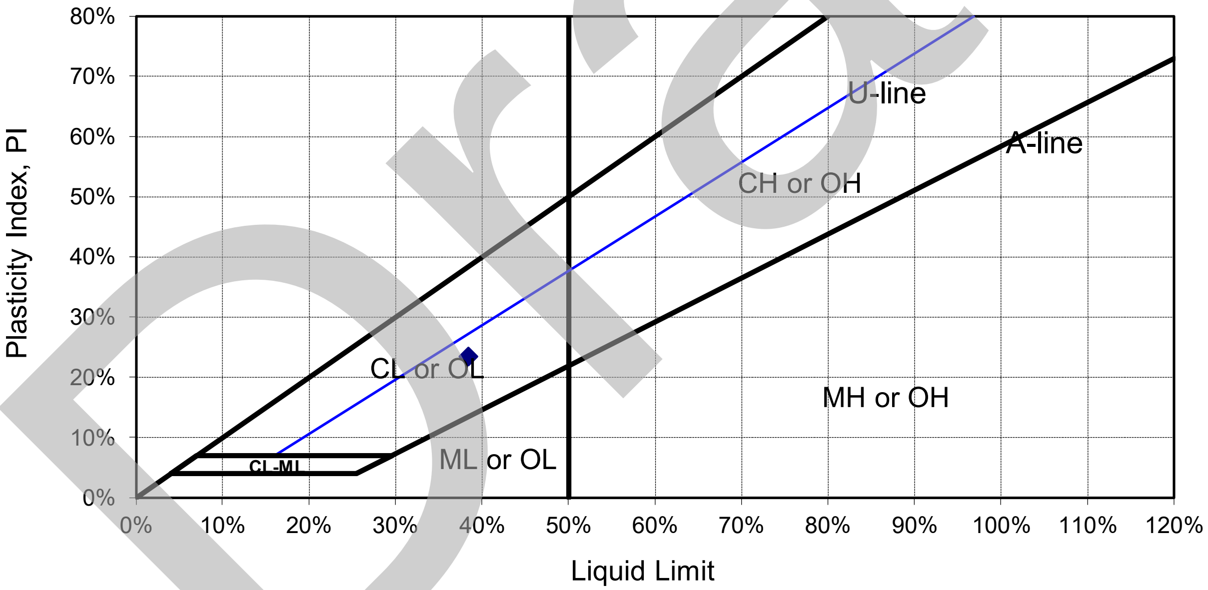
SNC • LAVALIN

Sample: NLB-1128 BH2 at 26m (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	27	29	
Tare Wt, g	14.21	Tare Wt, g	14.11	14.34	
Wet + Tare, g	27.91	Wet + tare, g	35.55	37.19	
Dry + Tare, g	26.12	Dry + tare, g	29.64	30.94	
M%	15.0%	Water content	38.1%	37.7%	AVERAGE
		Adjusted W/C	38.5%	38.4%	38.4%

SUMMARY		COMMENTS
Plastic Limit:	**15.0%**	-
Liquid Limit:	**38.4%**	
Plasticity Index:	**23.4%**	
Classification:	**CL**	
Natural Water Content:	**12.5%**	



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Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-Feb-2022

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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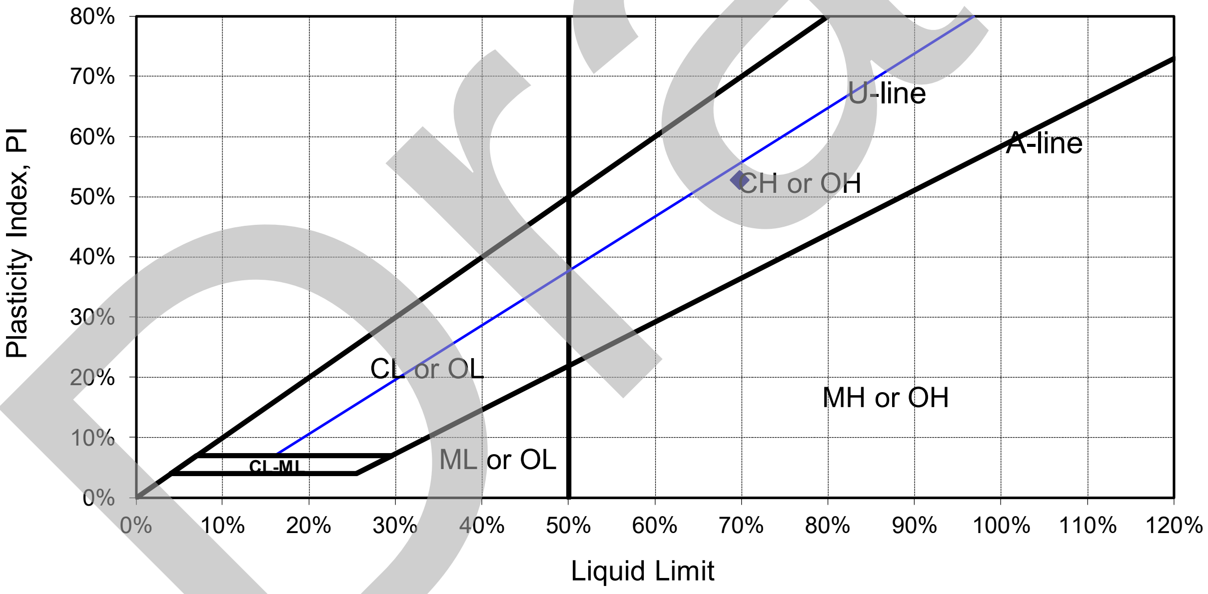
SNC·LAVALIN

Sample: NLB-1175 BH2 at 100-100.45m (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	28	29	
Tare Wt, g	14.07	Tare Wt, g	13.90	13.92	
Wet + Tare, g	23.25	Wet + tare, g	32.91	35.09	
Dry + Tare, g	21.92	Dry + tare, g	25.19	26.47	
M%	16.9%	Water content	68.4%	68.7%	AVERAGE
		Adjusted W/C	69.4%	70.1%	69.7%

SUMMARY		COMMENTS
Plastic Limit:	**16.9%**	-
Liquid Limit:	**69.7%**	
Plasticity Index:	**52.8%**	
Classification:	**CH**	
Natural Water Content:	**19.0%**	



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Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-Feb-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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SNC·LAVALIN

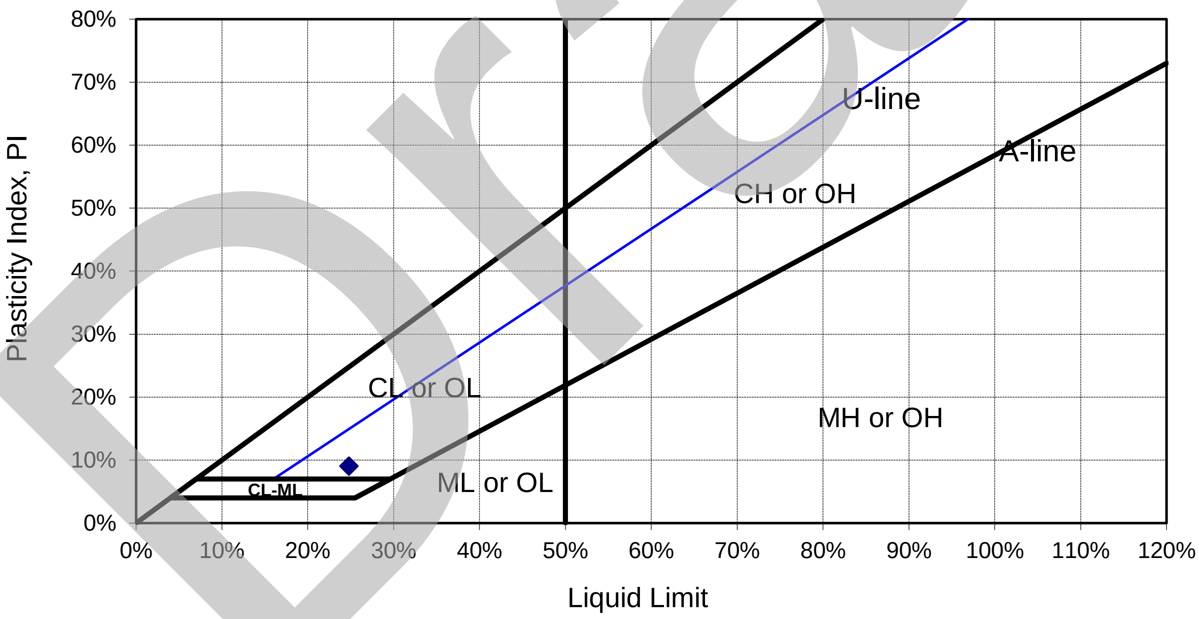
Sample:	NLB-156 FHII03 at 22.5ft	(air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	25	23	
Tare Wt, g	14.25	Tare Wt, g	14.15	14.36	
Wet + Tare, g	24.98	Wet + tare, g	31.04	30.56	
Dry + Tare, g	23.52	Dry + tare, g	27.66	27.34	
M%	15.7%	Water content	25.0%	24.8%	AVERAGE
		Adjusted W/C	25.0%	24.6%	24.8%

SUMMARY		COMMENTS
Plastic Limit:	**15.7%**	-
Liquid Limit:	**24.8%**	
Plasticity Index:	**9.0%**	
Classification:	**CL**	

Natural Water Content: **12.2%**

.



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-May-2022

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-162 FHII03 at 33-34.2ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	22	20	
Tare Wt, g	13.05	Tare Wt, g	13.08	14.40	
Wet + Tare, g	25.59	Wet + tare, g	31.52	34.75	
Dry + Tare, g	23.82	Dry + tare, g	27.96	30.86	
M%	16.4%	Water content	23.9%	23.6%	AVERAGE
		Adjusted W/C	23.5%	23.0%	23.3%

SUMMARY		COMMENTS
Plastic Limit:	**16.4%**	-
Liquid Limit:	**23.3%**	
Plasticity Index:	**6.8%**	
Classification:	**CL-ML**	

Natural Water Content: **12.8%**

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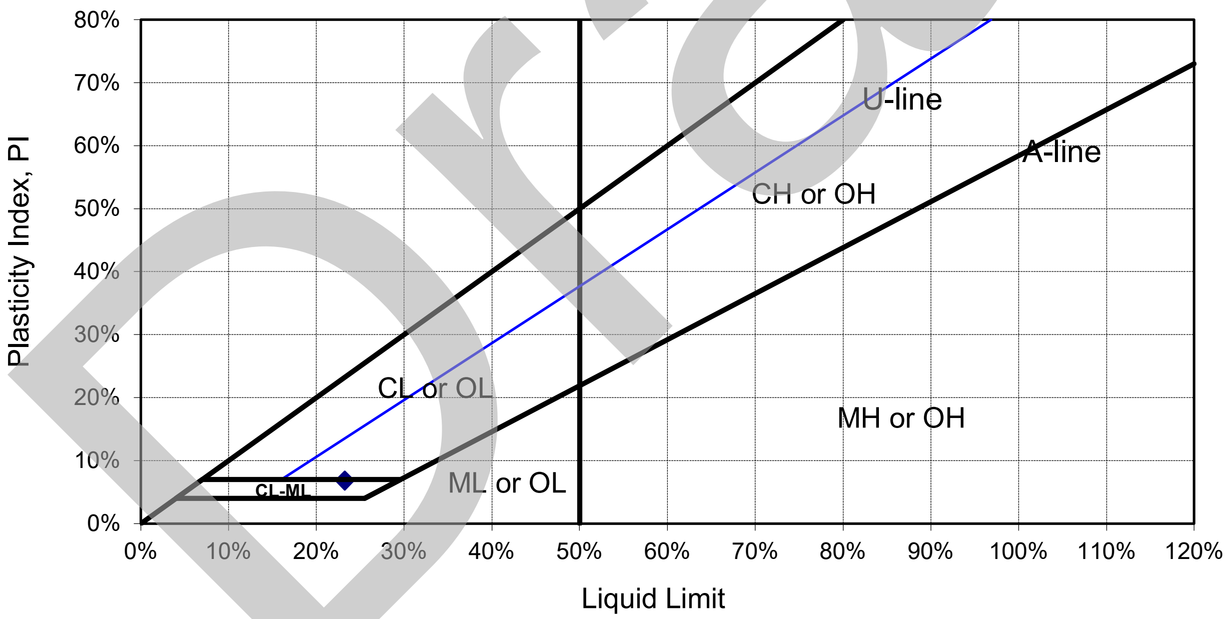

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-May-2022

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-169 FHII03 at 48-49.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	21	22	
Tare Wt, g	13.44	Tare Wt, g	14.47	14.39	
Wet + Tare, g	20.65	Wet + tare, g	24.73	25.18	
Dry + Tare, g	19.75	Dry + tare, g	22.09	22.41	
M%	14.3%	Water content	34.6%	34.5%	AVERAGE
		Adjusted W/C	33.9%	34.0%	33.9%

SUMMARY		COMMENTS
Plastic Limit:	**14.3%**	-
Liquid Limit:	**33.9%**	
Plasticity Index:	**19.7%**	
Classification:	**CL**	

Natural Water Content: **13.1%**

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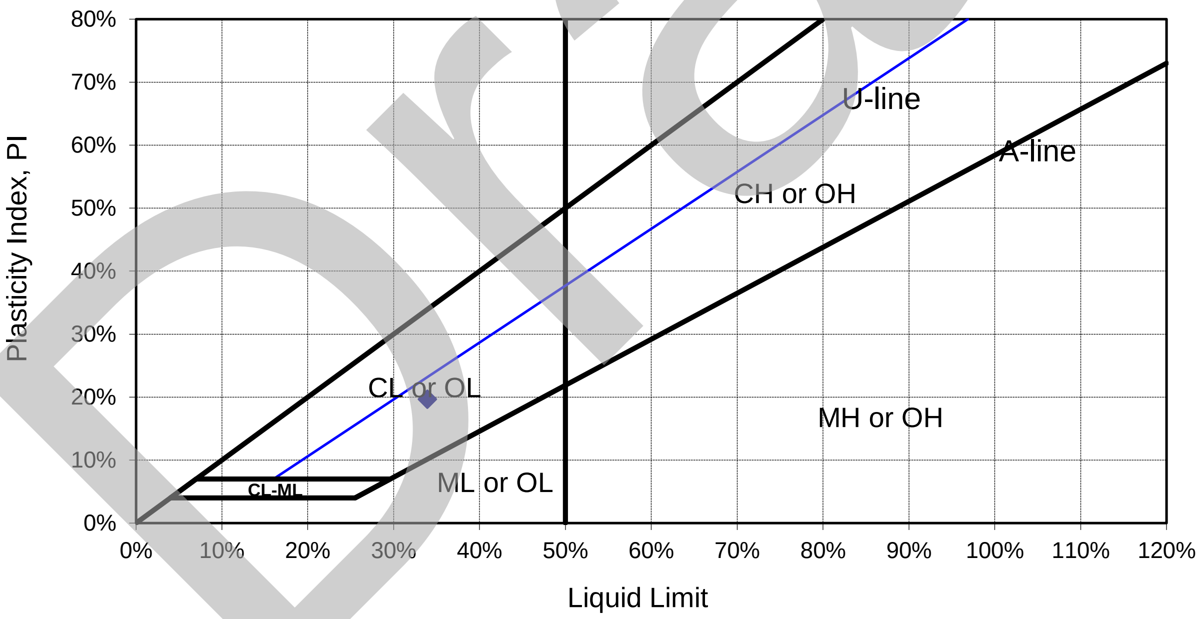

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Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-May-2022

ATTERBERG LIMITS TEST REPORT

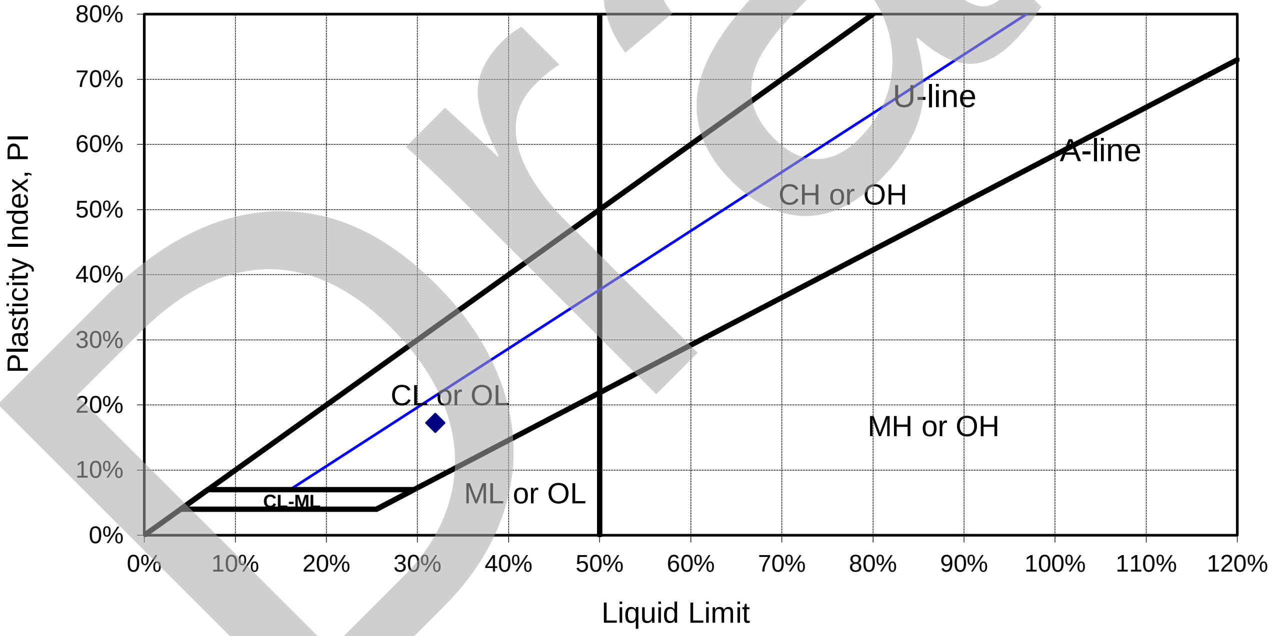
(Test Reference: ASTM D 4318)

Sample: BH FHII 3 Sample NLB-187 from 97-98.2ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	21	23	
Tare Wt, g	14.12	Tare Wt, g	14.09	13.97	
Wet + Tare, g	26.98	Wet + tare, g	56.37	50.41	
Dry + Tare, g	25.33	Dry + tare, g	46.01	41.47	
M%	14.7%	Water content	32.5%	32.5%	AVERAGE
		Adjusted W/C	31.7%	32.2%	32.0%

SUMMARY		COMMENTS
Plastic Limit:	**14.7%**	-
Liquid Limit:	**32.0%**	
Plasticity Index:	**17.2%**	
Classification:	**CL**	

Natural Water Content: **12.8%**



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Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 28-Apr-2022

Geoscience & Materials

ATTERBERG LIMITS TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D 4318)

SNC·LAVALIN

Sample: NLB-194 FHII04 at 14ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	26	28	
Tare Wt, g	13.75	Tare Wt, g	14.07	13.85	
Wet + Tare, g	27.45	Wet + tare, g	28.85	33.82	
Dry + Tare, g	25.72	Dry + tare, g	25.57	29.46	
M%	14.5%	Water content	28.5%	27.9%	AVERAGE
		Adjusted W/C	28.7%	28.4%	28.5%

SUMMARY		COMMENTS
Plastic Limit:	**14.5%**	-
Liquid Limit:	**28.5%**	
Plasticity Index:	**14.1%**	
Classification:	**CL**	

Natural Water Content: **10.9%**

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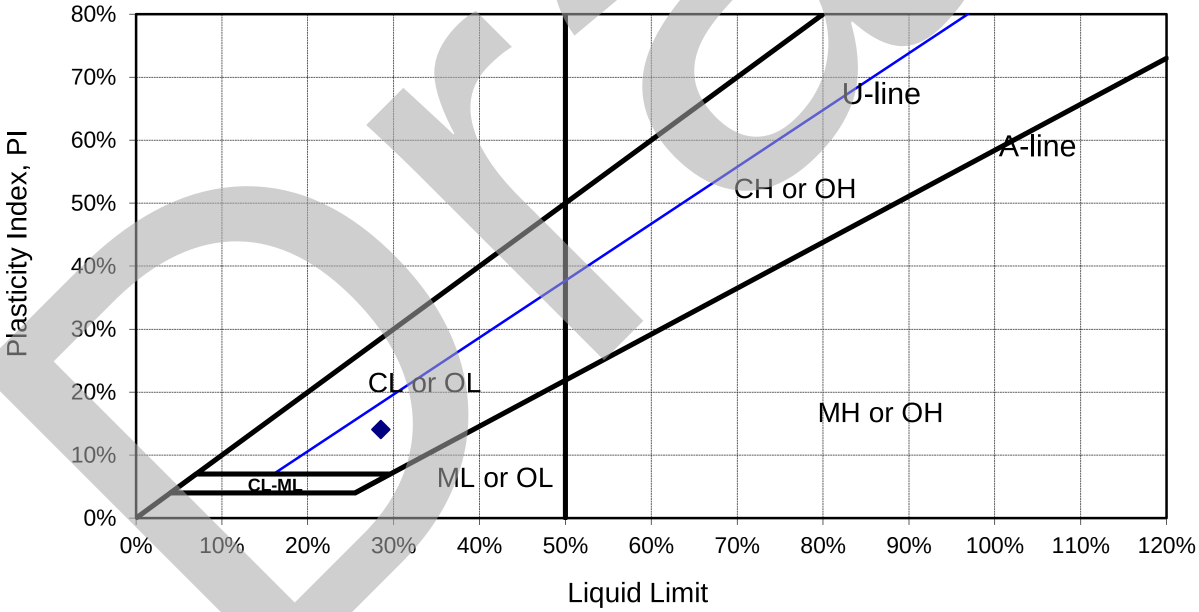

Checker: Don Hazelinta **Reviewer:** Don Hazelinta

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Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-May-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-208 FHII04 at 43.25ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	27	29	
Tare Wt, g	13.88	Tare Wt, g	13.96	14.31	
Wet + Tare, g	25.47	Wet + tare, g	27.03	27.77	
Dry + Tare, g	23.66	Dry + tare, g	23.29	23.94	
M%	18.5%	Water content	40.1%	39.8%	AVERAGE
		Adjusted W/C	40.5%	40.6%	40.5%

SUMMARY		COMMENTS
Plastic Limit:	**18.5%**	-
Liquid Limit:	**40.5%**	
Plasticity Index:	**22.0%**	
Classification:	**CL**	

Natural Water Content: **15.8%**

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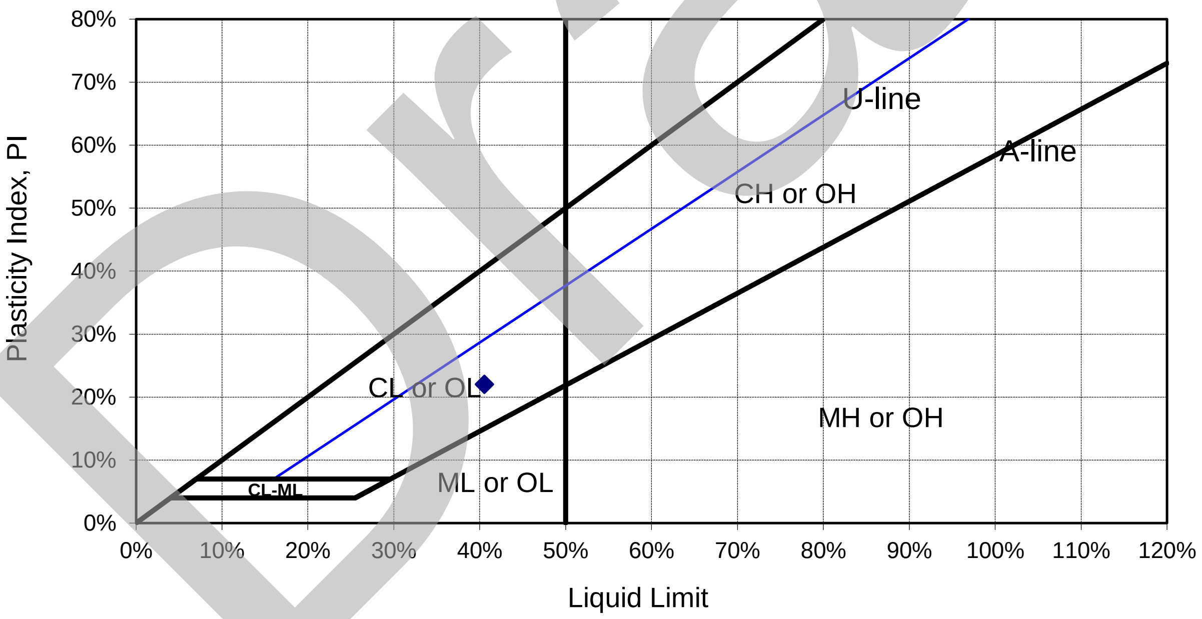


Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-May-2022

ATTERBERG LIMITS TEST REPORT

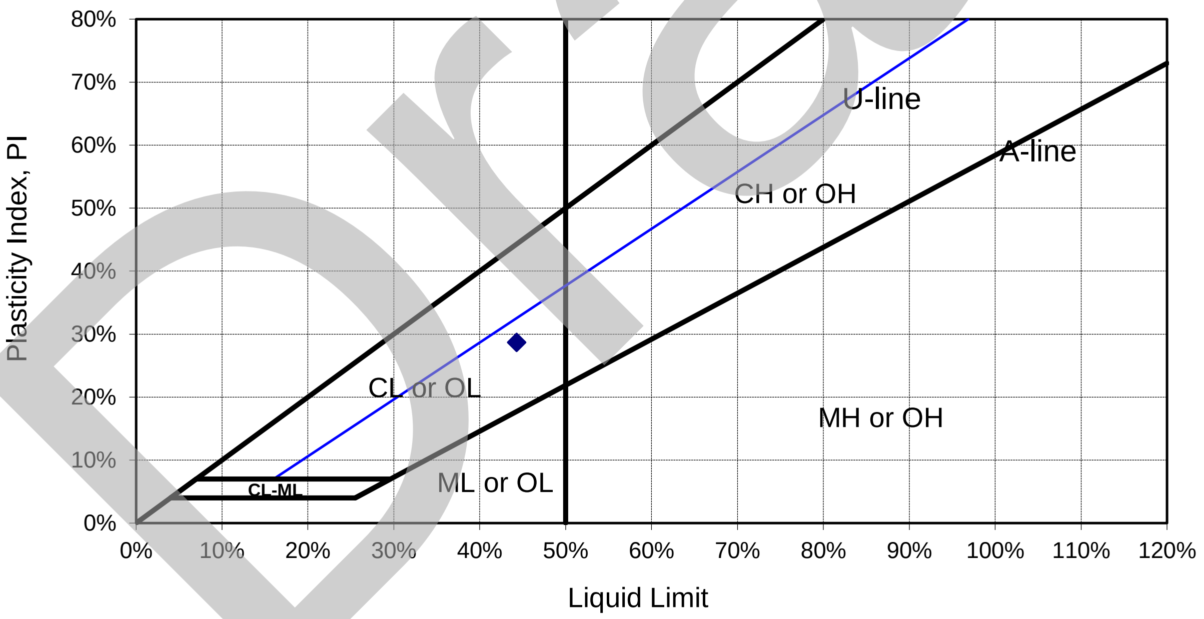
(Test Reference: ASTM D 4318)

Sample: NLB-227 FHII4 at 100ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	23	24	
Tare Wt, g	14.01	Tare Wt, g	14.20	13.77	
Wet + Tare, g	22.16	Wet + tare, g	23.00	24.03	
Dry + Tare, g	21.06	Dry + tare, g	20.27	20.88	
M%	15.6%	Water content	45.0%	44.3%	AVERAGE
		Adjusted W/C	44.5%	44.1%	44.3%

SUMMARY		COMMENTS
Plastic Limit:	**15.6%**	-
Liquid Limit:	**44.3%**	
Plasticity Index:	**28.7%**	
Classification:	**CL**	

Natural Water Content: **15.4%**



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 3-May-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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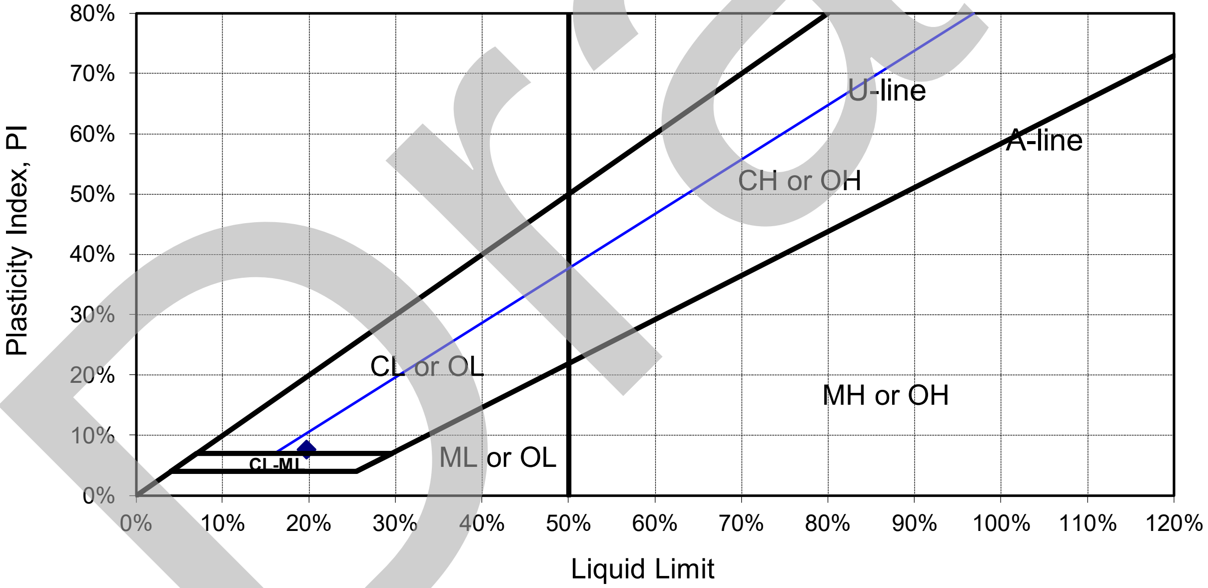
SNC·LAVALIN

Sample: BH FHII 5 Sample NLB-236 at 16ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	18	16	
Tare Wt, g	14.08	Tare Wt, g	14.41	14.32	
Wet + Tare, g	26.07	Wet + tare, g	64.06	55.01	
Dry + Tare, g	24.78	Dry + tare, g	55.53	48.05	
M%	12.1%	Water content	20.7%	20.6%	AVERAGE
		Adjusted W/C	19.9%	19.5%	19.7%

SUMMARY		COMMENTS
Plastic Limit:	**12.1%**	-
Liquid Limit:	**19.7%**	
Plasticity Index:	**7.6%**	
Classification:	**CL**	

Natural Water Content: **13.9%**



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 28-Apr-2022

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ATTERBERG LIMITS TEST REPORT

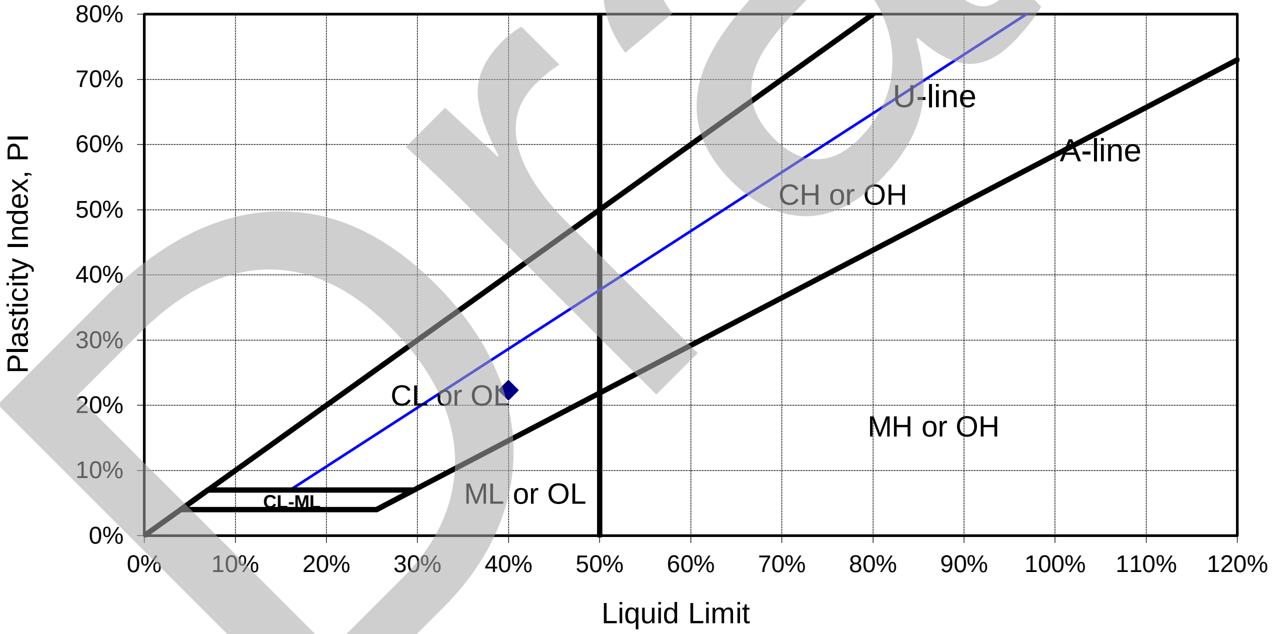
(Test Reference: ASTM D 4318)

Sample: BH FHII 5 Sample NLB-242 at 31.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	27	29	
Tare Wt, g	14.02	Tare Wt, g	14.21	14.08	
Wet + Tare, g	23.94	Wet + tare, g	54.16	53.72	
Dry + Tare, g	22.45	Dry + tare, g	42.89	42.51	
M%	17.7%	Water content	39.3%	39.4%	AVERAGE
		Adjusted W/C	39.7%	40.2%	40.0%

SUMMARY		COMMENTS
Plastic Limit:	**17.7%**	-
Liquid Limit:	**40.0%**	
Plasticity Index:	**22.3%**	
Classification:	**CL**	

Natural Water Content: **18.6%**



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 28-Apr-2022

Geoscience & Materials

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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SNC·LAVALIN

Sample: BH FHII 5 Sample NLB-248 at 40.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	25	27	
Tare Wt, g	13.99	Tare Wt, g	14.14	14.12	
Wet + Tare, g	23.18	Wet + tare, g	44.90	46.54	
Dry + Tare, g	21.28	Dry + tare, g	31.61	32.59	
M%	26.1%	Water content	76.1%	75.5%	AVERAGE
		Adjusted W/C	76.1%	76.3%	76.2%

SUMMARY		COMMENTS
Plastic Limit:	**26.1%**	-
Liquid Limit:	**76.2%**	
Plasticity Index:	**50.1%**	
Classification:	**CH**	

Natural Water Content: **30.8%**

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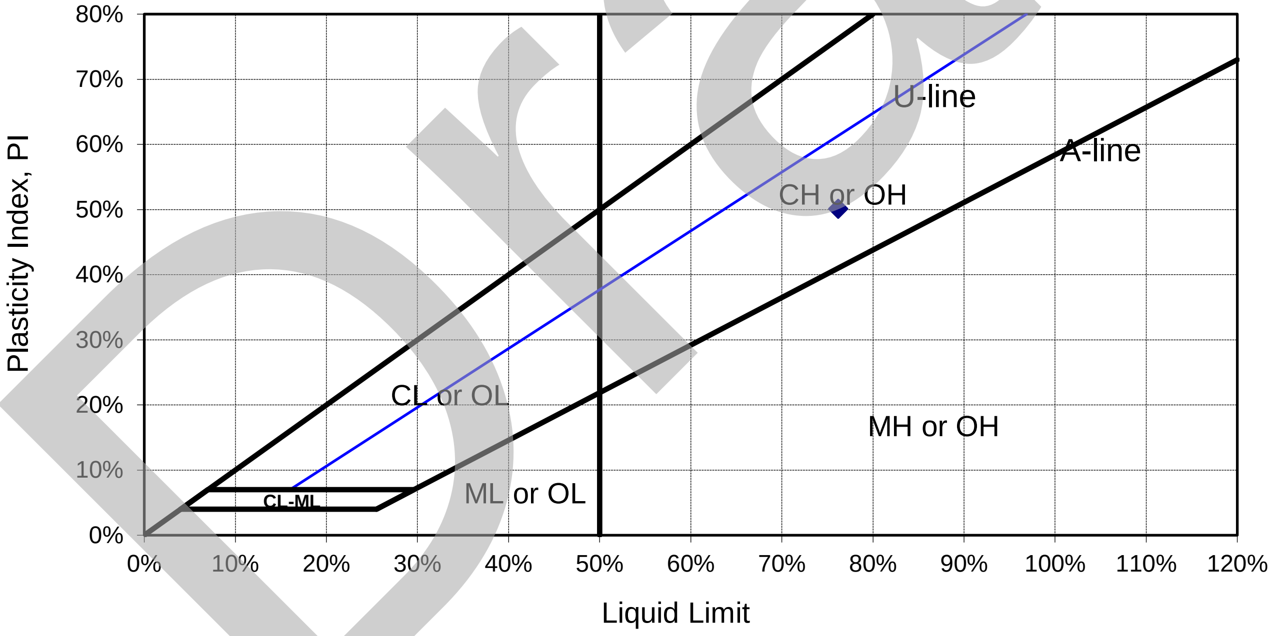

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 28-Apr-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

Sample: NLB-257 FHII05 at 68-69.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	26	28	
Tare Wt, g	14.06	Tare Wt, g	13.90	14.00	
Wet + Tare, g	26.00	Wet + tare, g	29.84	24.32	
Dry + Tare, g	24.44	Dry + tare, g	25.90	21.80	
M%	15.0%	Water content	32.8%	32.3%	AVERAGE
		Adjusted W/C	33.0%	32.8%	32.9%

SUMMARY		COMMENTS
Plastic Limit:	**15.0%**	-
Liquid Limit:	**32.9%**	
Plasticity Index:	**17.9%**	
Classification:	**CL**	

Natural Water Content: **11.0%**

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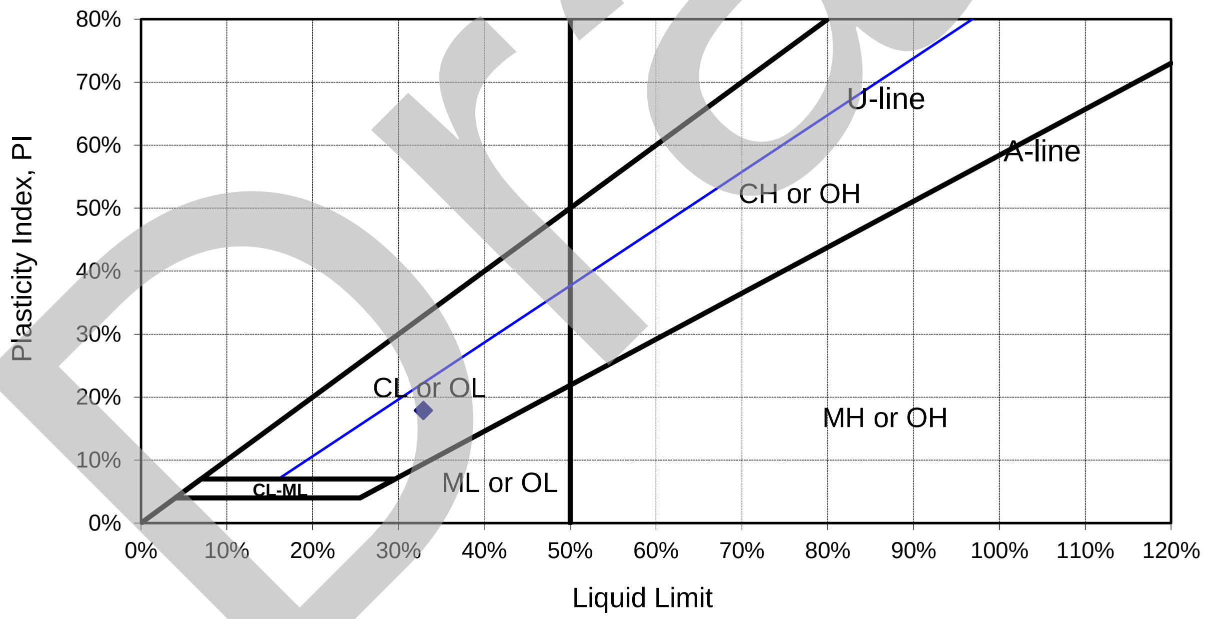

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-May-2022

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ATTERBERG LIMITS TEST REPORT

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(Test Reference: ASTM D 4318)

SNC·LAVALIN

Sample: NLB-276 FHII02 at 31.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	27	28	
Tare Wt, g	14.24	Tare Wt, g	14.00	14.44	
Wet + Tare, g	24.33	Wet + tare, g	26.14	25.80	
Dry + Tare, g	23.07	Dry + tare, g	23.52	23.32	
M%	14.3%	Water content	27.5%	27.9%	AVERAGE
		Adjusted W/C	27.8%	28.4%	28.1%

SUMMARY		COMMENTS
Plastic Limit:	**14.3%**	-
Liquid Limit:	**28.1%**	
Plasticity Index:	**13.8%**	
Classification:	**CL**	

Natural Water Content: **9.1%**

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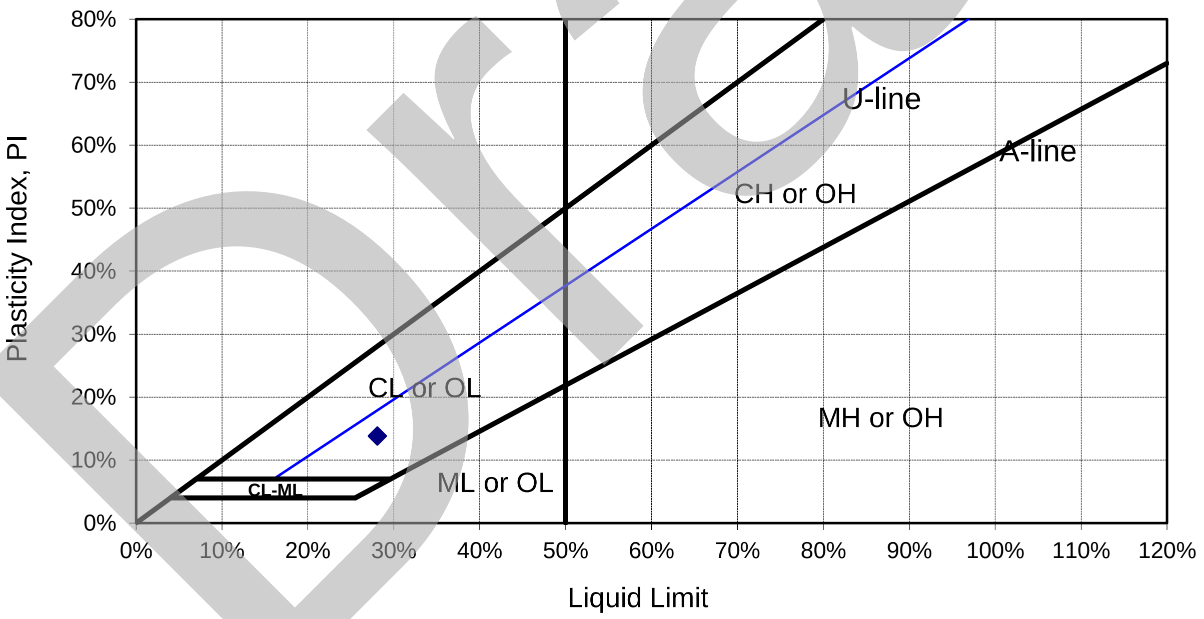

Checker: Don Hazelton **Reviewer:** Don Hazelton

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-May-2022

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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SNC·LAVALIN

Sample: NLB-295 FHII2 at 86ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	22	21	
Tare Wt, g	14.26	Tare Wt, g	14.44	14.28	
Wet + Tare, g	22.51	Wet + tare, g	23.84	24.62	
Dry + Tare, g	21.65	Dry + tare, g	21.74	22.33	
M%	11.6%	Water content	28.8%	28.4%	AVERAGE
		Adjusted W/C	28.3%	27.8%	28.1%

SUMMARY		COMMENTS
Plastic Limit:	**11.6%**	-
Liquid Limit:	**28.1%**	
Plasticity Index:	**16.4%**	
Classification:	**CL**	

Natural Water Content: **12.8%**

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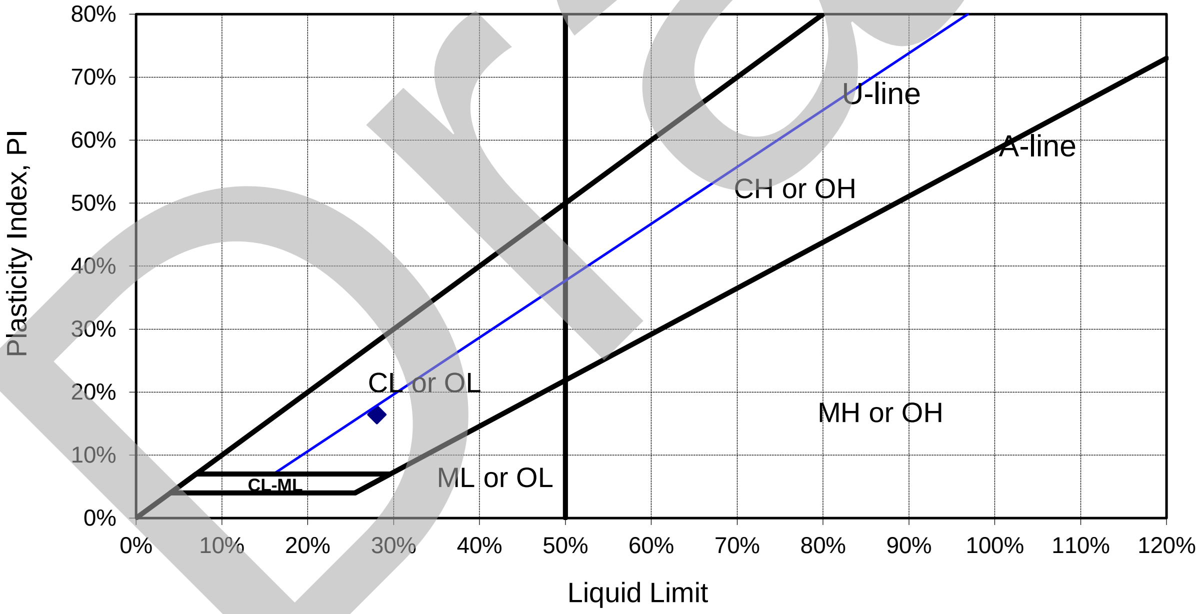

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Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 29-Apr-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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Sample: BH FHII 9 Sample NLB-349 at 16ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	23	25	
Tare Wt, g	14.19	Tare Wt, g	14.18	14.08	
Wet + Tare, g	28.21	Wet + tare, g	37.51	39.12	
Dry + Tare, g	26.64	Dry + tare, g	32.63	33.94	
M%	12.6%	Water content	26.4%	26.1%	AVERAGE
		Adjusted W/C	26.2%	26.1%	26.1%

SUMMARY		COMMENTS
Plastic Limit:	**12.6%**	-
Liquid Limit:	**26.1%**	
Plasticity Index:	**13.5%**	
Classification:	**CL**	

Natural Water Content: **13.3%**

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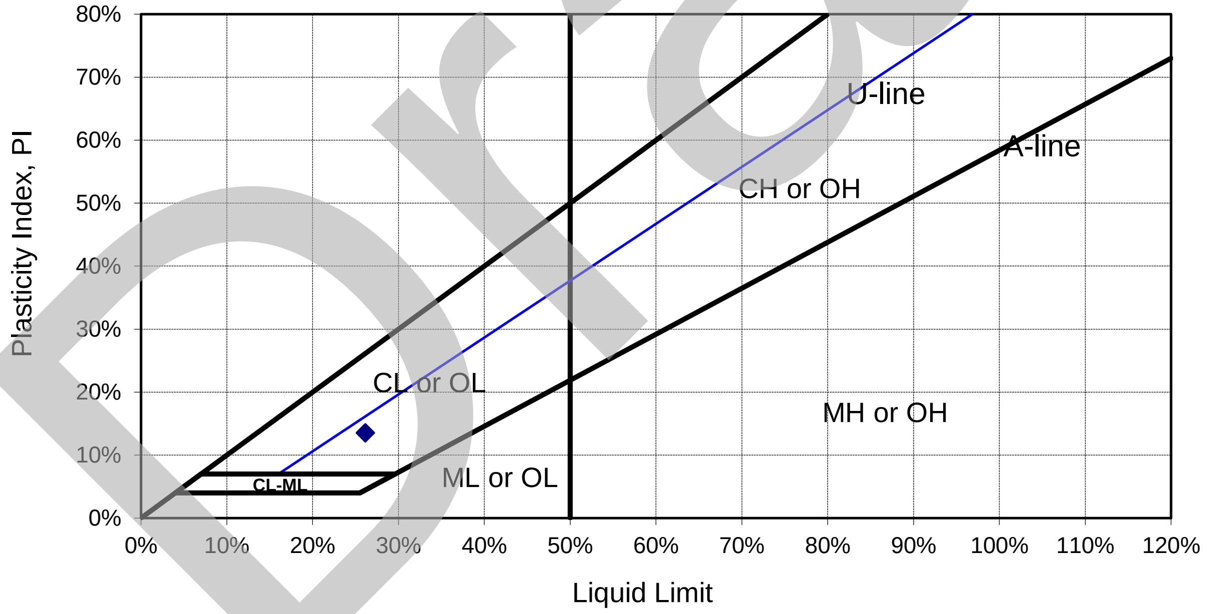

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Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 28-Apr-2022

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

Sample: NLB-414 FHII07 at 25.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	24	24	
Tare Wt, g	14.29	Tare Wt, g	14.12	13.72	
Wet + Tare, g	25.92	Wet + tare, g	24.64	23.54	
Dry + Tare, g	24.68	Dry + tare, g	22.44	21.54	
M%	11.9%	Water content	26.4%	25.6%	AVERAGE
		Adjusted W/C	26.3%	25.4%	25.9%

SUMMARY		COMMENTS
Plastic Limit:	**11.9%**	-
Liquid Limit:	**25.9%**	
Plasticity Index:	**13.9%**	
Classification:	**CL**	

Natural Water Content: **11.7%**

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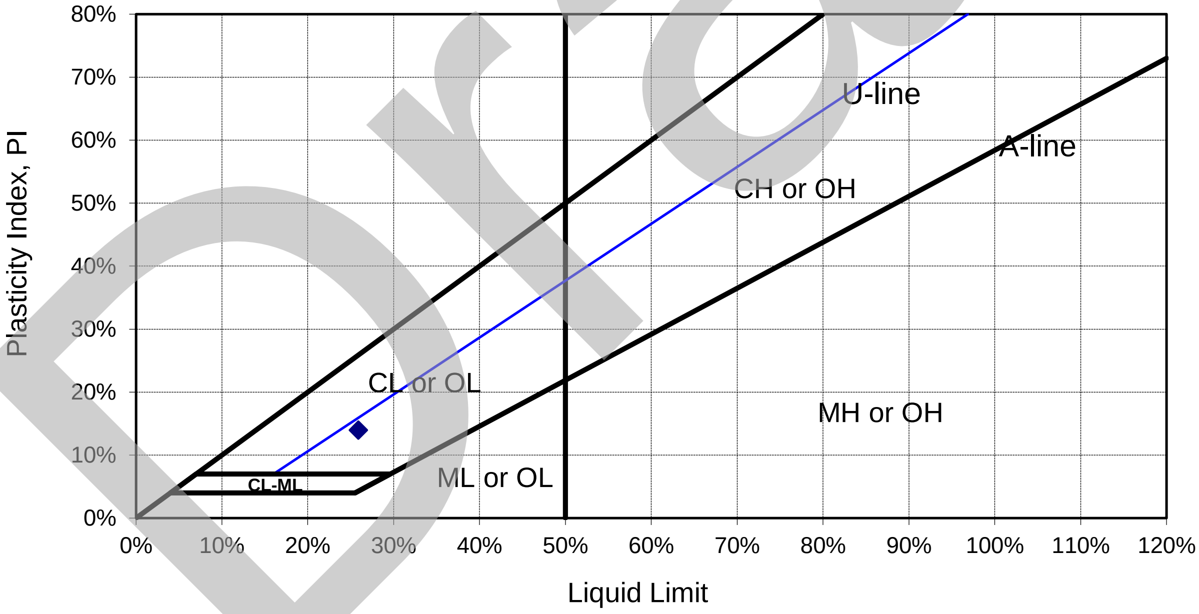

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Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 11-May-2022

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ATTERBERG LIMITS TEST REPORT

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(Test Reference: ASTM D 4318)

SNC·LAVALIN

Sample: BH FHII 11 Sample NLB-452 at 36ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	28	27	
Tare Wt, g	13.95	Tare Wt, g	14.11	14.28	
Wet + Tare, g	22.98	Wet + tare, g	34.54	42.47	
Dry + Tare, g	21.40	Dry + tare, g	28.16	33.58	
M%	21.2%	Water content	45.4%	46.1%	AVERAGE
		Adjusted W/C	46.1%	46.5%	46.3%

SUMMARY		COMMENTS
Plastic Limit:	**21.2%**	-
Liquid Limit:	**46.3%**	
Plasticity Index:	**25.1%**	
Classification:	**CL**	

Natural Water Content: **20.9%**

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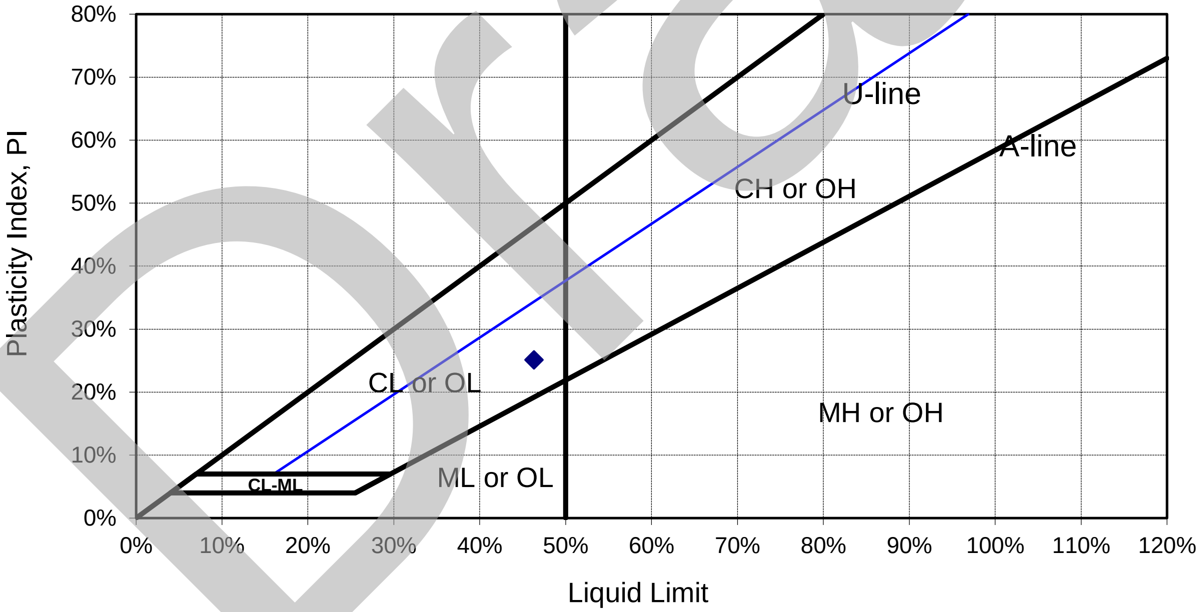


Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 28-Apr-2022

ATTERBERG LIMITS TEST REPORT

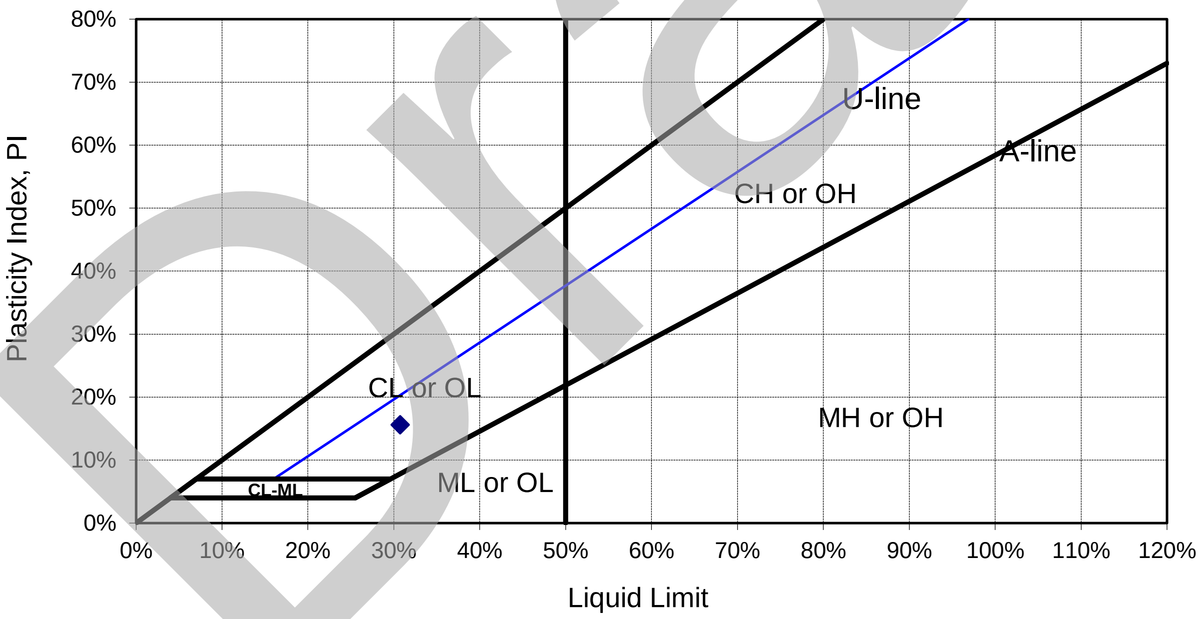
(Test Reference: ASTM D 4318)

Sample: BH FHII 8 Sample NLB-495 at 12ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	20	20	
Tare Wt, g	14.29	Tare Wt, g	14.01	14.25	
Wet + Tare, g	26.21	Wet + tare, g	46.49	51.17	
Dry + Tare, g	24.64	Dry + tare, g	38.69	42.29	
M%	15.2%	Water content	31.6%	31.7%	AVERAGE
		Adjusted W/C	30.7%	30.8%	30.8%

SUMMARY		COMMENTS
Plastic Limit:	**15.2%**	-
Liquid Limit:	**30.8%**	
Plasticity Index:	**15.6%**	
Classification:	**CL**	

Natural Water Content: **18.9%**



Checker: **Reviewer:**

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Client: SMHI
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Date: 28-Apr-2022

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(Test Reference: ASTM D 4318)

SNC·LAVALIN

Sample:	NLB-551 FHII12 at 78ft	(air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	25	24	
Tare Wt, g	13.9	Tare Wt, g	13.96	14.31	
Wet + Tare, g	28.93	Wet + tare, g	30.37	29.35	
Dry + Tare, g	27.15	Dry + tare, g	26.15	25.47	
M%	13.4%	Water content	34.6%	34.8%	AVERAGE
		Adjusted W/C	34.6%	34.6%	34.6%

SUMMARY		COMMENTS
Plastic Limit:	**13.4%**	-
Liquid Limit:	**34.6%**	
Plasticity Index:	**21.2%**	
Classification:	**CL**	

Natural Water Content:	**11.1%**

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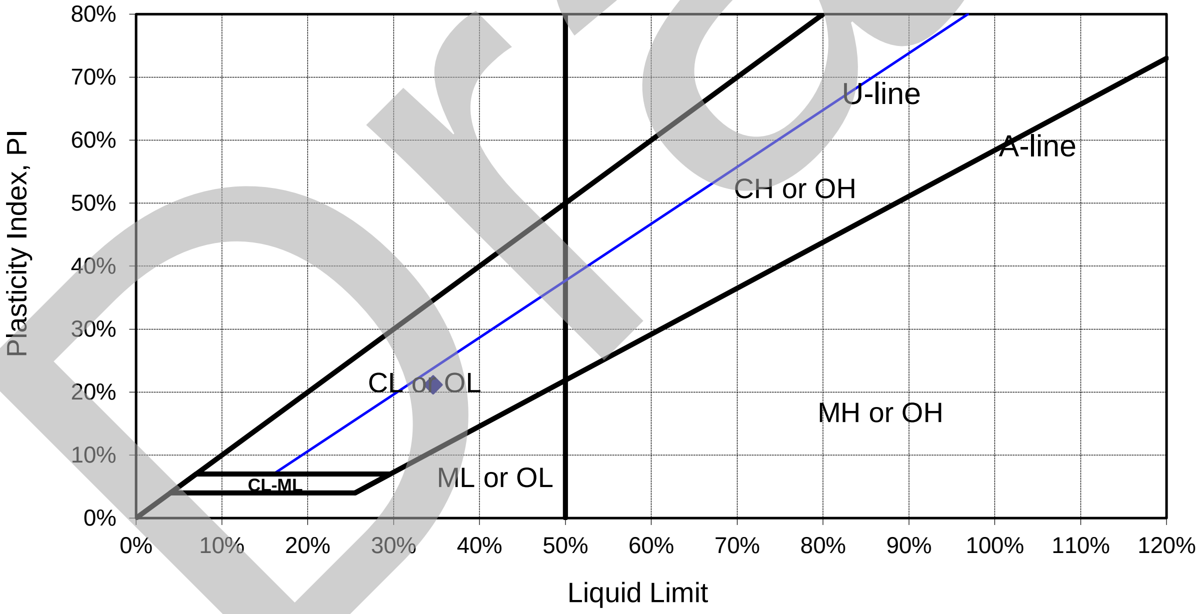

Checker:		**Reviewer:**	

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Date: 10-May-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

Sample: BH FHII 14 Sample NLB-571 at 45.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	28	26	
Tare Wt, g	18.55	Tare Wt, g	19.11	18.30	
Wet + Tare, g	33.76	Wet + tare, g	46.69	44.34	
Dry + Tare, g	31.96	Dry + tare, g	40.55	38.51	
M%	13.4%	Water content	28.6%	28.8%	AVERAGE
		Adjusted W/C	29.1%	29.0%	29.0%

SUMMARY		COMMENTS
Plastic Limit:	**13.4%**	-
Liquid Limit:	**29.0%**	
Plasticity Index:	**15.6%**	
Classification:	**CL**	

Natural Water Content: **12.1%**

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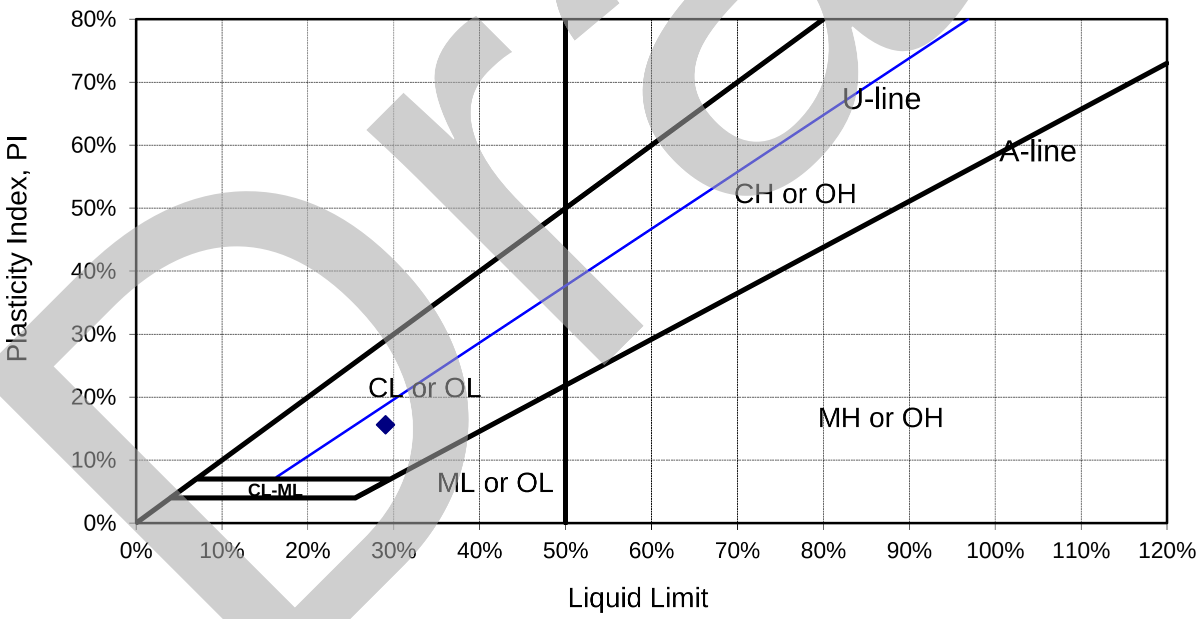

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Reviewer:

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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Sample: BH FHII 19 Sample NLB-584 from 3-4.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	17	17	
Tare Wt, g	14.41	Tare Wt, g	14.27	14.06	
Wet + Tare, g	22.10	Wet + tare, g	30.39	33.97	
Dry + Tare, g	20.64	Dry + tare, g	24.37	26.58	
M%	23.4%	Water content	59.6%	59.0%	AVERAGE
		Adjusted W/C	56.8%	56.2%	56.5%

SUMMARY		COMMENTS
Plastic Limit:	**23.4%**	-
Liquid Limit:	**56.5%**	
Plasticity Index:	**33.1%**	
Classification:	**CH**	

Natural Water Content: **32.0%**

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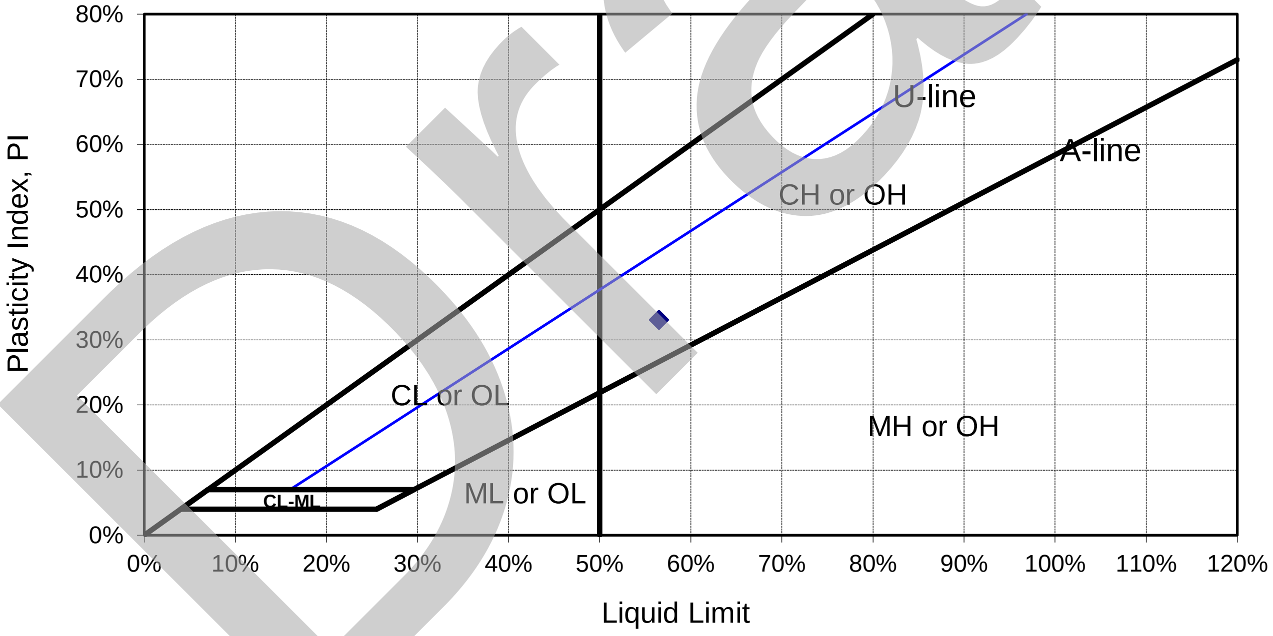

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ATTERBERG LIMITS TEST REPORT

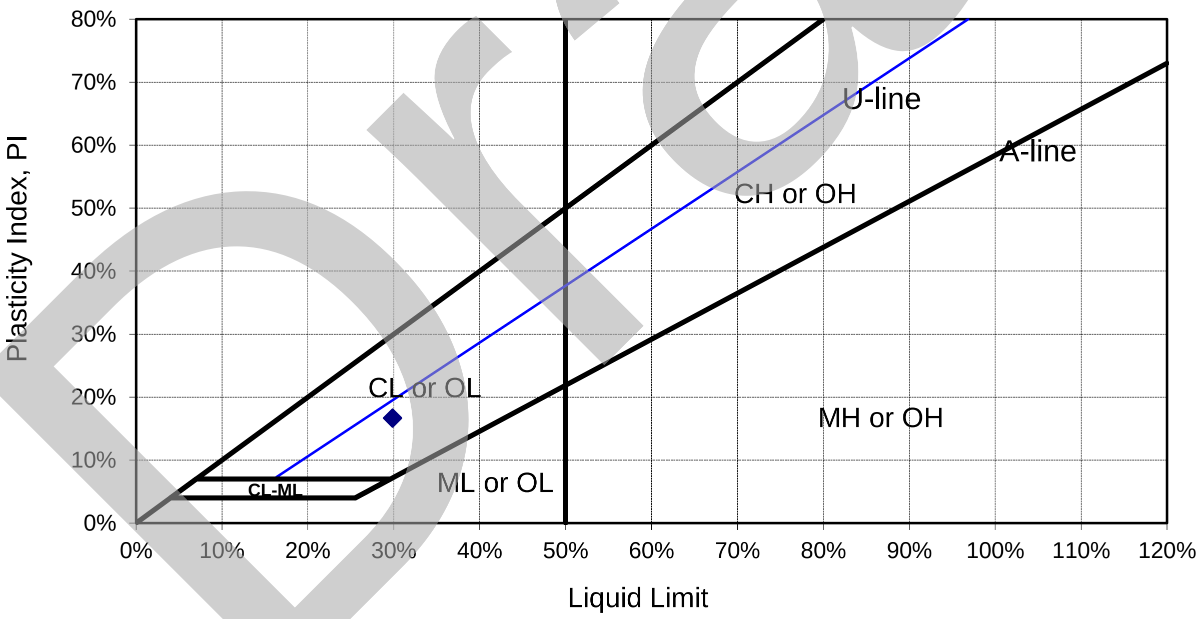
(Test Reference: ASTM D 4318)

Sample: BH FHII 19 Sample NLB-607 at 64ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	21	22	
Tare Wt, g	18.6	Tare Wt, g	18.60	18.90	
Wet + Tare, g	35.60	Wet + tare, g	42.08	46.15	
Dry + Tare, g	33.62	Dry + tare, g	36.58	39.82	
M%	13.2%	Water content	30.6%	30.3%	AVERAGE
		Adjusted W/C	29.9%	29.8%	29.8%

SUMMARY		COMMENTS
Plastic Limit:	**13.2%**	-
Liquid Limit:	**29.8%**	
Plasticity Index:	**16.7%**	
Classification:	**CL**	

Natural Water Content: **13.9%**



Checker:

Reviewer:

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ATTERBERG LIMITS TEST REPORT

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Sample:	BH FHII 13	Sample NLB-625 from 8-9.5ft	(air-dried)	

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	18	19	
Tare Wt, g	14.03	Tare Wt, g	14.24	14.09	
Wet + Tare, g	20.37	Wet + tare, g	53.05	48.79	
Dry + Tare, g	19.18	Dry + tare, g	38.81	36.05	
M%	23.1%	Water content	58.0%	58.0%	AVERAGE
		Adjusted W/C	55.6%	56.0%	55.8%

SUMMARY		COMMENTS
Plastic Limit:	**23.1%**	-
Liquid Limit:	**55.8%**	
Plasticity Index:	**32.7%**	
Classification:	**CH**	

Natural Water Content:	**40.1%**

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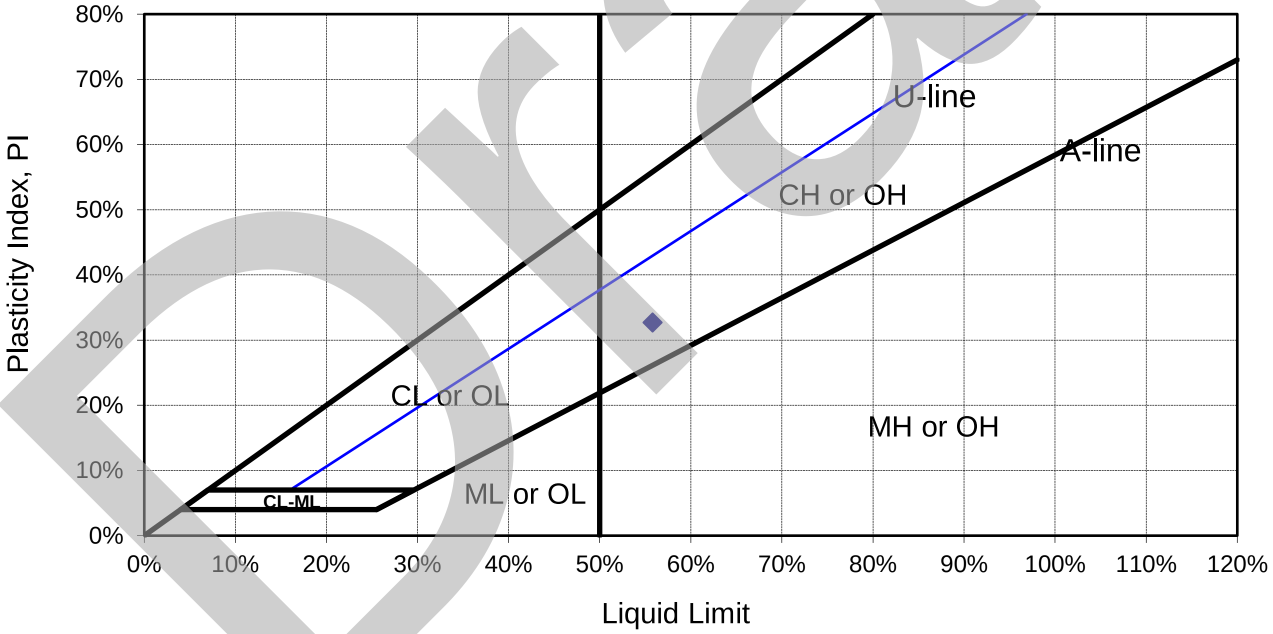

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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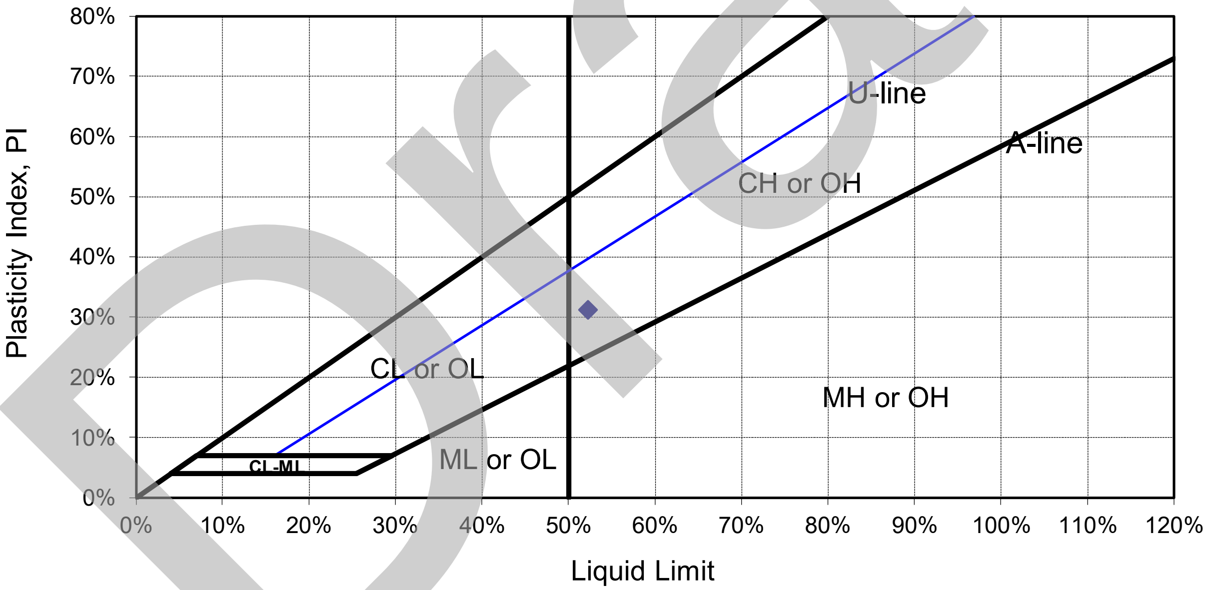
Sample: BH FHII 13 Sample NLB-633 at 28-28.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	29	27	
Tare Wt, g	14.29	Tare Wt, g	13.93	14.22	
Wet + Tare, g	22.81	Wet + tare, g	45.56	51.65	
Dry + Tare, g	21.33	Dry + tare, g	34.83	38.91	
M%	21.0%	Water content	51.3%	51.6%	AVERAGE
		Adjusted W/C	52.4%	52.1%	52.3%

SUMMARY		COMMENTS
Plastic Limit:	**21.0%**	-
Liquid Limit:	**52.3%**	
Plasticity Index:	**31.2%**	
Classification:	**CH**	

Natural Water Content: **21.4%**



Checker: **Reviewer:**

Client: SMHI
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Project #: 659183
Date: 28-Apr-2022

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ATTERBERG LIMITS TEST REPORT

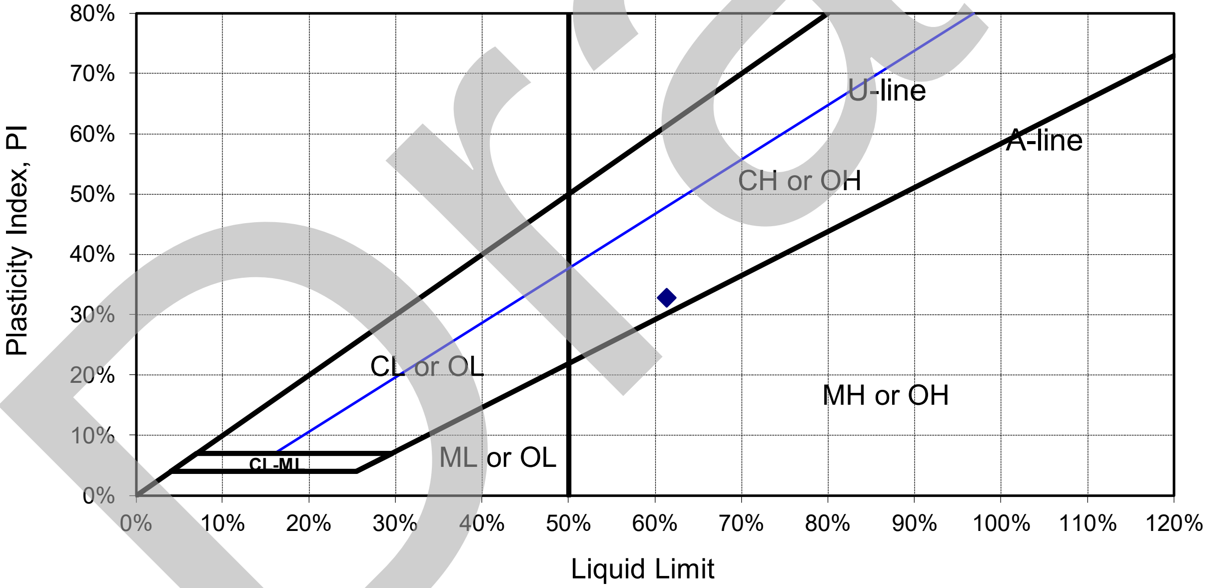
(Test Reference: ASTM D 4318)

Sample: BH FHII 21 Sample NLB-665 at 28-29.6ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	18	20	
Tare Wt, g	14.09	Tare Wt, g	14.09	14.10	
Wet + Tare, g	25.26	Wet + tare, g	34.88	33.39	
Dry + Tare, g	22.78	Dry + tare, g	26.82	25.88	
M%	28.5%	Water content	63.3%	63.8%	AVERAGE
		Adjusted W/C	60.7%	62.0%	61.4%

SUMMARY		COMMENTS
Plastic Limit:	**28.5%**	-
Liquid Limit:	**61.4%**	
Plasticity Index:	**32.8%**	
Classification:	**CH**	

Natural Water Content: **39.4%**



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Reviewer:

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ATTERBERG LIMITS TEST REPORT

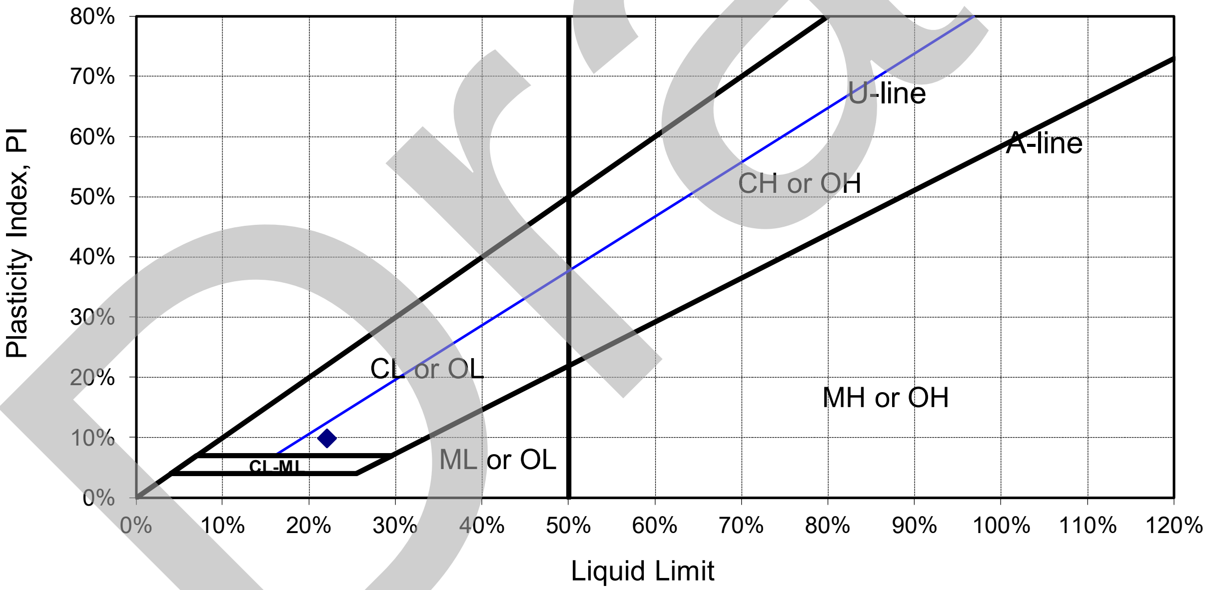
(Test Reference: ASTM D 4318)

Sample: BH FHII 21 Sample NLB-691 at 98-99.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	15	15	
Tare Wt, g	14.14	Tare Wt, g	14.10	13.98	
Wet + Tare, g	31.07	Wet + tare, g	34.59	38.02	
Dry + Tare, g	29.22	Dry + tare, g	30.65	33.48	
M%	12.3%	Water content	23.8%	23.3%	AVERAGE
		Adjusted W/C	22.3%	21.8%	22.1%

SUMMARY		COMMENTS
Plastic Limit:	**12.3%**	-
Liquid Limit:	**22.1%**	
Plasticity Index:	**9.8%**	
Classification:	**CL**	

Natural Water Content: **15.4%**



Checker: **Reviewer:**

Client: SMHI
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Date: 28-Apr-2022

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ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

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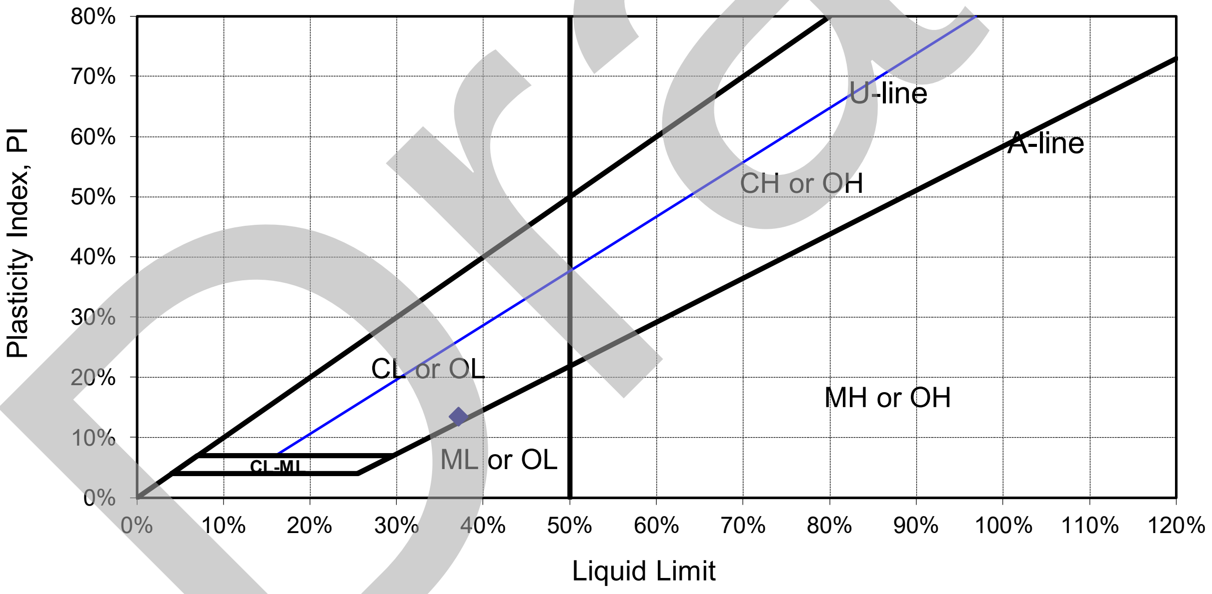
SNC·LAVALIN

Sample: NLB-752 FHII20 at 23-24.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	20	20	
Tare Wt, g	14.41	Tare Wt, g	13.87	13.90	
Wet + Tare, g	21.87	Wet + tare, g	23.32	22.54	
Dry + Tare, g	20.44	Dry + tare, g	20.71	20.15	
M%	23.7%	Water content	38.2%	38.2%	AVERAGE
		Adjusted W/C	37.1%	37.2%	37.1%

SUMMARY		COMMENTS
Plastic Limit:	**23.7%**	-
Liquid Limit:	**37.1%**	
Plasticity Index:	**13.4%**	
Classification:	**CL**	

Natural Water Content: **35.5%**



Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 10-May-2022

Geoscience & Materials

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

CERTIFIED BY CCIL

SNC·LAVALIN

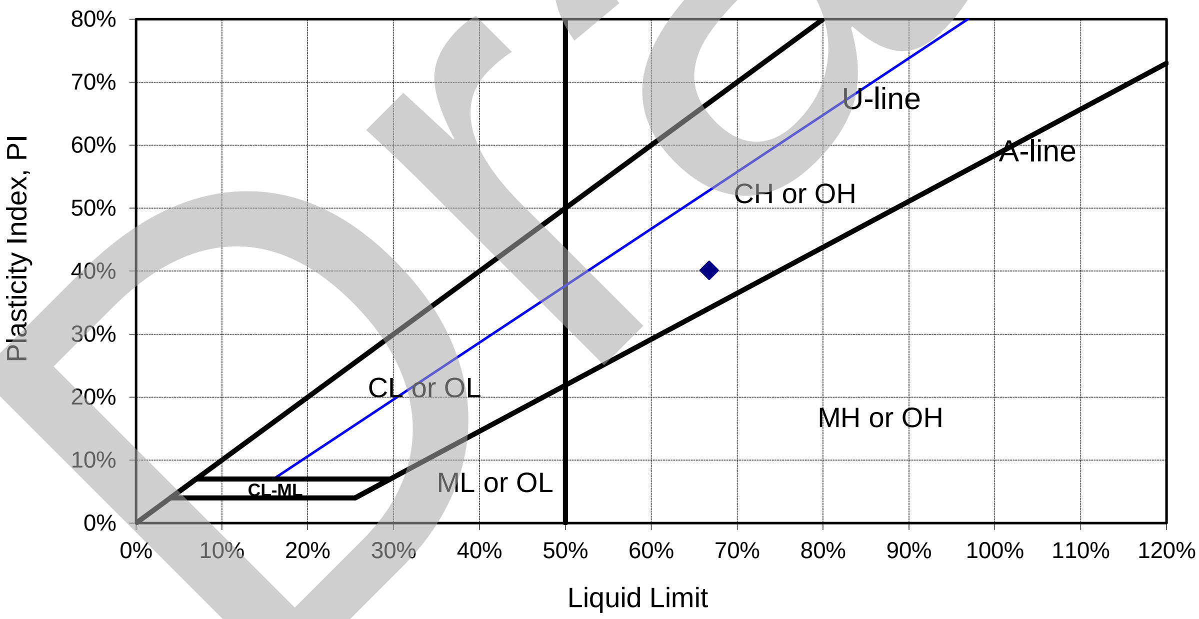
Sample: NLB-766 FHII20 at 58-59.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	23	21	
Tare Wt, g	13.85	Tare Wt, g	13.77	14.01	
Wet + Tare, g	23.60	Wet + tare, g	20.80	24.10	
Dry + Tare, g	21.55	Dry + tare, g	17.96	20.02	
M%	26.6%	Water content	67.8%	67.9%	AVERAGE
		Adjusted W/C	67.1%	66.4%	66.7%

SUMMARY		COMMENTS
Plastic Limit:	**26.6%**	-
Liquid Limit:	**66.7%**	
Plasticity Index:	**40.1%**	
Classification:	**CH**	

Natural Water Content: **39.8%**

.



Checker: Don [illegible] **Reviewer:** Don [illegible]

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 11-May-2022

Geoscience & Materials

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

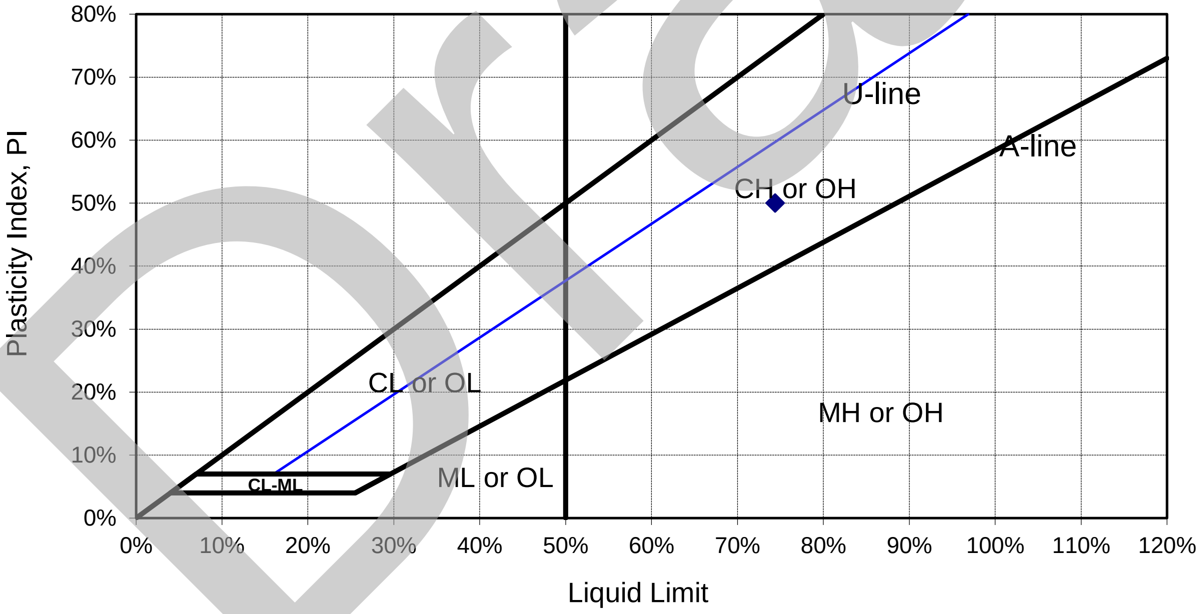
Sample: NLB-771 FHII20 at 68-69.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	28	27	
Tare Wt, g	13.72	Tare Wt, g	13.86	13.91	
Wet + Tare, g	22.08	Wet + tare, g	23.49	26.15	
Dry + Tare, g	20.44	Dry + tare, g	19.41	20.97	
M%	24.4%	Water content	73.5%	73.4%	AVERAGE
		Adjusted W/C	74.6%	74.1%	74.4%

SUMMARY		COMMENTS
Plastic Limit:	**24.4%**	-
Liquid Limit:	**74.4%**	
Plasticity Index:	**50.0%**	
Classification:	**CH**	

Natural Water Content: **37.8%**

.



Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 11-May-2022

Geoscience & Materials

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

CERTIFIED BY CCIL

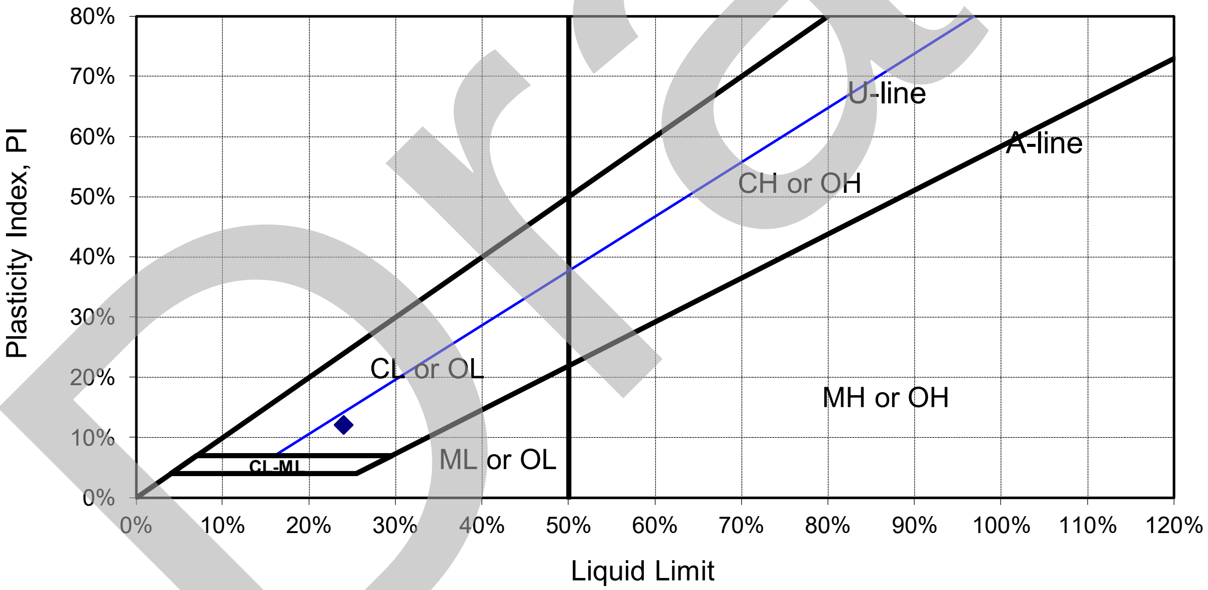
SNC·LAVALIN

Sample: BH FHII 24 Sample NLB-827 at 80-81.5ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	18	18	
Tare Wt, g	14.09	Tare Wt, g	14.17	14.15	
Wet + Tare, g	25.24	Wet + tare, g	54.44	51.21	
Dry + Tare, g	24.06	Dry + tare, g	46.39	43.80	
M%	11.8%	Water content	25.0%	25.0%	AVERAGE
		Adjusted W/C	24.0%	24.0%	24.0%

SUMMARY		COMMENTS
Plastic Limit:	**11.8%**	-
Liquid Limit:	**24.0%**	
Plasticity Index:	**12.1%**	
Classification:	**CL**	

Natural Water Content: **11.9%**



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 28-Apr-2022

Geoscience & Materials

ATTERBERG LIMITS TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D 4318)

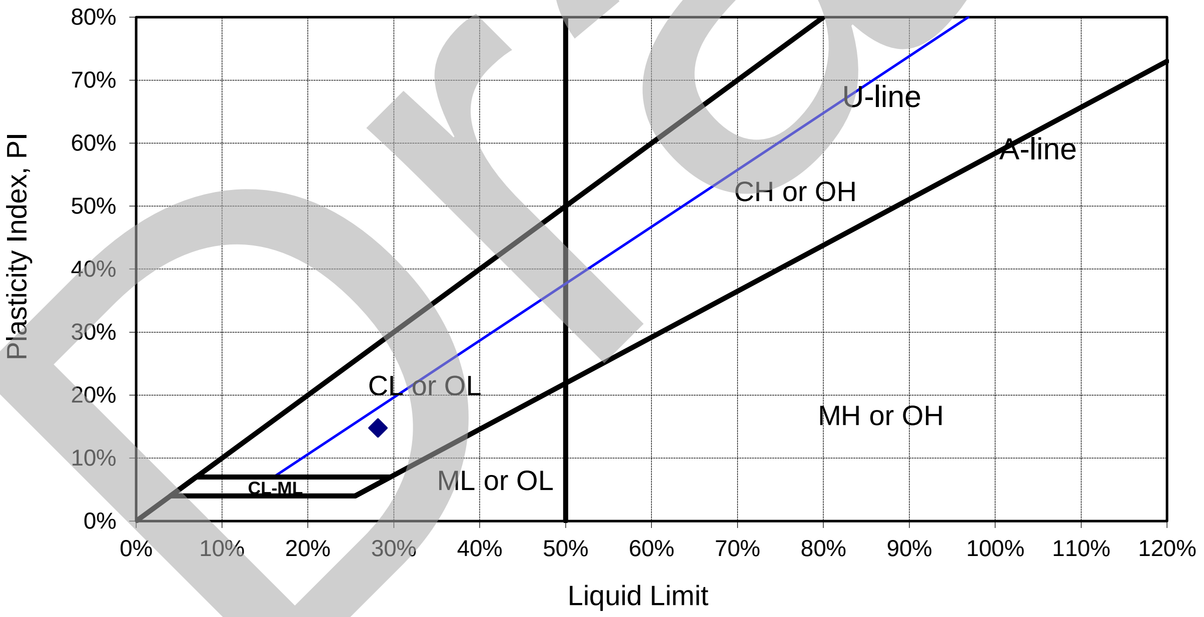
SNC·LAVALIN

Sample: BH FHII 18 Sample NLB-924 at 46ft (air-dried)

PLASTIC LIMIT		LIQUID LIMIT (METHOD B)			
		# of Blows	18	16	
Tare Wt, g	14.13	Tare Wt, g	13.98	14.00	
Wet + Tare, g	22.60	Wet + tare, g	55.38	52.43	
Dry + Tare, g	21.60	Dry + tare, g	45.93	43.66	
M%	13.4%	Water content	29.6%	29.6%	AVERAGE
		Adjusted W/C	28.4%	28.0%	28.2%

SUMMARY		COMMENTS
Plastic Limit:	**13.4%**	-
Liquid Limit:	**28.2%**	
Plasticity Index:	**14.8%**	
Classification:	**CL**	
Natural Water Content:	**10.7%**	

.



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning Study
Project #: 659183
Date: 28-Apr-2022

Appendix VII (C)

Wash Sieve Analysis

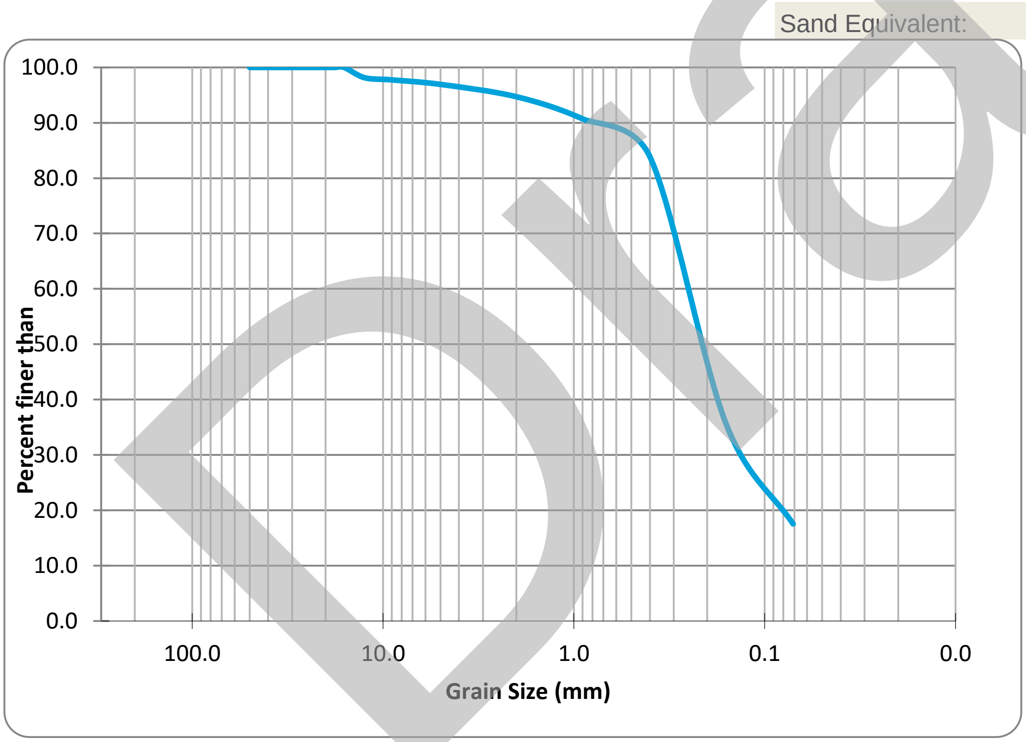
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-1010 at 9-9.45m

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	98.1			
9.00	97.7			
5.00	96.9			
2.00	94.7			
0.900	90.7			
0.400	83.9			
0.160	35.8			
0.071	17.5			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	13.4	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
RH
Description:
Sand with some fines, trace gravel
Sampled from:
BH-01

COBBLES	GRAVEL	SAND	FINES
0.0 %	3.1 %	79.4 %	17.5 %

Comments:

Checker:

Reviewer:

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The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 17-Feb-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

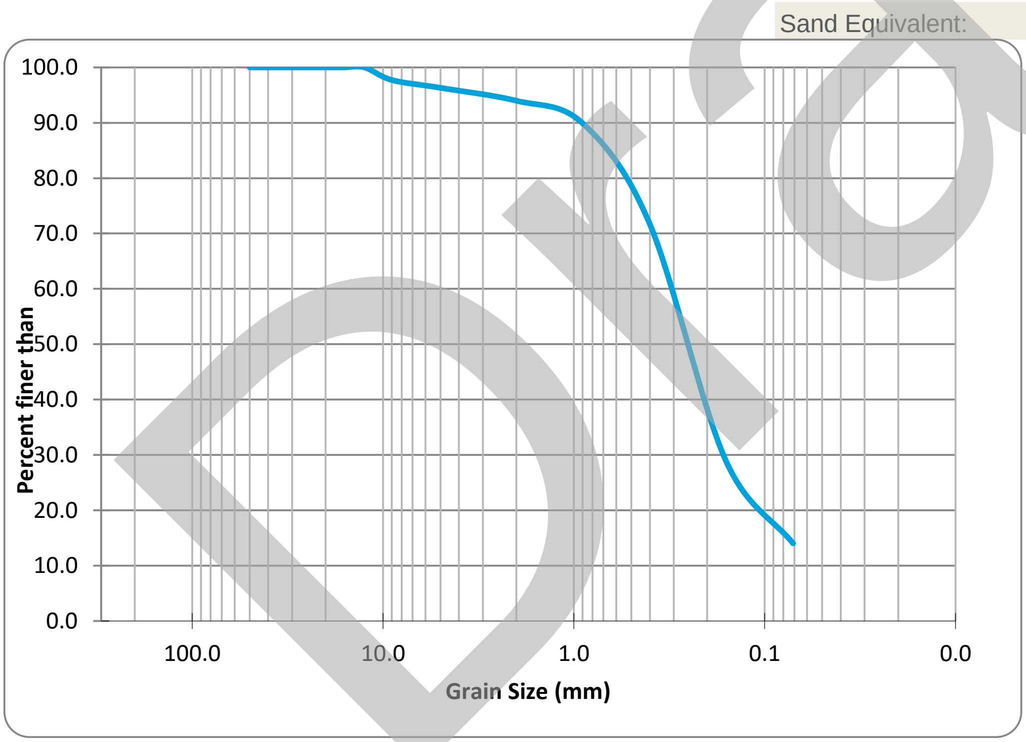
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-1012 at 12-12.4m

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	97.7			
5.00	96.3			
2.00	94.0			
0.900	89.9			
0.400	71.7			
0.160	29.0			
0.071	14.0			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	13.2	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	3.7 %	82.3 %	14.0 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
RH
Description:
Sand with some fines, trace gravel
Sampled from:
BH-01

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 17-Feb-22

Geoscience & Materials

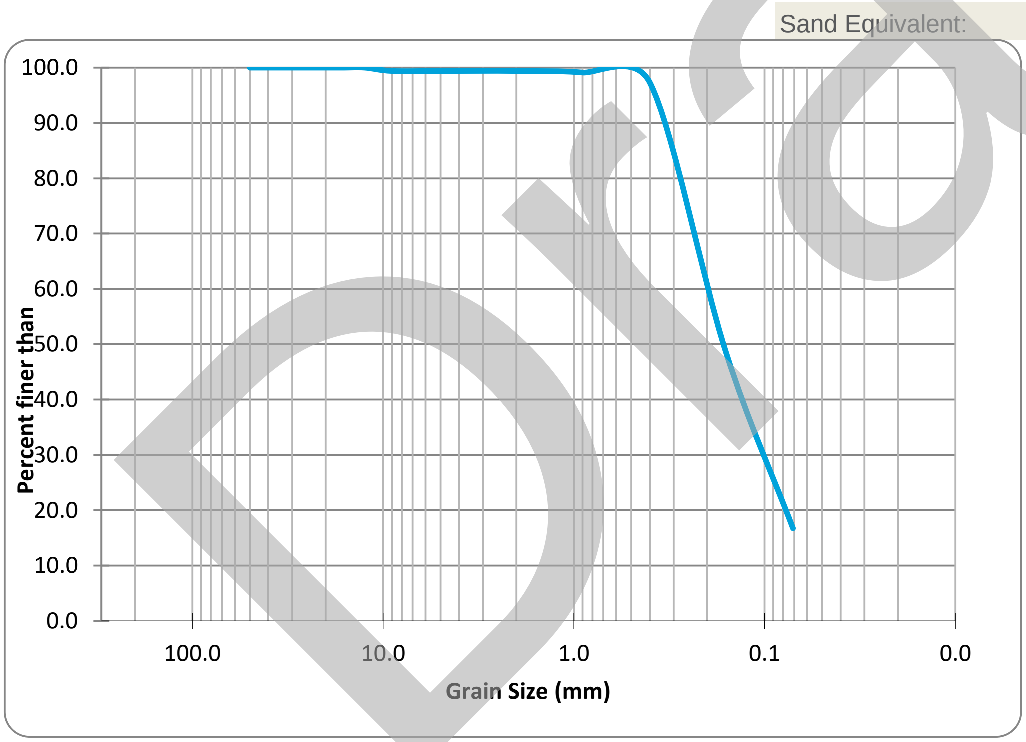
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-1167 at 75-75.35m

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	99.4			
5.00	99.4			
2.00	99.4			
0.900	99.1			
0.400	97.3			
0.160	48.7			
0.071	16.7			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	21.7	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.6 %	82.7 %	16.7 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
RH
Description:
Sand with some fines, trace gravel
Sampled from:
BH-02

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 17-Feb-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

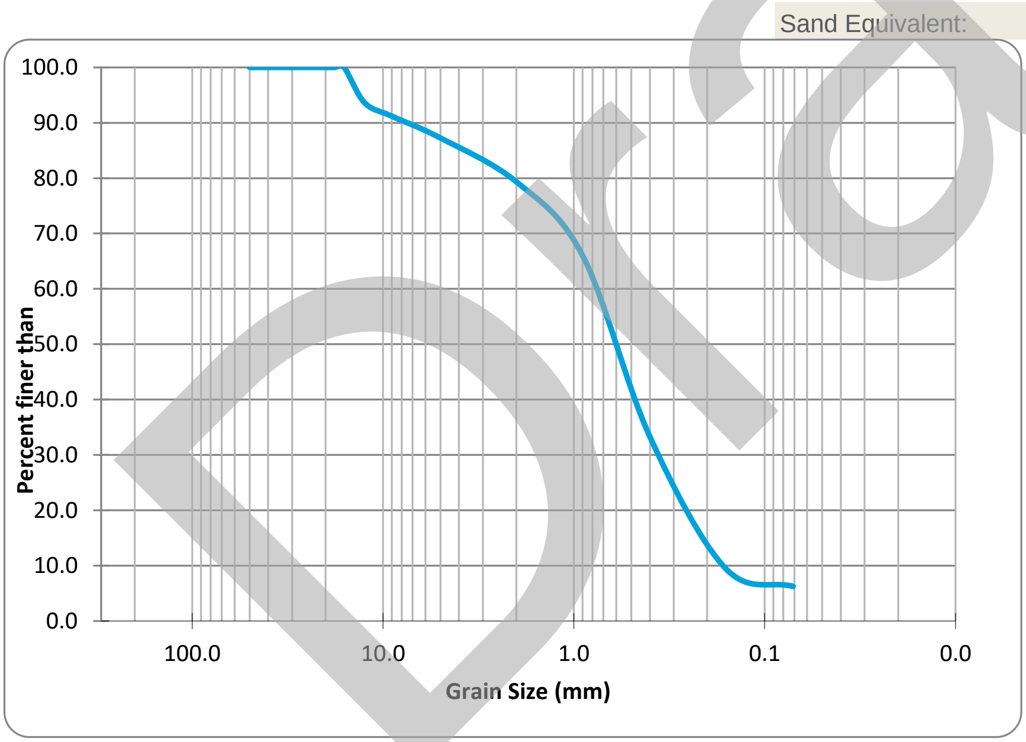
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-1169 at 81-81.45m

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	93.6			
9.00	91.2			
5.00	87.2			
2.00	79.3			
0.900	66.0			
0.400	33.3			
0.160	9.5			
0.071	6.3			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	8.2	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
RH
Description:
Sand with some gravel, trace fines
Sampled from:
BH-02

COBBLES	GRAVEL	SAND	FINES
0.0 %	12.8 %	81.0 %	6.3 %

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 17-Feb-22

Geoscience & Materials

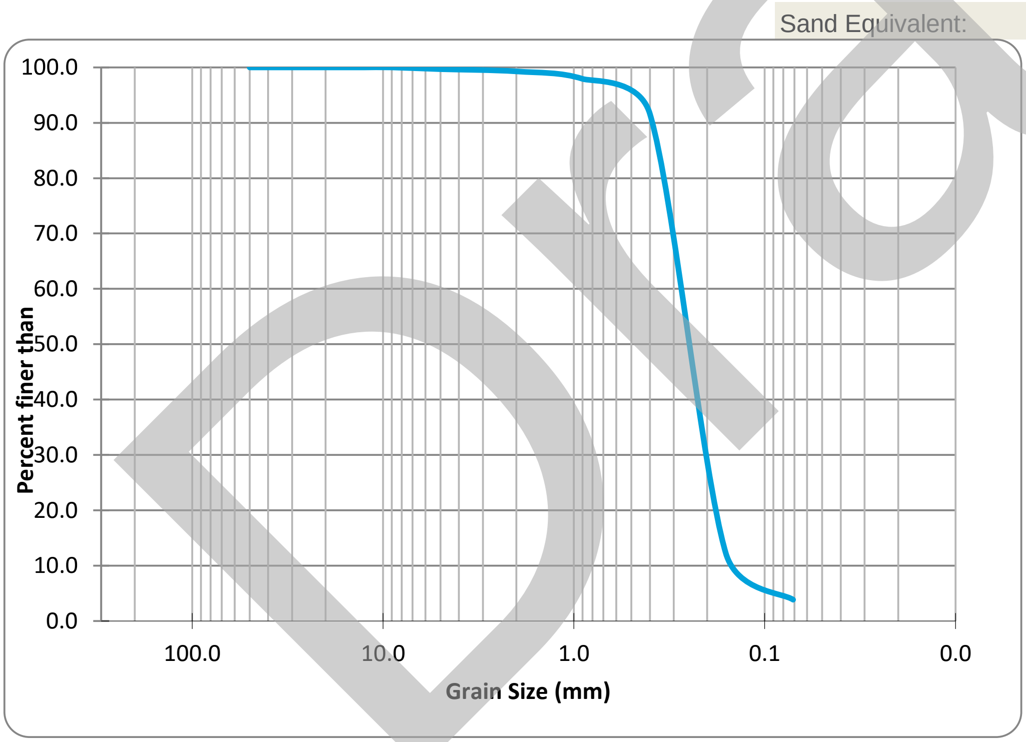
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-004 at 7.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	99.7			
2.00	99.3			
0.900	97.9			
0.400	91.6			
0.160	12.3			
0.071	3.9			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	13.4	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.3 %	95.8 %	3.9 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand, trace fines, gravel
Sampled from:
BH SHII-1

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 25-Apr-22

Geoscience & Materials

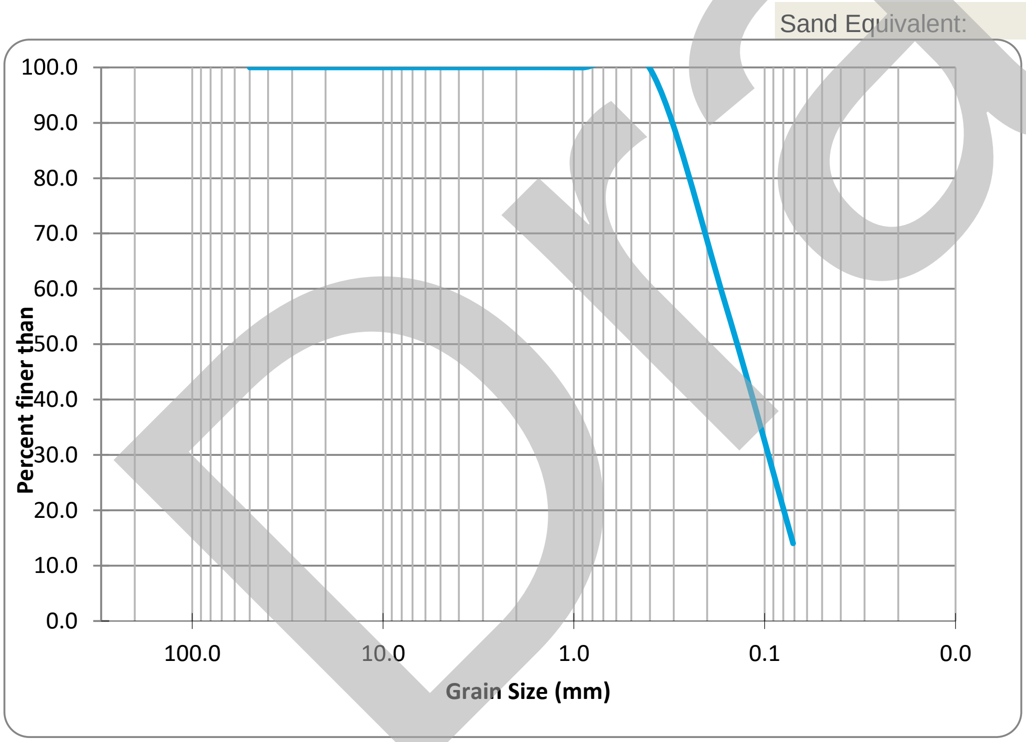
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample:	NLB-018 at 35.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	100.0			
0.400	99.8			
0.160	57.0			
0.071	14.0			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	20.8	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	86.0 %	14.0 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with some fines
Sampled from:
BH SHII-01

Comments:

Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	07-May-22

Geoscience & Materials

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WASH SIEVE TEST REPORT

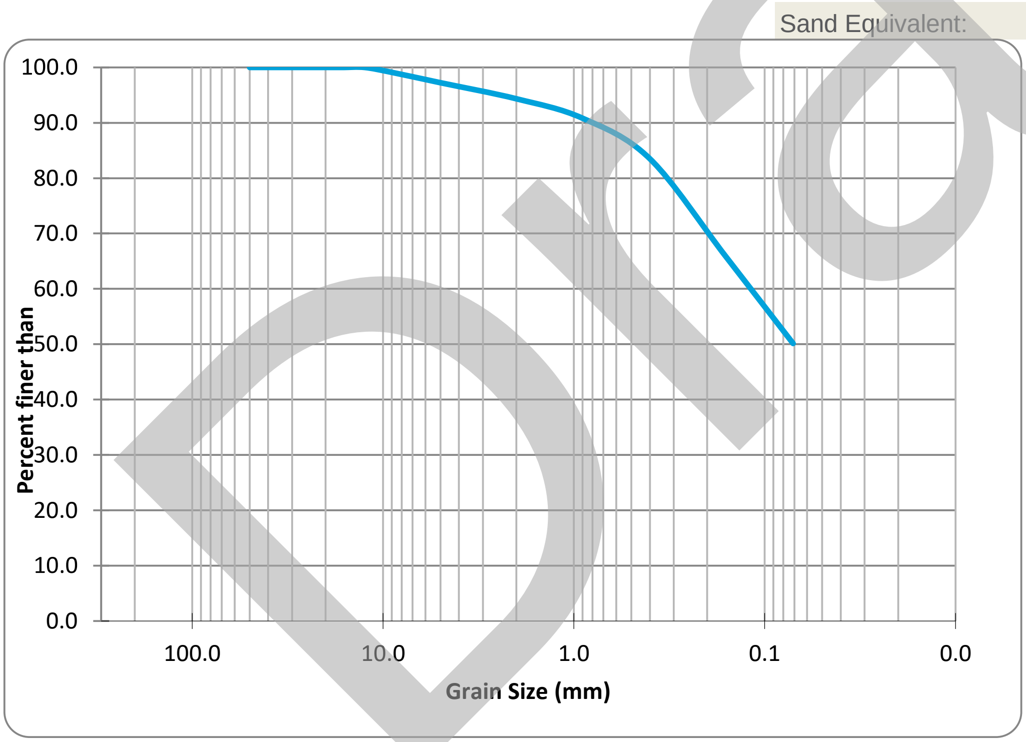
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-024B at 8-9ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	99.1			
5.00	97.2			
2.00	94.3			
0.900	90.8			
0.400	83.5			
0.160	65.9			
0.071	50.1			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	9.8	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	2.8 %	47.1 %	50.1 %

Additional Sample Info.

Date Sampled:	-
Date Received:	-
Location:	-
Supplied by:	-
Sampled by:	NLB
Tested by:	GDK
Description:	-
Sampled from:	BH FHII-01

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 07-May-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

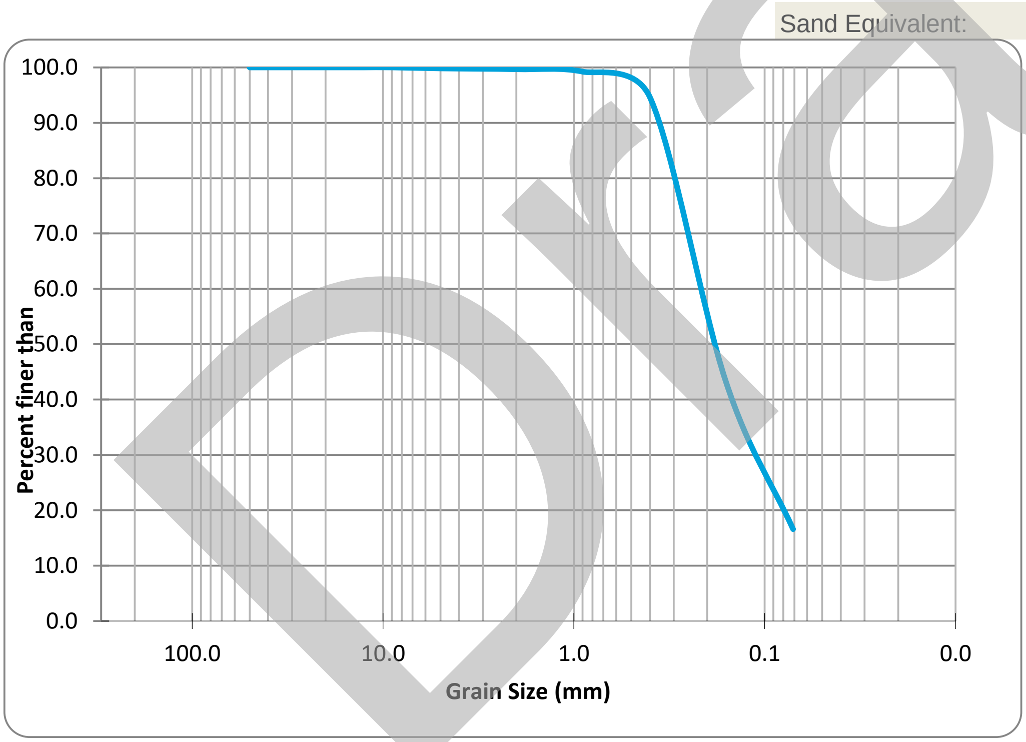
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-031 at 22.5-23.7ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	99.8			
2.00	99.7			
0.900	99.2			
0.400	94.6			
0.160	43.3			
0.071	16.6			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	17.9	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.2 %	83.2 %	16.6 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with some fines
Sampled from:
BH FHII-01

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 07-May-22

Geoscience & Materials

WASH SIEVE TEST REPORT

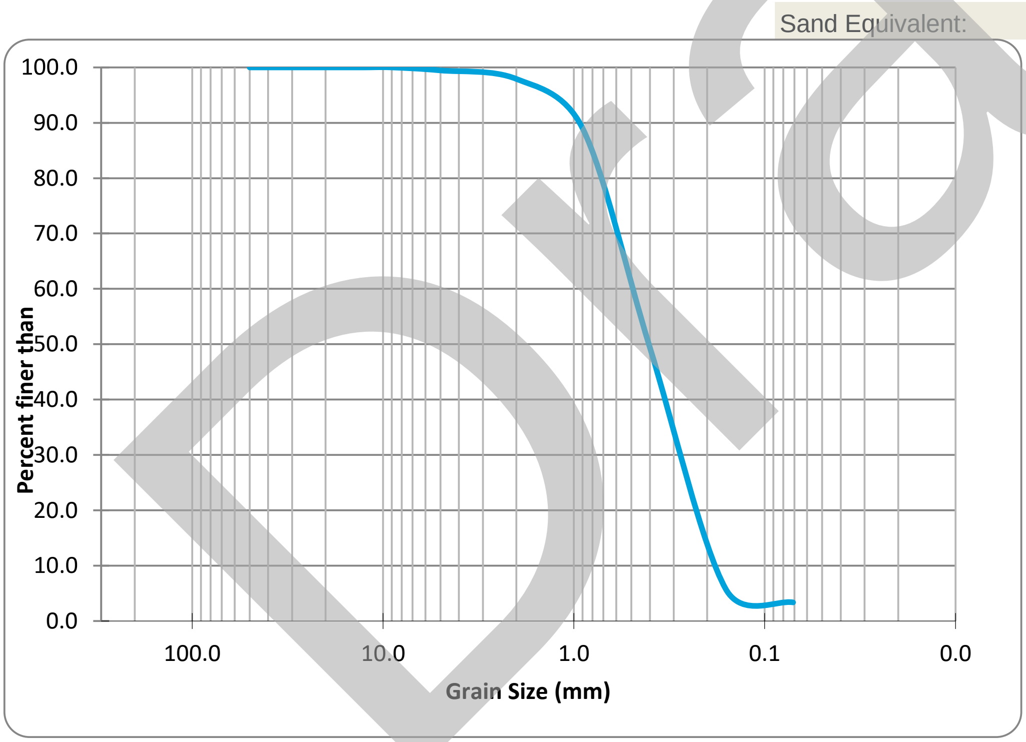
(Test Reference: ASTM C 136 and C 117)

Sample:	NLB-034 at 30ft

Sieve Analysis (mm)	
Sieve	% Finer
50.0	100.0
31.5	100.0
22.4	100.0
18.0	100.0
16.0	100.0
12.5	100.0
9.00	100.0
5.00	99.5
2.00	97.9
0.900	89.0
0.400	49.4
0.160	5.8
0.071	3.4

Specifications (mm)		
Sieve	Min	Max

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	18.4	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.5 %	96.1 %	3.4 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand, trace fines, gravel
Sampled from:
BH FHII-1

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 25-Apr-22

Geoscience & Materials

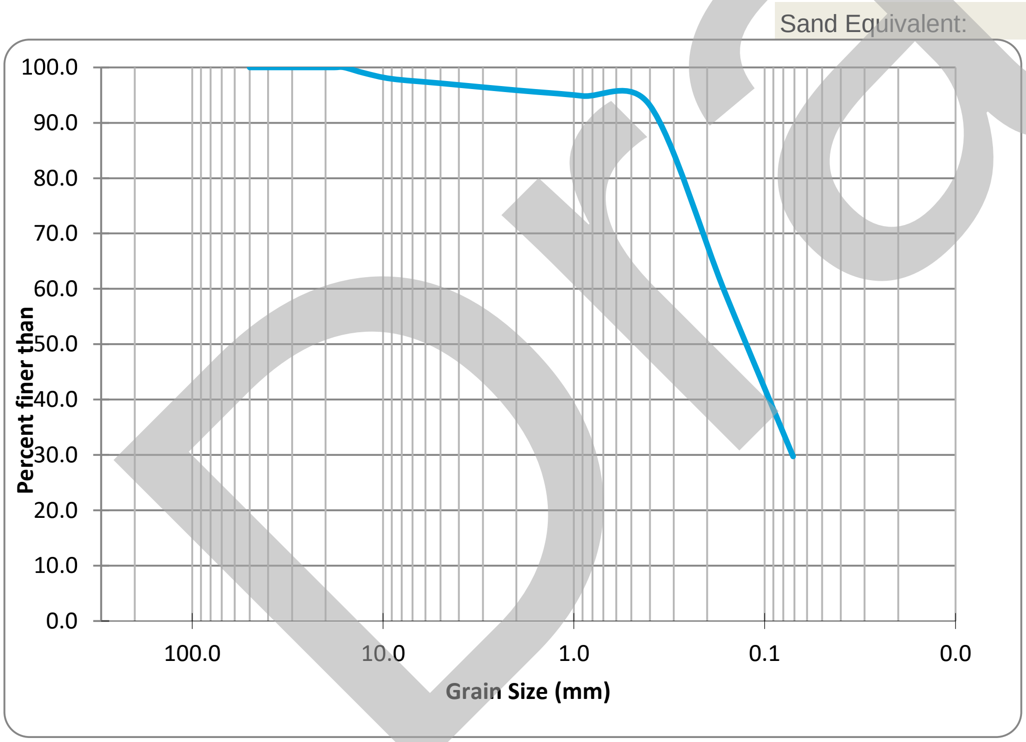
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-072 at 33-34ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	99.0			
9.00	97.9			
5.00	97.1			
2.00	95.9			
0.900	94.8			
0.400	93.1			
0.160	59.0			
0.071	29.7			

Other Properties		
Properties	Results	Specification
Moisture Content:	23.2	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	2.9 %	67.4 %	29.7 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with fines, trace gravel
Sampled from:
BH SHII-4

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 25-Apr-22

Geoscience & Materials

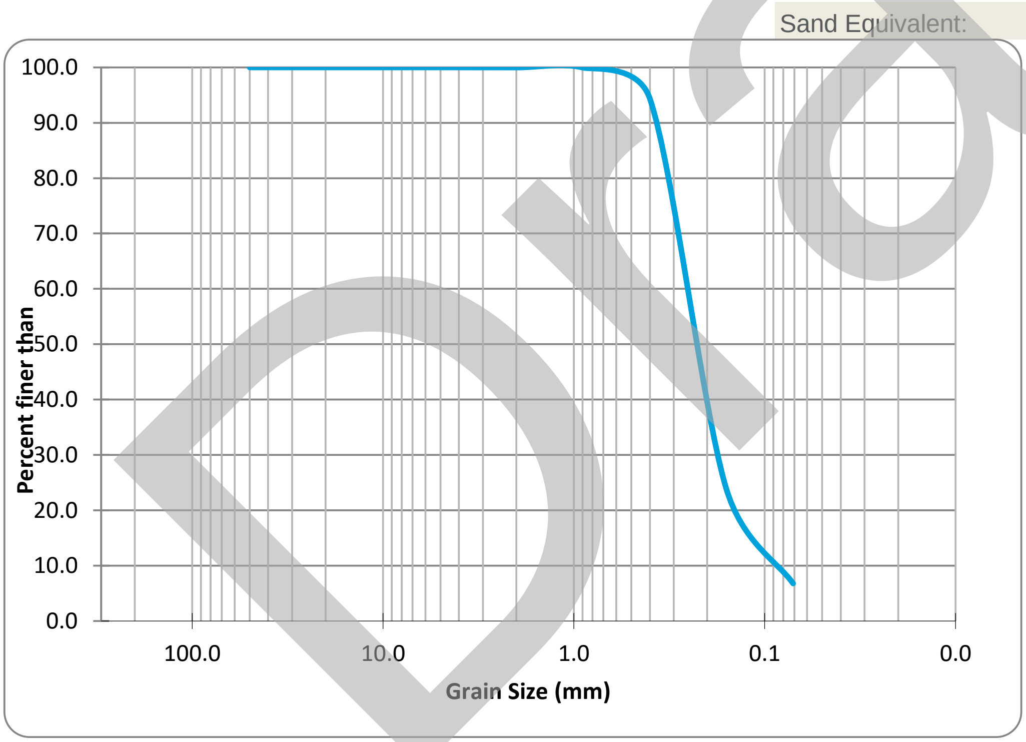
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-076 at 43ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	100.0			
0.400	94.4			
0.160	24.2			
0.071	6.8			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	19.5	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	93.2 %	6.8 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand, trace fines
Sampled from:
BH SHII-4

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 25-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

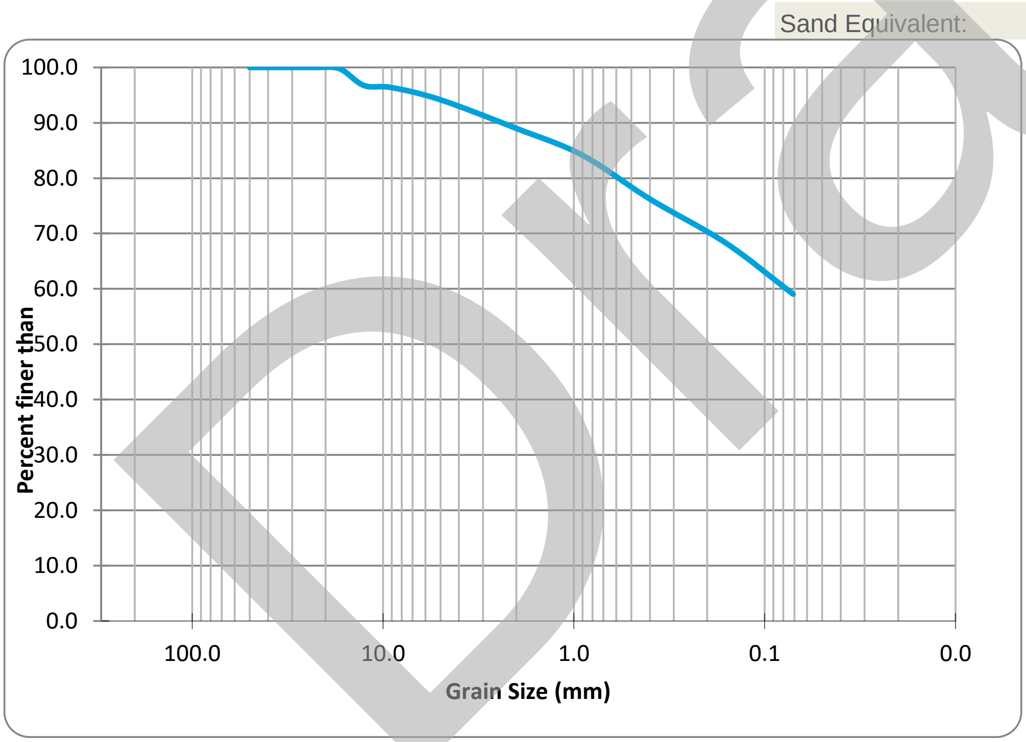
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-079 at 2.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	99.3			
12.5	96.7			
9.00	96.4			
5.00	94.2			
2.00	89.0			
0.900	84.1			
0.400	76.2			
0.160	68.3			
0.071	59.1			

Other Properties		
Properties	Results	Specification
Moisture Content:	4.7	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	5.8 %	35.1 %	59.1 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
-
Sampled from:
BH SHII-7

Comments:

Checker: Don

Reviewer: Don

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 16-Apr-22

Geoscience & Materials

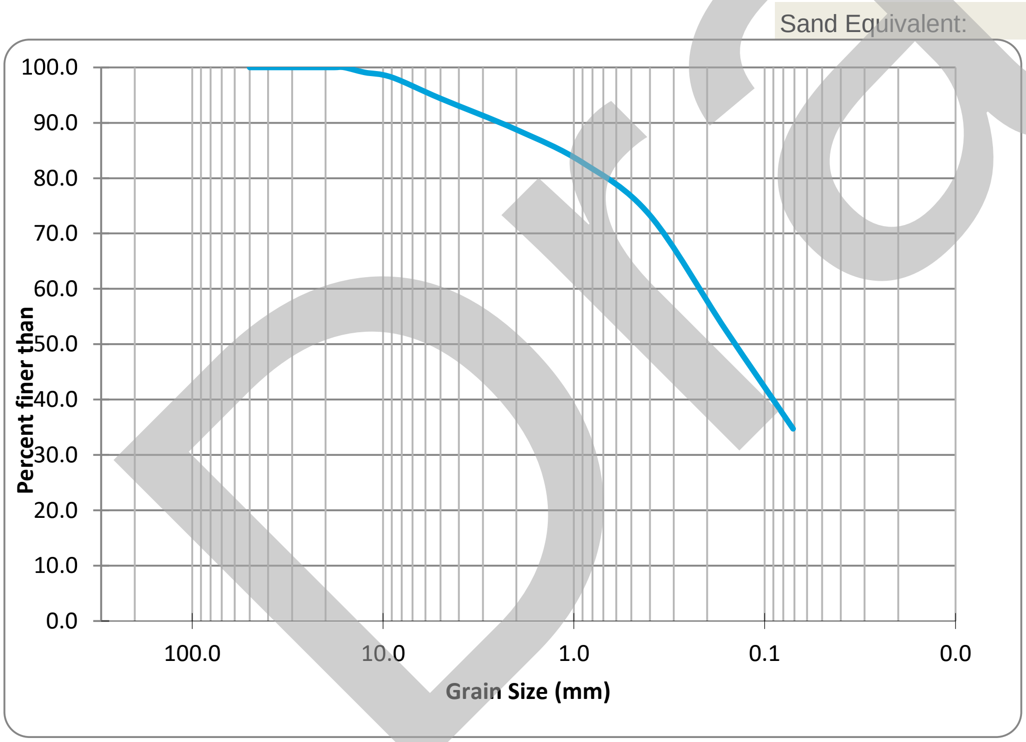
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample:	NLB-096 at 38-39.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	99.1			
9.00	98.2			
5.00	94.4			
2.00	88.8			
0.900	82.8			
0.400	73.3			
0.160	52.6			
0.071	34.7			

Other Properties		
Properties	Results	Specification
Moisture Content:	14.4	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	5.6 %	59.7 %	34.7 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with fines, trace gravel
Sampled from:
BH SHII-7

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 16-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

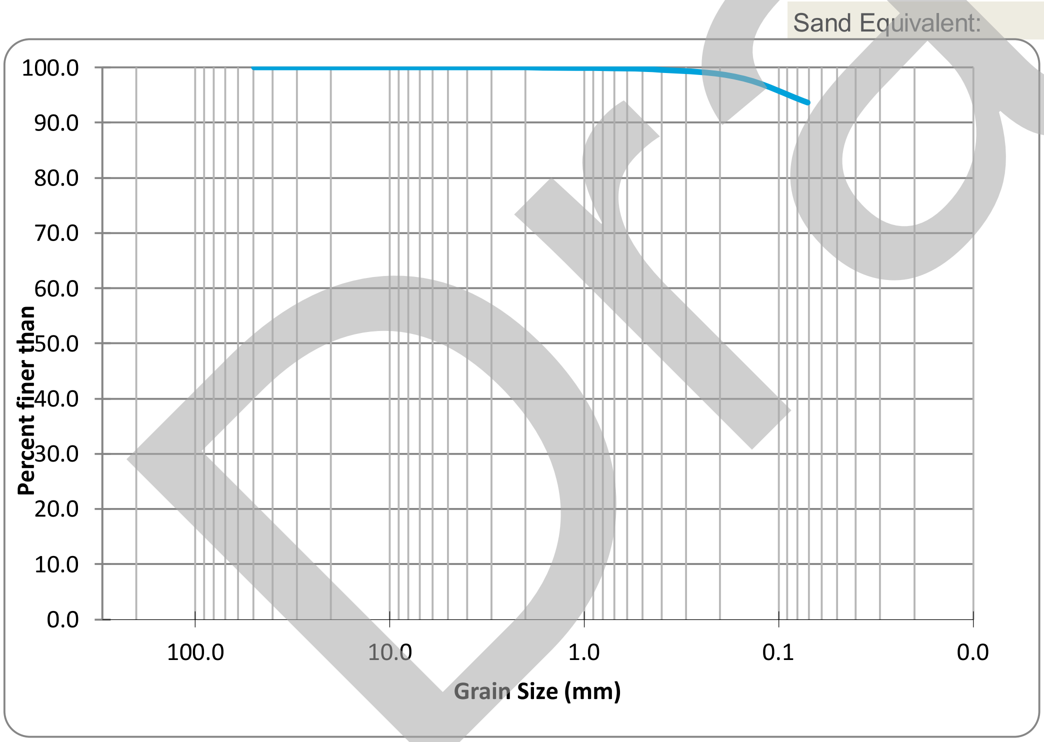
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-101 at 1.5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.9			
0.400	99.6			
0.160	98.2			
0.071	93.7			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	9.2	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH PHII-6

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	6.3 %	93.7 %

Comments:

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	18-Apr-22

Geoscience & Materials

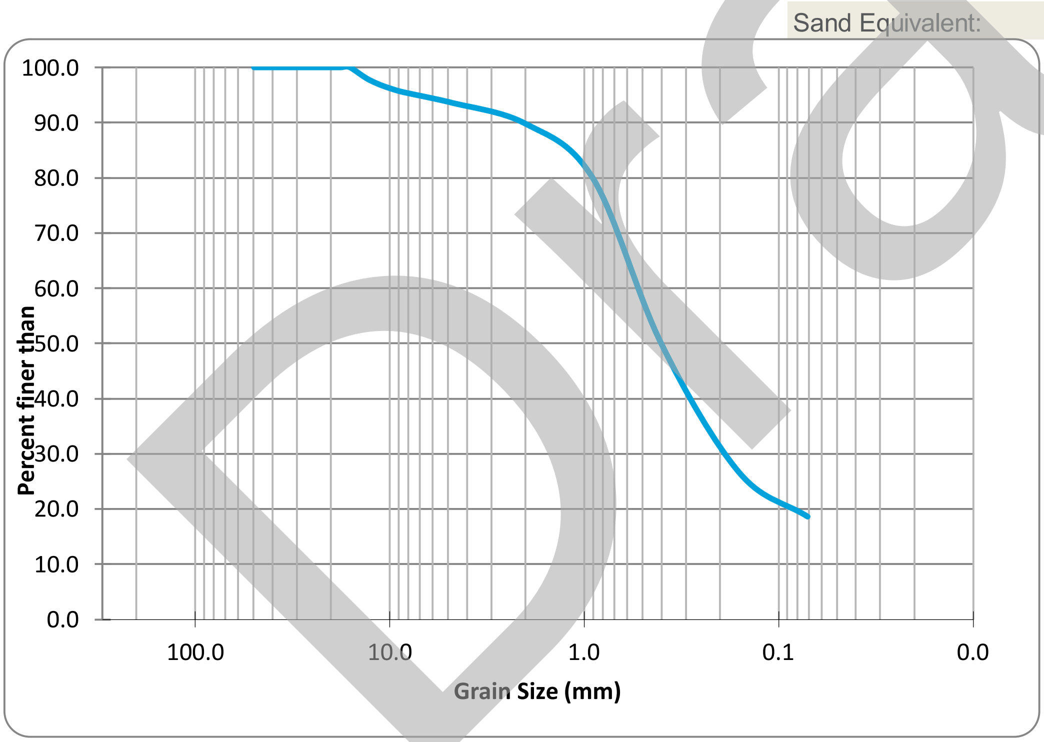
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-104 at 8'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	97.6			
9.00	95.8			
5.00	93.8			
2.00	89.9			
0.900	79.9			
0.400	49.8			
0.160	26.7			
0.071	18.6			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	1.7	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	6.2 %	75.1 %	18.6 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH PHII-6

Comments:

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 19-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

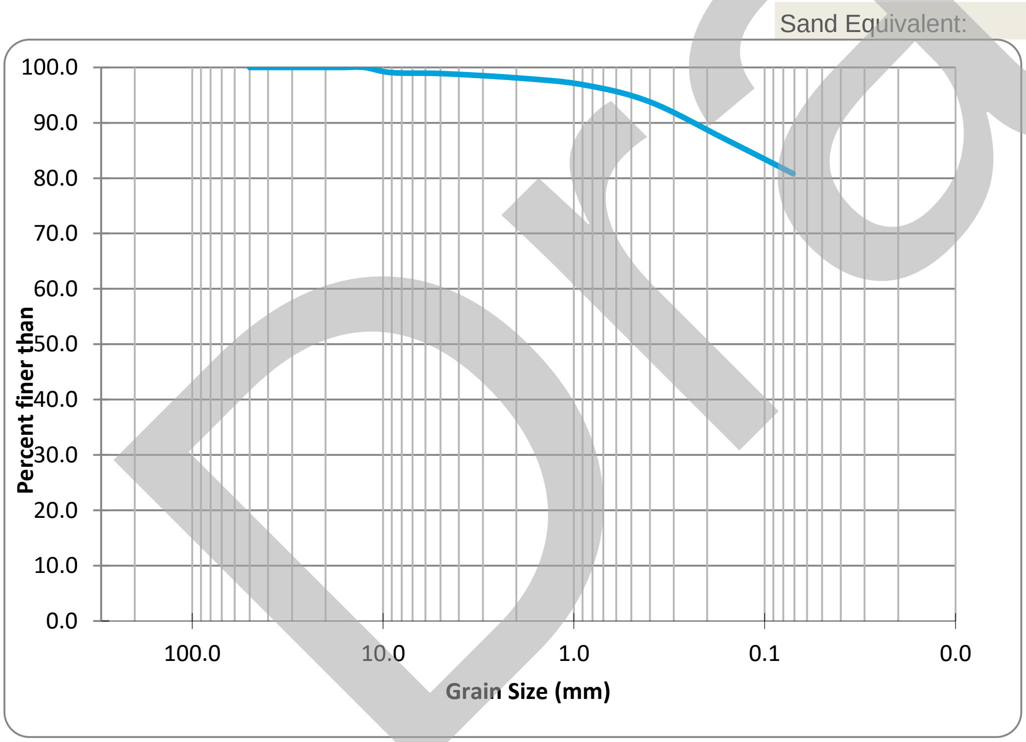
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-112 at 1.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	99.1			
5.00	98.9			
2.00	98.1			
0.900	96.9			
0.400	93.8			
0.160	87.0			
0.071	80.8			

Other Properties		
Properties	Results	Specification
Moisture Content:	9.6	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	1.1 %	18.1 %	80.8 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
-
Sampled from:
BH SHII-2

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 25-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

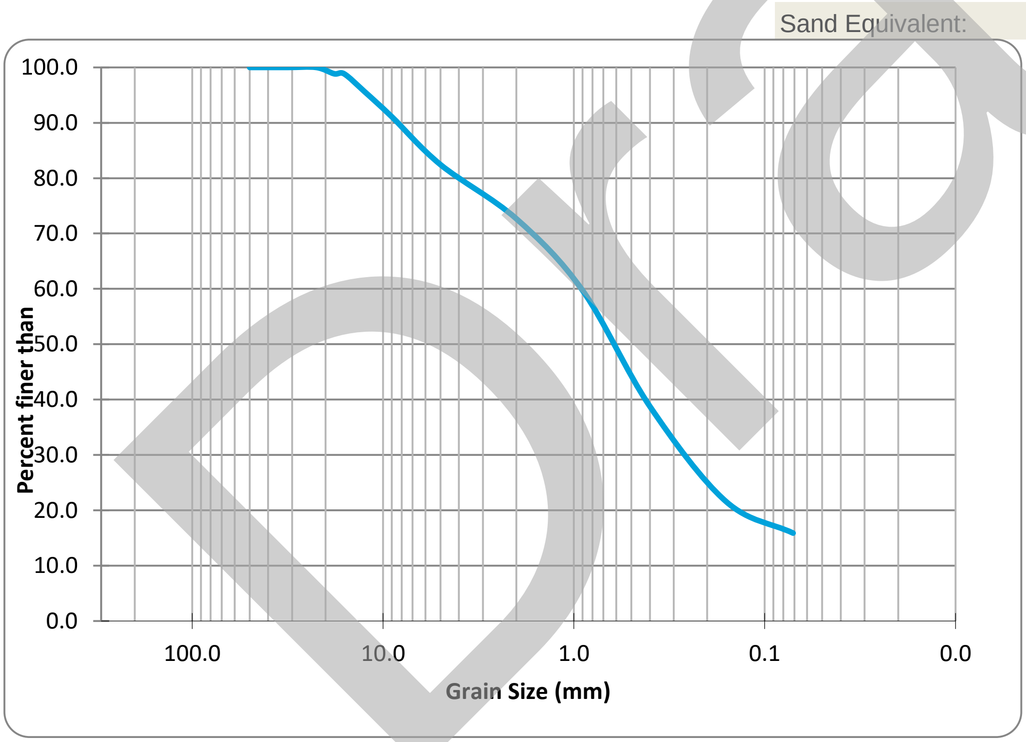
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-119 at 7ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	98.8			
16.0	98.8			
12.5	95.6			
9.00	91.1			
5.00	82.4			
2.00	72.6			
0.900	59.7			
0.400	38.8			
0.160	21.6			
0.071	15.9			

Other Properties		
Properties	Results	Specification
Moisture Content:	1.2	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	17.6 %	66.6 %	15.9 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with some fines, gravel
Sampled from:
BH PHII1

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 25-Apr-22

Geoscience & Materials

WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

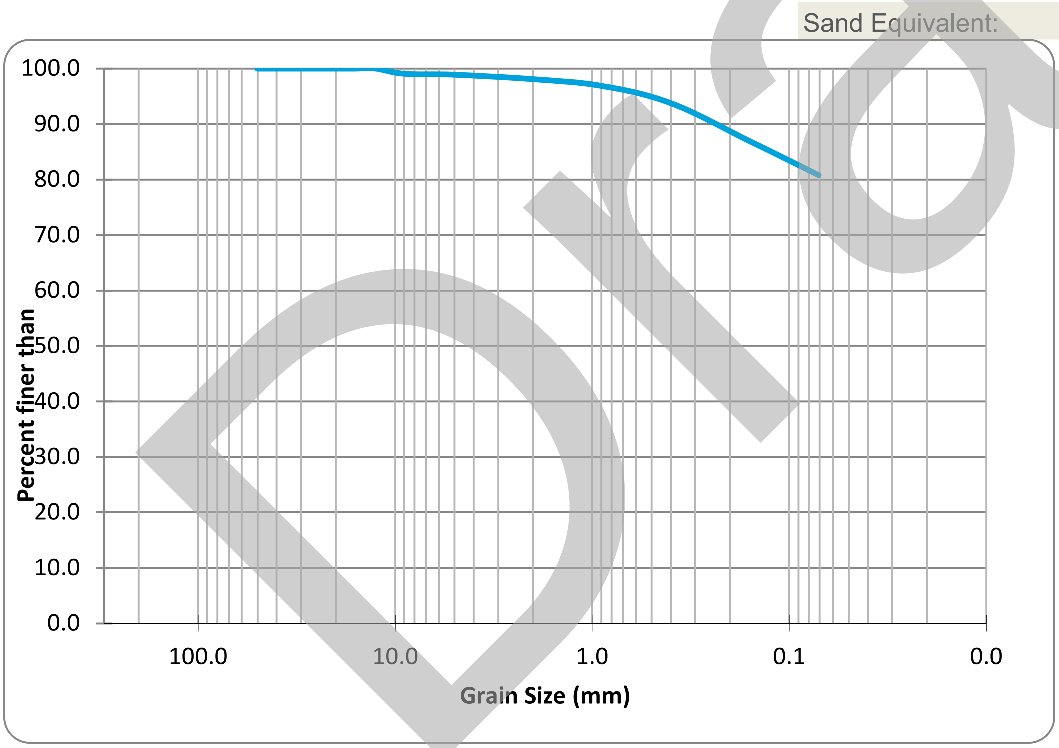
SNC · LAVALIN

Sample: NLB-122 at 1.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	99.1			
5.00	98.9			
2.00	98.1			
0.900	96.9			
0.400	93.8			
0.160	87.0			
0.071	80.8			

Other Properties

Properties	Results	Specification
Moisture Content:	9.6	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	1.1 %	18.1 %	80.8 %

Additional Sample Info.

Date Sampled:	-
Date Received:	-
Location:	-
Supplied by:	-
Sampled by:	NLB
Tested by:	GDK
Description:	-
Sampled from:	BH SHII-2

Comments:

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 25-Apr-22

Geoscience & Materials

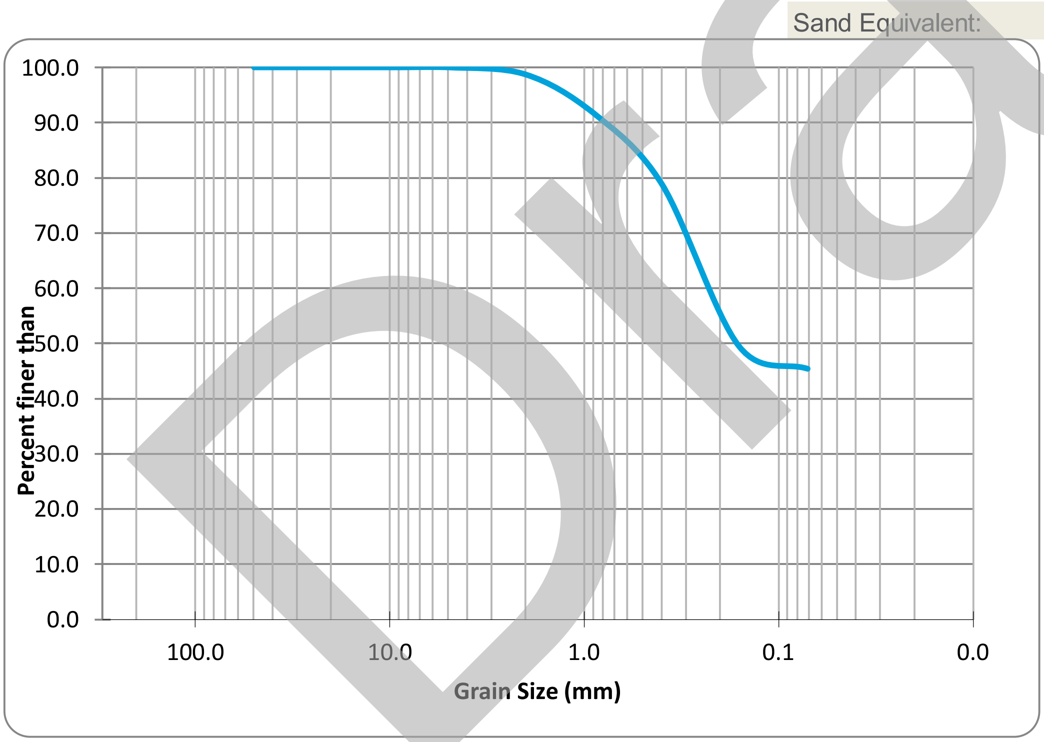
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-134 at 29.3ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	98.8			
0.900	91.8			
0.400	78.9			
0.160	49.5			
0.071	45.4			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	12.6	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with fines
Sampled from:
BH SHII-02

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	54.6 %	45.4 %

Comments:

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 07-May-22

Geoscience & Materials

WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

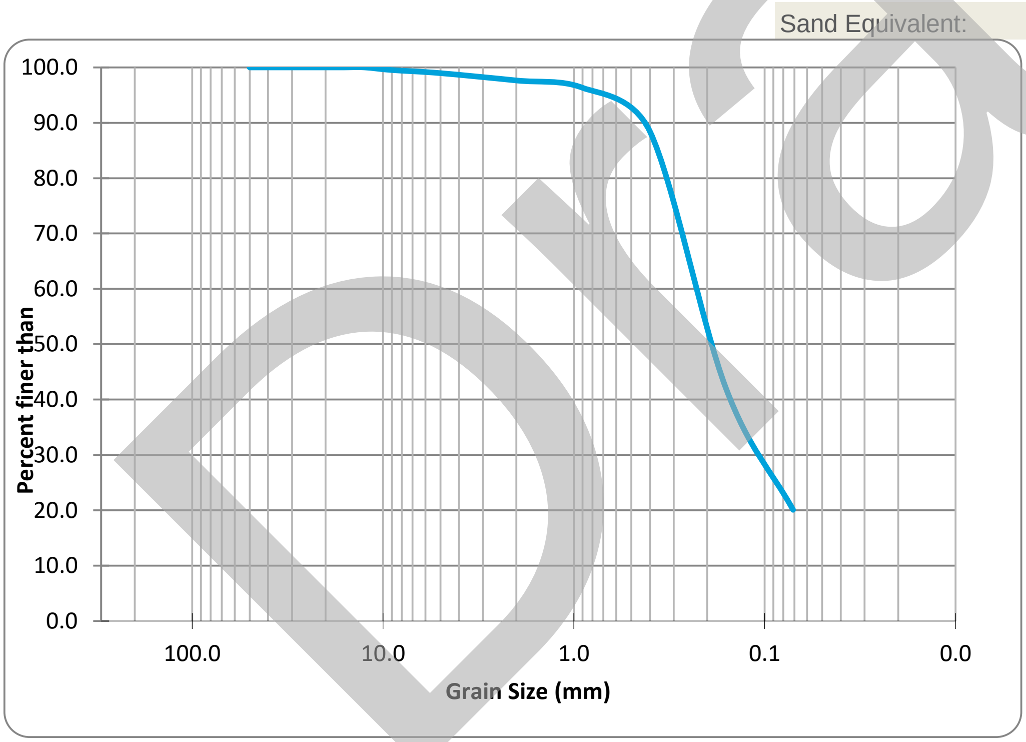
CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-143 at 2ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	99.5			
5.00	99.0			
2.00	97.6			
0.900	96.3			
0.400	88.5			
0.160	42.1			
0.071	20.1			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	4.2	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	1.0 %	78.9 %	20.1 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with fines, trace gravel
Sampled from:
BH PHII-02

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 08-May-22

Geoscience & Materials

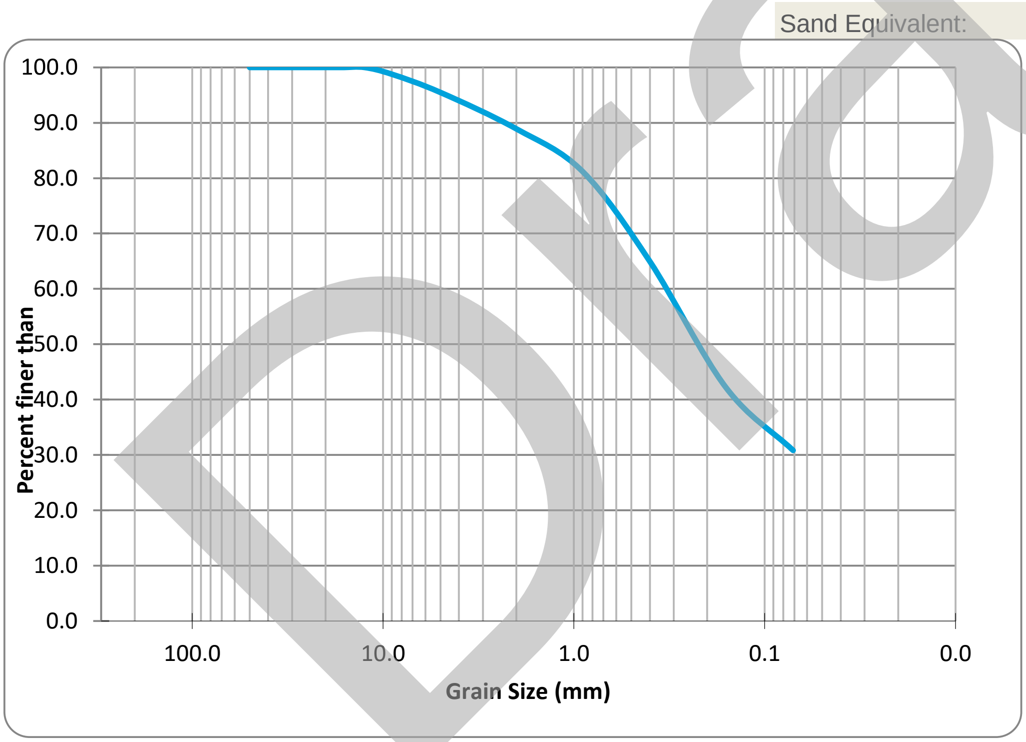
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-150 at 11ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	98.8			
5.00	95.5			
2.00	88.9			
0.900	81.2			
0.400	65.0			
0.160	42.2			
0.071	30.8			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	4.3	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	4.5 %	64.7 %	30.8 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with fines, trace gravel
Sampled from:
BH FHII-03

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 07-May-22

Geoscience & Materials

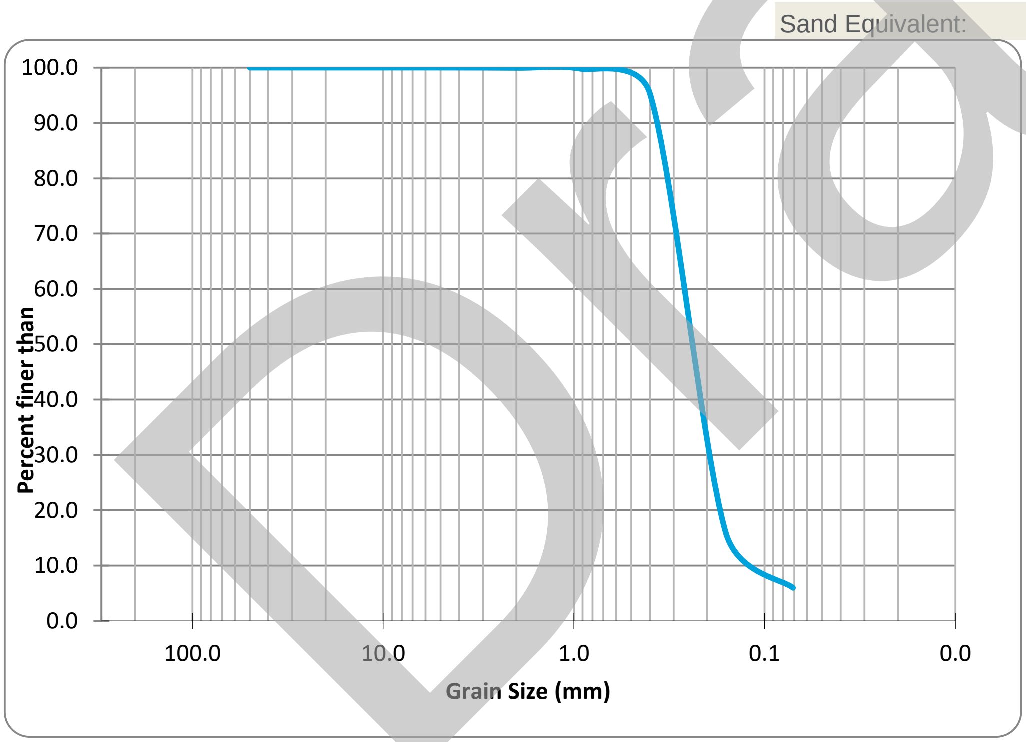
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-168 at 45.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.7			
0.400	95.4			
0.160	16.0			
0.071	6.0			

Other Properties		
Properties	Results	Specification
Moisture Content:	20.4	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand, trace fines
Sampled from:
BH FHII-03

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	94.0 %	6.0 %

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 08-May-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

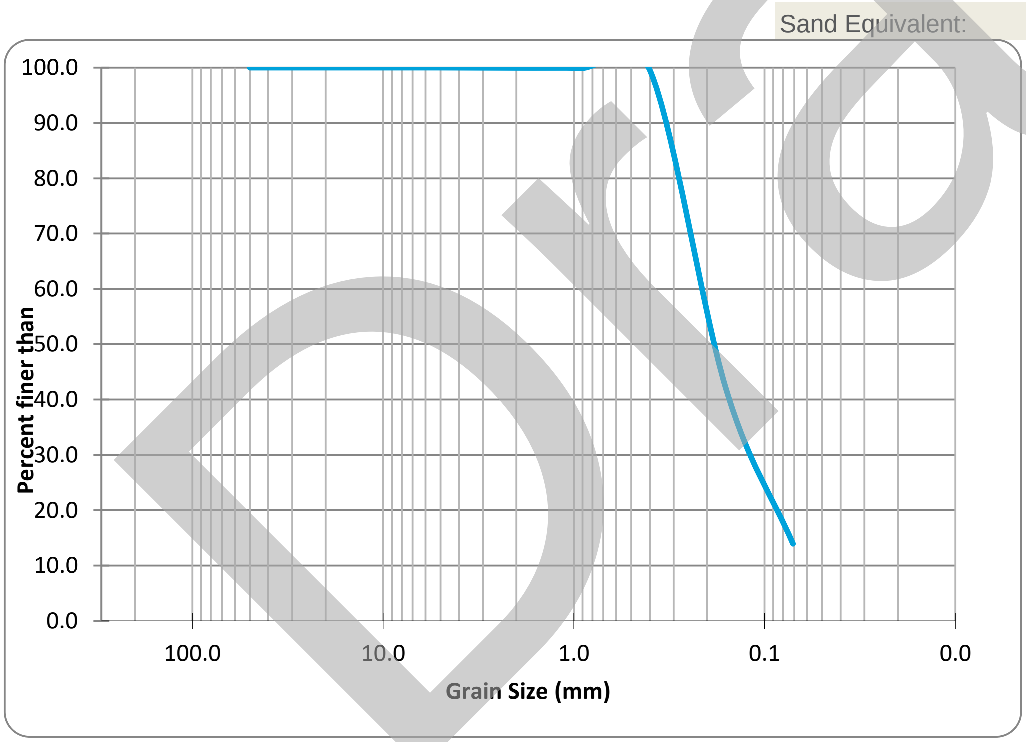
SNC·LAVALIN

Sample: NLB-179 at 75ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.9			
0.400	99.6			
0.160	42.1			
0.071	13.9			

Other Properties

Properties	Results	Specification
Moisture Content:	17.3	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	86.1 %	13.9 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with some fines
Sampled from:
BH FHII-03

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 07-May-22

Geoscience & Materials

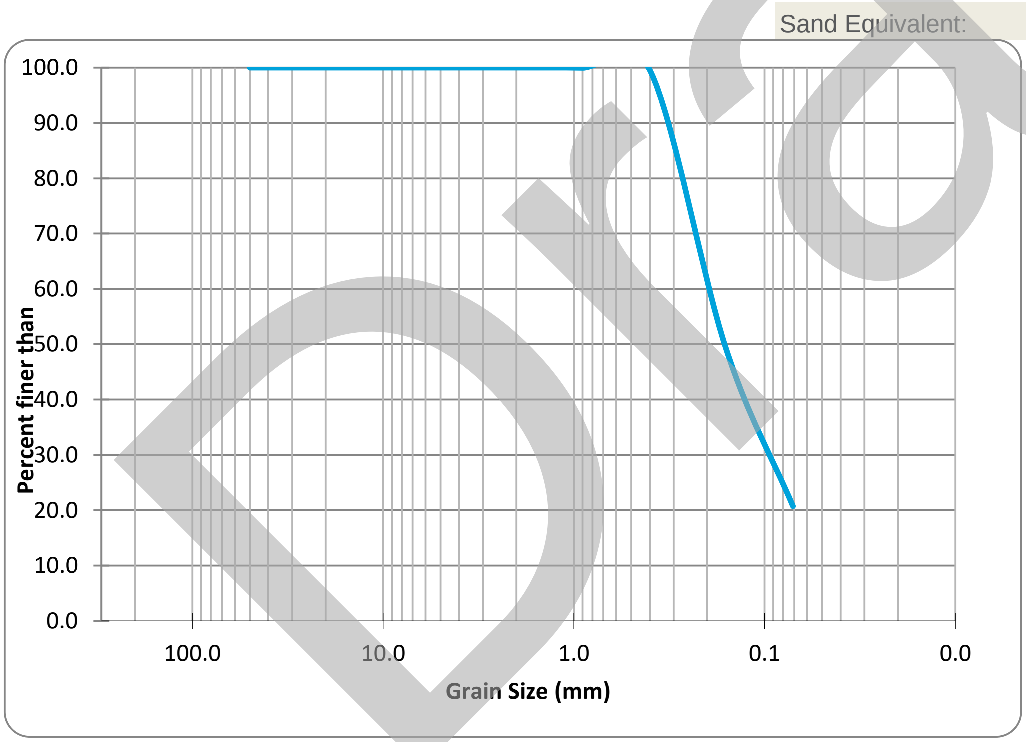
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-199 at 25ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	100.0			
0.400	99.6			
0.160	49.4			
0.071	20.7			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	17.6	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	79.3 %	20.7 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with some fines
Sampled from:
BH FHII-04

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 08-May-22

Geoscience & Materials

WASH SIEVE TEST REPORT

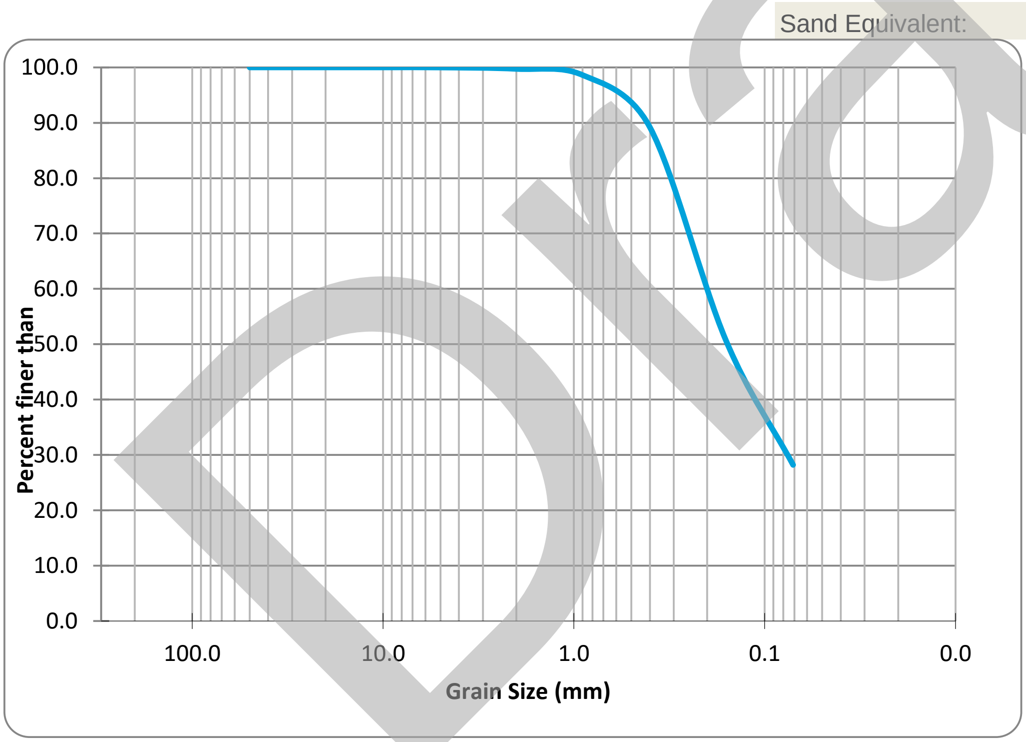
(Test Reference: ASTM C 136 and C 117)

Sample: NLB-205 at 37-38.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	99.7			
0.900	98.6			
0.400	89.2			
0.160	50.8			
0.071	28.2			

Other Properties

Properties	Results	Specification
Moisture Content:	15.5	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	71.8 %	28.2 %

Additional Sample Info.

Date Sampled:	-
Date Received:	-
Location:	-
Supplied by:	-
Sampled by:	NLB
Tested by:	GDK
Description:	Sand with fines
Sampled from:	BH FHII-4

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 16-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

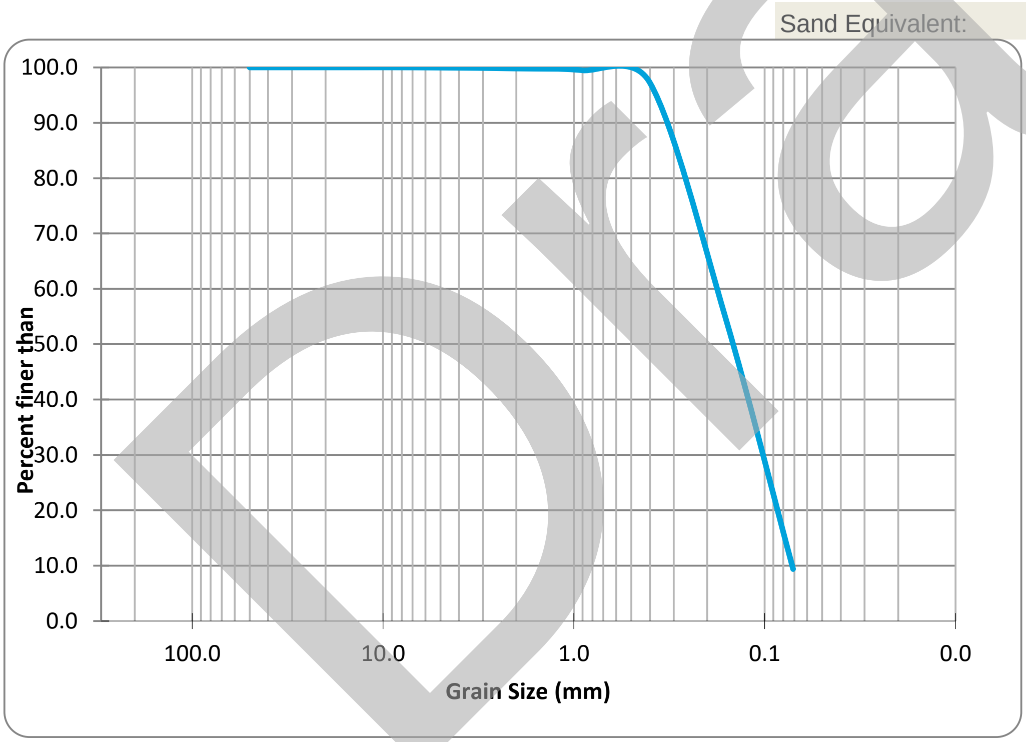
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-218 at 69.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	99.8			
0.900	99.5			
0.400	97.3			
0.160	54.6			
0.071	9.4			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	20.3	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	90.6 %	9.4 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand, trace fines
Sampled from:
BH FHII-4

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 16-Apr-22

Geoscience & Materials

WASH SIEVE TEST REPORT

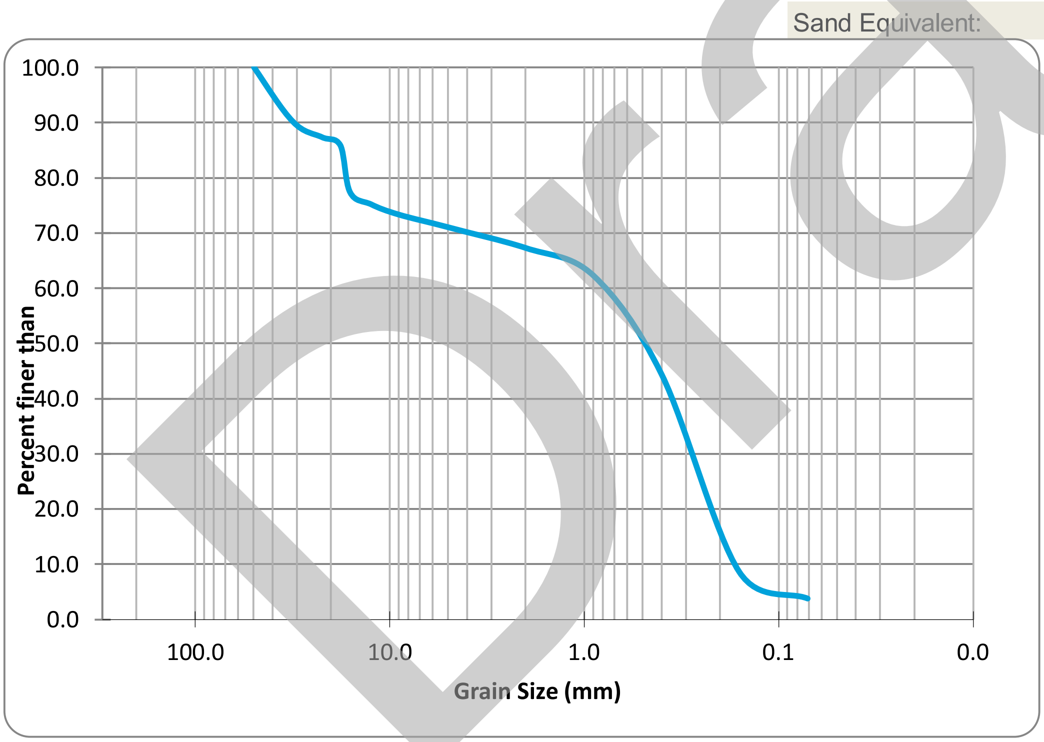
(Test Reference: ASTM C 136 and C 117)

Sample: NLB-241 at 29'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	90.2			
22.4	87.4			
18.0	85.9			
16.0	77.4			
12.5	75.2			
9.00	73.4			
5.00	71.1			
2.00	67.3			
0.900	62.3			
0.400	44.4			
0.160	8.7			
0.071	3.8			

Other Properties

Properties	Results	Specification
Moisture Content:	12.1	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.

Date Sampled:	-
Date Received:	-
Location:	-
Supplied by:	-
Sampled by:	NLB
Tested by:	DM
Description:	-
Sampled from:	BH FHII-5

COBBLES	GRAVEL	SAND	FINES
0.0 %	28.9 %	67.2 %	3.8 %

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 18-Apr-22

Geoscience & Materials

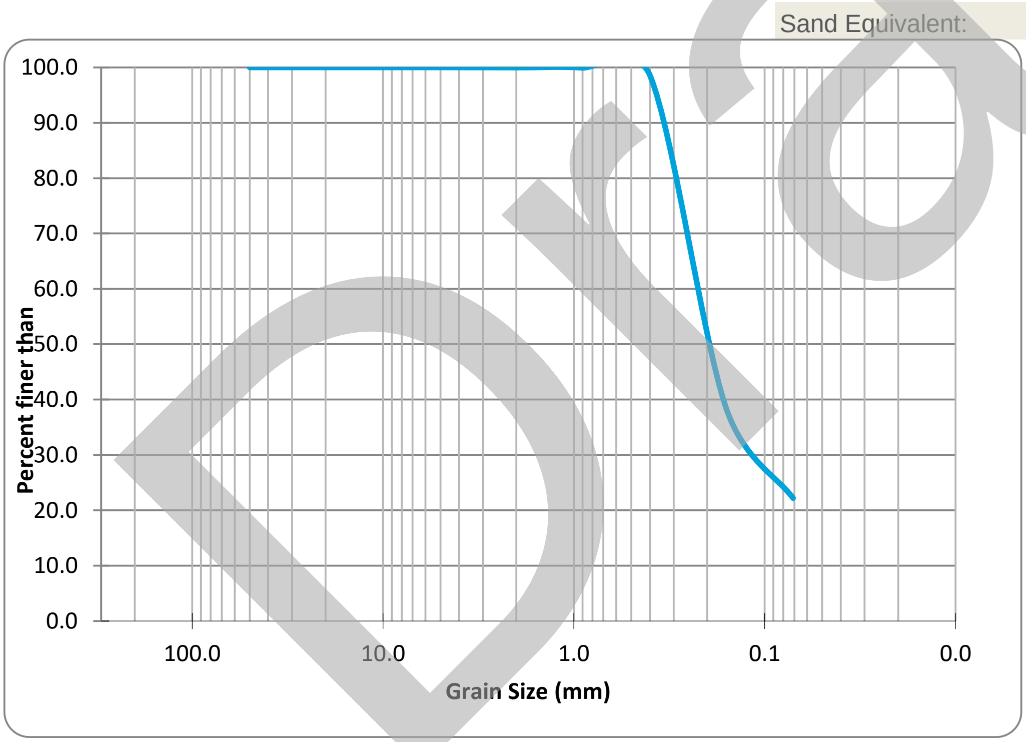
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-264 at 6ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.9			
0.400	98.6			
0.160	38.6			
0.071	22.2			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	10.5	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	77.8 %	22.2 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with fines
Sampled from:
BH FHII-02

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 07-May-22

Geoscience & Materials

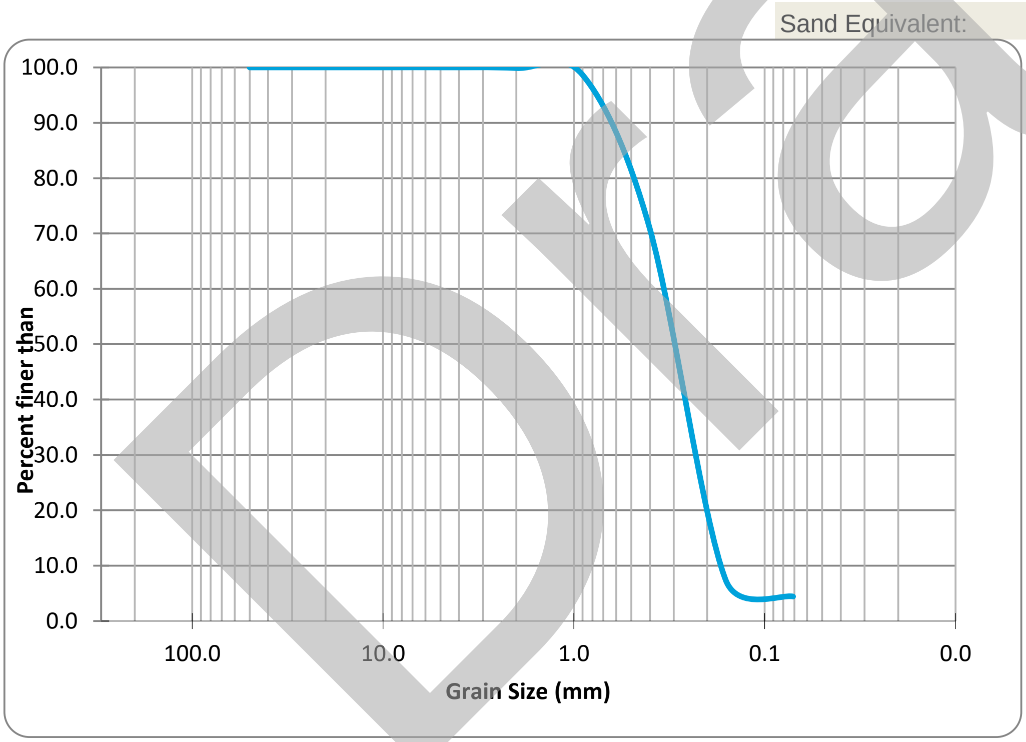
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-273 at 25.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	99.9			
0.900	98.6			
0.400	70.9			
0.160	7.4			
0.071	4.4			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	17.9	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	95.6 %	4.4 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand, trace fines
Sampled from:
BH FHII-02

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 08-May-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

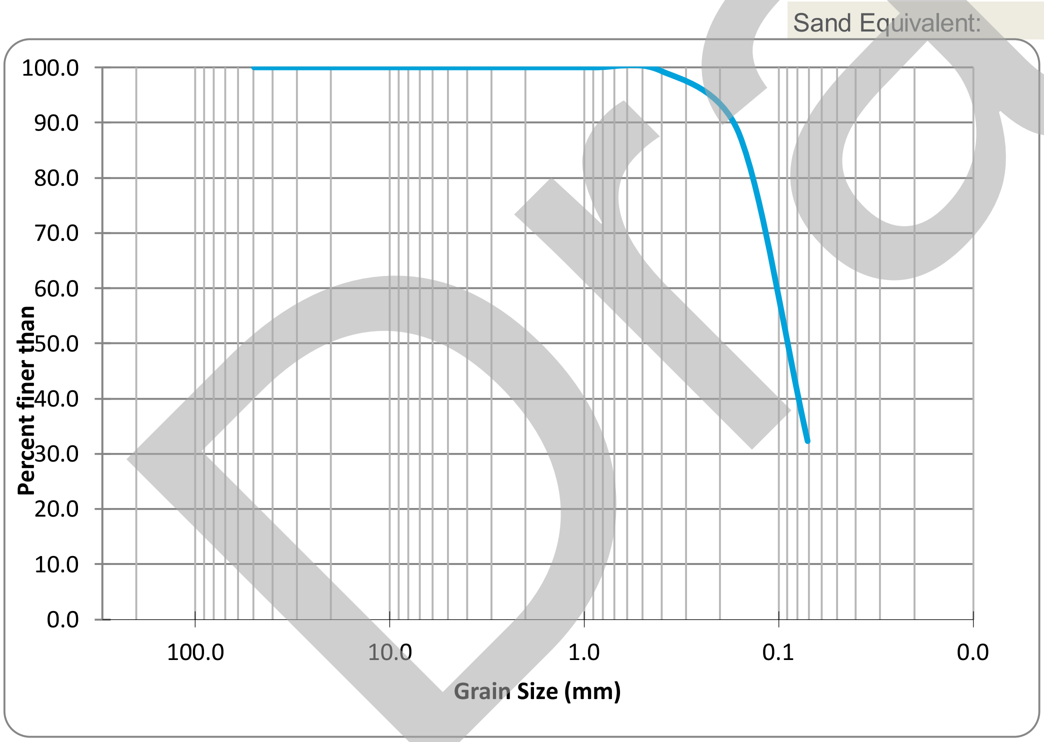
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-286 at 60'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	100.0			
0.400	99.4			
0.160	88.0			
0.071	32.4			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	20.1	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-2

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	67.6 %	32.4 %

Comments:

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 20-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

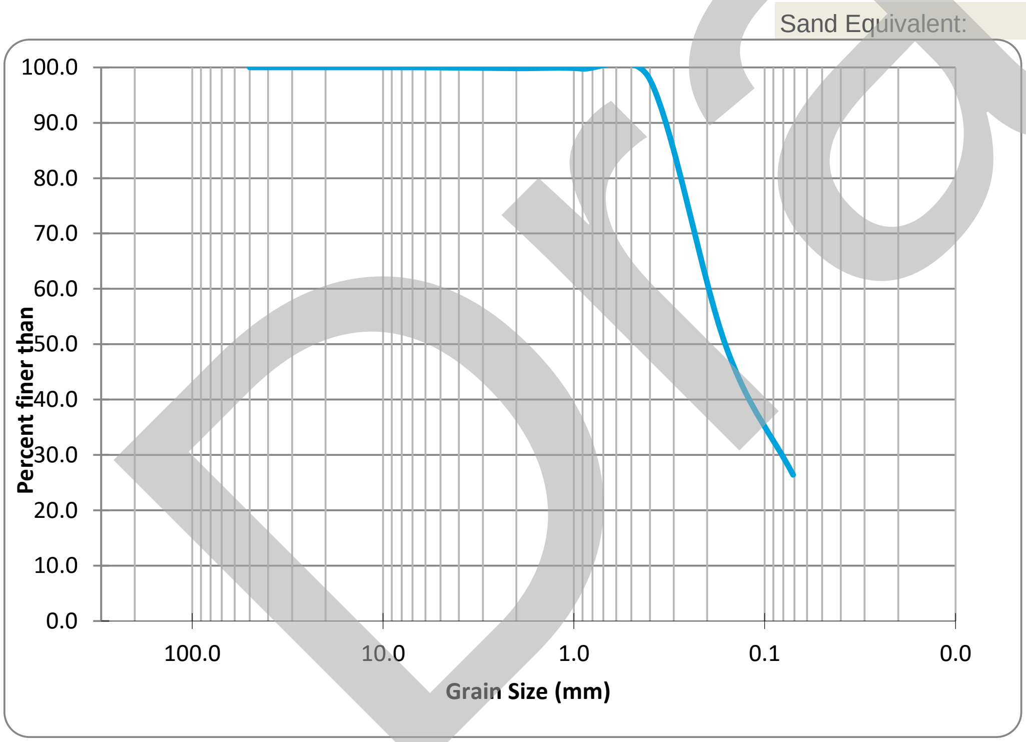
(Test Reference: ASTM C 136 and C 117)

Sample: NLB-323 at 64ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	99.8			
0.900	99.8			
0.400	97.8			
0.160	49.7			
0.071	26.4			

Other Properties

Properties	Results	Specification
Moisture Content:	16.4	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	73.6 %	26.4 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with fines
Sampled from:
BH FHII-6

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 16-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

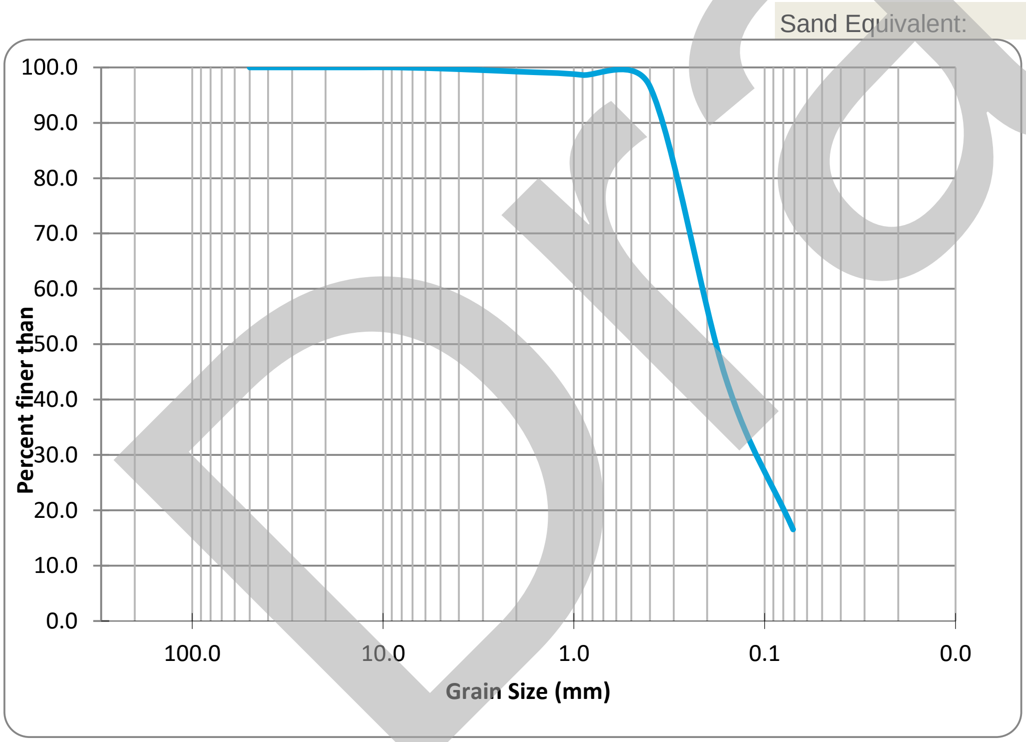
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-326 at 68-68.75ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	99.8			
2.00	99.2			
0.900	98.6			
0.400	96.6			
0.160	43.9			
0.071	16.5			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	20.3	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.2 %	83.3 %	16.5 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with some fines
Sampled from:
BH FHII-6

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 16-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

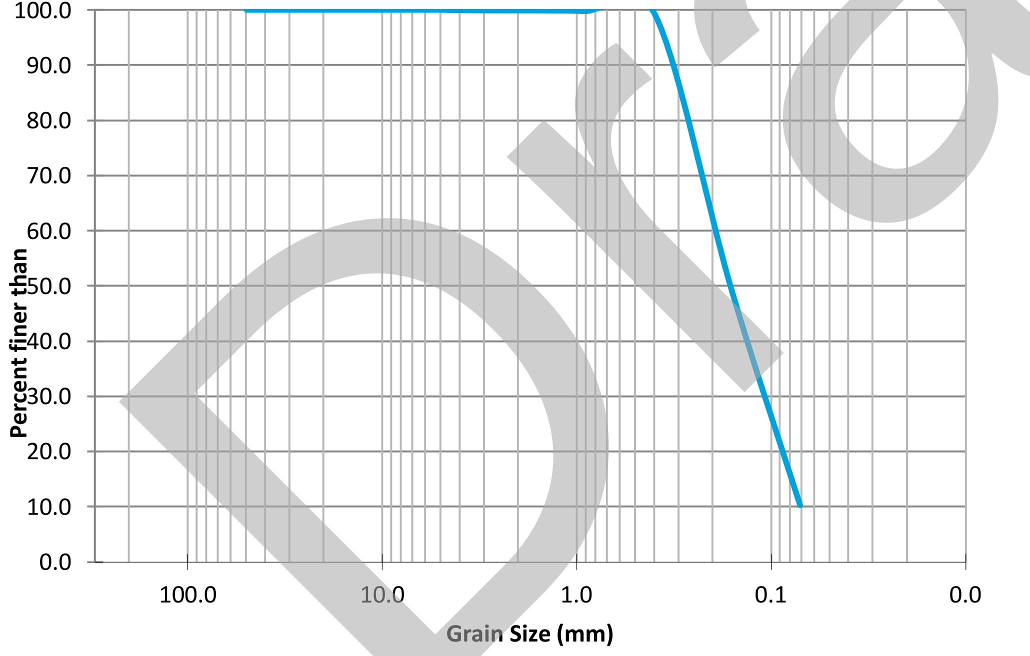
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-331 at 80'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	99.9			
0.900	99.9			
0.400	99.5			
0.160	49.3			
0.071	10.3			

Other Properties		
Properties	Results	Specification
Moisture Content:	20.1	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	89.7 %	10.3 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-6

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 18-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

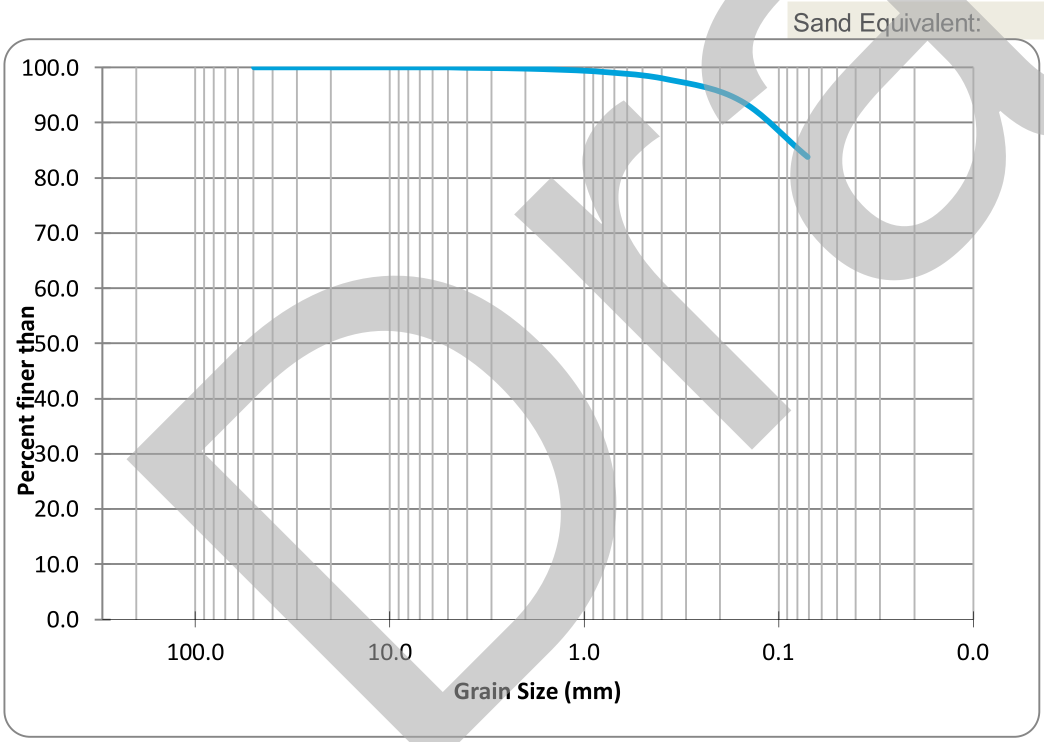
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-344 at 5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	99.9			
0.900	99.3			
0.400	98.0			
0.160	94.2			
0.071	83.8			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	14.3	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	16.2 %	83.8 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-9

Comments:

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 18-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

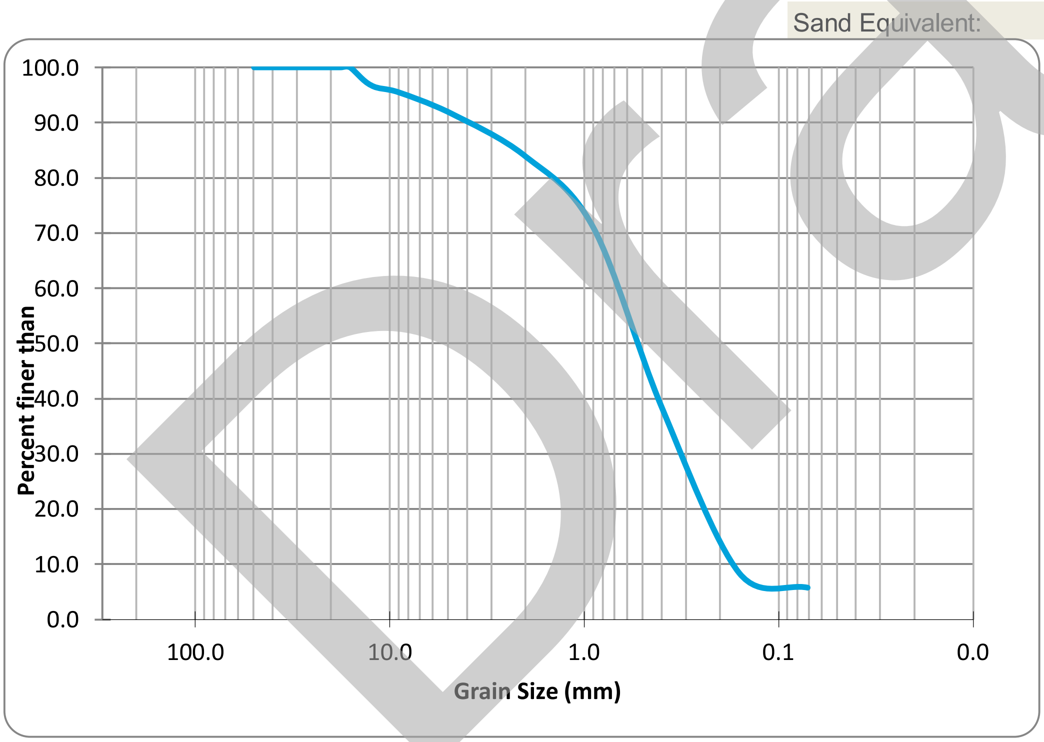
SNC·LAVALIN

Sample: NLB-351 at 19.5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	96.8			
9.00	95.5			
5.00	91.9			
2.00	84.0			
0.900	71.1			
0.400	38.5			
0.160	8.5			
0.071	5.7			

Other Properties

Properties	Results	Specification
Moisture Content:	12.6	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	8.1 %	86.2 %	5.7 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-9

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 18-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

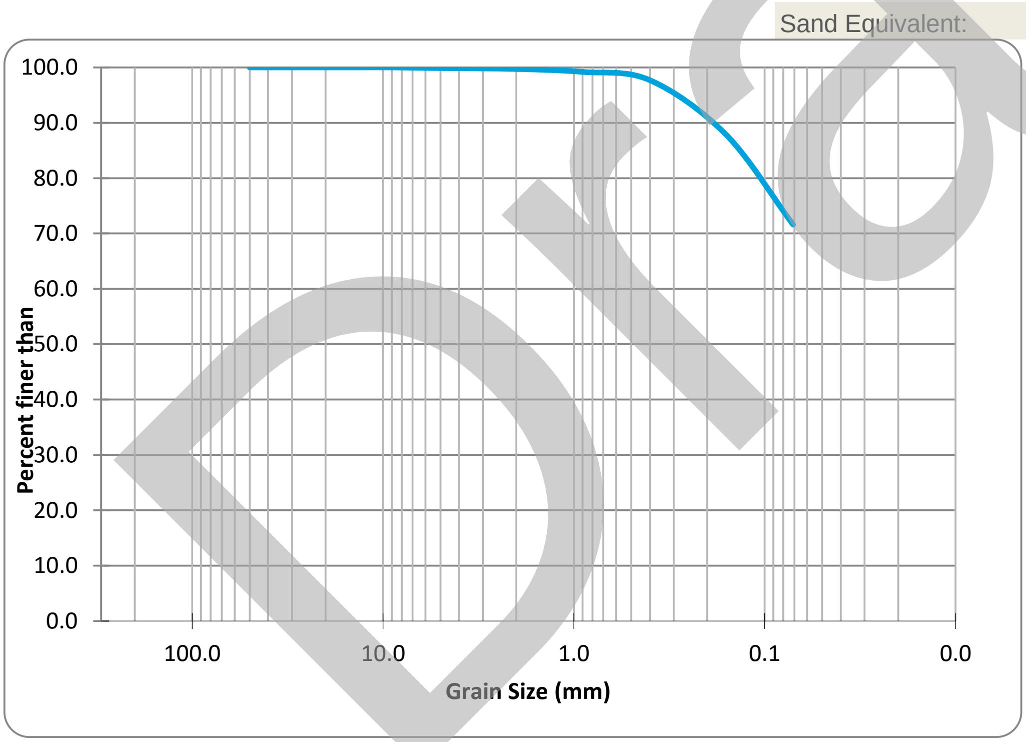
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-375 at 7ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	99.9			
2.00	99.7			
0.900	99.2			
0.400	97.7			
0.160	87.9			
0.071	71.6			

Other Properties		
Properties	Results	Specification
Moisture Content:	17.7	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.1 %	28.3 %	71.6 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
-
Sampled from:
BH FHII-10

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 16-Apr-22

Geoscience & Materials

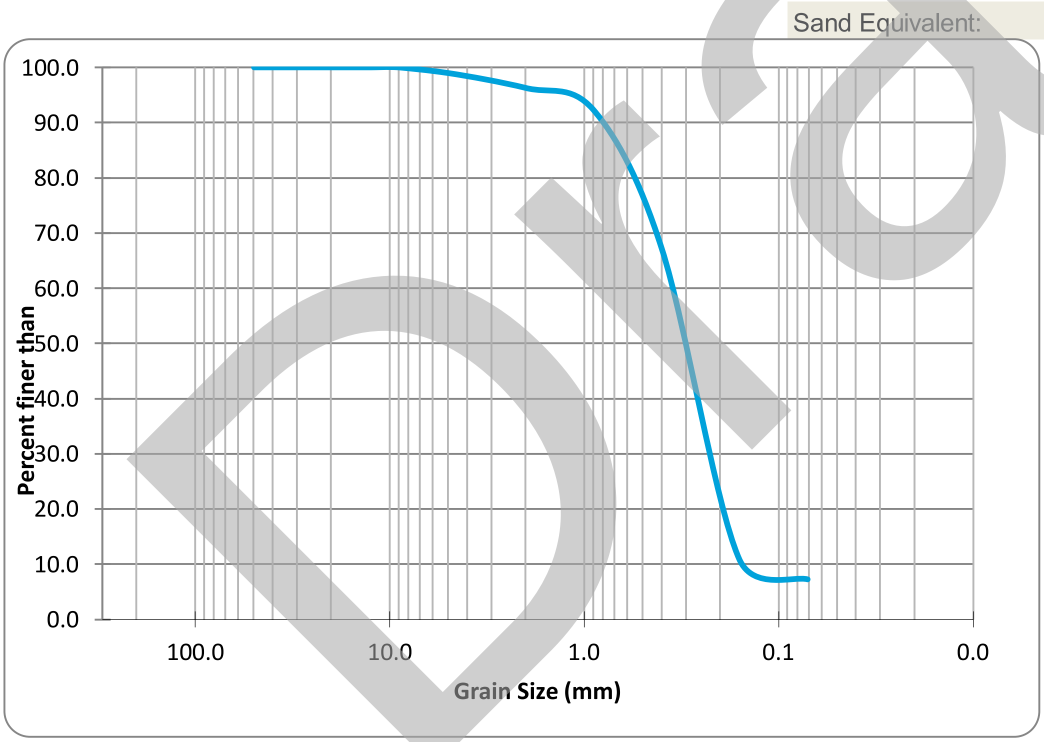
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-406 at 5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	99.0			
2.00	96.3			
0.900	92.3			
0.400	67.3			
0.160	11.0			
0.071	7.3			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	0.8	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	1.0 %	91.7 %	7.3 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-7

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 20-Apr-22

Geoscience & Materials

WASH SIEVE TEST REPORT

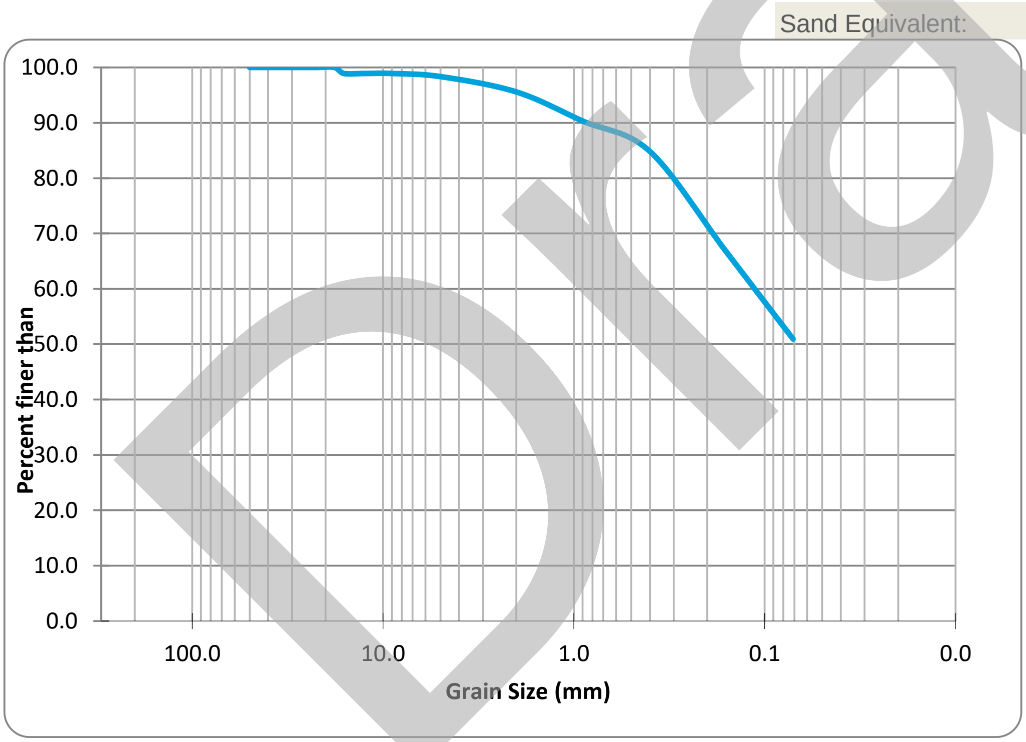
(Test Reference: ASTM C 136 and C 117)

CERTIFIED BY CCIL

Sample: NLB-434 at 2ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	98.9			
12.5	98.9			
9.00	98.9			
5.00	98.3			
2.00	95.6			
0.900	90.3			
0.400	84.8			
0.160	66.8			
0.071	50.9			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	4.8	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	1.7 %	47.4 %	50.9 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
-
Sampled from:
BH FHII-11

Comments:

Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	22-Apr-22

Geoscience & Materials

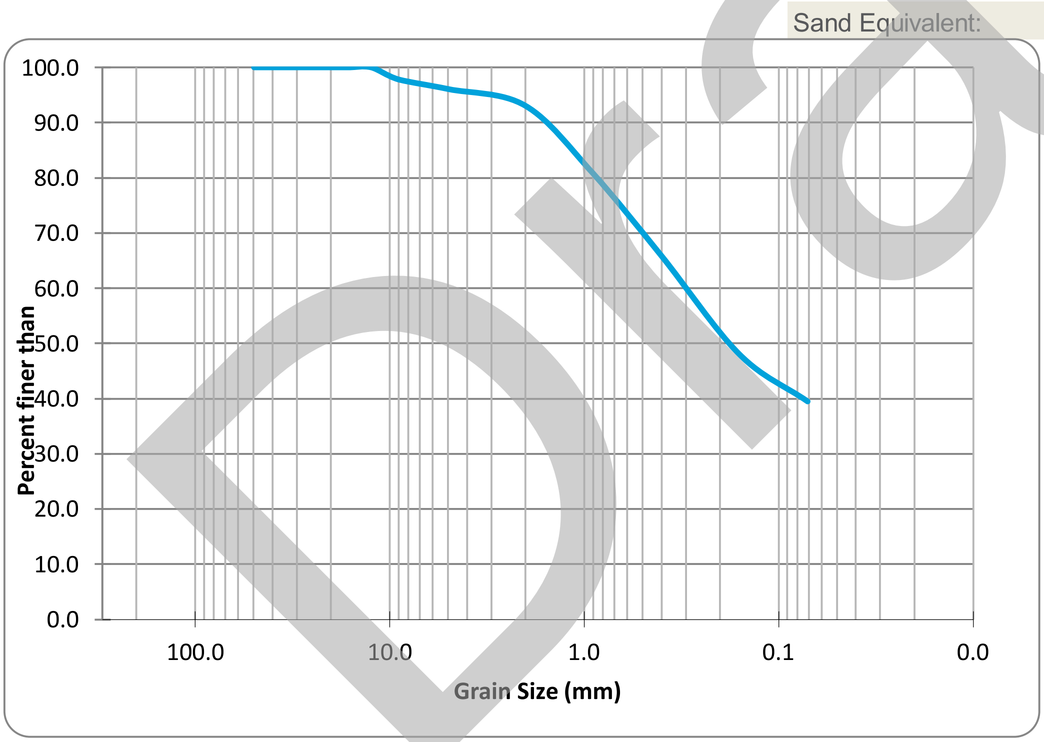
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-510 at 48-49.5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	97.9			
5.00	96.1			
2.00	93.0			
0.900	80.8			
0.400	65.8			
0.160	48.1			
0.071	39.6			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	19.1	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	3.9 %	56.6 %	39.6 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-8

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 18-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

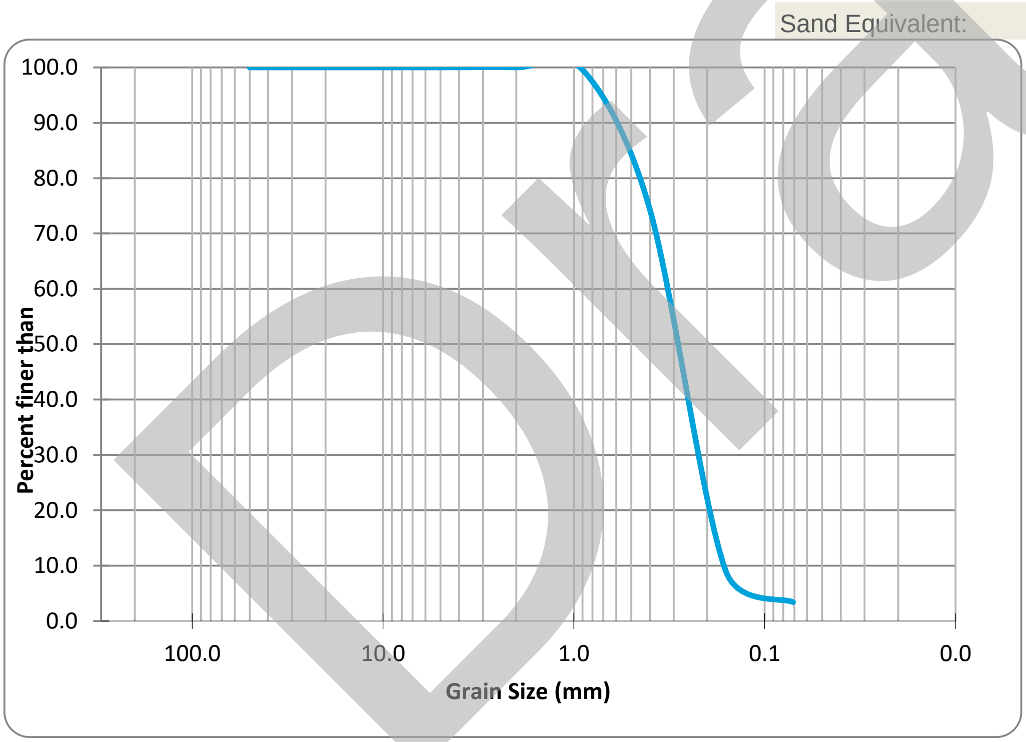
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample:	NLB-546 at 63-64.4ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.6			
0.400	74.4			
0.160	9.0			
0.071	3.4			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	18.5	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand, trace fines
Sampled from:
BH FHII12

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	96.6 %	3.4 %

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 16-Apr-22

Geoscience & Materials

WASH SIEVE TEST REPORT

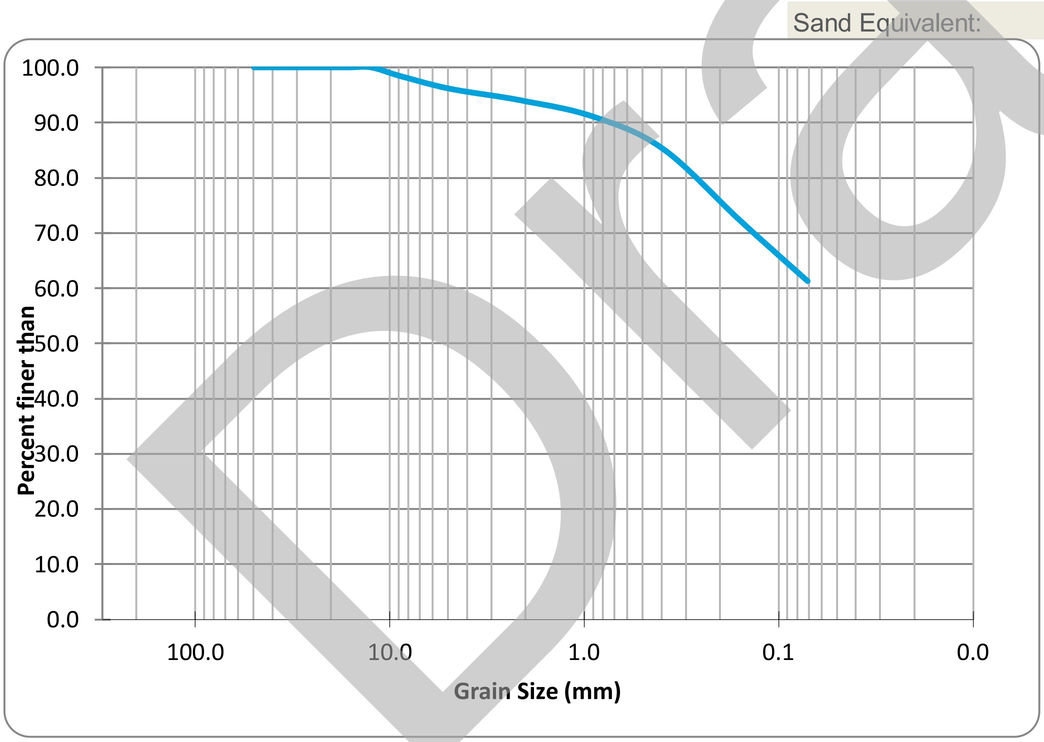
(Test Reference: ASTM C 136 and C 117)

Sample: NLB-555 at 6'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	98.6			
5.00	96.2			
2.00	93.9			
0.900	91.1			
0.400	85.5			
0.160	72.4			
0.071	61.3			

Other Properties

Properties	**Results**	**Specification**
Moisture Content:	7.9	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	3.8 %	35.0 %	61.3 %

Additional Sample Info.

Date Sampled:	-
Date Received:	-
Location:	-
Supplied by:	-
Sampled by:	NLB
Tested by:	DM
Description:	-
Sampled from:	BH FHII-14

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 19-Apr-22

Geoscience & Materials

WASH SIEVE TEST REPORT

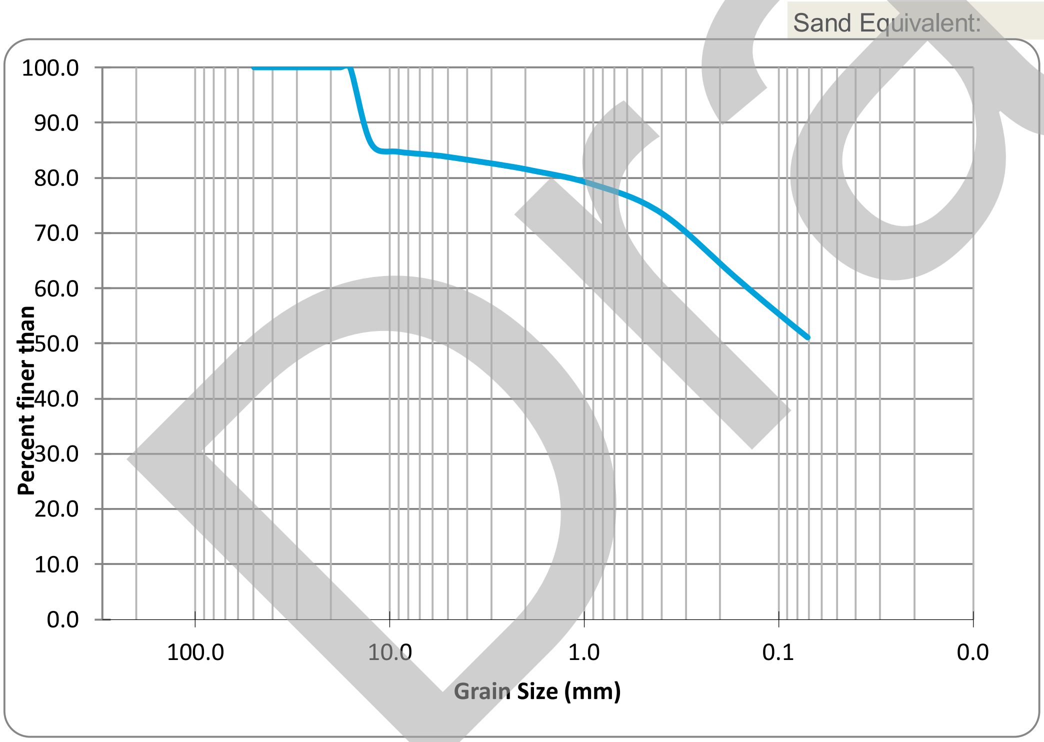
(Test Reference: ASTM C 136 and C 117)

Sample: NLB-582 at 1'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	86.3			
9.00	84.8			
5.00	83.8			
2.00	81.6			
0.900	78.8			
0.400	73.6			
0.160	61.4			
0.071	51.1			

Other Properties

Properties	Results	Specification
Moisture Content:	7.4	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.

Date Sampled:	-
Date Received:	-
Location:	-
Supplied by:	-
Sampled by:	NLB
Tested by:	DM
Description:	-
Sampled from:	BH FHII-19

COBBLES	GRAVEL	SAND	FINES
0.0 %	16.2 %	32.7 %	51.1 %

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 19-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

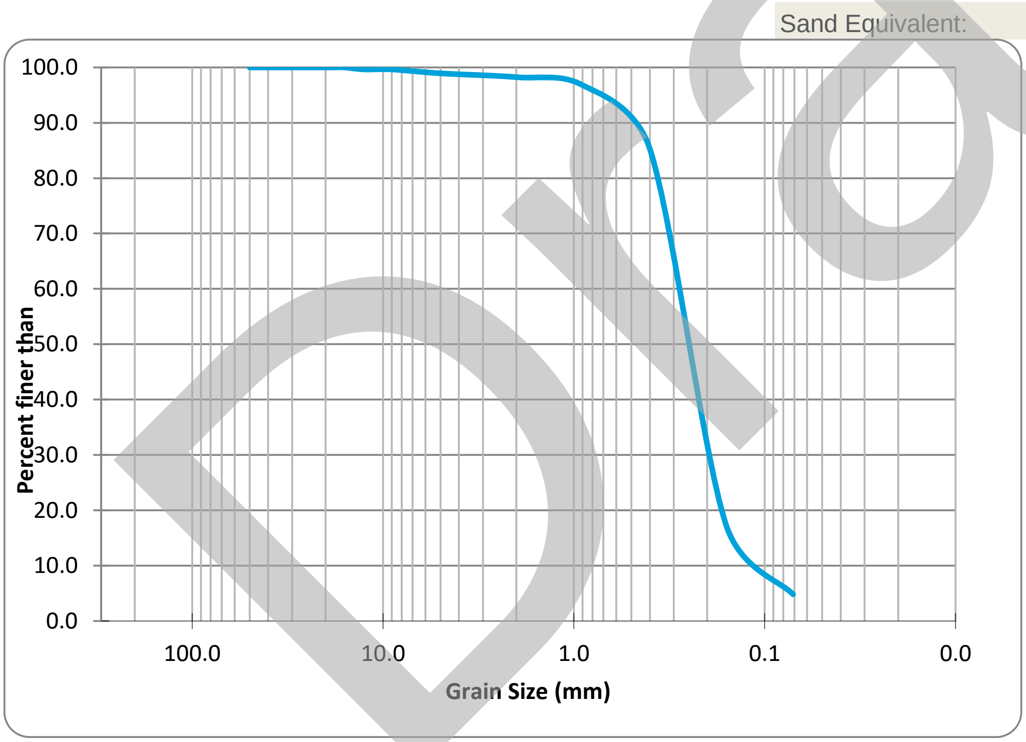
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-648 at 67ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	99.6			
9.00	99.6			
5.00	98.9			
2.00	98.2			
0.900	96.8			
0.400	85.3			
0.160	17.5			
0.071	4.8			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	19.1	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	1.1 %	94.1 %	4.8 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand, trace fines, gravel
Sampled from:
BH FHII-13

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 22-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

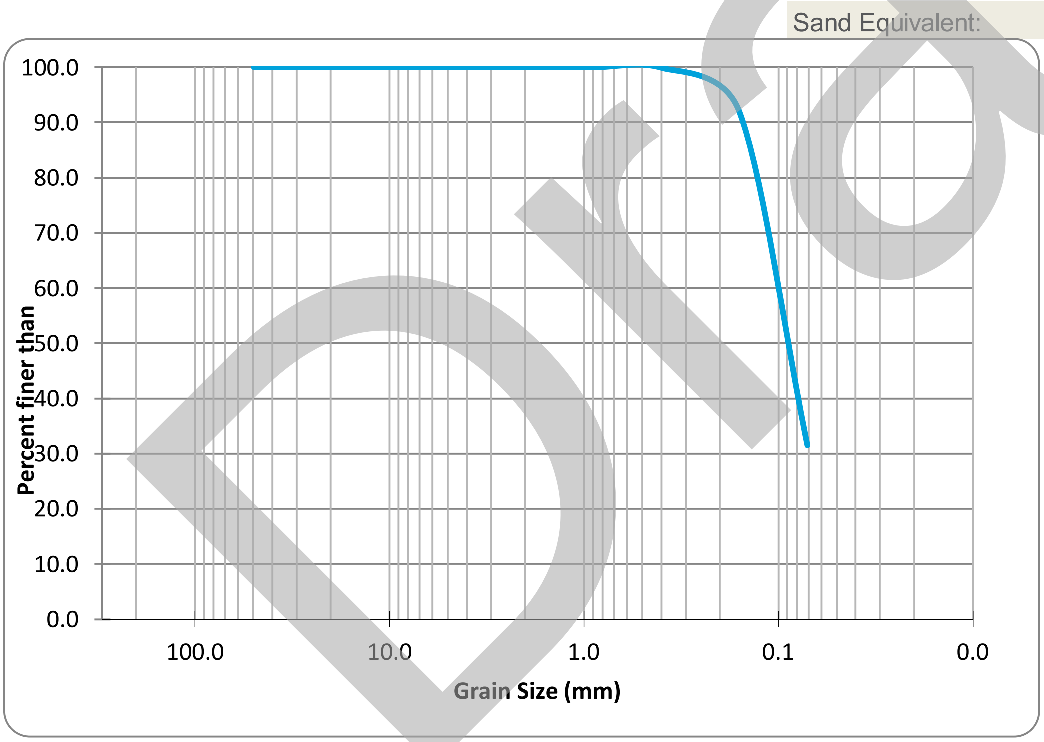
SNC·LAVALIN

Sample: NLB-655 at 5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	100.0			
0.400	99.9			
0.160	92.2			
0.071	31.5			

Other Properties

Properties	Results	Specification
Moisture Content:	11.6	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	68.5 %	31.5 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-21

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 19-Apr-22

Geoscience & Materials

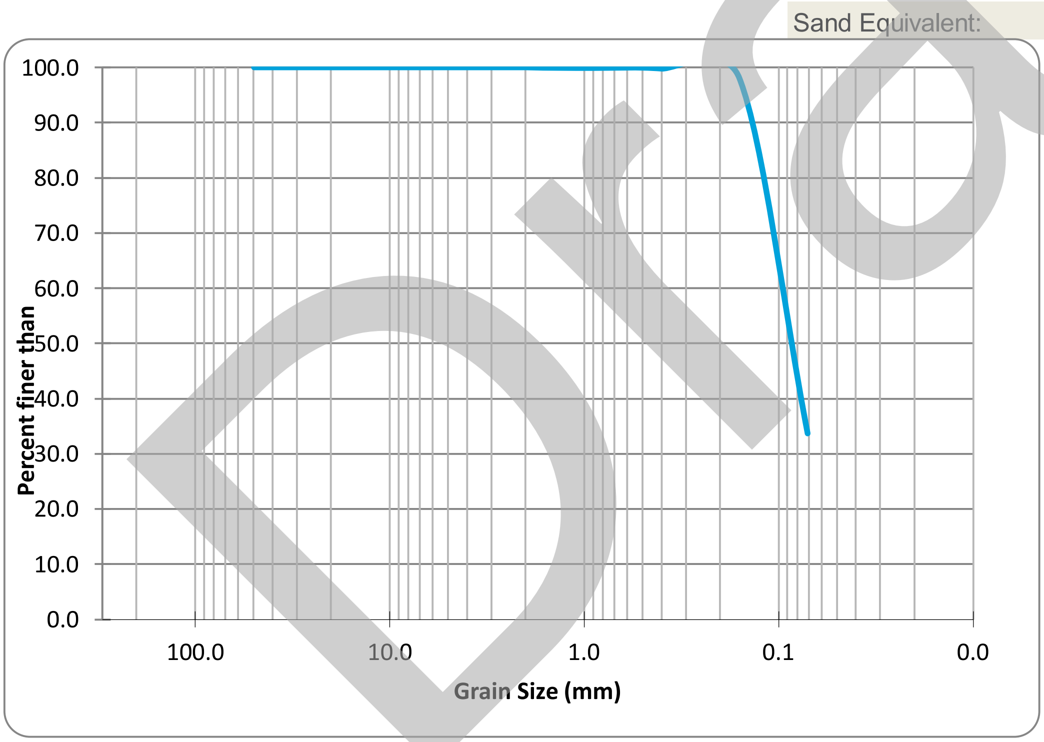
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-675 at 53'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.9			
0.400	99.8			
0.160	98.2			
0.071	33.7			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	24.4	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-21

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	66.3 %	33.7 %

Comments:

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 19-Apr-22

Geoscience & Materials

WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

CERTIFIED BY CCIL

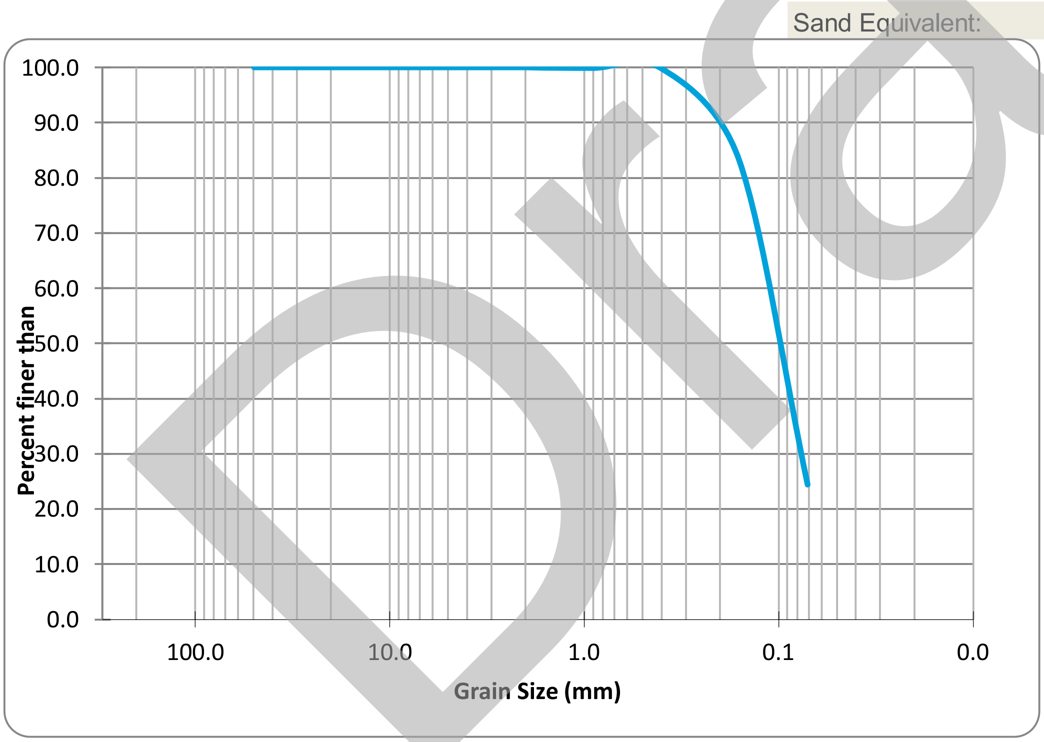
SNC·LAVALIN

Sample: NLB-694 at 3-4'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.9			
0.400	99.8			
0.160	83.2			
0.071	24.5			

Other Properties

Properties	Results	Specification
Moisture Content:	16.5	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-22

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	75.5 %	24.5 %

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 20-Apr-22

Geoscience & Materials

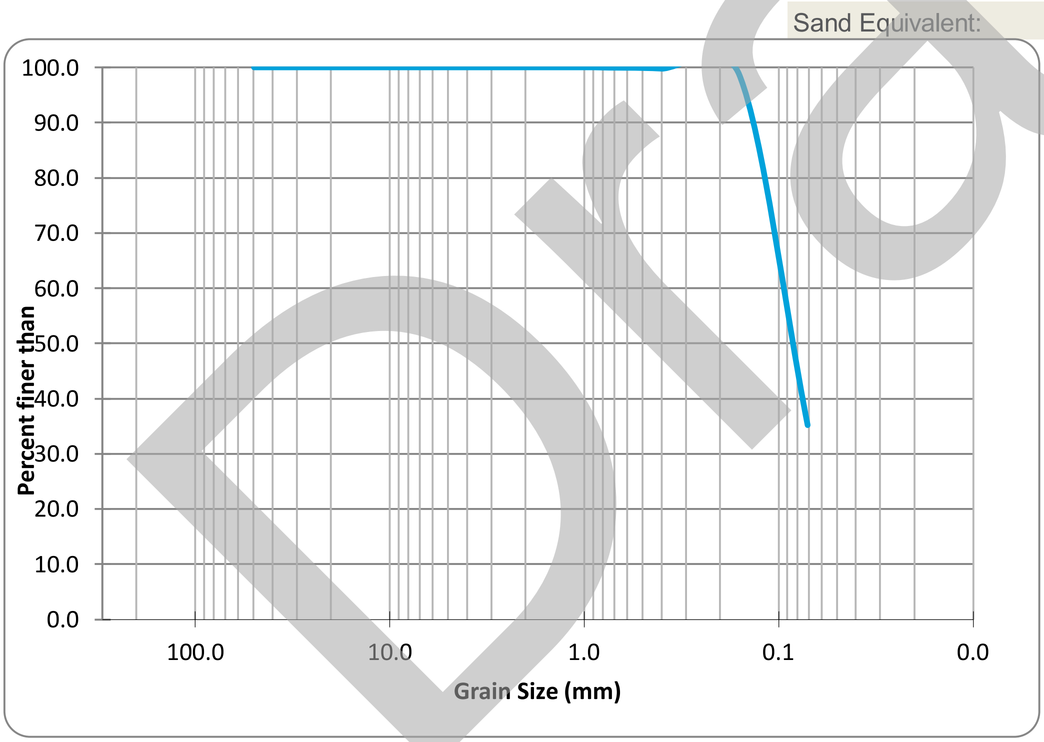
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-697 at 11'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	100.0			
0.400	99.8			
0.160	98.7			
0.071	35.3			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	29.7	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	64.7 %	35.3 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-22

Comments:

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 20-Apr-22

Geoscience & Materials

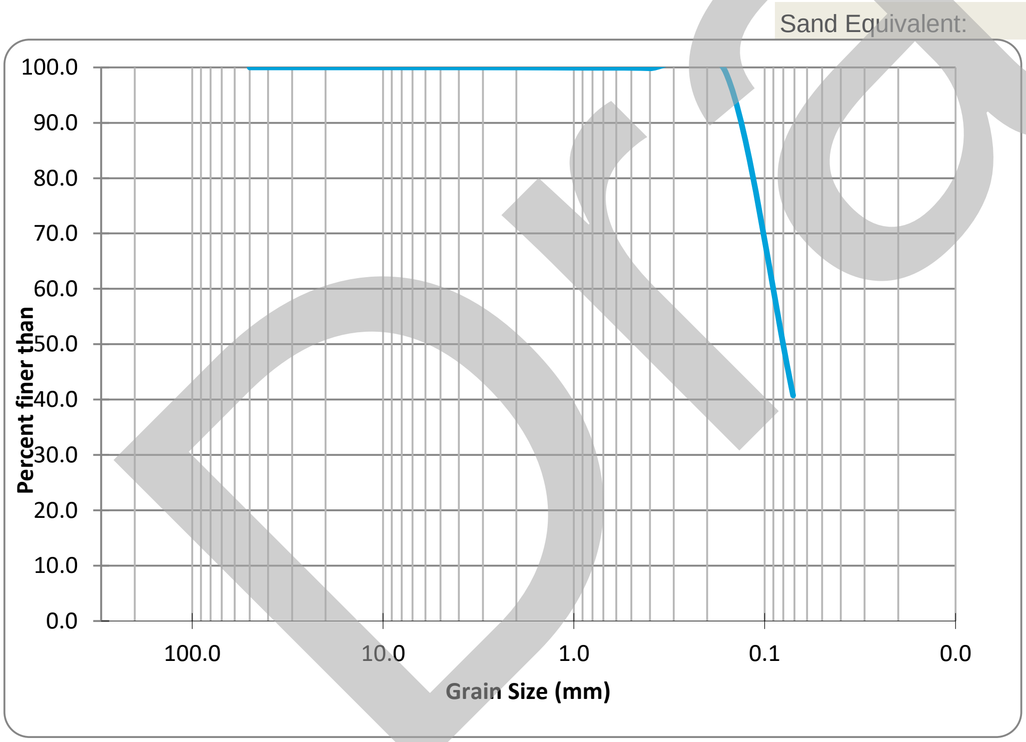
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-745 at 7ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.9			
0.400	99.9			
0.160	99.1			
0.071	40.7			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	6.2	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
Sand with fines
Sampled from:
BH FHII-20

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	59.3 %	40.7 %

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 07-May-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

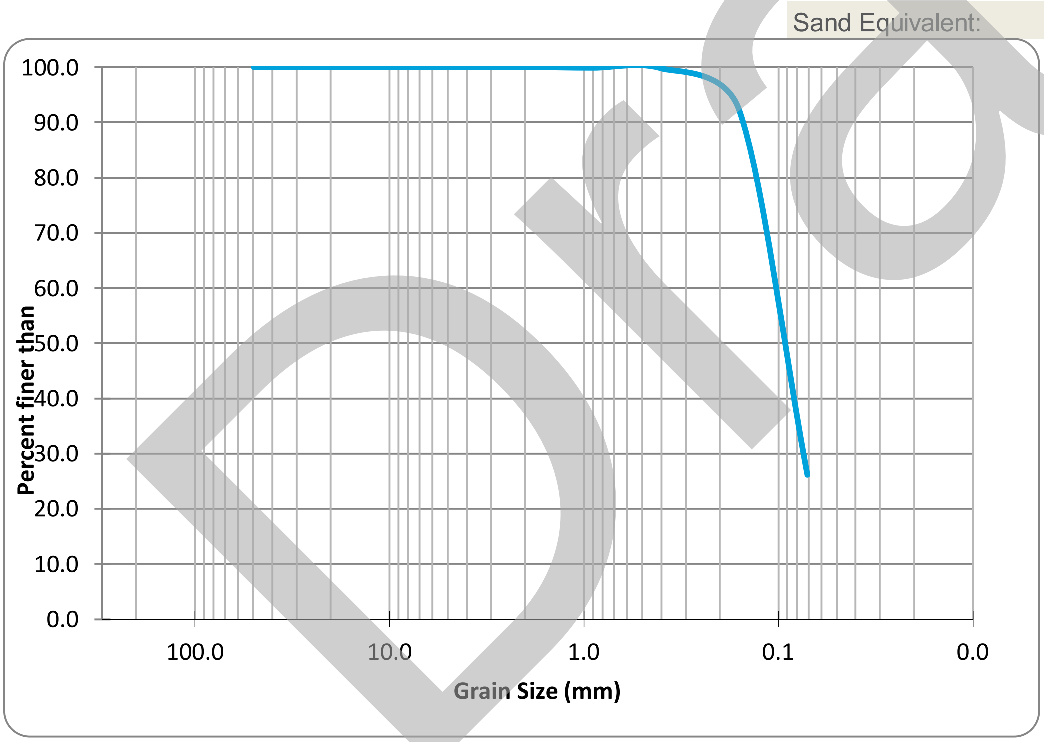
(Test Reference: ASTM C 136 and C 117)

SNC • LAVALIN

Sample: NLB-796 at 5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	100.0			
0.400	99.8			
0.160	92.3			
0.071	26.1			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	13.1	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.

Date Sampled:
-

Date Received:
-

Location:
-

Supplied by:
-

Sampled by:
NLB

Tested by:
DM

Description:
-

Sampled from:
BH FHII-24

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	73.9 %	26.1 %

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 20-Apr-22

Geoscience & Materials

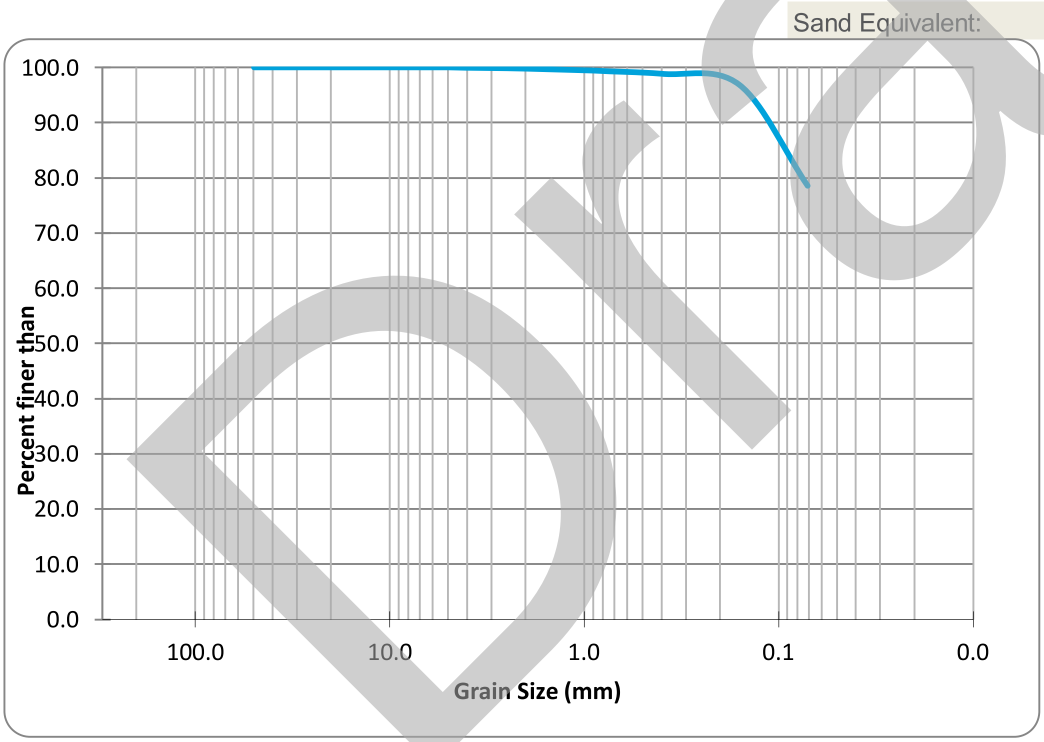
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-801 at 18-19.5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	99.8			
0.900	99.5			
0.400	98.8			
0.160	97.0			
0.071	78.6			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	32.2	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	21.4 %	78.6 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-24

Comments:

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	20-Apr-22

Geoscience & Materials

CERTIFIED BY CCIL

WASH SIEVE TEST REPORT

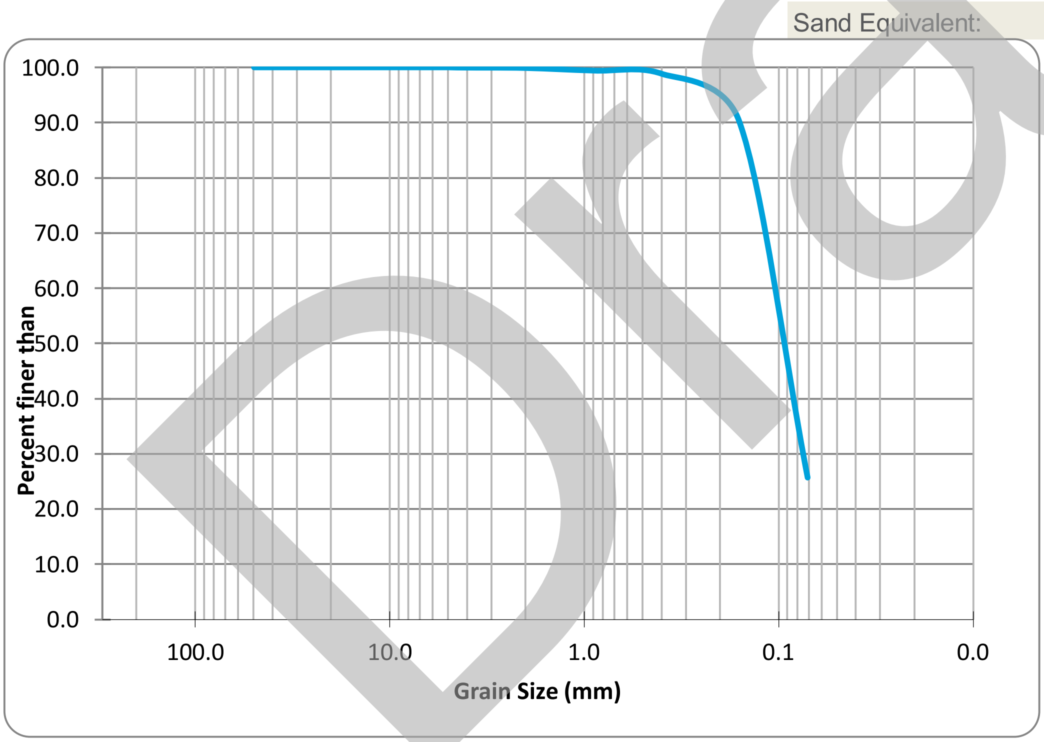
(Test Reference: ASTM C 136 and C 117)

SNC·LAVALIN

Sample: NLB-830 at 3-4.2'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	99.9			
0.900	99.5			
0.400	98.9			
0.160	90.3			
0.071	25.7			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	5.8	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-23

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	74.3 %	25.7 %

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 20-Apr-22

Geoscience & Materials

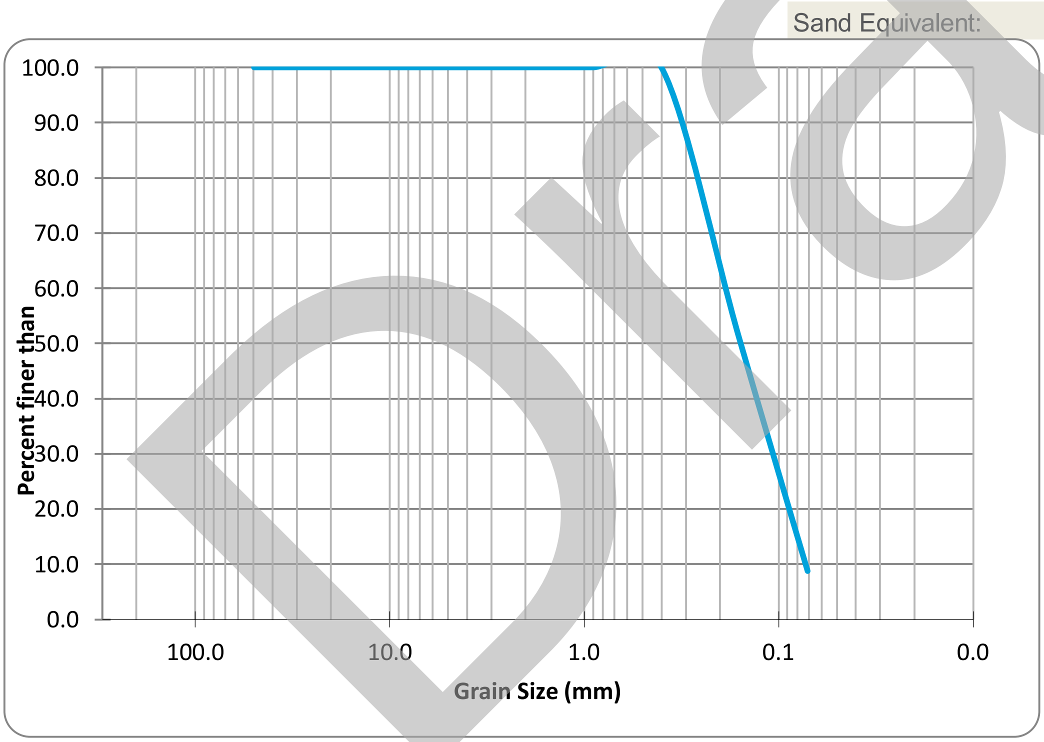
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-836 at 16'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	100.0			
0.400	100.0			
0.160	51.0			
0.071	8.8			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	26.1	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	91.2 %	8.8 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-23

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 20-Apr-22

Geoscience & Materials

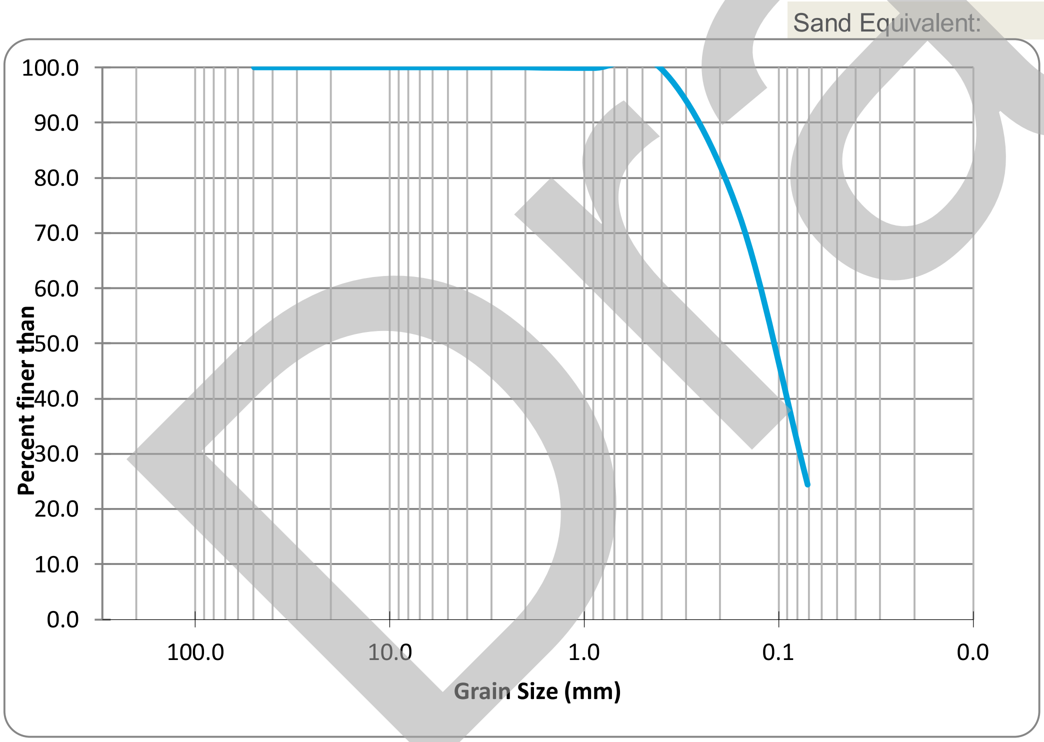
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-846 at 43-44.5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.9			
0.400	99.7			
0.160	73.4			
0.071	24.5			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	20.4	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	75.5 %	24.5 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-23

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 20-Apr-22

Geoscience & Materials

WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

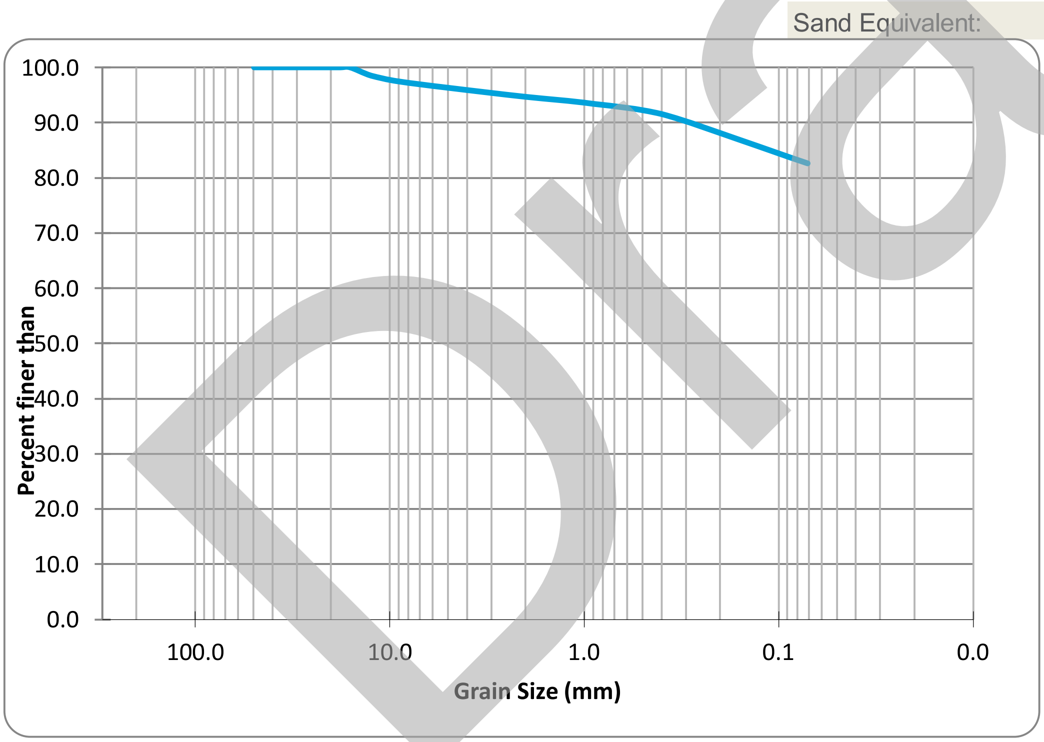
SNC·LAVALIN

Sample: NLB-873 at 3'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	98.6			
9.00	97.5			
5.00	96.3			
2.00	94.7			
0.900	93.5			
0.400	91.6			
0.160	87.0			
0.071	82.7			

Other Properties

Properties	Results	Specification
Moisture Content:	16.0	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	3.7 %	13.6 %	82.7 %

Additional Sample Info.

Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-16

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 19-Apr-22

Geoscience & Materials

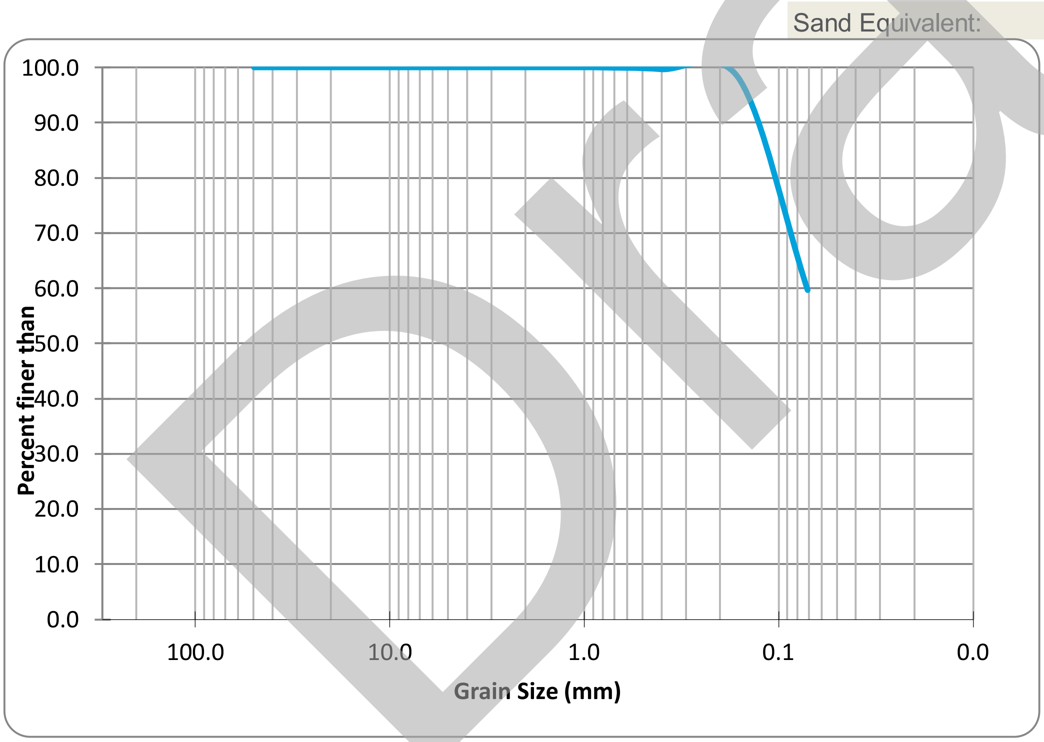
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-906 at 2.5'

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	100.0			
0.400	99.7			
0.160	98.0			
0.071	59.7			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	10.7	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
DM
Description:
-
Sampled from:
BH FHII-18

COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	40.3 %	59.7 %

Comments:

Checker:

Reviewer:

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The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 19-Apr-22

Geoscience & Materials

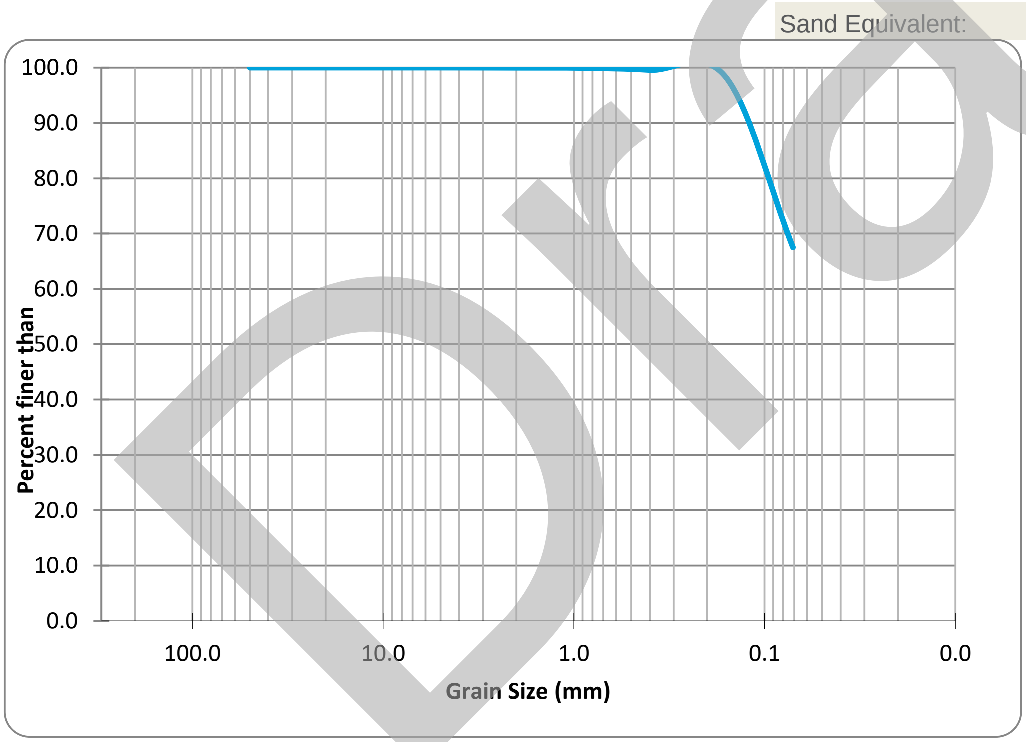
WASH SIEVE TEST REPORT

(Test Reference: ASTM C 136 and C 117)

Sample: NLB-941 at 1.5ft

Sieve Analysis (mm)		Specifications (mm)		
Sieve	% Finer	Sieve	Min	Max
50.0	100.0			
31.5	100.0			
22.4	100.0			
18.0	100.0			
16.0	100.0			
12.5	100.0			
9.00	100.0			
5.00	100.0			
2.00	100.0			
0.900	99.9			
0.400	99.6			
0.160	98.3			
0.071	67.5			

Other Properties		
Properties	**Results**	**Specification**
Moisture Content:	15.1	
Lightweights:	-	
Percent Fracture:	-	
Plasticity Index:	-	
Fineness Modulus:	-	
Soundness:	-	
LA Abrasion:	-	
Micro Deval:	-	
Freeze/Thaw:	-	
Clay Lumps:	-	
Flat & Elongated:	-	
Relative Density:	-	
Absorption:	-	
Unit Weight:	-	
Sand Equivalent:	-	



COBBLES	GRAVEL	SAND	FINES
0.0 %	0.0 %	32.5 %	67.5 %

Additional Sample Info.
Date Sampled:
-
Date Received:
-
Location:
-
Supplied by:
-
Sampled by:
NLB
Tested by:
GDK
Description:
-
Sampled from:
BH FHII-17

Comments:

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 16-Apr-22

Geoscience & Materials

Appendix VII (D)

Hydrometer and Sieve Test

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-1003 BH1 at 3-3.45m

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Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	98
#10	2.00	93
#20	0.850	89
#40	0.425	83
#60	0.250	75
#100	0.150	66
#200	0.075	54

Hydrometer Analysis

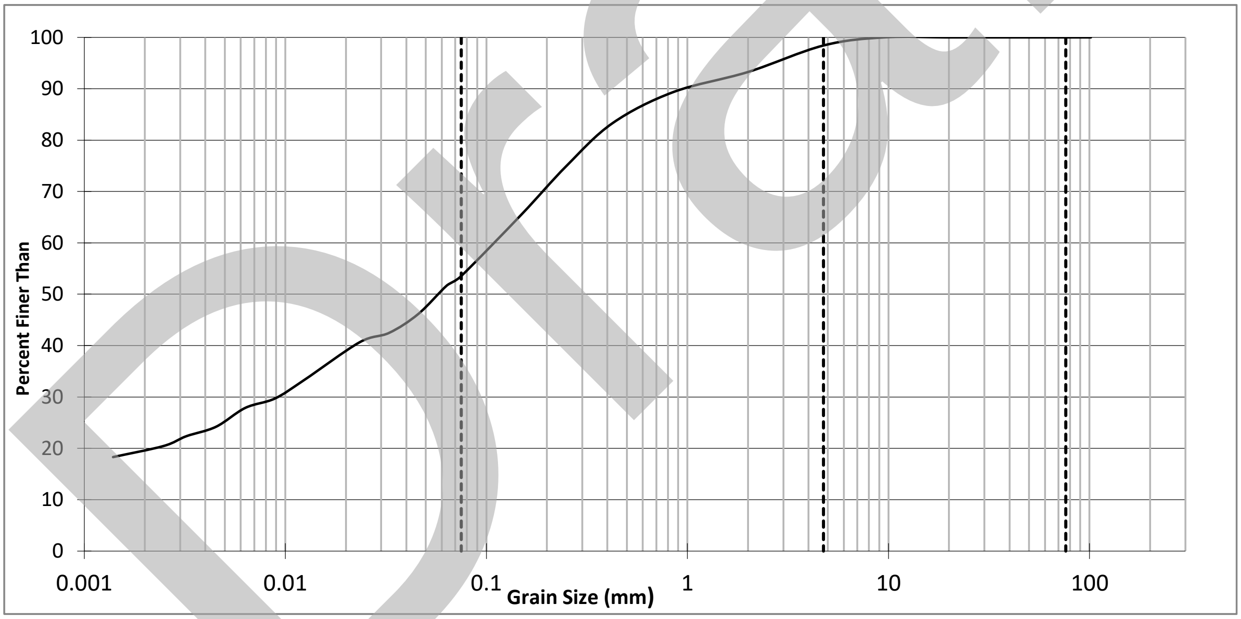
Dia. (mm)	% Finer
0.0634	51.7
0.0458	46.2
0.0329	42.5
0.0234	40.6
0.0124	33.3
0.0089	29.7
0.0063	27.9
0.0045	24.2
0.0032	22.4
0.0025	20.5
0.0014	18.3

Summary of Analysis

Particle Size Distribution Summary

% Cobble	0.0
% Gravel	1.6
% Sand	44.9
% Silt Size (<75µ>2µ)	34.0
% Clay Size (<2µ)	19.5

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 53.5 %	SAND 44.9 %	GRAVEL 1.6 %	COBBLE 0.0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 3/11/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-1005 BH1 at 4.5-4.95m

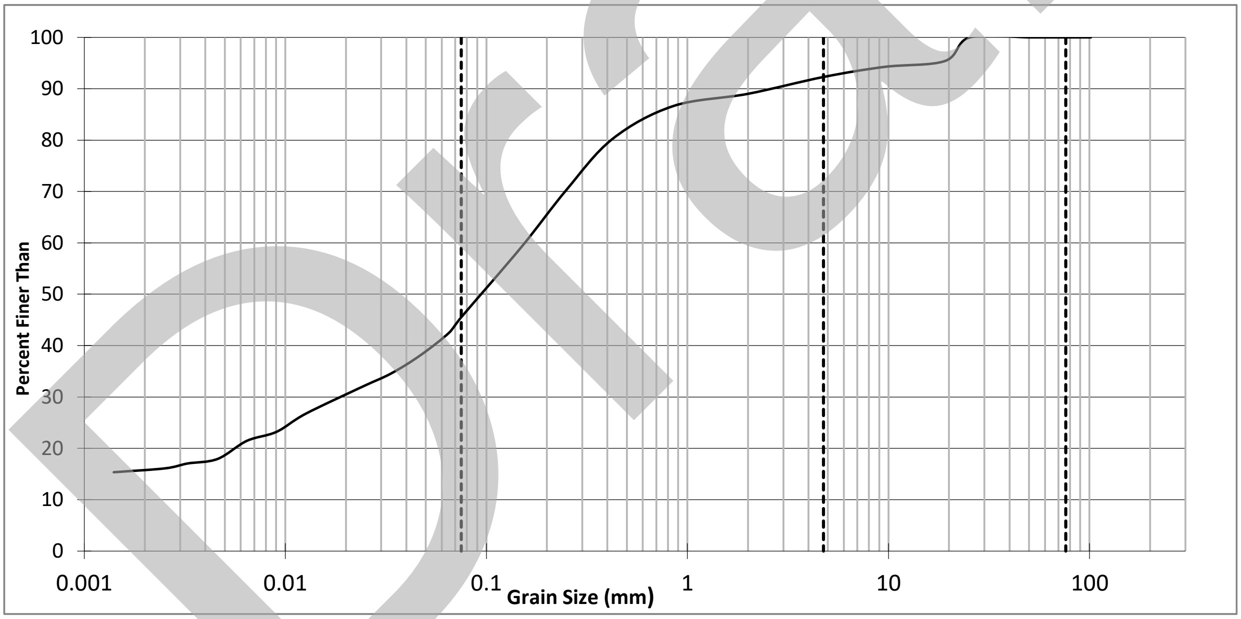
Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	95
3/8"	9.50	94
#4	4.75	92
#10	2.00	89
#20	0.850	87
#40	0.425	80
#60	0.250	70
#100	0.150	59
#200	0.075	46

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0653	42.5
0.0470	38.1
0.0337	34.6
0.0240	32.0
0.0126	26.7
0.0090	23.2
0.0064	21.5
0.0046	17.9
0.0033	17.1
0.0025	16.1
0.0014	15.4

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	7.7
% Sand	46.8
% Silt Size (<75µ>2µ)	29.8
% Clay Size (<2µ)	15.7

Dispersing Agent used:
Sodium Hexametaphosphate

Small sample size - may not be representative



FINES (silt, clay) 45.5 %	SAND 46.8 %	GRAVEL 7.7 %	COBBLE 0.0 %

Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional
Project #:	659183
Date:	3/11/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-1006 BH1 at 4.5 - 6m

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	90
3/8"	9.50	90
#4	4.75	90
#10	2.00	87
#20	0.850	83
#40	0.425	76
#60	0.250	67
#100	0.150	57
#200	0.075	44

Hydrometer Analysis

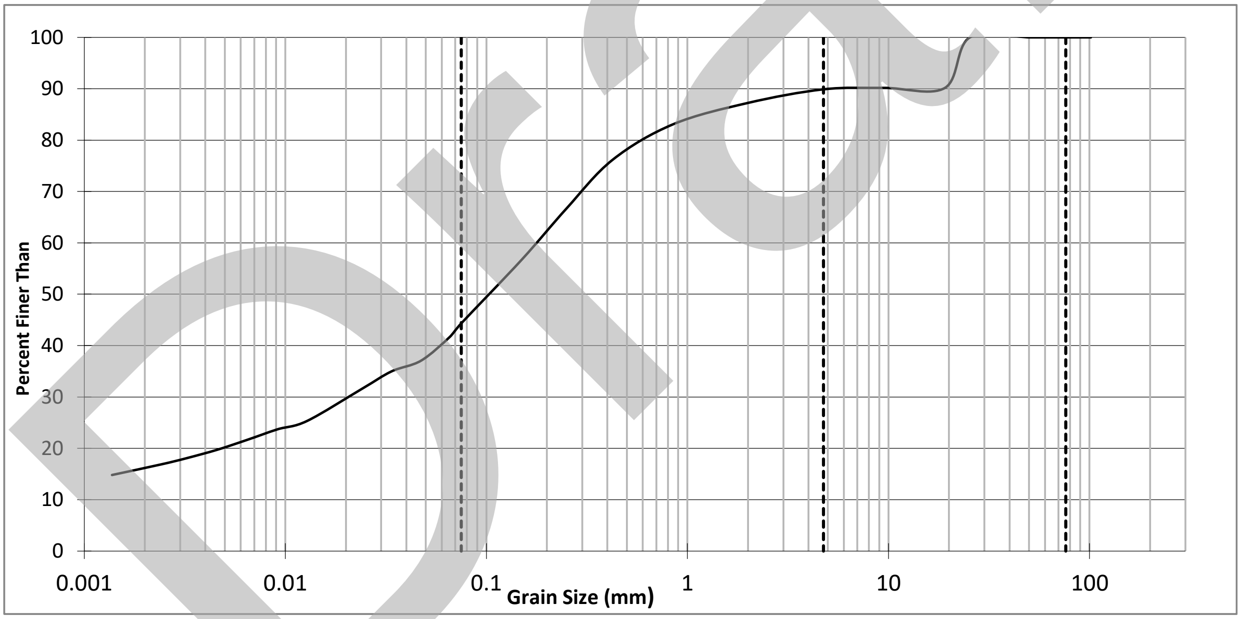
Dia. (mm)	% Finer
0.0657	41.7
0.0473	37.1
0.0338	35.0
0.0242	31.6
0.0128	25.3
0.0091	23.7
0.0065	21.7
0.0046	19.7
0.0033	18.1
0.0024	16.8
0.0014	14.8

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	10.1
% Sand	45.6
% Silt Size (<75μ>2μ)	28.3
% Clay Size (<2μ)	16.0

Dispersing Agent used:
Sodium Hexametaphosphate

Small samples size - may not be representative



FINES (silt, clay) 44.3 %	SAND 45.6 %	GRAVEL 10.1 %	COBBLE 0.0 %

Checker: **Reviewer:**

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Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2/9/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

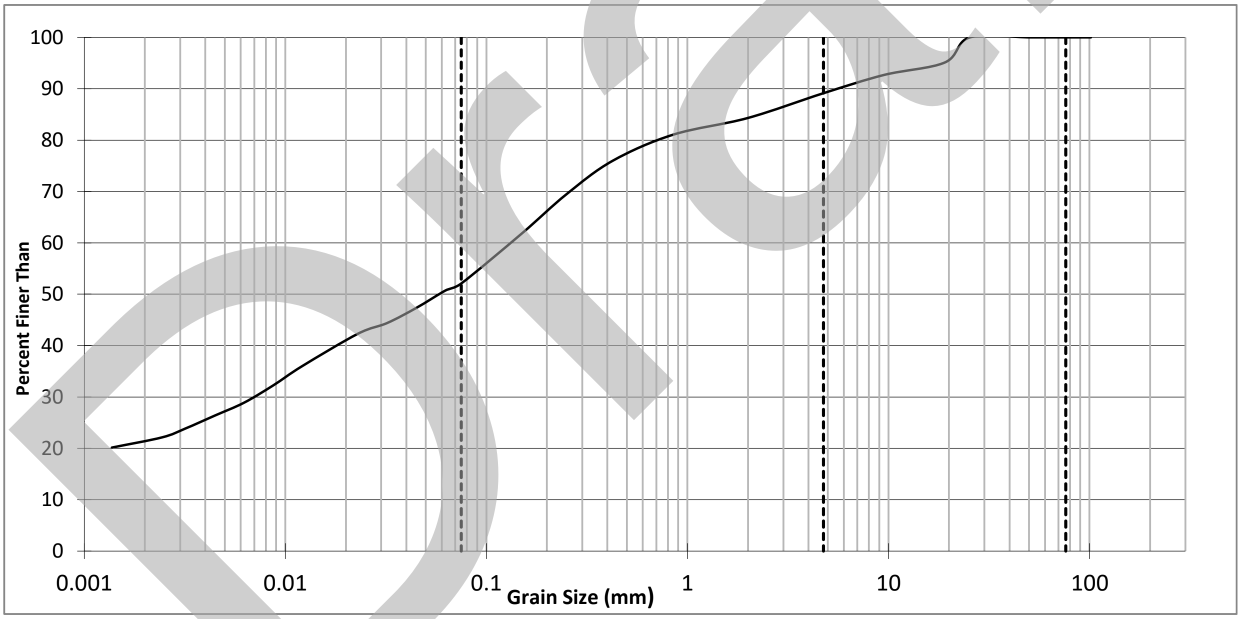
Sample: NLB-1015 BH1 at 16.5-16.95m

Mechanical Analysis			Hydrometer Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer
4"	101.6	100	0.0625	50.7
3"	76.2	100	0.0449	47.4
2"	50.8	100	0.0322	44.4
1"	25.4	100	0.0229	42.3
3/4"	19.1	95	0.0122	36.0
3/8"	9.50	93	0.0087	32.3
#4	4.75	89	0.0062	28.9
#10	2.00	84	0.0045	26.4
#20	0.850	81	0.0032	23.8
#40	0.425	76	0.0024	22.1
#60	0.250	69	0.0014	20.2
#100	0.150	62		
#200	0.075	52		

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	10.9
% Sand	37.0
% Silt Size (<75µ>2µ)	30.8
% Clay Size (<2µ)	21.3

Dispersing Agent used:
Sodium Hexametaphosphate

Small sample size - may not be representative



FINES (silt, clay) 52.1 %	SAND 37.0 %	GRAVEL 10.9 %	COBBLE 0.0 %

Checker:

Reviewer:

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 3/11/2022

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-1025 BH1 at 25.5-25.65m

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	99
#10	2.00	96
#20	0.850	92
#40	0.425	87
#60	0.250	81
#100	0.150	75
#200	0.075	68

Hydrometer Analysis

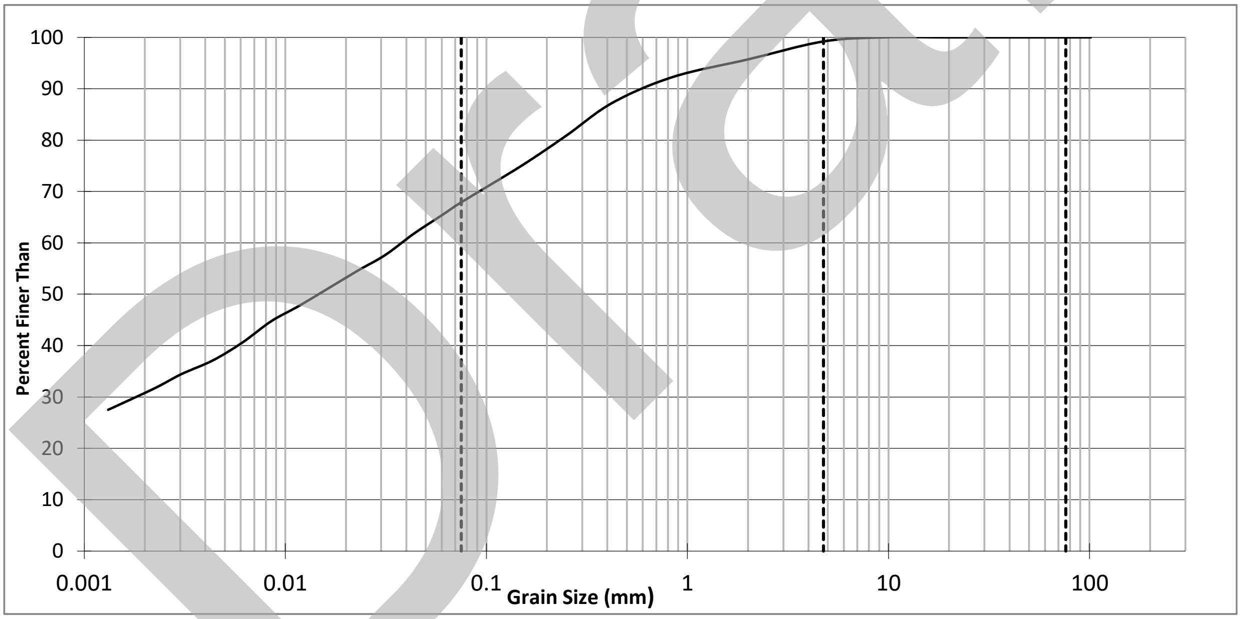
Dia. (mm)	% Finer
0.0607	65.5
0.0436	61.8
0.0314	57.6
0.0225	54.4
0.0119	47.9
0.0085	44.8
0.0061	40.6
0.0044	37.1
0.0030	34.4
0.0022	31.7
0.0013	27.5

Summary of Analysis

Particle Size Distribution Summary

% Cobble	0.0
% Gravel	0.8
% Sand	31.3
% Silt Size (<75µ>2µ)	37.3
% Clay Size (<2µ)	30.6

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 67.9 %	SAND 31.3 %	GRAVEL 0.8 %	COBBLE 0.0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2/9/2022

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-1032 BH1 at 36-36.45m

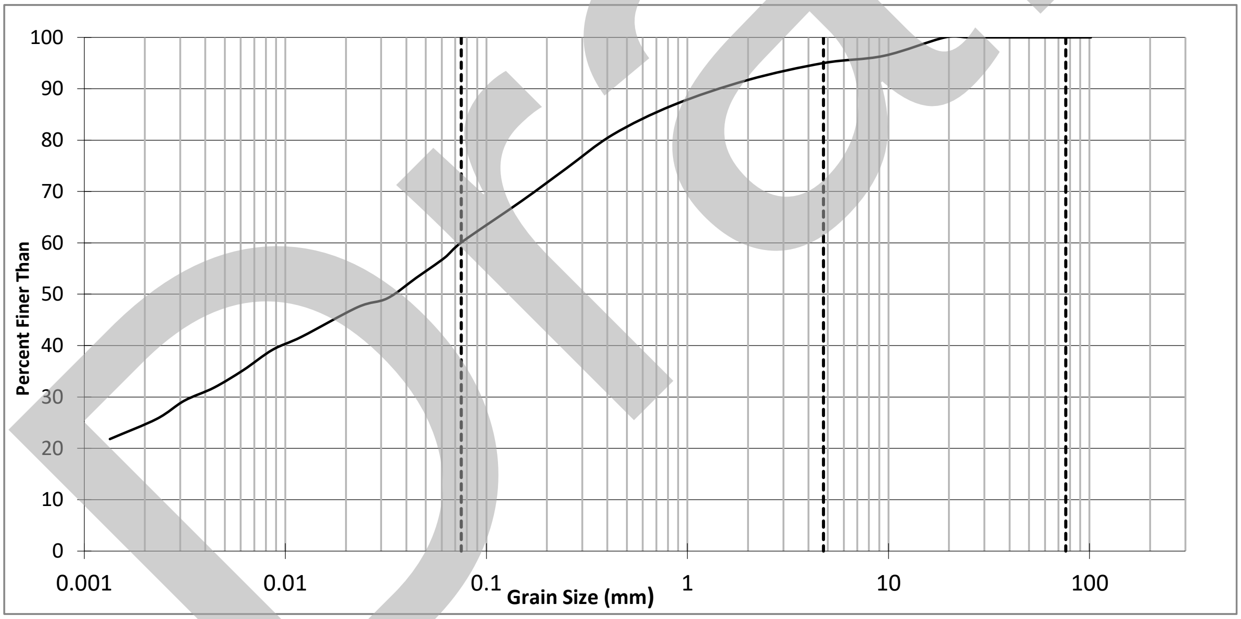
Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	96
#4	4.75	95
#10	2.00	92
#20	0.850	87
#40	0.425	81
#60	0.250	75
#100	0.150	68
#200	0.075	60

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0622	57.1
0.0448	53.2
0.0322	49.2
0.0229	47.5
0.0121	41.8
0.0086	39.2
0.0062	35.2
0.0044	31.8
0.0031	29.3
0.0023	25.7
0.0013	21.8

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	5.0
% Sand	34.9
% Silt Size (<75µ>2µ)	35.5
% Clay Size (<2µ)	24.6

Dispersing Agent used:
Sodium Hexametaphosphate

Small samples size - may not be representative



FINES (silt, clay) 60.1 %	SAND 34.9 %	GRAVEL 5.0 %	COBBLE 0.0 %

Checker:

Reviewer:

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2/9/2022

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-1096 BH2 at 0-1.5m

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	90
3/4"	19.1	90
3/8"	9.50	90
#4	4.75	88
#10	2.00	83
#20	0.850	79
#40	0.425	74
#60	0.250	67
#100	0.150	60
#200	0.075	51

Hydrometer Analysis

Dia. (mm)	% Finer
0.0613	46.3
0.0440	43.6
0.0316	40.6
0.0227	36.7
0.0121	29.9
0.0087	26.1
0.0062	23.9
0.0044	21.3
0.0031	18.7
0.0022	17.4
0.0013	14.3

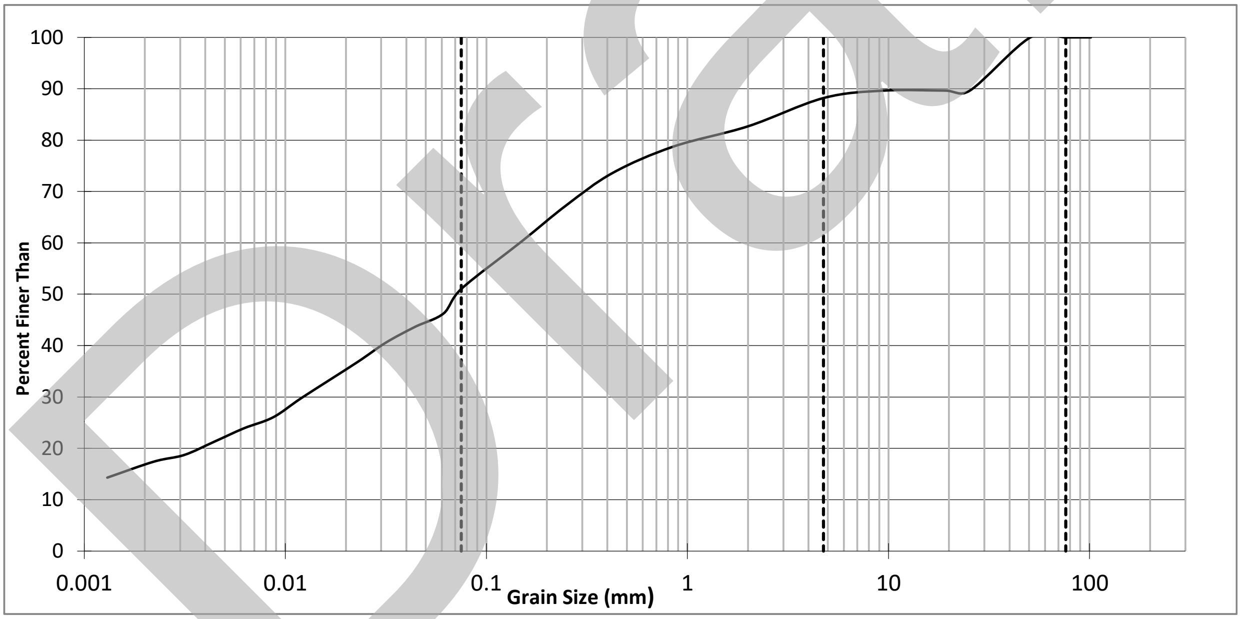
Summary of Analysis

Particle Size Distribution Summary

% Cobble	0.0
% Gravel	11.8
% Sand	37.2
% Silt Size (<75µ>2µ)	34.4
% Clay Size (<2µ)	16.6

Dispersing Agent used:
Sodium Hexametaphosphate

Small sample size - may not be representative



FINES (silt, clay) 51.0 %	SAND 37.2 %	GRAVEL 11.8 %	COBBLE 0.0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 4/22/2022

HYDROMETER TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D7928)

SNC·LAVALIN

Sample: NLB-1097 BH2 at 1.5-1.95m

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	97
#4	4.75	96
#10	2.00	92
#20	0.850	90
#40	0.425	84
#60	0.250	77
#100	0.150	68
#200	0.075	57

Hydrometer Analysis

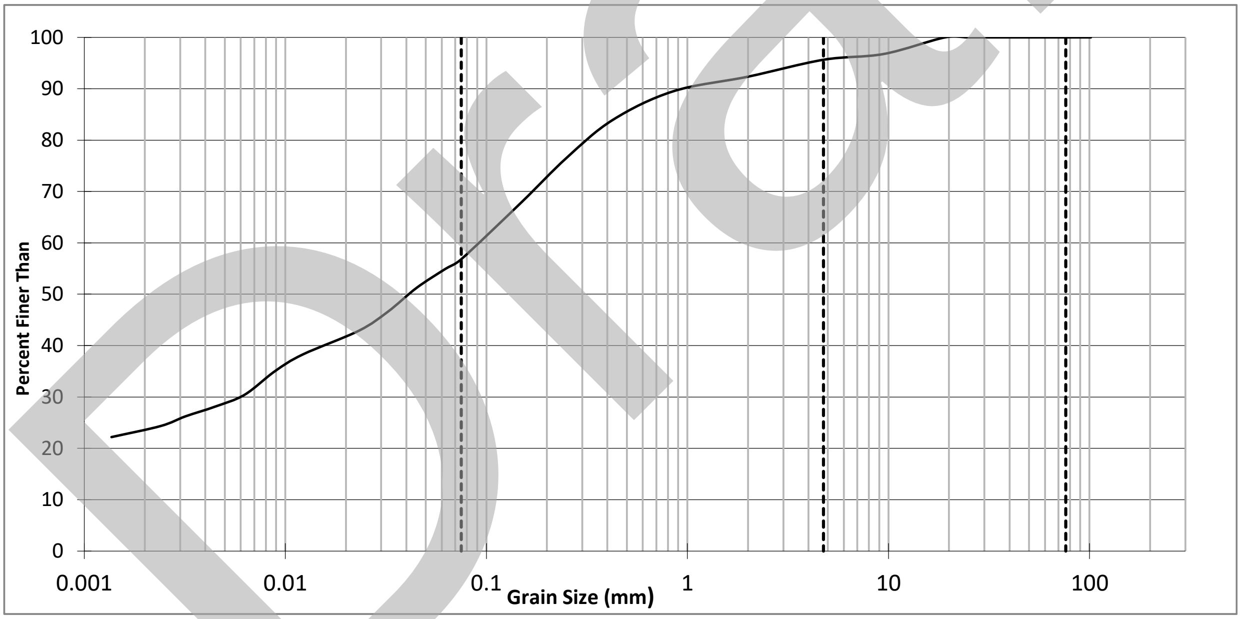
Dia. (mm)	% Finer
0.0627	55.0
0.0450	51.3
0.0324	46.6
0.0232	42.9
0.0122	38.3
0.0089	35.0
0.0063	30.4
0.0045	28.1
0.0032	26.2
0.0024	24.3
0.0014	22.2

Summary of Analysis

Particle Size Distribution Summary

% Cobble	0.0
% Gravel	4.4
% Sand	38.8
% Silt Size (<75µ>2µ)	33.3
% Clay Size (<2µ)	23.5

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 56.8 %	SAND 38.8 %	GRAVEL 4.4 %	COBBLE 0.0 %

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 3/11/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

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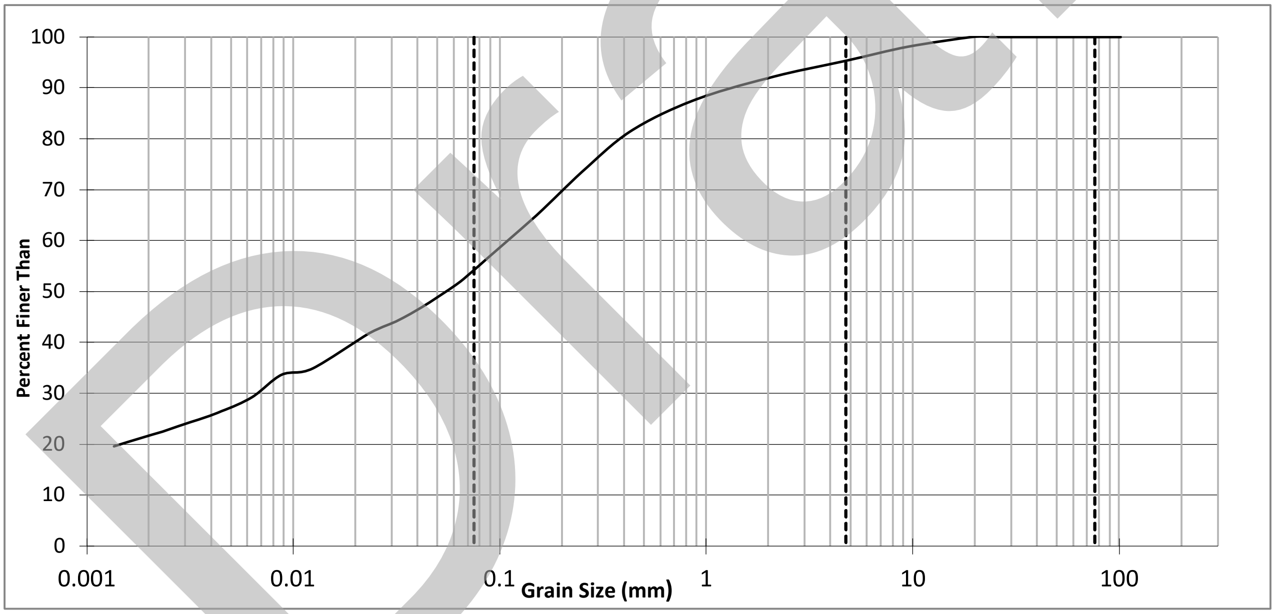
SNC·LAVALIN

Sample: NLB-1099 BH2 at 3-3.45m

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100	0.0633	51.8	% Cobble	0.0
3"	76.2	100	0.0456	47.9	% Gravel	4.6
2"	50.8	100	0.0327	44.4	% Sand	41.1
1"	25.4	100	0.0234	41.9	% Silt Size (<75µ>2µ)	32.8
3/4"	19.1	100	0.0124	34.9	% Clay Size (<2µ)	21.5
3/8"	9.50	98	0.0088	33.7		
#4	4.75	95	0.0063	29.3	Dispersing Agent used:	
#10	2.00	92	0.0045	26.5	*Sodium Hexametaphosphate*	
#20	0.850	87	0.0032	24.4		
#40	0.425	81	0.0023	22.6		
#60	0.250	74	0.0013	19.7		
#100	0.150	65			Small sample size - may not be representative	
#200	0.075	54				



FINES (silt, clay) 54.3 %	SAND 41.1 %	GRAVEL 4.6 %	COBBLE 0.0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-02-09

Geoscience & Materials

HYDROMETER TEST REPORT

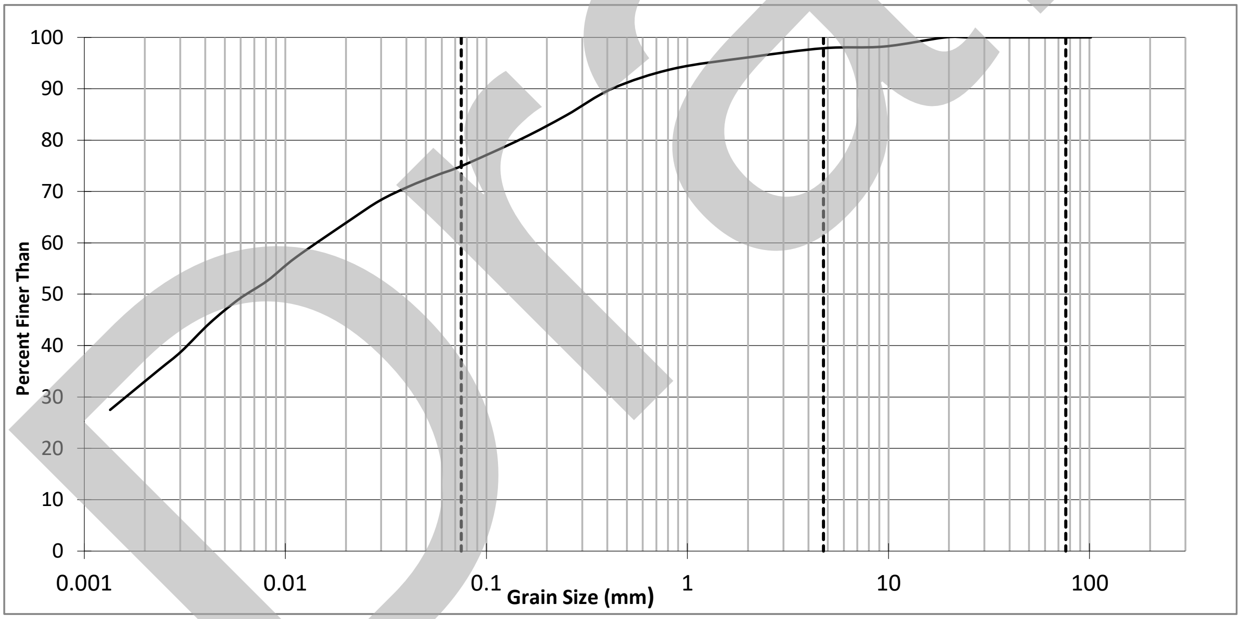
(Test Reference: ASTM D7928)

Sample: NLB-1108 BH2 at 10m

Mechanical Analysis			Hydrometer Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer
4"	101.6	100	0.0575	73.3
3"	76.2	100	0.0412	71.0
2"	50.8	100	0.0295	68.2
1"	25.4	100	0.0212	64.5
3/4"	19.1	100	0.0113	57.2
3/8"	9.50	98	0.0081	52.6
#4	4.75	98	0.0058	49.0
#10	2.00	96	0.0042	44.4
#20	0.850	94	0.0030	38.9
#40	0.425	90	0.0023	35.2
#60	0.250	85	0.0013	27.5
#100	0.150	80		
#200	0.075	75		

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	2.1
% Sand	23.0
% Silt Size (<75µ>2µ)	42.3
% Clay Size (<2µ)	32.6

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 74.9 %	SAND 23.0 %	GRAVEL 2.1 %	COBBLE 0.0 %

Checker:

Reviewer:

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Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 3/11/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

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SNC·LAVALIN

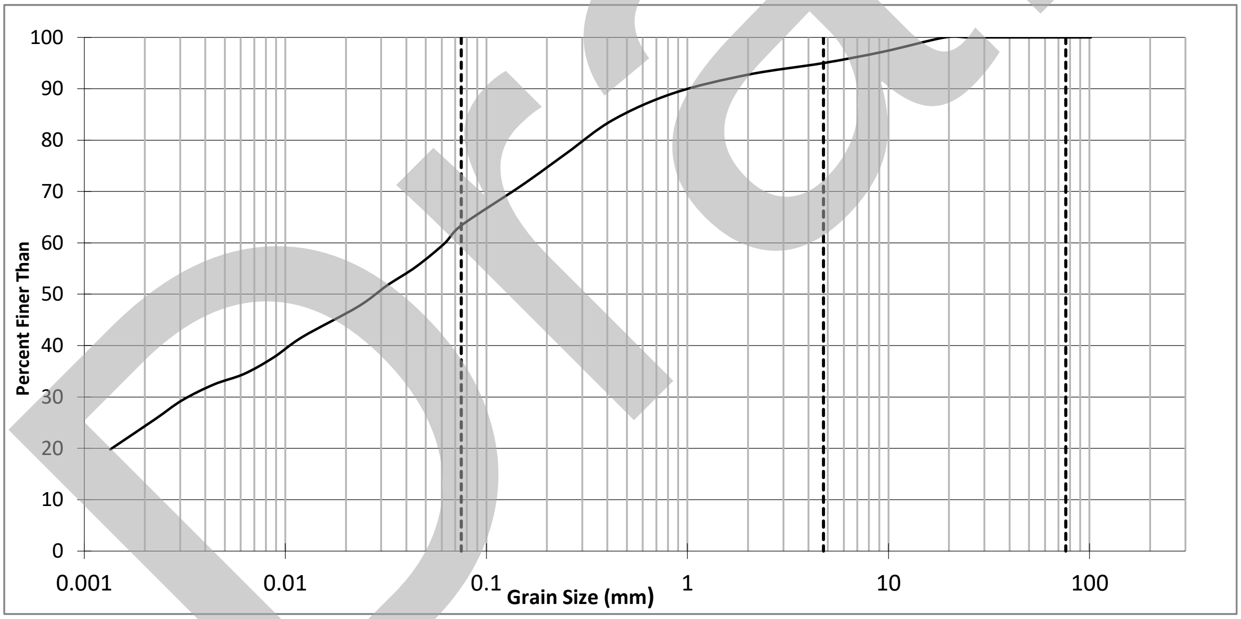
Sample: NLB-1115 BH2 at 15-15.45m

Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	97
#4	4.75	95
#10	2.00	93
#20	0.850	89
#40	0.425	84
#60	0.250	77
#100	0.150	71
#200	0.075	63

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0619	59.9
0.0447	55.3
0.0321	51.7
0.0231	47.6
0.0122	41.7
0.0087	37.7
0.0062	34.5
0.0044	32.4
0.0031	29.3
0.0023	25.7
0.0013	19.8

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	5.0
% Sand	31.6
% Silt Size (<75µ>2µ)	39.3
% Clay Size (<2µ)	24.1

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 63.4 %	SAND 31.6 %	GRAVEL 5.0 %	COBBLE 0.0 %

Checker: Don

Reviewer: Don

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2/17/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-1172 BH2 at 92m

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	100
#60	0.250	100
#100	0.150	99
#200	0.075	69

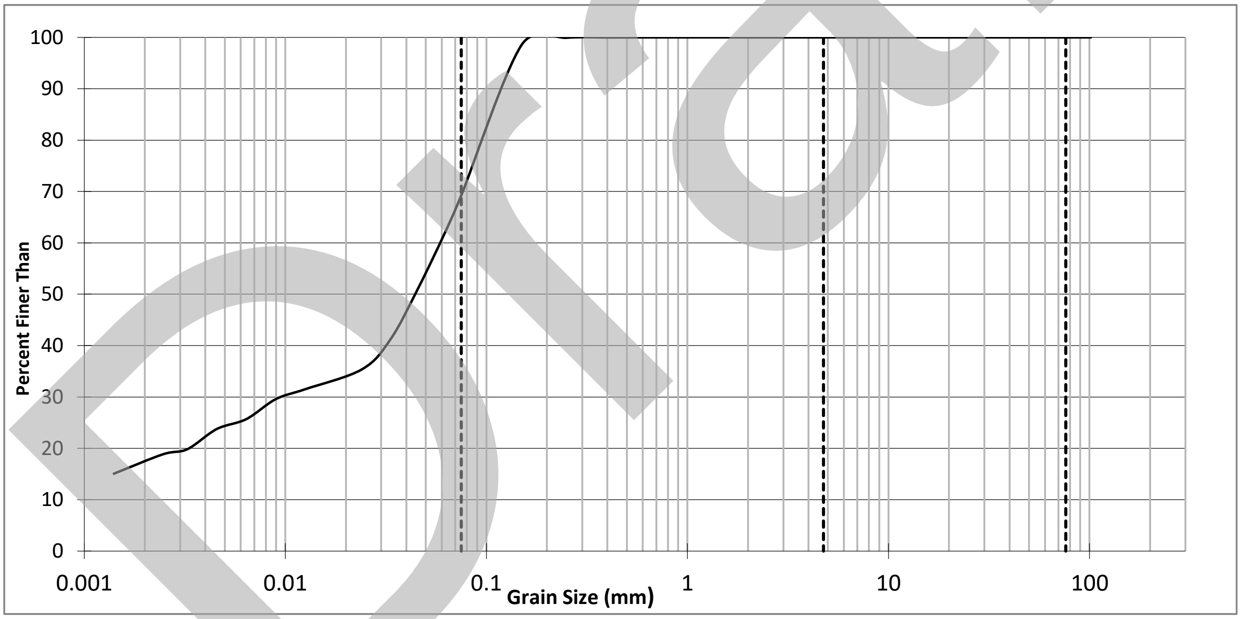
Hydrometer Analysis

Dia. (mm)	% Finer
0.0618	61.7
0.0456	51.0
0.0334	41.2
0.0241	35.4
0.0126	31.5
0.0090	29.6
0.0064	25.7
0.0046	23.7
0.0033	19.8
0.0025	18.8
0.0014	15.1

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	30.8
% Silt Size (<75µ>2µ)	52.0
% Clay Size (<2µ)	17.2

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 69.2 %	SAND 30.8 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker: **Reviewer:**

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 3/11/2022

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-1175 BH2 at 100-100.45m

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	100
#60	0.250	99
#100	0.150	97
#200	0.075	84

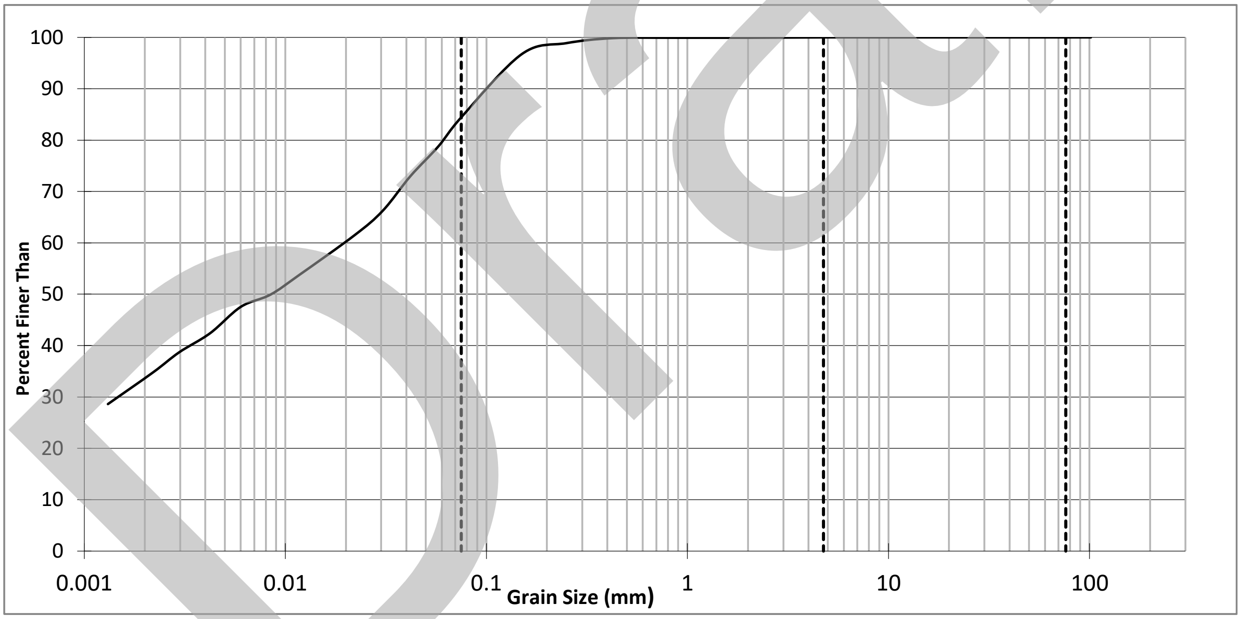
Hydrometer Analysis

Dia. (mm)	% Finer
0.0577	78.8
0.0419	73.0
0.0305	66.3
0.0220	61.5
0.0117	53.8
0.0084	49.9
0.0060	47.5
0.0042	42.4
0.0030	38.7
0.0022	34.8
0.0013	28.6

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	15.6
% Silt Size (<75µ>2µ)	51.0
% Clay Size (<2µ)	33.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 84.4 %	SAND 15.6 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker:

Reviewer:

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2/9/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-066 BH SHII-4 at 22ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	99
#10	2.00	98
#20	0.850	95
#40	0.425	93
#60	0.250	92
#100	0.150	90
#200	0.075	72

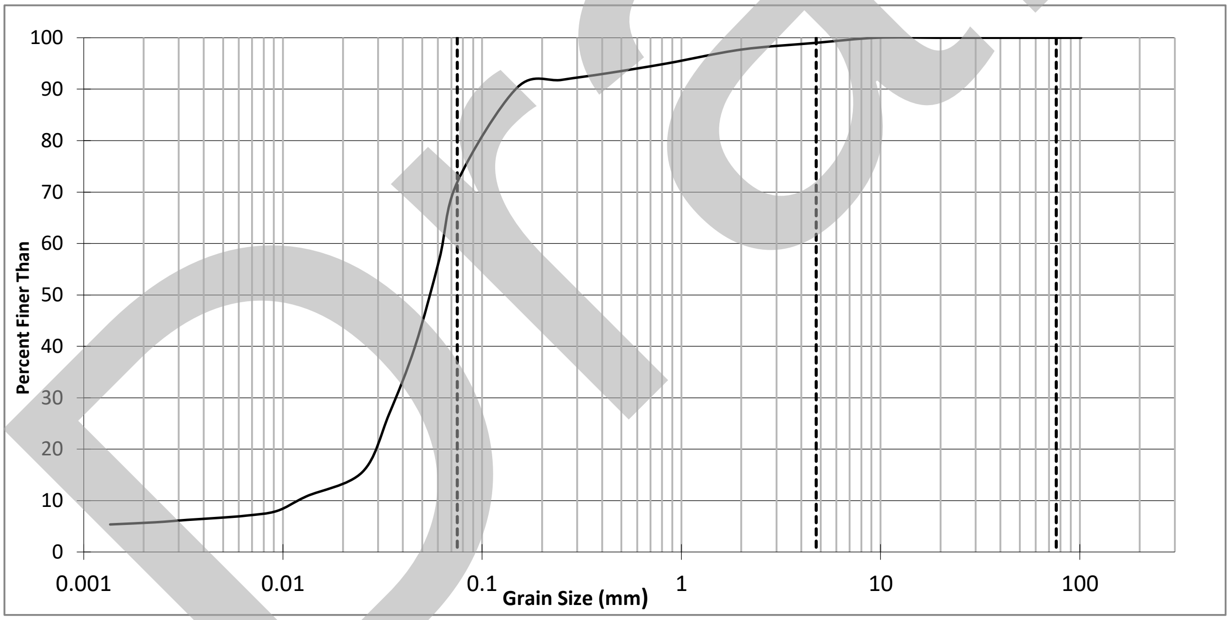
Hydrometer Analysis

Dia. (mm)	% Finer
0.0610	57.0
0.0461	40.0
0.0341	26.8
0.0250	15.5
0.0131	10.8
0.0093	8.0
0.0066	7.1
0.0047	6.6
0.0033	6.2
0.0023	5.8
0.0014	5.4

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	1.0
% Sand	27.1
% Silt Size (<75µ>2µ)	66.3
% Clay Size (<2µ)	5.6

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 71.9 %	SAND 27.1 %	GRAVEL 1.0 %	COBBLE 0.0 %

Checker:

Reviewer:

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Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-22

Geoscience & Materials

HYDROMETER TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D7928)

SNC·LAVALIN

Sample: NLB-090 BH SHII-7 at 27ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	98
#4	4.75	94
#10	2.00	91
#20	0.850	86
#40	0.425	81
#60	0.250	74
#100	0.150	67
#200	0.075	58

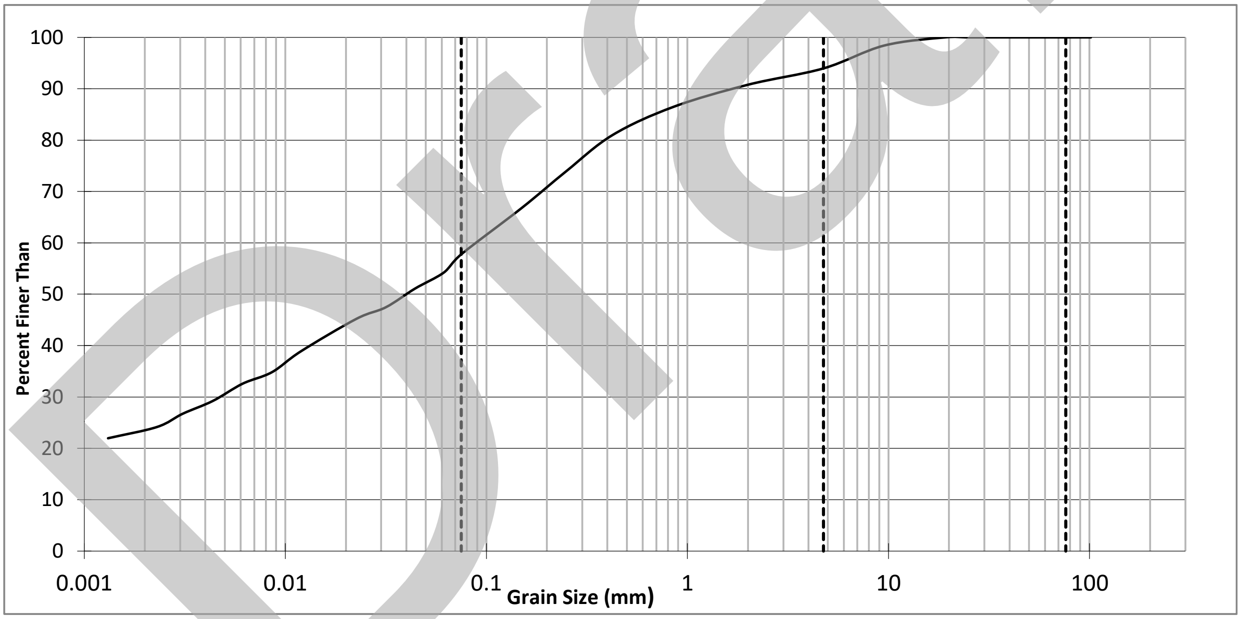
Hydrometer Analysis

Dia. (mm)	% Finer
0.0615	54.2
0.0441	51.1
0.0316	47.5
0.0226	45.2
0.0120	38.9
0.0086	34.8
0.0061	32.6
0.0044	29.2
0.0031	26.7
0.0023	24.2
0.0013	22.0

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	6.0
% Sand	36.2
% Silt Size (<75µ>2µ)	34.3
% Clay Size (<2µ)	23.5

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 57.8 %	SAND 36.2 %	GRAVEL 6.0 %	COBBLE 0.0 %

Checker: **Reviewer:**

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Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/11/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC • LAVALIN

Sample: NLB-157 BH FHII-3 at 23-24.5ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	95
#20	0.850	94
#40	0.425	94
#60	0.250	86
#100	0.150	66
#200	0.075	39

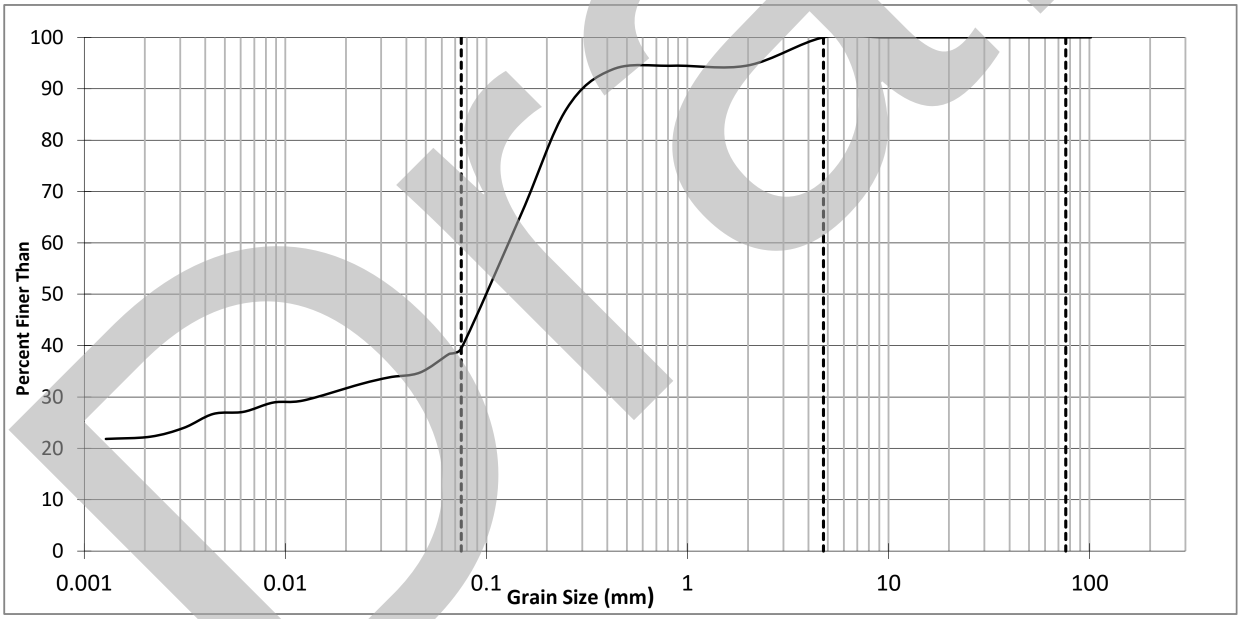
Hydrometer Analysis

Dia. (mm)	% Finer
0.0652	38.4
0.0468	34.8
0.0332	33.8
0.0236	32.5
0.0123	29.3
0.0087	28.9
0.0062	27.1
0.0044	26.7
0.0031	24.0
0.0021	22.3
0.0013	21.8

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	60.6
% Silt Size (<75µ>2µ)	17.2
% Clay Size (<2µ)	22.2

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 39.4 %	SAND 60.6 %	GRAVEL 0.0 %	COBBLE 0.0 %

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Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 4/22/2022

Geoscience & Materials

HYDROMETER TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D7928)

SNC·LAVALIN

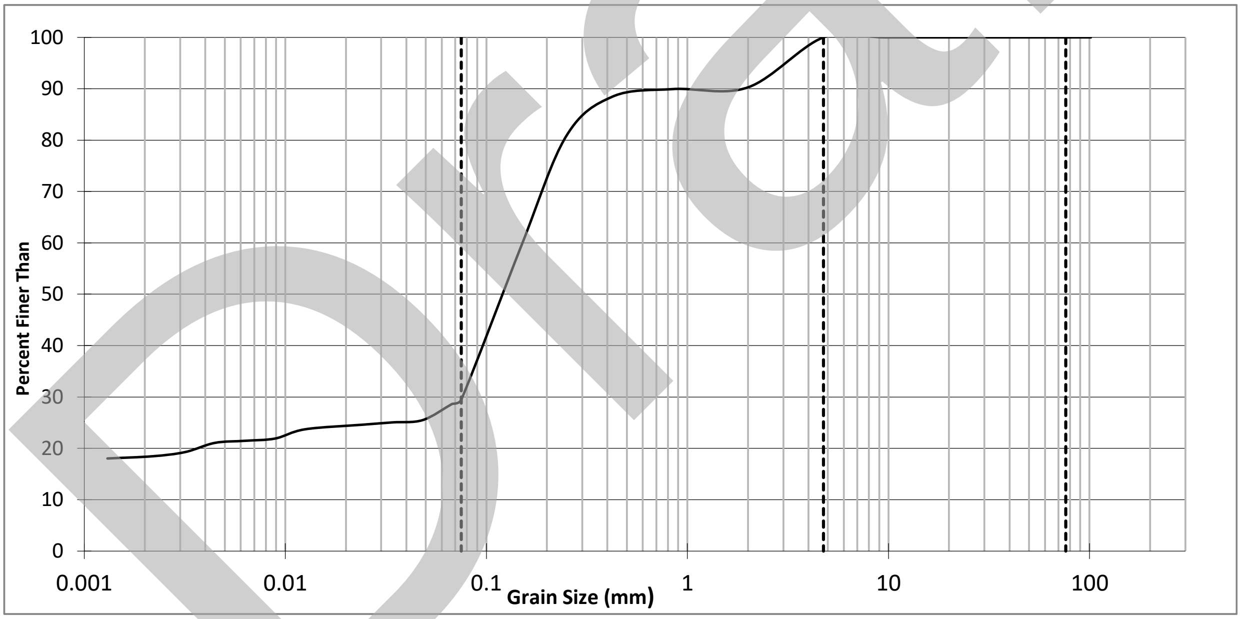
Sample: NLB-162 BH FHII-3 at 33-34.2ft

Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	90
#20	0.850	90
#40	0.425	88
#60	0.250	81
#100	0.150	60
#200	0.075	29

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0674	28.6
0.0482	25.5
0.0342	25.1
0.0242	24.6
0.0125	23.7
0.0089	21.9
0.0063	21.5
0.0045	21.1
0.0032	19.3
0.0022	18.5
0.0013	18.0

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	70.5
% Silt Size (<75µ>2µ)	11.1
% Clay Size (<2µ)	18.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 29.5 %	SAND 70.5 %	GRAVEL 0.0 %	COBBLE 0.0 %

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 4/22/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

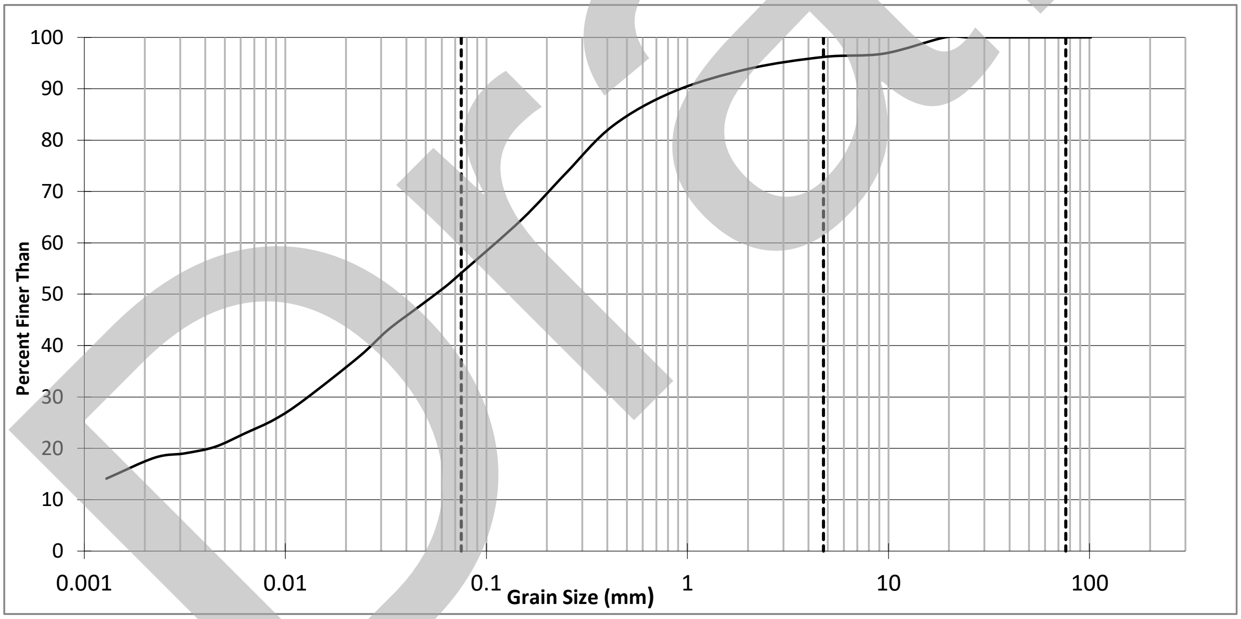
SNC · LAVALIN

Sample: NLB-193 BH FHII-4 at 10ft

Mechanical Analysis			Hydrometer Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer
4"	101.6	100	0.0626	51.5
3"	76.2	100	0.0450	47.3
2"	50.8	100	0.0323	43.0
1"	25.4	100	0.0233	37.9
3/4"	19.1	100	0.0124	29.4
3/8"	9.50	97	0.0089	25.7
#4	4.75	96	0.0063	22.9
#10	2.00	94	0.0045	20.3
#20	0.850	89	0.0032	19.0
#40	0.425	83	0.0022	18.2
#60	0.250	74	0.0013	14.1
#100	0.150	65		
#200	0.075	54		

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	3.8
% Sand	42.0
% Silt Size (<75µ>2µ)	37.0
% Clay Size (<2µ)	17.2

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 54.2 %	SAND 42.0 %	GRAVEL 3.8 %	COBBLE 0.0 %

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/19/2022

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

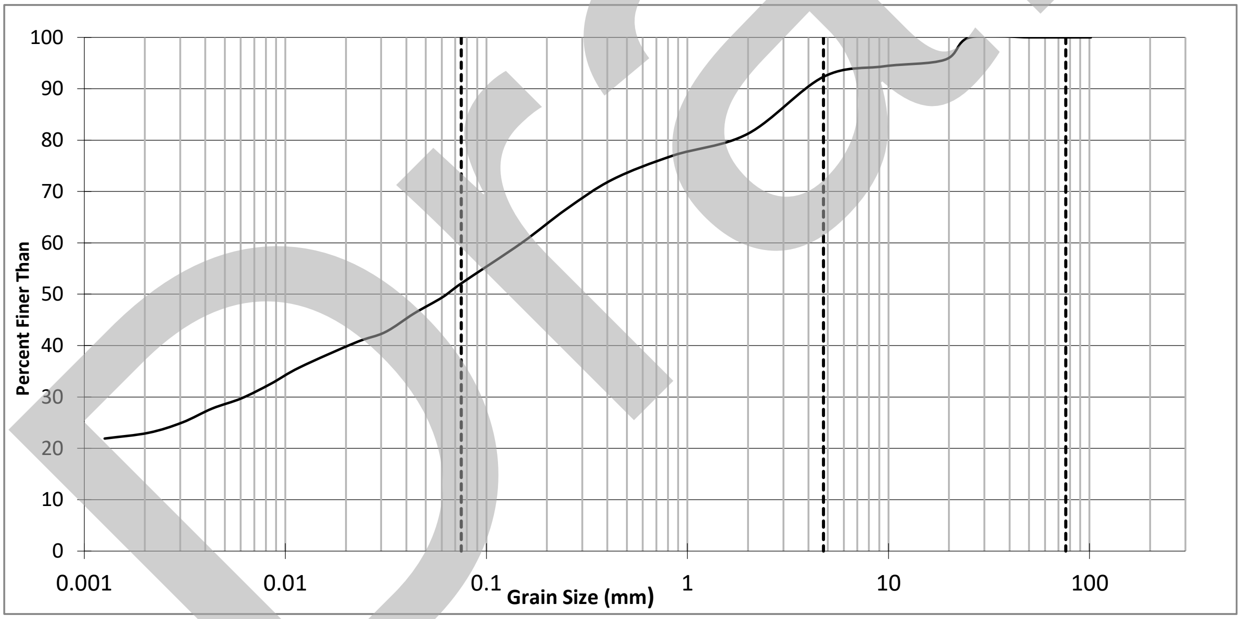
Sample: NLB-196 BH FHII-4 at 19ft

Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	96
3/8"	9.50	94
#4	4.75	92
#10	2.00	81
#20	0.850	77
#40	0.425	72
#60	0.250	67
#100	0.150	60
#200	0.075	52

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0607	49.5
0.0436	46.2
0.0314	42.6
0.0224	40.6
0.0118	35.8
0.0085	32.6
0.0061	29.7
0.0043	27.7
0.0031	25.0
0.0021	23.0
0.0013	21.9

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	7.7
% Sand	40.2
% Silt Size (<75µ>2µ)	29.2
% Clay Size (<2µ)	22.9

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 52.1 %	SAND 40.2 %	GRAVEL 7.7 %	COBBLE 0.0 %

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 4/22/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-202 BH FHII-4 at 32-33.5ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	99
#60	0.250	90
#100	0.150	64
#200	0.075	37

Hydrometer Analysis

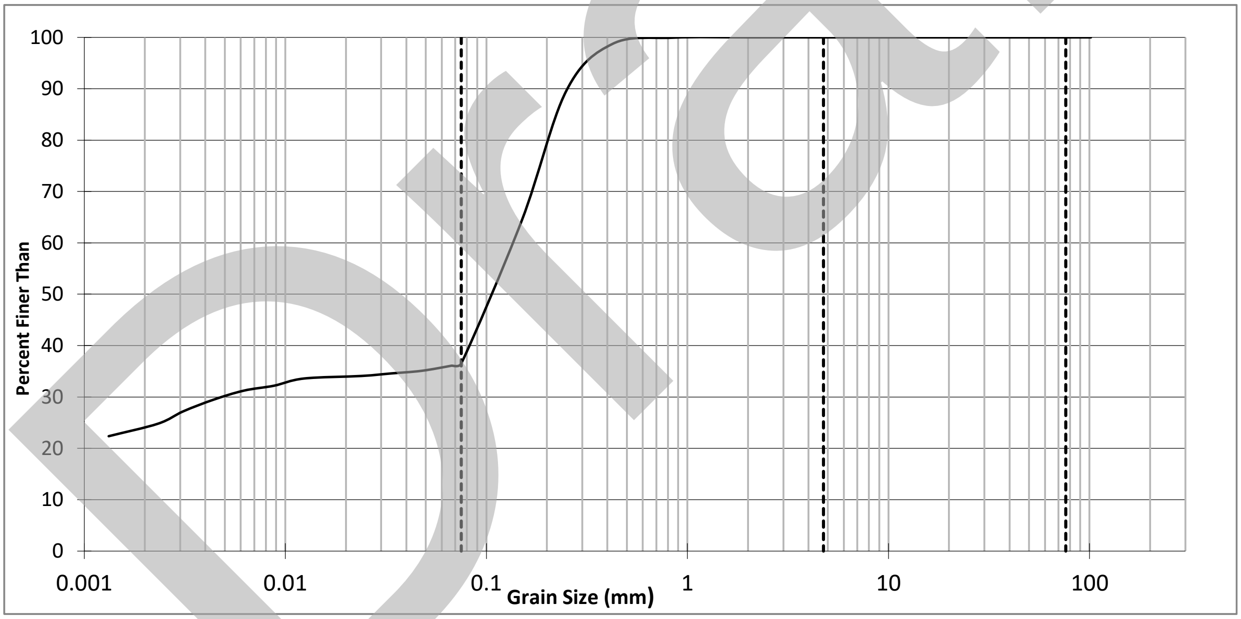
Dia. (mm)	% Finer
0.0671	36.1
0.0476	35.1
0.0337	34.6
0.0239	34.1
0.0124	33.6
0.0088	32.2
0.0062	31.2
0.0044	29.5
0.0031	27.2
0.0023	24.8
0.0013	22.4

Summary of Analysis

Particle Size Distribution Summary

% Cobble	0.0
% Gravel	0.0
% Sand	63.5
% Silt Size (<75µ>2µ)	12.5
% Clay Size (<2µ)	24.0

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 36.5 %	SAND 63.5 %	GRAVEL 0.0 %	COBBLE 0.0 %

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/11/2022

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

SNC • LAVALIN

Sample: NLB-228 BH FHII-4 at 105ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	96
#4	4.75	95
#10	2.00	90
#20	0.850	86
#40	0.425	82
#60	0.250	76
#100	0.150	70
#200	0.075	62

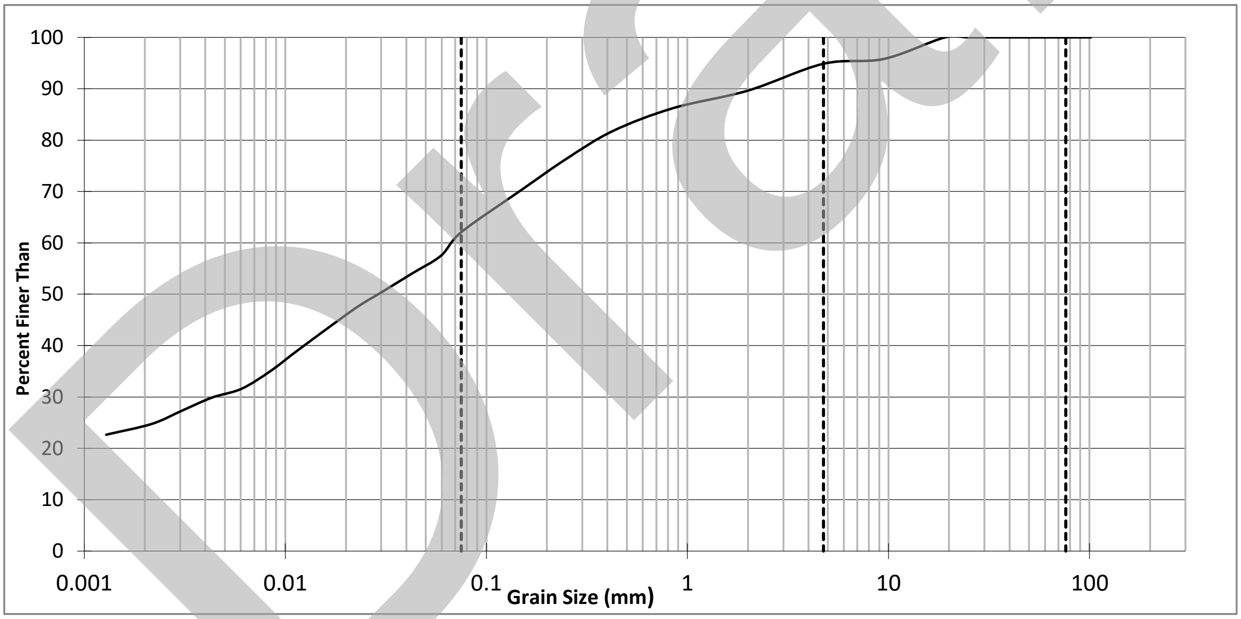
Hydrometer Analysis

Dia. (mm)	% Finer
0.0595	57.5
0.0428	54.1
0.0307	50.6
0.0221	47.1
0.0118	39.3
0.0085	35.1
0.0061	31.6
0.0043	29.9
0.0031	27.4
0.0022	24.8
0.0013	22.7

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	5.1
% Sand	32.8
% Silt Size (<75µ>2µ)	37.7
% Clay Size (<2µ)	24.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 62.1 %	SAND 32.8 %	GRAVEL 5.1 %	COBBLE 0.0 %

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 4/22/2022

Geoscience & Materials

HYDROMETER TEST REPORT

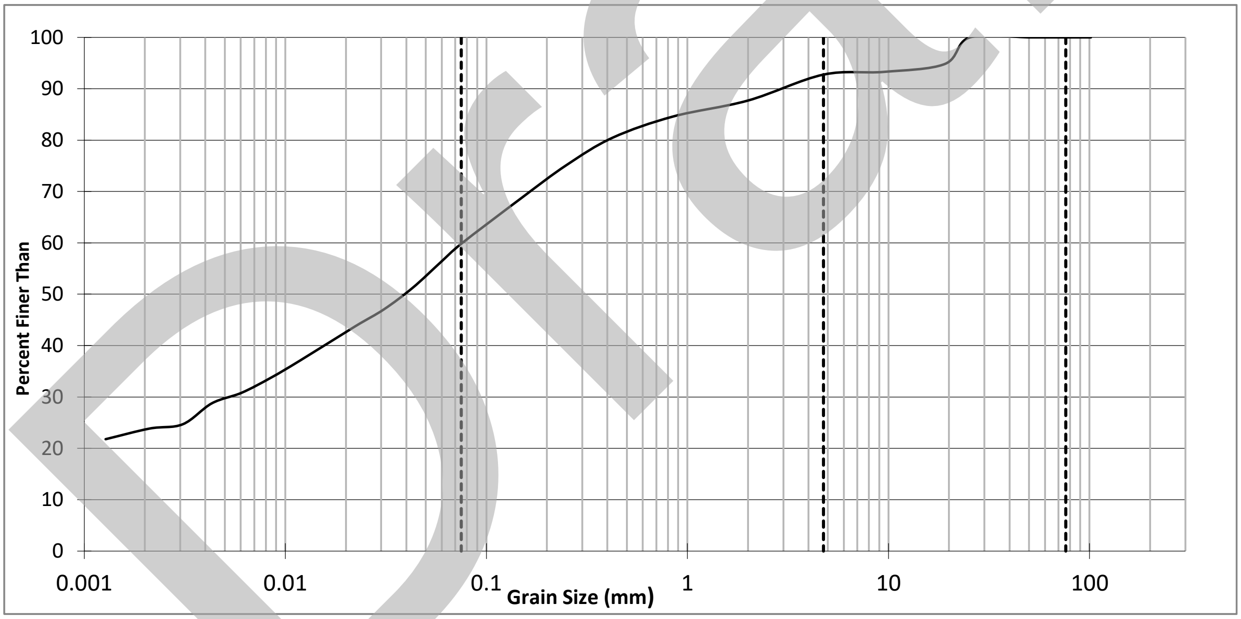
(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-278 BH FHII-02 at 35ft

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100	0.0593	56.2	% Cobble	0.0
3"	76.2	100	0.0429	51.2	% Gravel	7.2
2"	50.8	100	0.0310	47.1	% Sand	32.9
1"	25.4	100	0.0222	43.7	% Silt Size (<75µ>2µ)	36.2
3/4"	19.1	95	0.0118	37.1	% Clay Size (<2µ)	23.7
3/8"	9.50	93	0.0085	33.7		
#4	4.75	93	0.0061	30.8	Dispersing Agent used:	
#10	2.00	88	0.0043	28.8	*Sodium Hexametaphosphate*	
#20	0.850	85	0.0031	24.7		
#40	0.425	80	0.0021	23.9		
#60	0.250	75	0.0013	21.8		
#100	0.150	69				
#200	0.075	60				



FINES (silt, clay) 59.9 %	SAND 32.9 %	GRAVEL 7.2 %	COBBLE 0.0 %

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/1/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

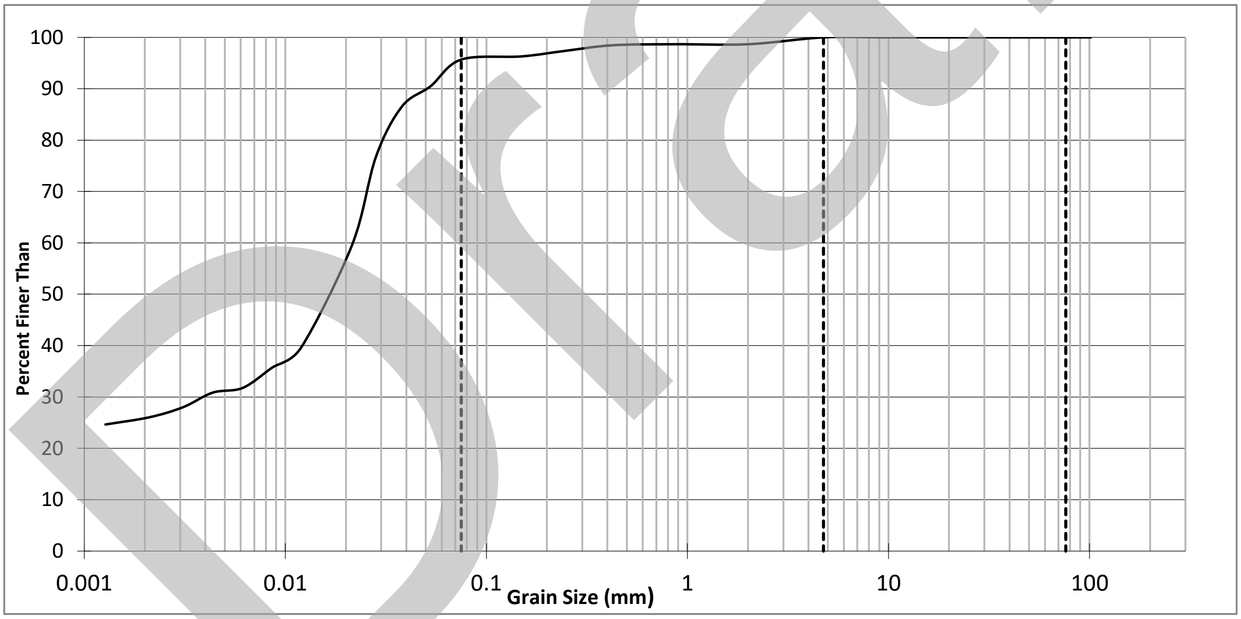
Sample: NLB-523 BH FHII-12 at 5ft

Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	99
#20	0.850	99
#40	0.425	98
#60	0.250	97
#100	0.150	96
#200	0.075	96

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0527	90.5
0.0381	86.6
0.0282	76.8
0.0215	59.7
0.0120	39.6
0.0086	35.7
0.0061	31.8
0.0044	30.8
0.0031	28.0
0.0021	26.1
0.0013	24.6

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	4.3
% Silt Size (<75µ>2µ)	69.8
% Clay Size (<2µ)	25.9

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 95.7 %	SAND 4.3 %	GRAVEL 0.0 %	COBBLE 0.0 %

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/1/2022

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-536 BH FHII-12 at 38-39.5ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	97
#20	0.850	95
#40	0.425	92
#60	0.250	88
#100	0.150	83
#200	0.075	76

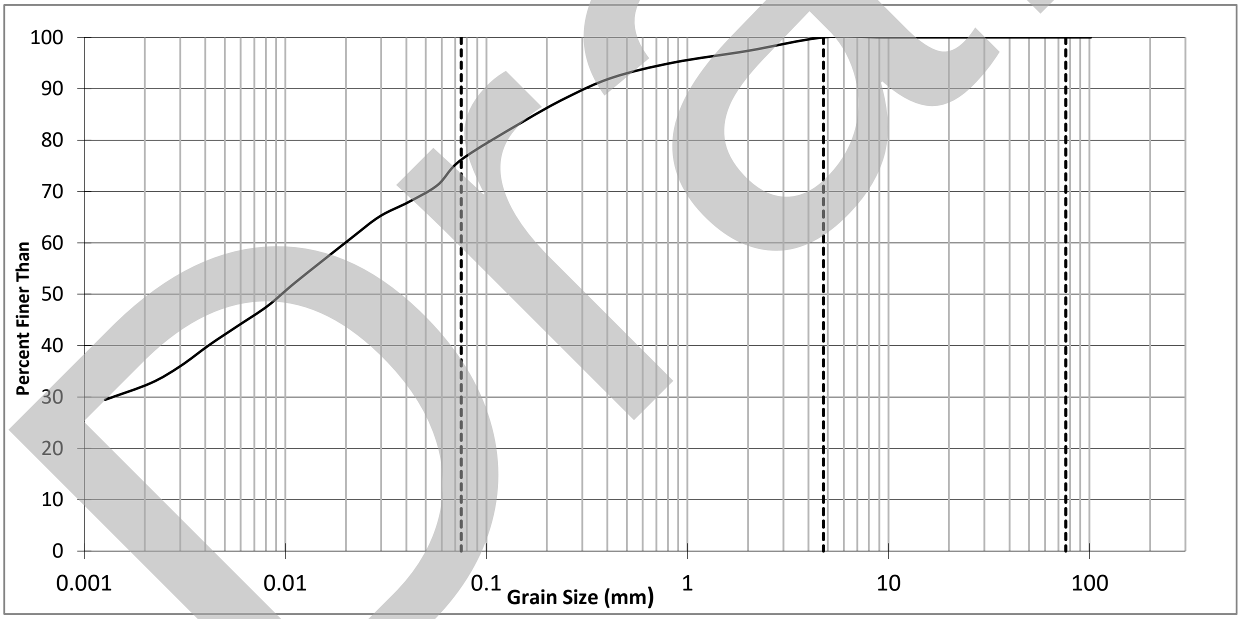
Hydrometer Analysis

Dia. (mm)	% Finer
0.0572	71.3
0.0411	68.0
0.0294	65.1
0.0212	60.9
0.0113	52.4
0.0082	47.7
0.0059	43.9
0.0042	40.2
0.0030	36.0
0.0021	32.7
0.0013	29.4

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	23.8
% Silt Size (<75µ>2µ)	44.0
% Clay Size (<2µ)	32.2

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 76.2 %	SAND 23.8 %	GRAVEL 0.0 %	COBBLE 0.0 %

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/1/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

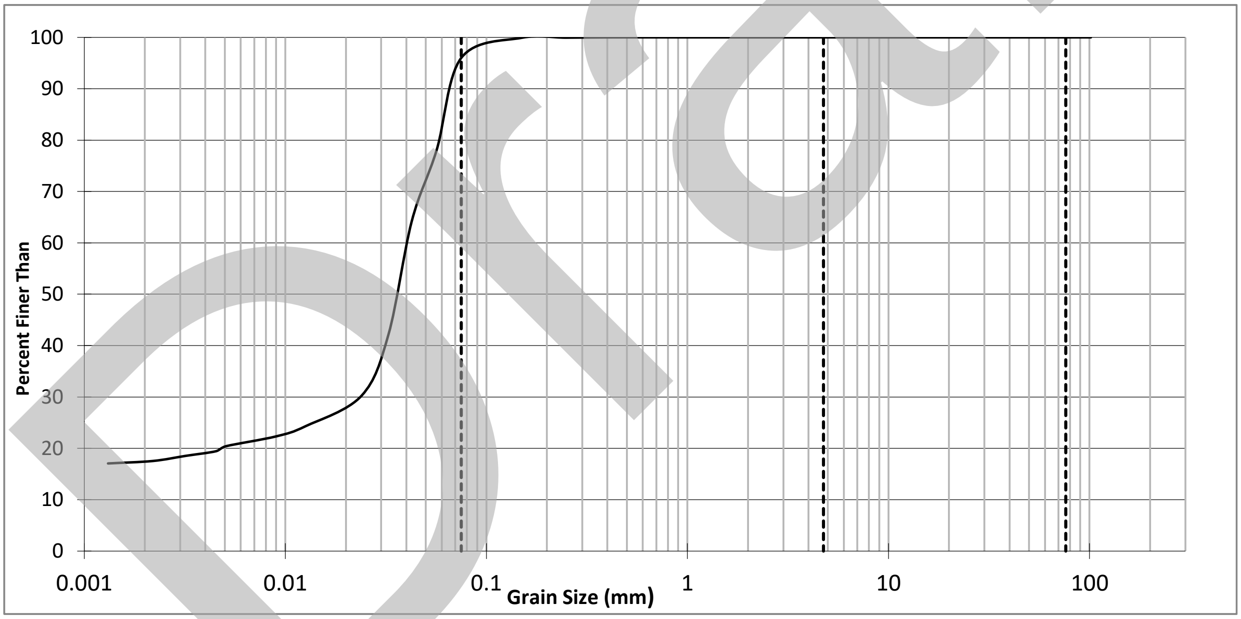
Sample: NLB-752 BH FHII-20 at 23-24.5ft

Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	100
#60	0.250	100
#100	0.150	100
#200	0.075	96

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0566	78.1
0.0425	64.1
0.0326	42.2
0.0240	30.3
0.0126	24.3
0.0090	22.3
0.0051	20.4
0.0045	19.4
0.0032	18.5
0.0022	17.5
0.0013	17.1

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	4.0
% Silt Size (<75µ>2µ)	78.6
% Clay Size (<2µ)	17.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 96.0 %	SAND 4.0 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/1/2022

Geoscience & Materials

HYDROMETER TEST REPORT

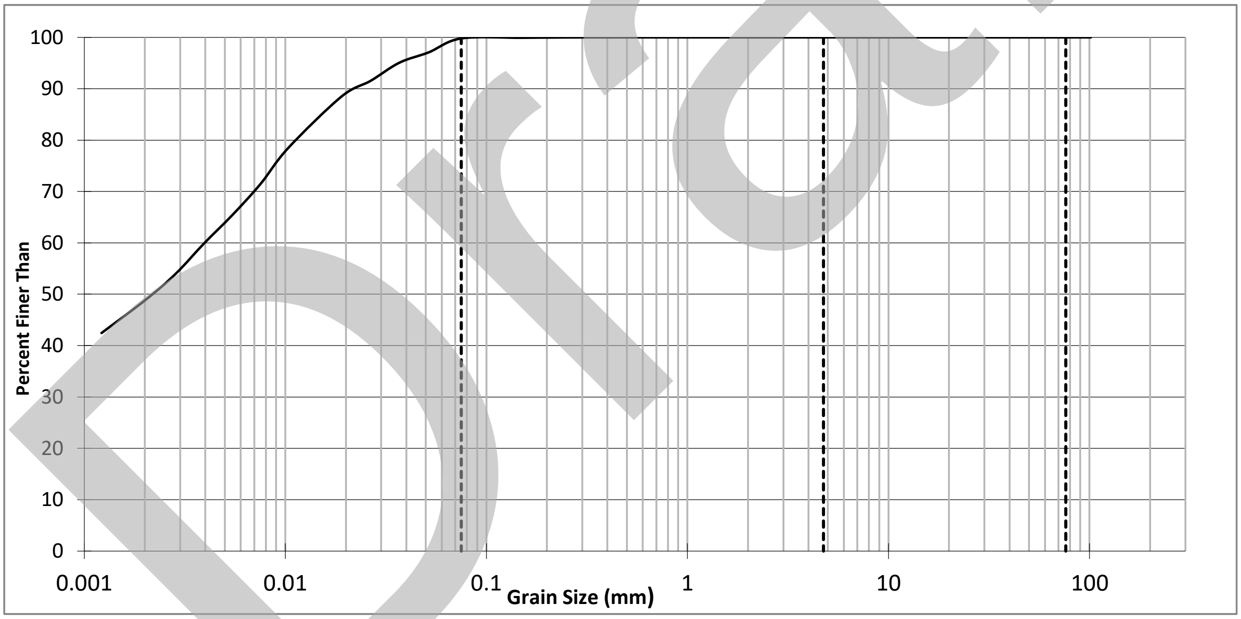
(Test Reference: ASTM D7928)

Sample: NLB-757 BH FHII-20 at 37ft

Mechanical Analysis			Hydrometer Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer
4"	101.6	100	0.0516	97.1
3"	76.2	100	0.0369	95.1
2"	50.8	100	0.0266	91.5
1"	25.4	100	0.0191	88.5
3/4"	19.1	100	0.0103	78.5
3/8"	9.50	100	0.0075	71.5
#4	4.75	100	0.0055	65.4
#10	2.00	100	0.0039	59.9
#20	0.850	100	0.0028	54.0
#40	0.425	100	0.0020	48.9
#60	0.250	100	0.0012	42.5
#100	0.150	100		
#200	0.075	100		

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	0.2
% Silt Size (<75µ>2µ)	51.0
% Clay Size (<2µ)	48.8

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 99.8 %	SAND 0.2 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/1/2022

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-766 BH FHII-20 at 58-59.5ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	100
#60	0.250	100
#100	0.150	100
#200	0.075	100

Hydrometer Analysis

Dia. (mm)	% Finer
0.0060	###
0.0060	###
0.0060	99.7
0.0059	97.2
0.0054	91.0
0.0049	84.4
0.0041	77.7
0.0033	70.1
0.0025	62.2
0.0020	56.1
0.0012	48.3

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	0.2
% Silt Size (<75µ>2µ)	43.4
% Clay Size (<2µ)	56.4

Dispersing Agent used:
Sodium Hexametaphosphate

FINES (silt, clay) 99.8 %	SAND 0.2 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker: **Reviewer:**

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-05-04

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

SNC • LAVALIN

Sample: NLB-771 BH FHII-20 at 68-69.5ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	100
#60	0.250	100
#100	0.150	100
#200	0.075	100

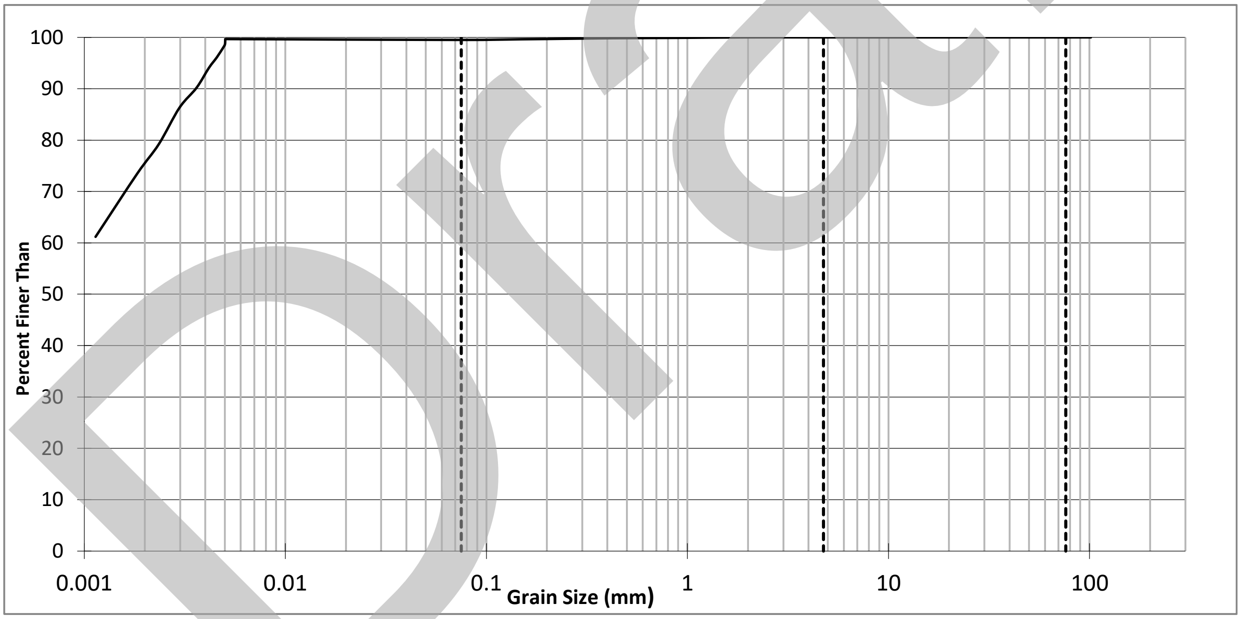
Hydrometer Analysis

Dia. (mm)	% Finer
0.0051	99.7
0.0050	99.7
0.0050	98.6
0.0049	98.1
0.0046	96.1
0.0042	94.0
0.0036	90.2
0.0030	86.3
0.0023	79.2
0.0018	73.5
0.0011	61.2

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	0.5
% Silt Size (<75µ>2µ)	23.1
% Clay Size (<2µ)	76.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 99.5 %	SAND 0.5 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker: **Reviewer:**

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Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/4/2022

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

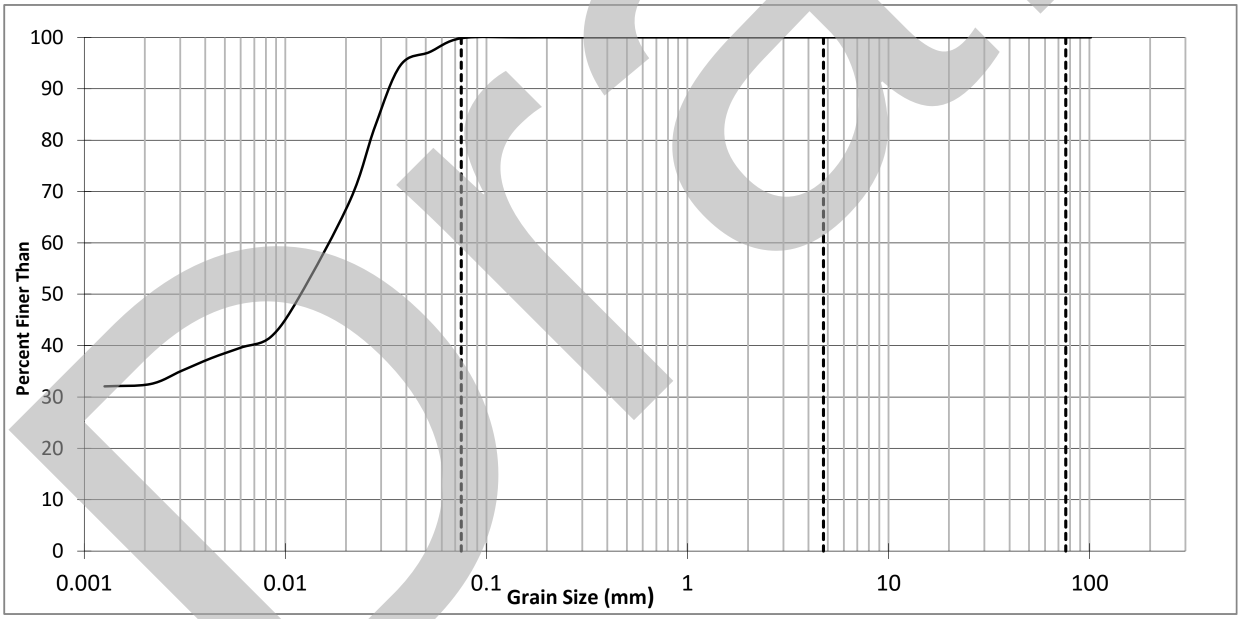
Sample: NLB-777 BH SHII-8 at 5ft

Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100
3"	76.2	100
2"	50.8	100
1"	25.4	100
3/4"	19.1	100
3/8"	9.50	100
#4	4.75	100
#10	2.00	100
#20	0.850	100
#40	0.425	100
#60	0.250	100
#100	0.150	100
#200	0.075	100

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0522	97.1
0.0374	94.6
0.0280	82.7
0.0210	68.3
0.0117	49.3
0.0085	41.7
0.0060	39.6
0.0043	37.6
0.0030	35.1
0.0021	32.5
0.0013	32.1

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0.0
% Gravel	0.0
% Sand	0.2
% Silt Size (<75µ>2µ)	67.4
% Clay Size (<2µ)	32.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 99.8 %	SAND 0.2 %	GRAVEL 0.0 %	COBBLE 0.0 %

Checker:

Reviewer:

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 5/11/2022

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-189 FHII 3 at 107ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	99.3
#10	2.00	99.1
#20	0.850	95.2
#40	0.425	90.2
#60	0.250	83.6
#100	0.150	76.2
#200	0.075	68.3

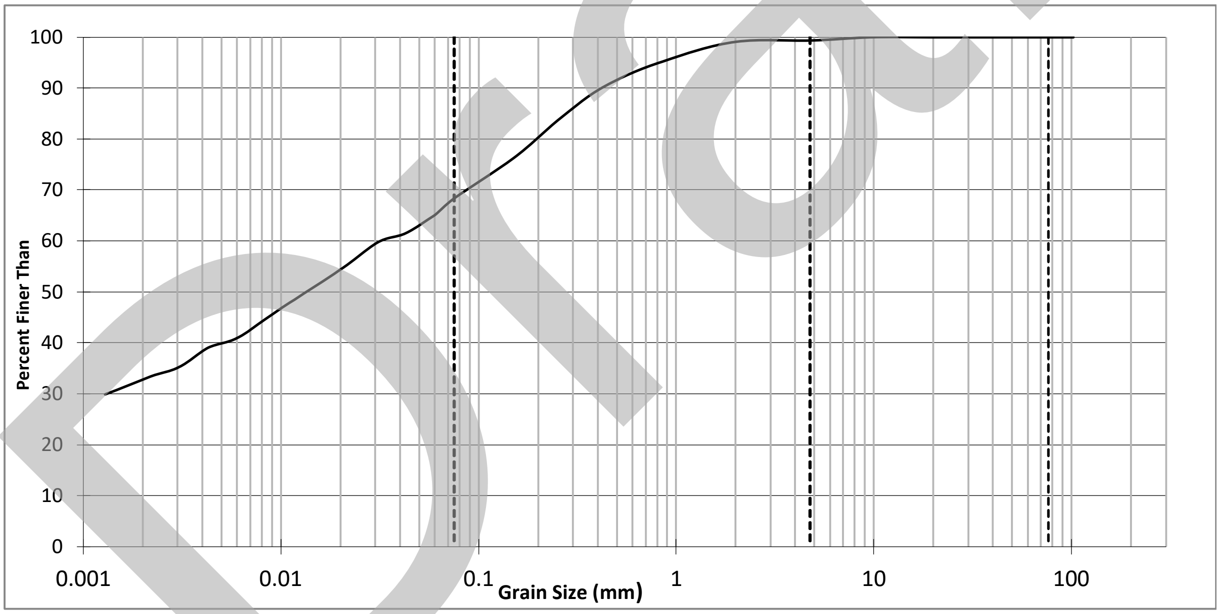
Hydrometer Analysis

Dia. (mm)	% Finer
0.0597	65.1
0.0429	61.6
0.0306	59.7
0.0197	54.2
0.0116	48.5
0.0083	44.7
0.0060	40.9
0.0043	39.0
0.0031	35.2
0.0022	33.4
0.0013	29.9

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0
% Gravel	1.0
% Sand	31.0
% Silt Size (<75µ>2µ)	35.6
% Clay Size (<2µ)	32.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 68 %	SAND 31 %	GRAVEL 1 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-239 FHII 5 fr 23-24.5ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	93.5
#4	4.75	90.6
#10	2.00	86.4
#20	0.850	78.9
#40	0.425	71.4
#60	0.250	63.2
#100	0.150	53.6
#200	0.075	43.4

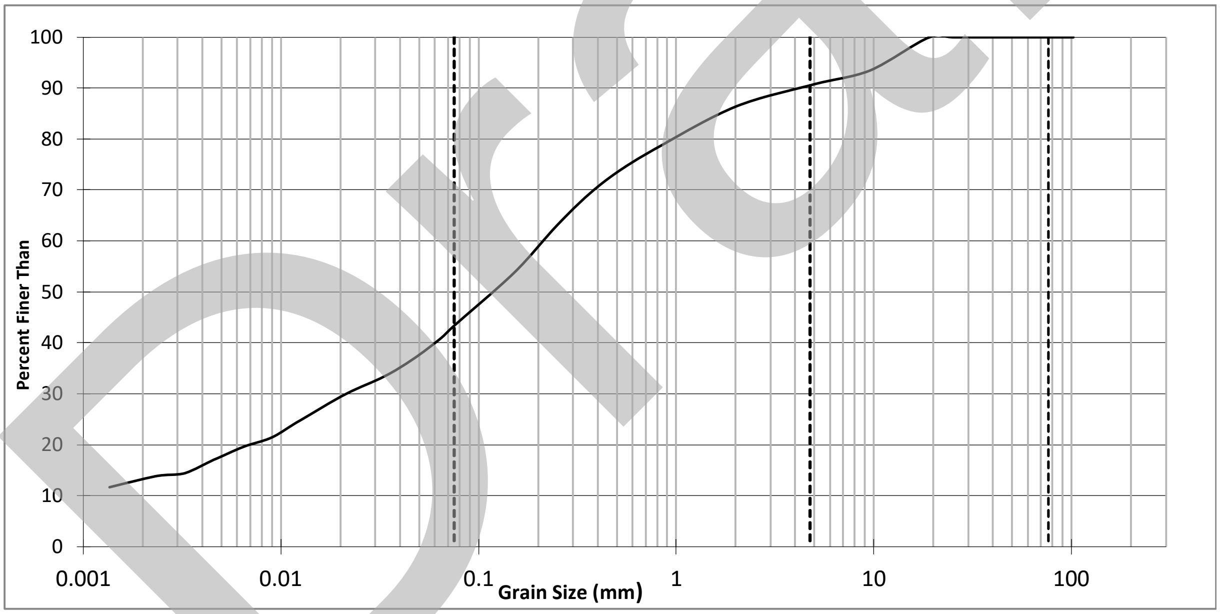
Hydrometer Analysis

Dia. (mm)	% Finer
0.0645	41.0
0.0464	36.8
0.0332	33.4
0.0213	30.0
0.0125	24.9
0.0090	21.5
0.0064	19.6
0.0046	17.0
0.0033	14.5
0.0023	13.8
0.0014	11.7

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0
% Gravel	9.0
% Sand	47.0
% Silt Size (<75µ>2µ)	30.2
% Clay Size (<2µ)	13.8

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 44 %	SAND 47 %	GRAVEL 9 %	COBBLE 0 %

Checker: **Reviewer:**

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-327 FHII 6 at 69ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	96.9
#40	0.425	85.9
#60	0.250	68.7
#100	0.150	56.9
#200	0.075	51.7

Hydrometer Analysis

Dia. (mm)	% Finer
0.0630	51.0
0.0447	49.9
0.0319	48.0
0.0203	46.2
0.0118	44.3
0.0084	42.4
0.0060	40.5
0.0042	37.9
0.0030	34.2
0.0022	30.4
0.0013	26.6

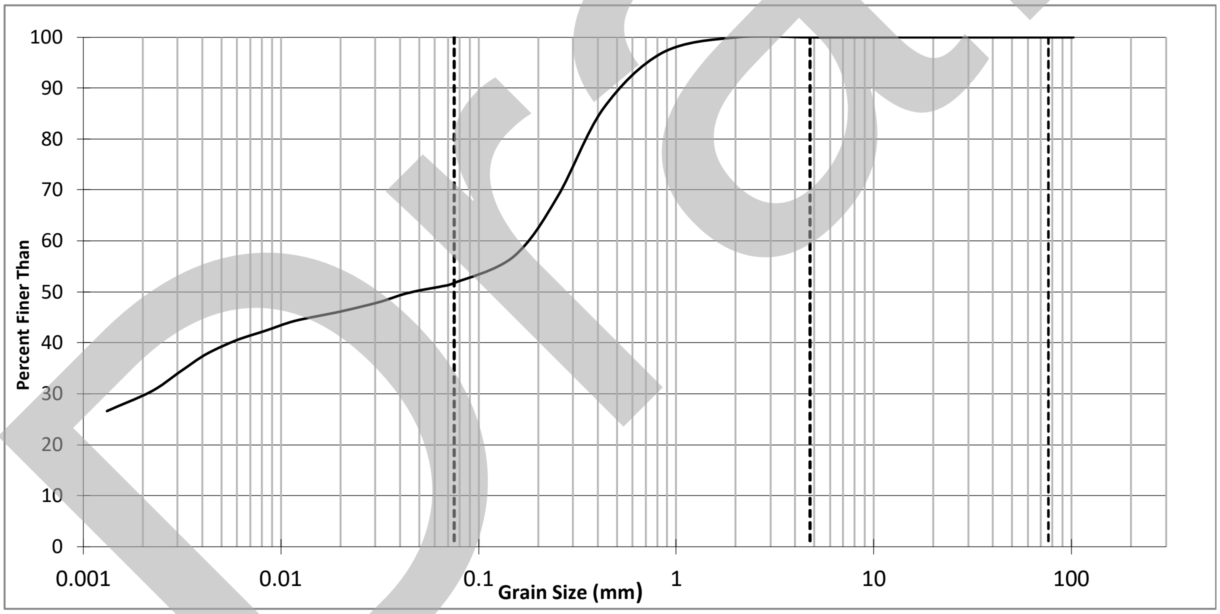
Summary of Analysis

Particle Size Distribution Summary

% Cobble	0
% Gravel	0
% Sand	48.0
% Silt Size (<75µ>2µ)	22.1
% Clay Size (<2µ)	29.9

Dispersing Agent used:

Sodium Hexametaphosphate



FINES (silt, clay) 52 %	SAND 48 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D7928)

SNC·LAVALIN

Sample: NLB-413 FHII 7 fr 23-24.5ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	94.5
#10	2.00	90.9
#20	0.850	86.9
#40	0.425	81.6
#60	0.250	73.7
#100	0.150	64.8
#200	0.075	54.1

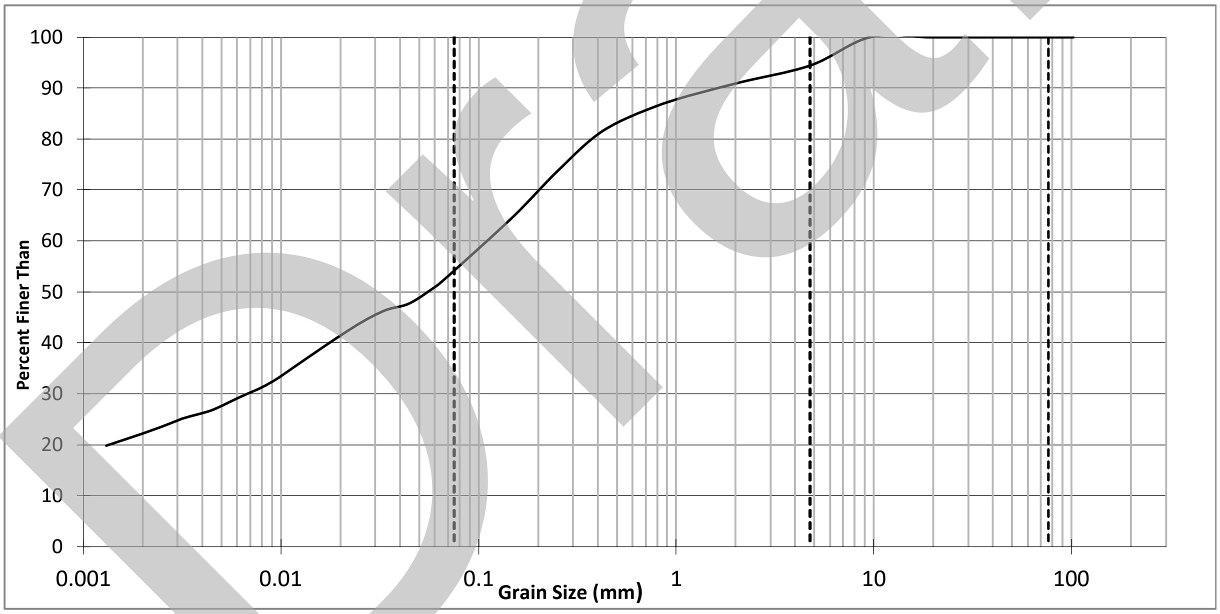
Hydrometer Analysis

Dia. (mm)	% Finer
0.0618	51.4
0.0444	47.8
0.0316	46.0
0.0204	41.7
0.0121	35.6
0.0087	32.0
0.0062	29.4
0.0044	26.8
0.0031	25.1
0.0022	22.9
0.0013	19.9

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0
% Gravel	6.0
% Sand	40.0
% Silt Size (<75µ>2µ)	32.0
% Clay Size (<2µ)	22.0

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 54 %	SAND 40 %	GRAVEL 6 %	COBBLE 0 %

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-438 FHII 11 fr 7-7.9ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	99.6
#20	0.850	99.1
#40	0.425	97.3
#60	0.250	94.8
#100	0.150	92.3
#200	0.075	82.9

Hydrometer Analysis

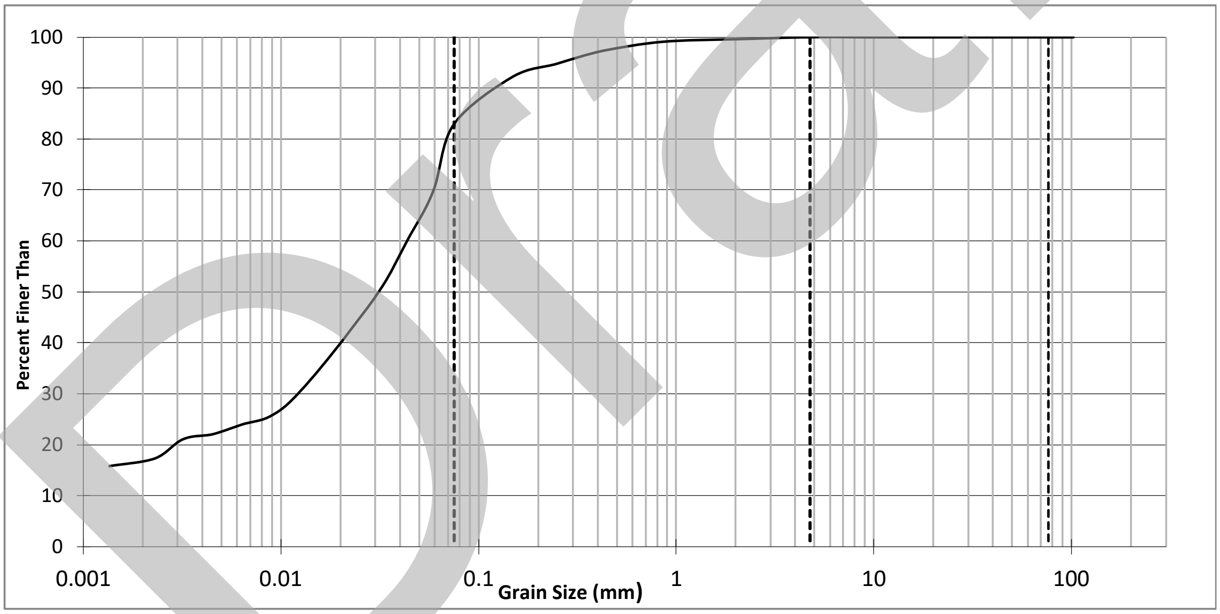
Dia. (mm)	% Finer
0.0587	69.5
0.0432	60.0
0.0318	50.5
0.0208	40.9
0.0125	30.5
0.0090	25.7
0.0063	24.0
0.0045	22.1
0.0032	21.1
0.0023	17.3
0.0013	15.8

Summary of Analysis

Particle Size Distribution Summary

% Cobble	0
% Gravel	0
% Sand	17.0
% Silt Size (<75μ>2μ)	66.0
% Clay Size (<2μ)	17.0

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 83 %	SAND 17 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D7928)

SNC·LAVALIN

Sample: NLB-499 FHII 8 at 20ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	95.7
#10	2.00	94.0
#20	0.850	89.6
#40	0.425	83.6
#60	0.250	74.8
#100	0.150	65.2
#200	0.075	53.8

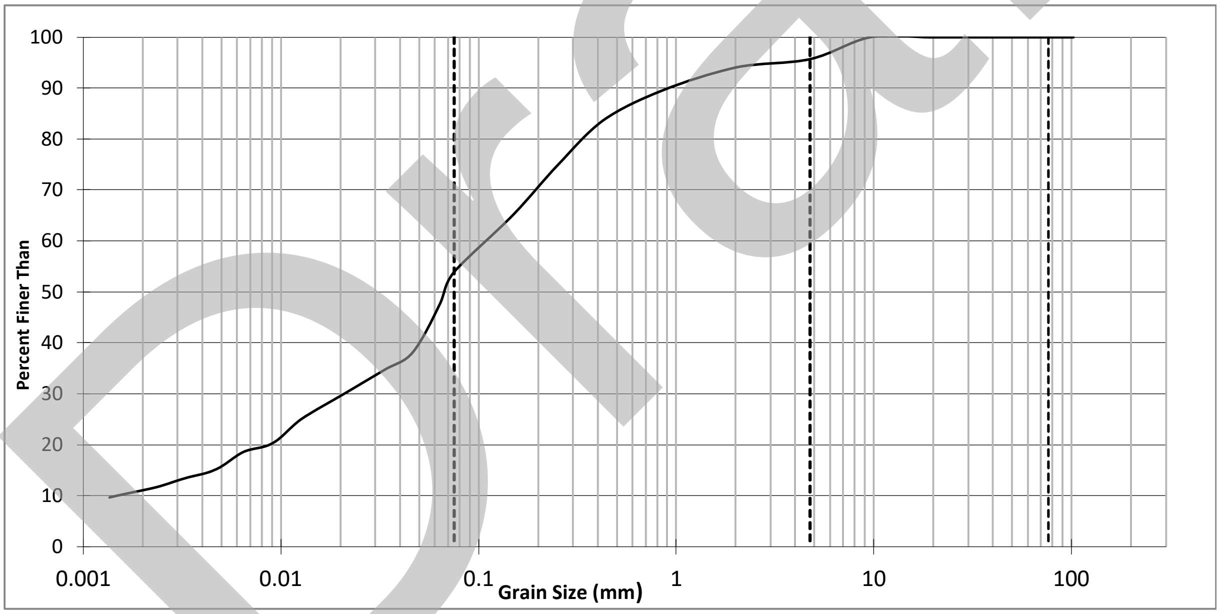
Hydrometer Analysis

Dia. (mm)	% Finer
0.0632	47.4
0.0464	38.2
0.0332	34.7
0.0214	30.2
0.0126	24.9
0.0091	20.3
0.0064	18.6
0.0046	15.0
0.0033	13.4
0.0023	11.7
0.0014	9.7

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0
% Gravel	4.0
% Sand	42.0
% Silt Size (<75µ>2µ)	42.8
% Clay Size (<2µ)	11.2

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 54 %	SAND 42 %	GRAVEL 4 %	COBBLE 0 %

Checker:

Reviewer:

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

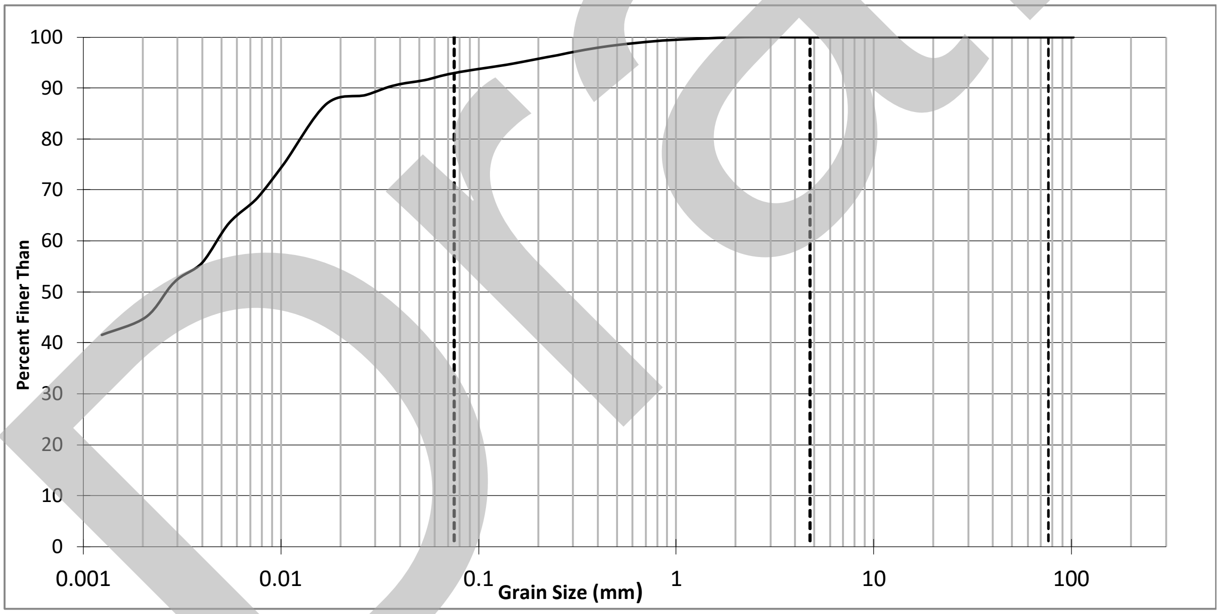
(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-584 FHII 19 fr 3-4.5ft

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100.0	0.0529	91.6	% Cobble	0
3"	76.2	100.0	0.0376	90.6	% Gravel	0
2"	50.8	100.0	0.0268	88.7	% Sand	7.0
1"	25.4	100.0	0.0170	86.9	% Silt Size (<75µ>2µ)	48.2
3/4"	19.1	100.0	0.0104	75.3	% Clay Size (<2µ)	44.8
3/8"	9.50	100.0	0.0076	68.5		
#4	4.75	100.0	0.0055	63.6	Dispersing Agent used:	
#10	2.00	99.9	0.0040	55.8	*Sodium Hexametaphosphate*	
#20	0.850	99.3	0.0029	51.9		
#40	0.425	98.1	0.0021	45.1		
#60	0.250	96.5	0.0012	41.6		
#100	0.150	94.8				
#200	0.075	93.0				



FINES (silt, clay) 93 %	SAND 7 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-609 FHII 19 at 68ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	96.5
#4	4.75	95.2
#10	2.00	93.4
#20	0.850	89.5
#40	0.425	84.2
#60	0.250	77.7
#100	0.150	69.4
#200	0.075	60.5

Hydrometer Analysis

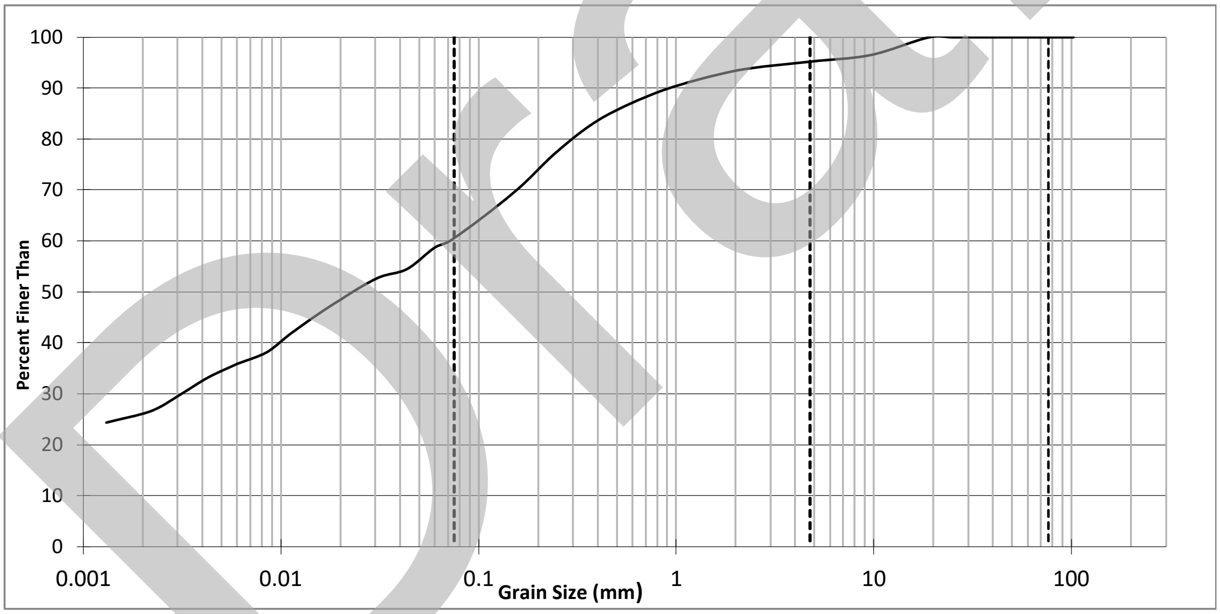
Dia. (mm)	% Finer
0.0600	58.7
0.0433	54.5
0.0309	52.8
0.0199	48.5
0.0118	42.5
0.0085	38.2
0.0060	35.9
0.0043	33.3
0.0031	29.9
0.0022	26.7
0.0013	24.4

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0
% Gravel	5.0
% Sand	35.0
% Silt Size (<75µ>2µ)	34.3
% Clay Size (<2µ)	25.7

Dispersing Agent used:

Sodium Hexametaphosphate



FINES (silt, clay) 60 %	SAND 35 %	GRAVEL 5 %	COBBLE 0 %

Checker: **Reviewer:**

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

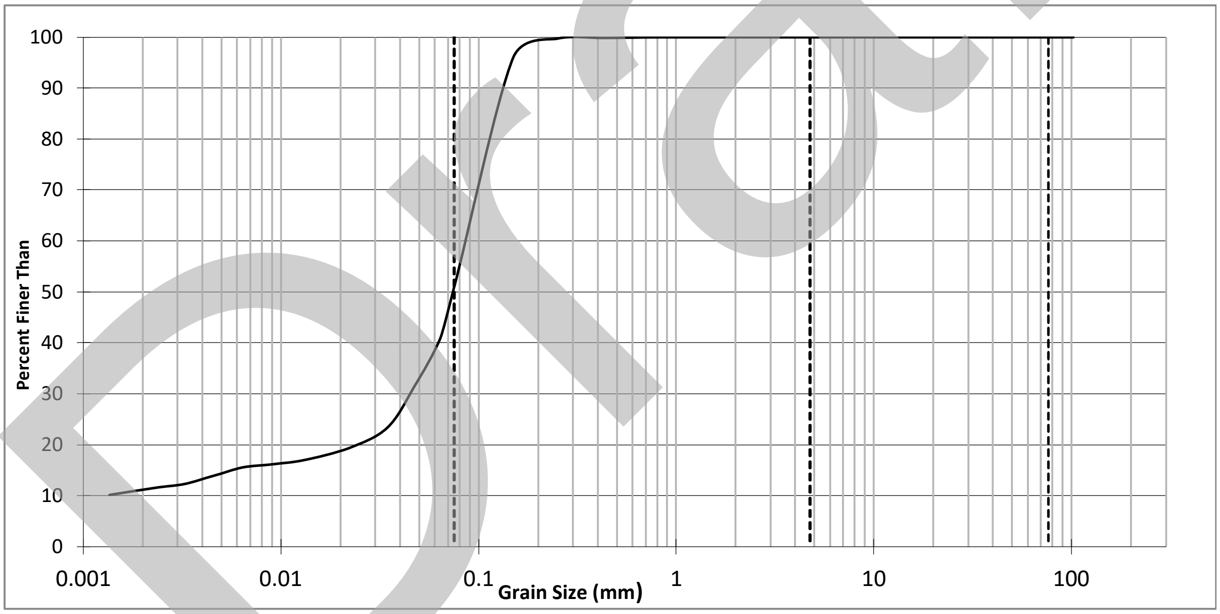
SNC·LAVALIN

Sample: NLB-618 PHII 8 at 10ft

Mechanical Analysis			Hydrometer Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer
4"	101.6	100.0	0.0637	40.9
3"	76.2	100.0	0.0470	31.3
2"	50.8	100.0	0.0343	23.4
1"	25.4	100.0	0.0220	19.4
3/4"	19.1	100.0	0.0128	17.0
3/8"	9.50	100.0	0.0091	16.2
#4	4.75	100.0	0.0064	15.5
#10	2.00	100.0	0.0046	13.9
#20	0.850	99.9	0.0032	12.3
#40	0.425	99.9	0.0023	11.5
#60	0.250	99.7	0.0014	10.2
#100	0.150	96.0		
#200	0.075	50.7		

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0
% Gravel	0
% Sand	49.0
% Silt Size (<75μ>2μ)	39.6
% Clay Size (<2μ)	11.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 51 %	SAND 49 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

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Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-627 FHII 13 fr 13-14.5ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.9
#40	0.425	99.7
#60	0.250	99.4
#100	0.150	99.0
#200	0.075	98.5

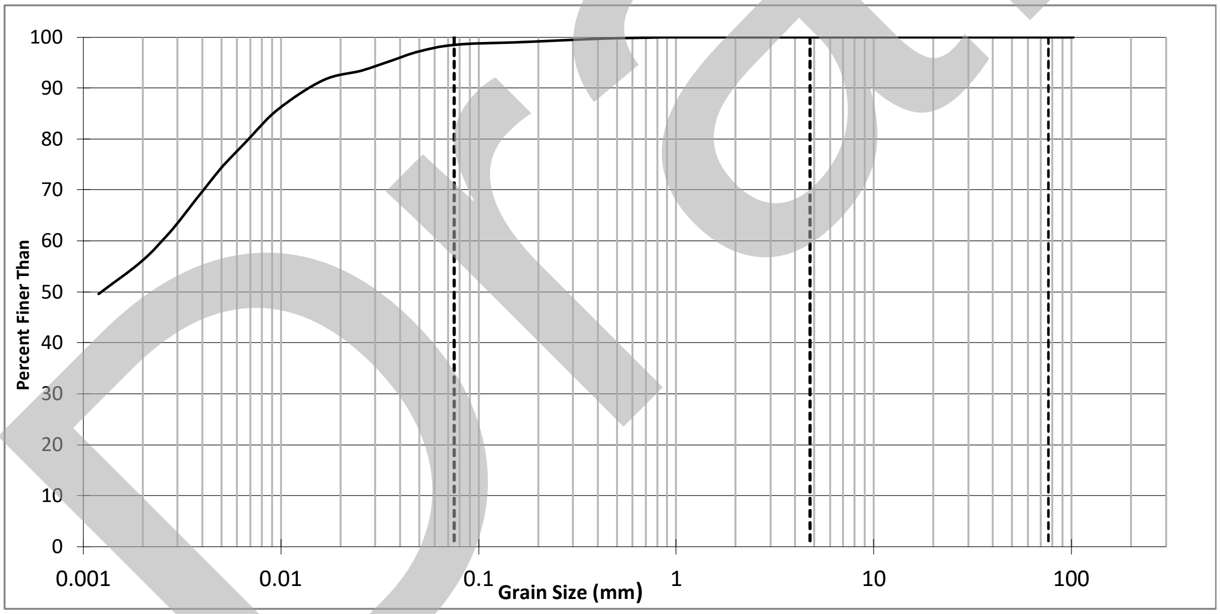
Hydrometer Analysis

Dia. (mm)	% Finer
0.0499	97.2
0.0357	95.3
0.0255	93.4
0.0163	91.6
0.0097	85.9
0.0070	80.5
0.0051	74.9
0.0037	68.3
0.0027	61.7
0.0020	56.1
0.0012	49.6

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0
% Gravel	0
% Sand	2.0
% Silt Size (<75µ>2µ)	42.2
% Clay Size (<2µ)	55.8

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 98 %	SAND 2 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

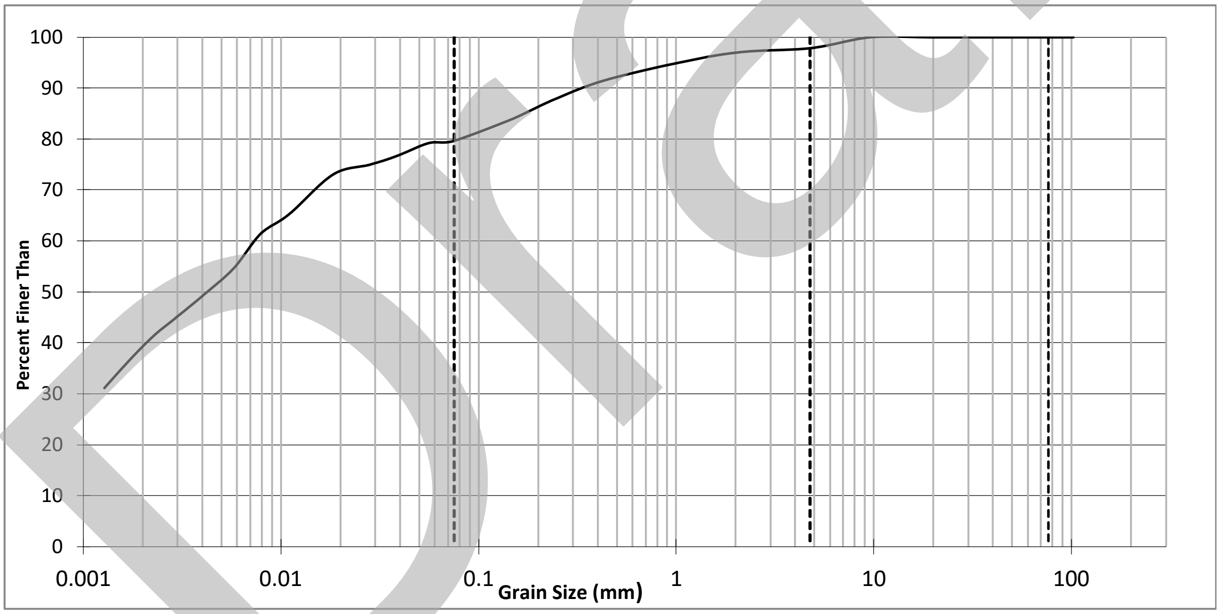
(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-632 FHII 13 at 26ft

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100.0	0.0565	79.3	% Cobble	0
3"	76.2	100.0	0.0404	77.0	% Gravel	2.0
2"	50.8	100.0	0.0288	75.0	% Sand	18.0
1"	25.4	100.0	0.0184	73.1	% Silt Size (<75µ>2µ)	40.5
3/4"	19.1	100.0	0.0110	65.3	% Clay Size (<2µ)	39.5
3/8"	9.50	100.0	0.0079	61.4		
#4	4.75	97.8	0.0057	54.6	Dispersing Agent used:	
#10	2.00	97.0	0.0041	49.7	*Sodium Hexametaphosphate*	
#20	0.850	94.3	0.0030	45.0		
#40	0.425	91.4	0.0021	40.4		
#60	0.250	88.1	0.0013	31.2		
#100	0.150	84.1				
#200	0.075	79.7				



FINES (silt, clay) 80 %	SAND 18 %	GRAVEL 2 %	COBBLE 0 %

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

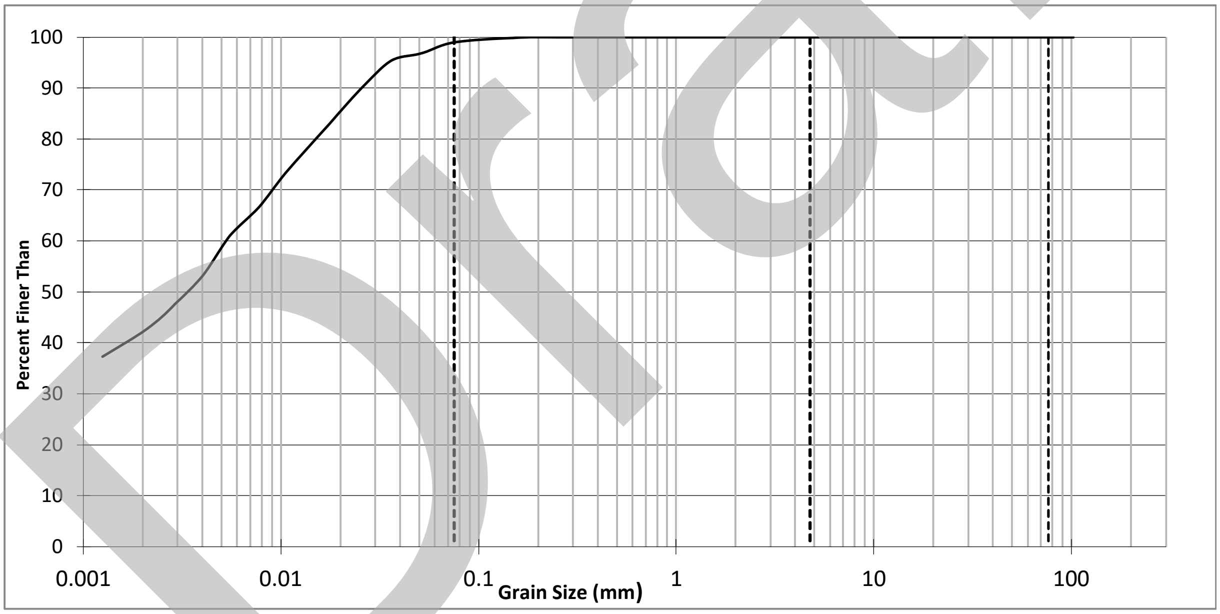
Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-666 FHII 21 at 30.5ft

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100.0	0.0510	96.8	% Cobble	0
3"	76.2	100.0	0.0364	95.4	% Gravel	0
2"	50.8	100.0	0.0264	90.6	% Sand	1.0
1"	25.4	100.0	0.0174	82.9	% Silt Size (<75μ>2μ)	56.8
3/4"	19.1	100.0	0.0105	73.3	% Clay Size (<2μ)	42.2
3/8"	9.50	100.0	0.0077	66.6		
#4	4.75	100.0	0.0055	61.0	Dispersing Agent used:	
#10	2.00	100.0	0.0040	53.3	*Sodium Hexametaphosphate*	
#20	0.850	100.0	0.0029	47.5		
#40	0.425	100.0	0.0021	42.7		
#60	0.250	99.9	0.0013	37.3		
#100	0.150	99.9				
#200	0.075	99.0				



FINES (silt, clay) 99 %	SAND 1 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-679 FHII 21 at 66ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	100.0
#40	0.425	99.9
#60	0.250	99.8
#100	0.150	99.4
#200	0.075	93.8

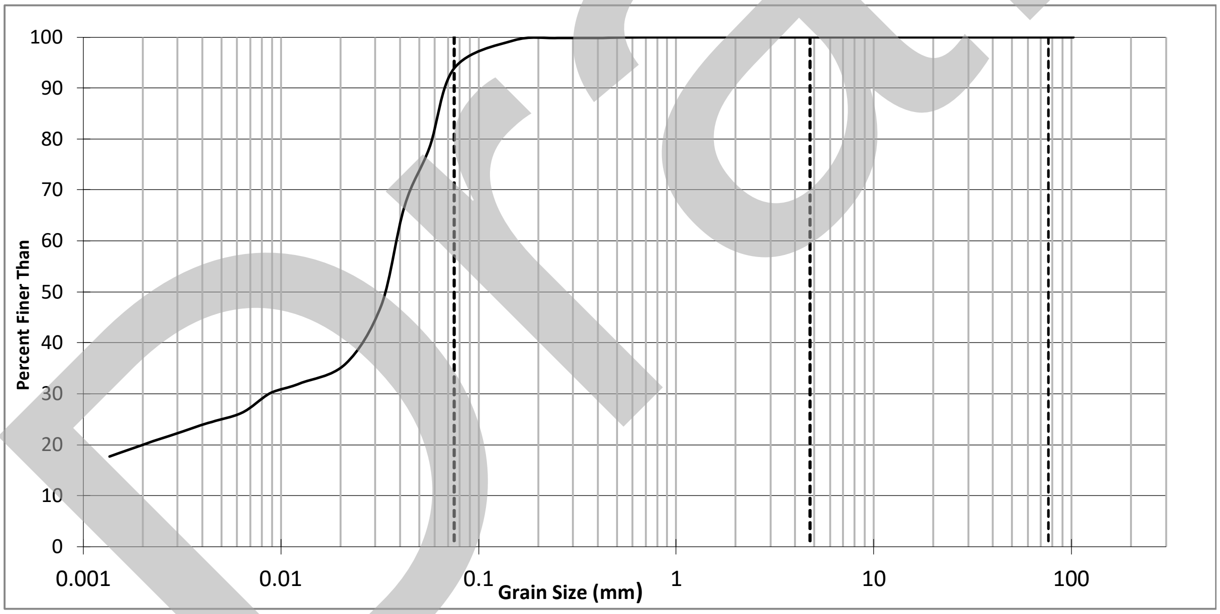
Hydrometer Analysis

Dia. (mm)	% Finer
0.0564	78.4
0.0420	66.8
0.0321	47.5
0.0212	35.9
0.0124	32.0
0.0088	30.1
0.0063	26.3
0.0044	24.5
0.0032	22.6
0.0023	20.7
0.0013	17.7

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0
% Gravel	0
% Sand	6.0
% Silt Size (<75μ>2μ)	74.0
% Clay Size (<2μ)	20.0

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 94 %	SAND 6 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

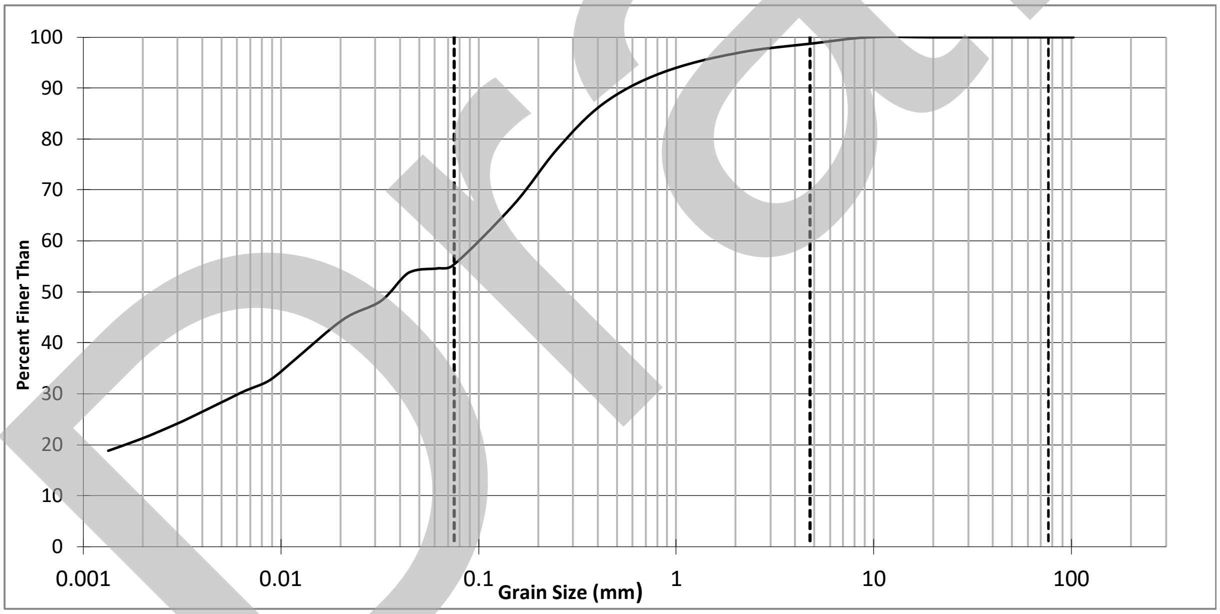
Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-691 FHII 21 fr 98-99.5ft

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100.0	0.0623	54.7	% Cobble	0
3"	76.2	100.0	0.0442	53.7	% Gravel	1.0
2"	50.8	100.0	0.0320	48.2	% Sand	43.0
1"	25.4	100.0	0.0205	44.6	% Silt Size (<75µ>2µ)	34.1
3/4"	19.1	100.0	0.0122	37.3	% Clay Size (<2µ)	21.9
3/8"	9.50	100.0	0.0088	32.7		
#4	4.75	98.7	0.0062	30.2	Dispersing Agent used:	
#10	2.00	96.9	#N/A	23.4	*Sodium Hexametaphosphate*	
#20	0.850	93.1	0.0032	24.7		
#40	0.425	86.9	0.0023	22.1		
#60	0.250	78.1	0.0013	18.8		
#100	0.150	67.1				
#200	0.075	55.3				



FINES (silt, clay) 56 %	SAND 43 %	GRAVEL 1 %	COBBLE 0 %

Checker: **Reviewer:**

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

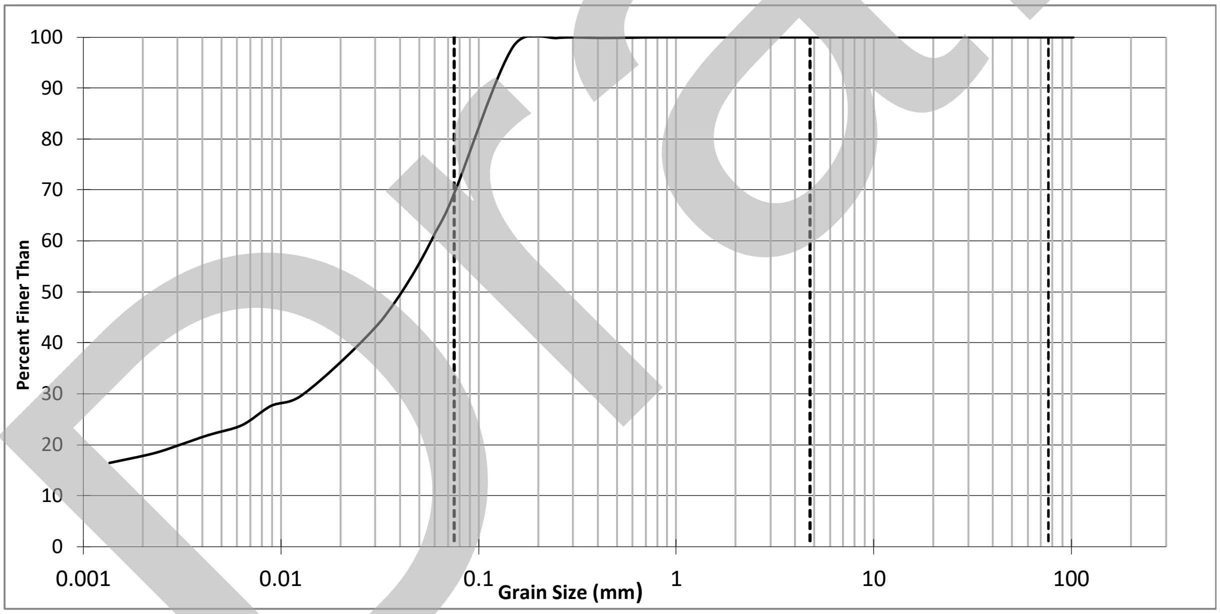
SNC·LAVALIN

Sample: NLB-696 FHII 22 fr 8-9.5ft

Mechanical Analysis			Hydrometer Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer
4"	101.6	100.0	0.0604	61.7
3"	76.2	100.0	0.0444	52.2
2"	50.8	100.0	0.0323	44.6
1"	25.4	100.0	0.0210	37.1
3/4"	19.1	100.0	0.0125	29.5
3/8"	9.50	100.0	0.0089	27.6
#4	4.75	100.0	0.0063	23.8
#10	2.00	100.0	0.0045	22.1
#20	0.850	100.0	0.0032	20.3
#40	0.425	99.9	0.0023	18.4
#60	0.250	99.8	0.0014	16.4
#100	0.150	98.2		
#200	0.075	69.2		

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0
% Gravel	0
% Sand	31.0
% Silt Size (<75μ>2μ)	51.4
% Clay Size (<2μ)	17.6

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 69 %	SAND 31 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D7928)

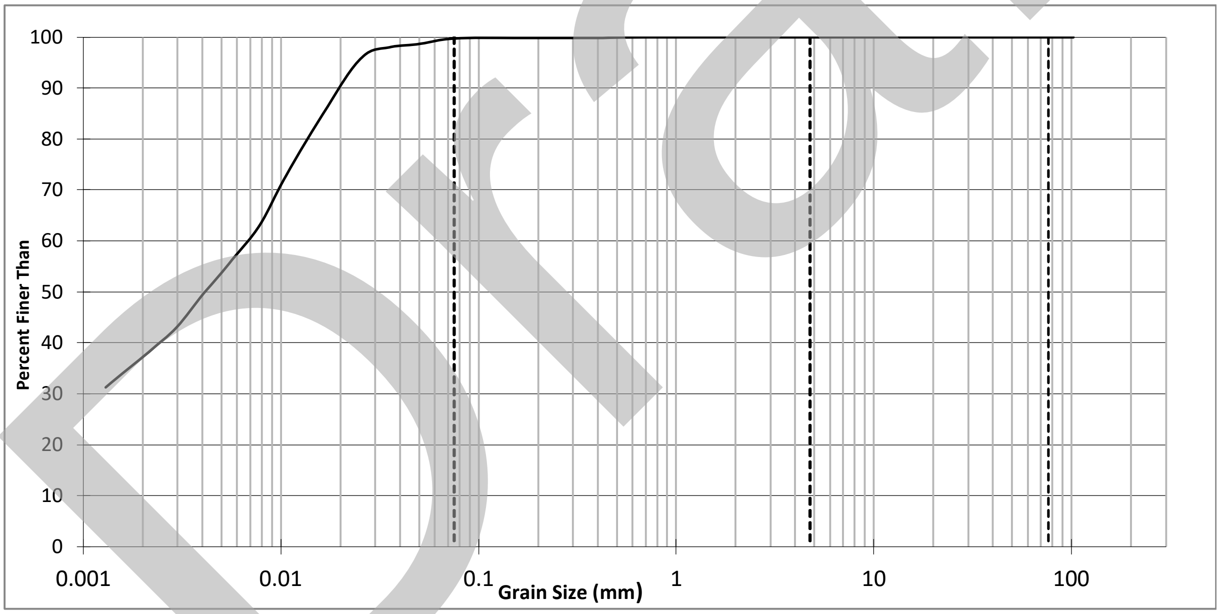
SNC·LAVALIN

Sample: NLB-707 FHII 22 at 37ft

Mechanical Analysis			Hydrometer Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer
4"	101.6	100.0	0.0507	98.7
3"	76.2	100.0	0.0360	98.0
2"	50.8	100.0	0.0257	96.1
1"	25.4	100.0	0.0172	86.4
3/4"	19.1	100.0	0.0106	72.8
3/8"	9.50	100.0	0.0078	63.2
#4	4.75	100.0	0.0057	56.4
#10	2.00	100.0	0.0041	49.8
#20	0.850	100.0	0.0030	43.0
#40	0.425	99.9	0.0021	38.2
#60	0.250	99.9	0.0013	31.3
#100	0.150	99.8		
#200	0.075	99.7		

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0
% Gravel	0
% Sand	0
% Silt Size (<75µ>2µ)	62.6
% Clay Size (<2µ)	37.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 100 %	SAND 0 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-718 FHII 22 at 60.5ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	100.0
#40	0.425	99.9
#60	0.250	99.9
#100	0.150	99.8
#200	0.075	99.1

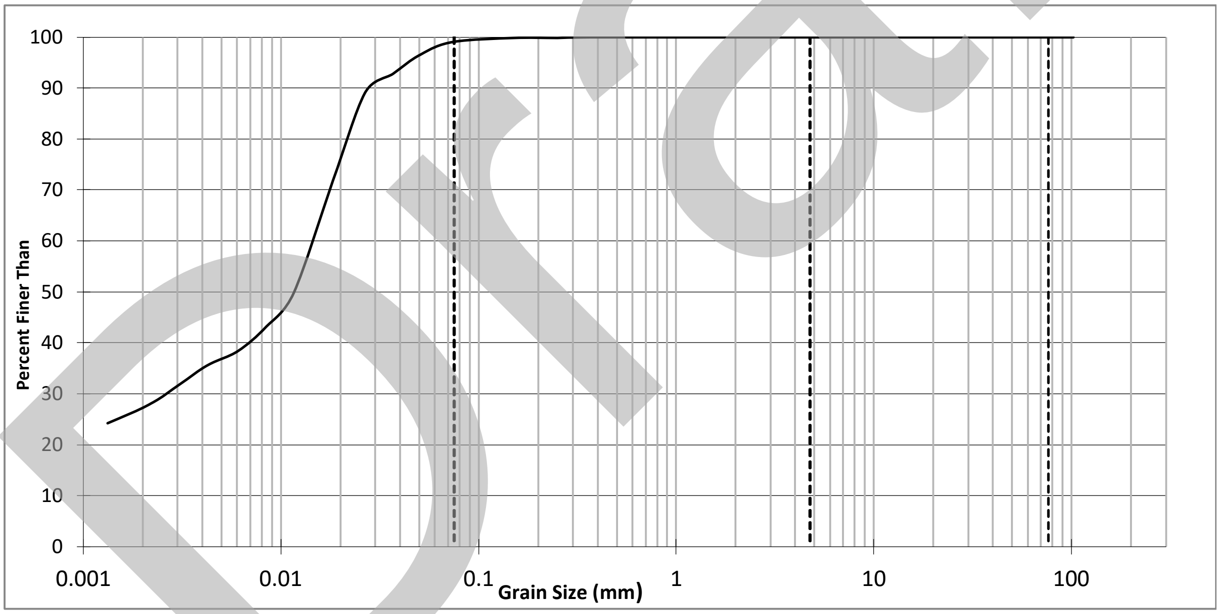
Hydrometer Analysis

Dia. (mm)	% Finer
0.0509	96.6
0.0368	92.8
0.0266	89.0
0.0183	71.8
0.0116	49.8
0.0084	43.2
0.0060	38.4
0.0043	35.7
0.0031	31.9
0.0022	28.1
0.0013	24.2

Summary of Analysis

Particle Size Distribution Summary	
% Cobble	0
% Gravel	0
% Sand	1.0
% Silt Size (<75μ>2μ)	71.9
% Clay Size (<2μ)	27.1

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 99 %	SAND 1 %	GRAVEL 0 %	COBBLE 0 %

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

HYDROMETER TEST REPORT

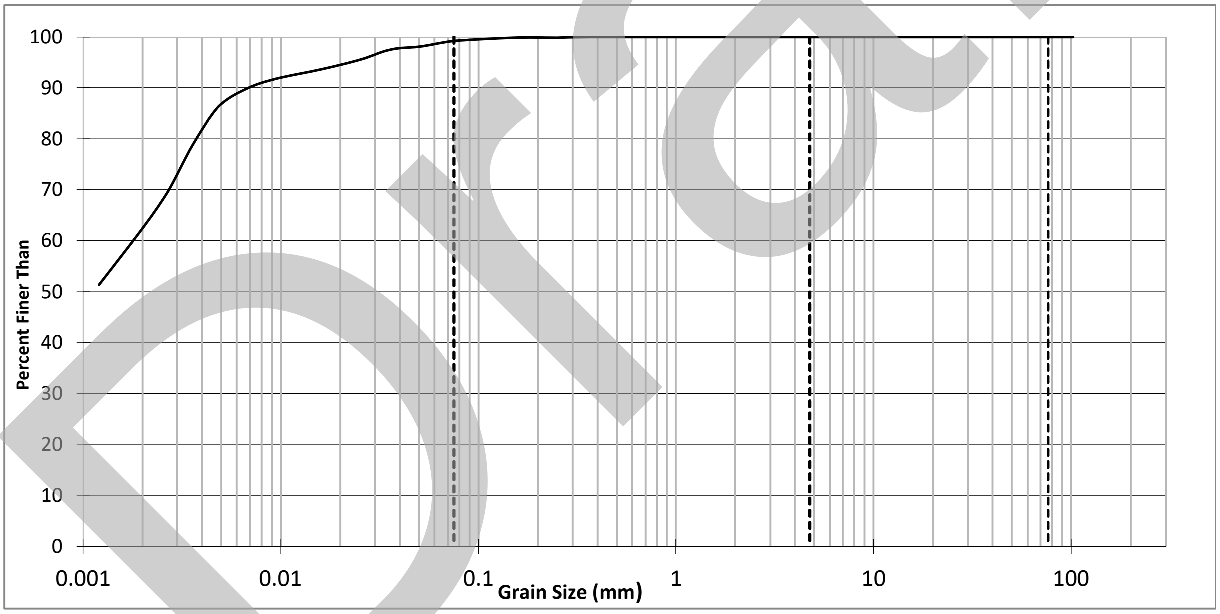
(Test Reference: ASTM D7928)

CERTIFIED BY CCIL

SNC·LAVALIN

Sample: NLB-815 FHII 24 at 48-49.5ft

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100.0	0.0501	98.1	% Cobble	0
3"	76.2	100.0	0.0356	97.5	% Gravel	0
2"	50.8	100.0	0.0254	95.6	% Sand	1.0
1"	25.4	100.0	0.0163	93.7	% Silt Size (<75μ>2μ)	36.4
3/4"	19.1	100.0	0.0095	91.8	% Clay Size (<2μ)	62.6
3/8"	9.50	100.0	0.0068	89.9		
#4	4.75	100.0	0.0049	86.4	Dispersing Agent used:	
#10	2.00	100.0	0.0036	78.8	*Sodium Hexametaphosphate*	
#20	0.850	100.0	0.0026	69.4		
#40	0.425	99.9	0.0019	61.8		
#60	0.250	99.9	0.0012	51.3		
#100	0.150	99.8				
#200	0.075	99.2				



FINES (silt, clay) 99 %	SAND 1 %	GRAVEL 0 %	COBBLE 0 %

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

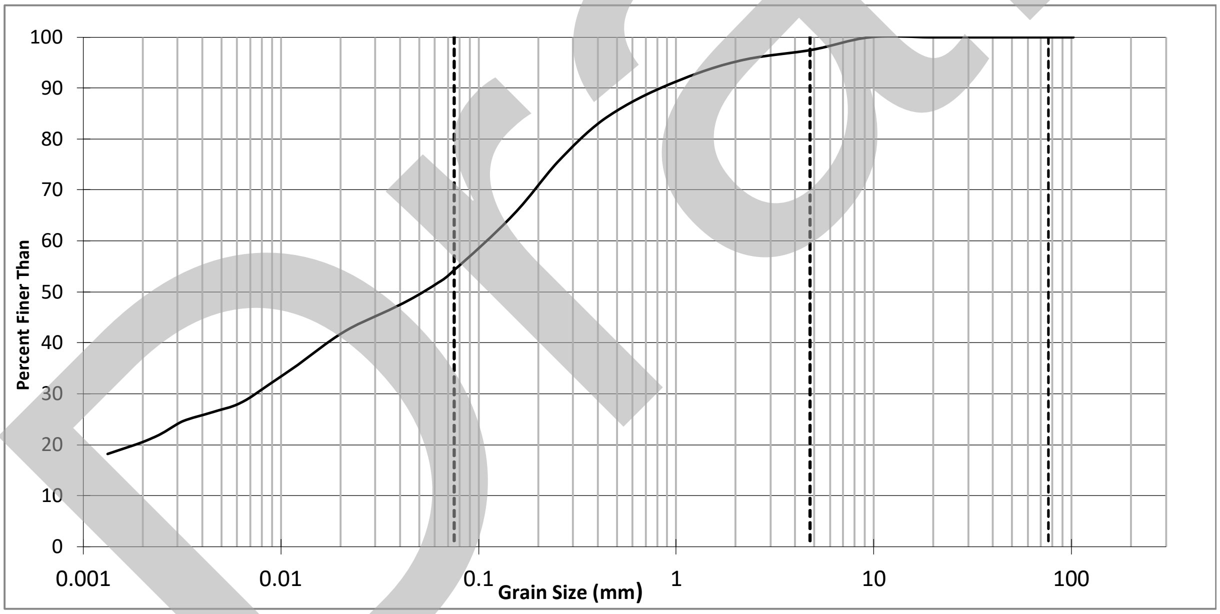
Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

Sample: NLB-827 FHII 24 fr 81-81.5ft

Mechanical Analysis			Hydrometer Analysis		Summary of Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer	Particle Size Distribution Summary	
4"	101.6	100.0	0.0624	51.8	% Cobble	0
3"	76.2	100.0	0.0447	48.4	% Gravel	3.0
2"	50.8	100.0	0.0320	45.7	% Sand	43.0
1"	25.4	100.0	0.0205	42.1	% Silt Size (<75µ>2µ)	33.7
3/4"	19.1	100.0	0.0121	35.7	% Clay Size (<2µ)	20.3
3/8"	9.50	100.0	0.0087	31.9		
#4	4.75	97.5	0.0063	28.2	Dispersing Agent used:	
#10	2.00	95.3	0.0044	26.4	*Sodium Hexametaphosphate*	
#20	0.850	90.2	0.0032	24.6		
#40	0.425	83.8	0.0022	21.3		
#60	0.250	75.4	0.0013	18.2		
#100	0.150	65.1				
#200	0.075	54.2				



FINES (silt, clay) 54 %	SAND 43 %	GRAVEL 3 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

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SNC·LAVALIN

Sample: NLB-833 FHII 23 at 10ft

Mechanical Analysis

Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	100.0
#40	0.425	99.9
#60	0.250	99.8
#100	0.150	97.5
#200	0.075	78.1

Hydrometer Analysis

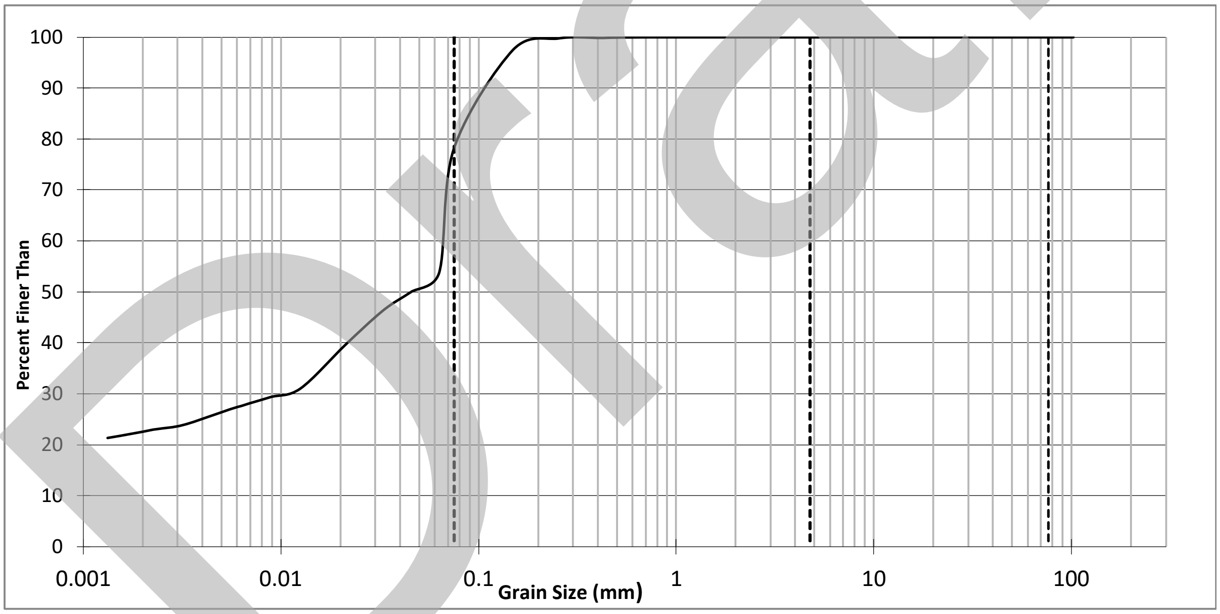
Dia. (mm)	% Finer
0.0630	53.8
0.0452	50.0
0.0324	46.2
0.0210	39.6
0.0125	31.0
0.0088	29.4
0.0063	27.7
0.0045	25.8
0.0032	23.9
0.0023	22.9
0.0013	21.4

Summary of Analysis

Particle Size Distribution Summary

% Cobble	0
% Gravel	0.0
% Sand	22.0
% Silt Size (<75μ>2μ)	55.6
% Clay Size (<2μ)	22.4

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 78 %	SAND 22 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

(Test Reference: ASTM D7928)

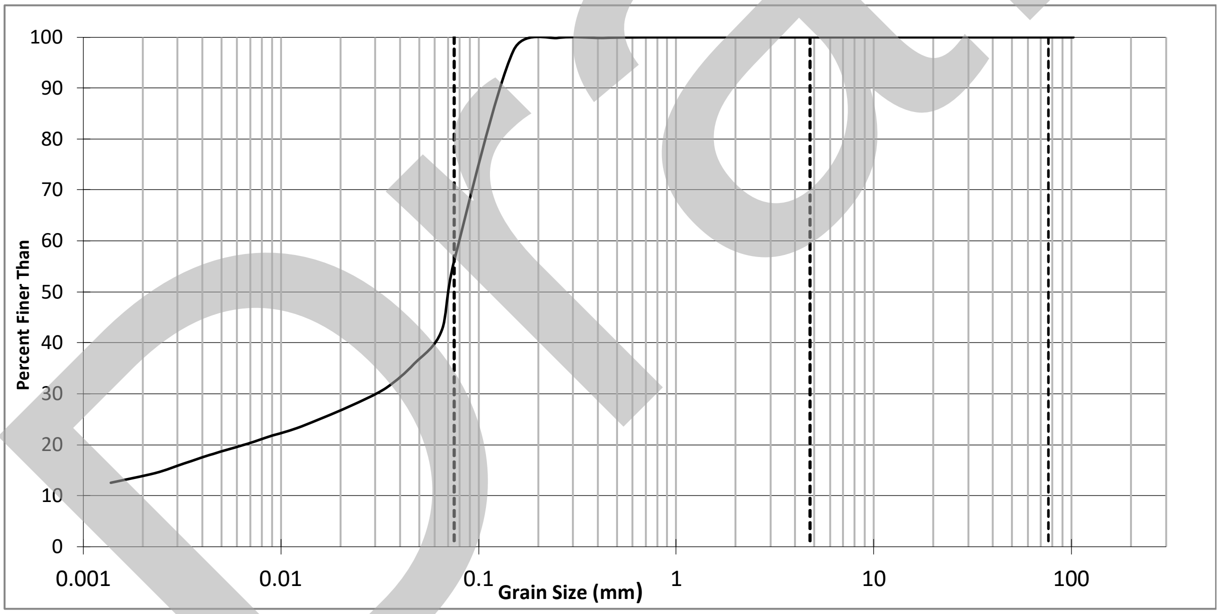
Sample: NLB-851 FHII 23 at 57ft

Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	100.0
#10	2.00	100.0
#20	0.850	99.9
#40	0.425	99.9
#60	0.250	99.8
#100	0.150	97.4
#200	0.075	55.9

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0651	42.5
0.0472	35.9
0.0339	31.2
0.0217	27.4
0.0127	23.7
0.0090	21.8
0.0064	19.9
0.0045	18.2
0.0032	16.4
0.0023	14.5
0.0014	12.5

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0
% Gravel	0
% Sand	44.0
% Silt Size (<75μ>2μ)	42.0
% Clay Size (<2μ)	14.0

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 56 %	SAND 44 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D7928)

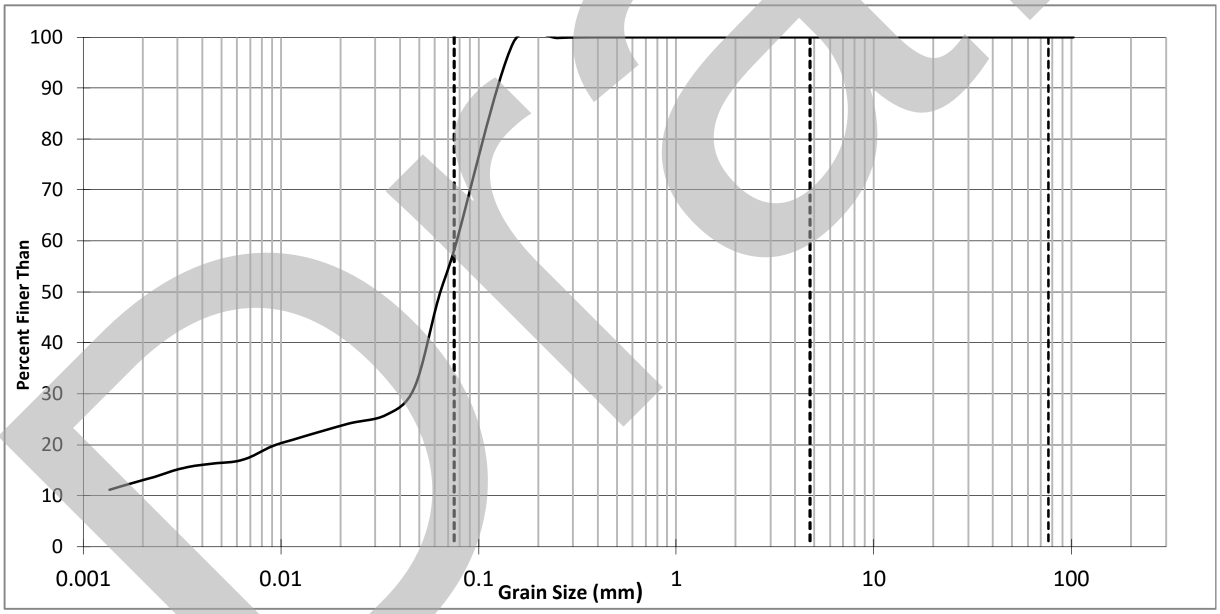
SNC·LAVALIN

Sample: NLB-855 FHII 23 fr 63-64.5ft

Mechanical Analysis			Hydrometer Analysis	
Sieve	Dia. (mm)	% Finer	Dia. (mm)	% Finer
4"	101.6	100.0	0.0623	48.7
3"	76.2	100.0	0.0472	31.1
2"	50.8	100.0	0.0340	25.9
1"	25.4	100.0	0.0217	24.1
3/4"	19.1	100.0	0.0126	21.5
3/8"	9.50	100.0	0.0090	19.7
#4	4.75	100.0	0.0064	17.1
#10	2.00	100.0	0.0045	16.4
#20	0.850	100.0	0.0032	15.5
#40	0.425	100.0	0.0023	13.7
#60	0.250	99.8	0.0014	11.2
#100	0.150	99.0		
#200	0.075	58.1		

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0
% Gravel	0
% Sand	42.0
% Silt Size (<75µ>2µ)	45.1
% Clay Size (<2µ)	12.9

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 58 %	SAND 42 %	GRAVEL 0 %	COBBLE 0 %

Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Geoscience & Materials

HYDROMETER TEST REPORT

CERTIFIED BY CCIL

(Test Reference: ASTM D7928)

SNC·LAVALIN

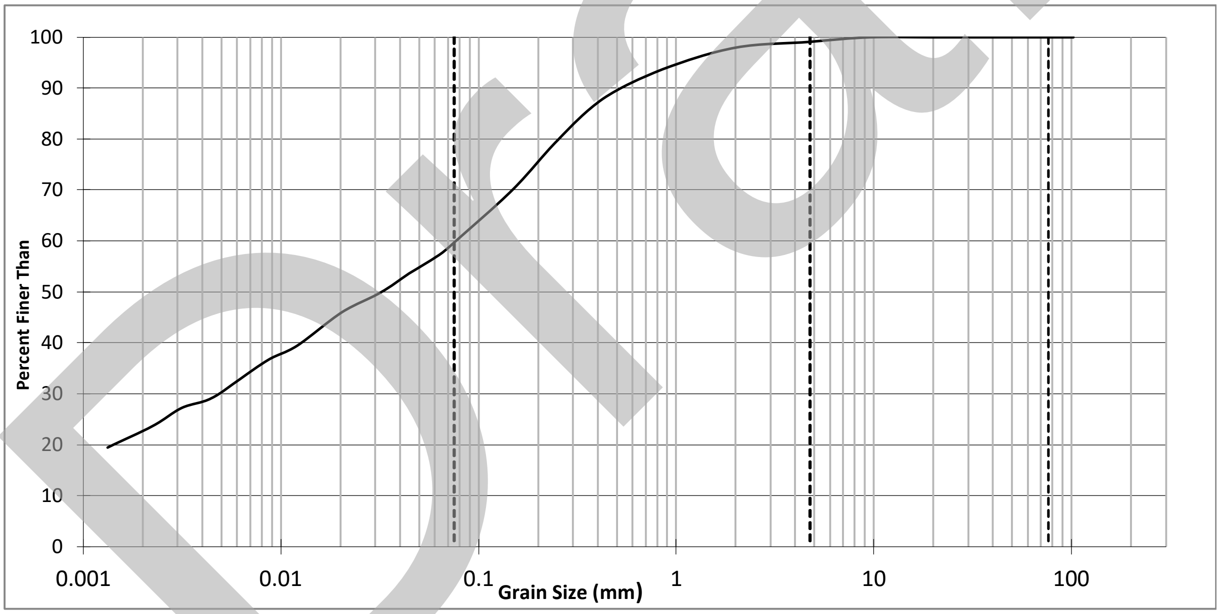
Sample: NLB-926 FHII 18 at 54ft

Mechanical Analysis		
Sieve	Dia. (mm)	% Finer
4"	101.6	100.0
3"	76.2	100.0
2"	50.8	100.0
1"	25.4	100.0
3/4"	19.1	100.0
3/8"	9.50	100.0
#4	4.75	99.1
#10	2.00	98.0
#20	0.850	93.6
#40	0.425	87.9
#60	0.250	79.8
#100	0.150	70.2
#200	0.075	59.7

Hydrometer Analysis	
Dia. (mm)	% Finer
0.0617	57.0
0.0443	53.6
0.0318	49.8
0.0204	46.1
0.0121	39.5
0.0086	36.7
0.0062	32.9
0.0044	29.1
0.0031	27.3
0.0022	23.7
0.0013	19.5

Summary of Analysis	
Particle Size Distribution Summary	
% Cobble	0
% Gravel	1.0
% Sand	39.0
% Silt Size (<75μ>2μ)	37.1
% Clay Size (<2μ)	22.9

Dispersing Agent used:
Sodium Hexametaphosphate



FINES (silt, clay) 60 %	SAND 39 %	GRAVEL 1 %	COBBLE 0 %

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional
Project #: 659183
Date: 2022-04-29

Appendix VII (E)

Consolidated Undrained Triaxial

SNC·LAVALIN

Consolidated Undrained Triaxial Test by ASTM D-4767

Client: Saskatoon Bypass
Project No. 659183
Checked by: KF
Date: 2/2/2022

SAMPLE NO.:	NLB-1176 at 1.5-1.95m, BH-2-S1			**CONFIGURATION SET-UP:**	
TEST APP:	#2 New	**Load Cell SN:**	DS-10Klb cap	**Model:**	SN# 17D300116
DESCRIPTION:		**Channel Box SN:**	New1-6574 SN 4250	**Transducer:**	#2 New 1000 kPa

Liquid Limit(%):	N/A		Gravel (%):	-
Plastic Limit(%):	N/A		Sand (%):	N/A
Plasticity Index (%):	N/A		Silt (%):	N/A
Specific Gravity:	2.65	(assumed)	Clay(%):	N/A

	AS SET UP	***AS TESTED***
Effective Confining Pressure (kPa):	16	16
Wet density (kg/m^3):	2197	2259
Dry density (kg/m^3):	1968	1949
Water content (	11.7%	15.9%
Void ratio:	0.35	0.42
Degree of saturation:	89.3%	100%
Strain rate (mm/min):	0.01	

COMMENTS:

Ver 5 - 2016/04/25

SNC·LAVALIN

Project Name:	Saskatoon Bypass	Test Name:	Consolidated Undrained
Project No.	659183	Sample Type:	Shelby
Sample No.:	NLB-1176 at 1.5-1.95m, BH-2-S1	Test App:	#2 New
Date:	2/2/2022	Conducted By:	MC
Confining Pressure:	16 kPa	Checked By:	KF

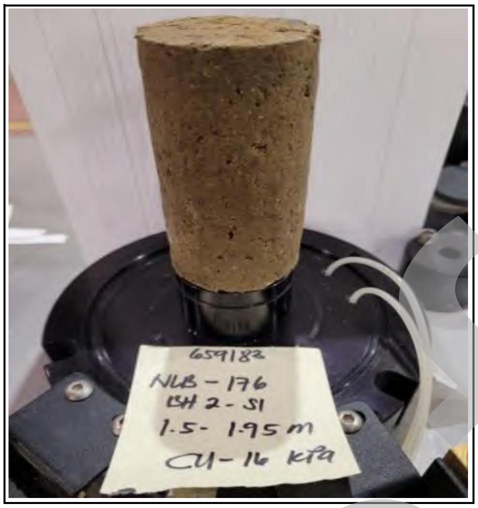


PHOTO OF SPECIMEN BEFORE TEST

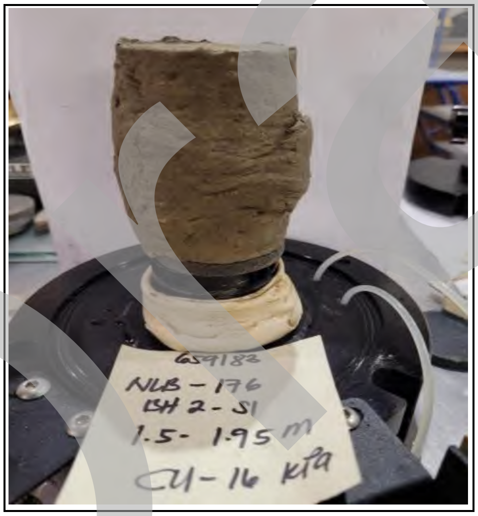


PHOTO OF SPECIMEN AFTER TEST

TEST EQUIPMENT

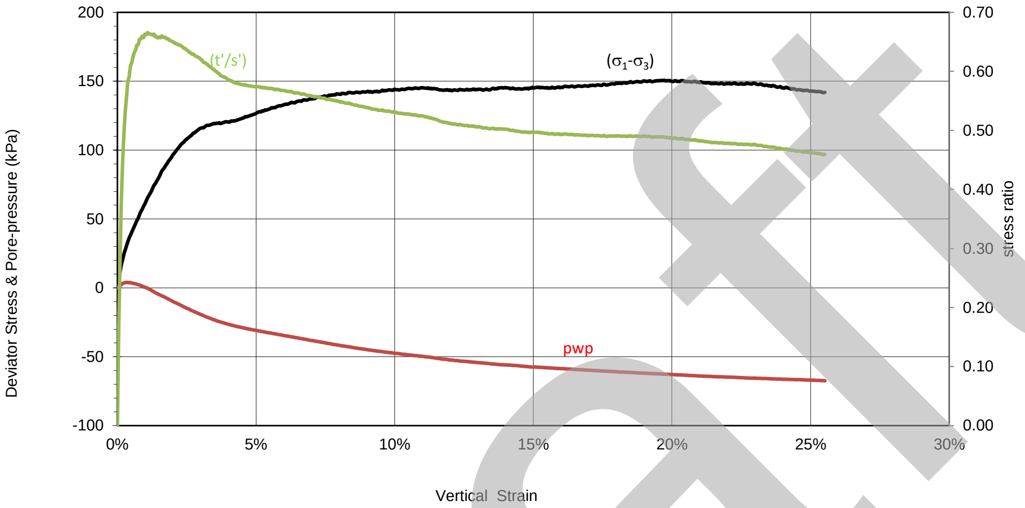
Karol Warner Constant Strain Loading Frame with a 10,000 lb. capacity.
Vertical Strains were measured by electronic displacement transducer.
Shear Stress were measured with an electronic load cell.
Cell and Pore pressure was applied with a compressed air-water system through a pressure control board.
Pressure were measured with electronic pressure transducers.

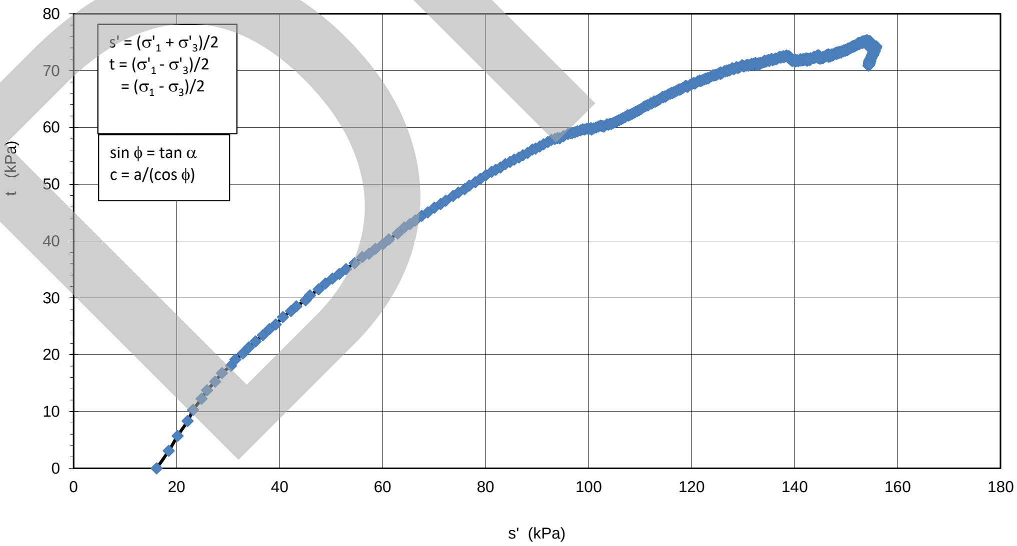
TEST PROCEDURE

This test was done in accordance with ASTM 4767-04 (Consolidated Undrained Triaxial Compression Test).

SNC·LAVALIN

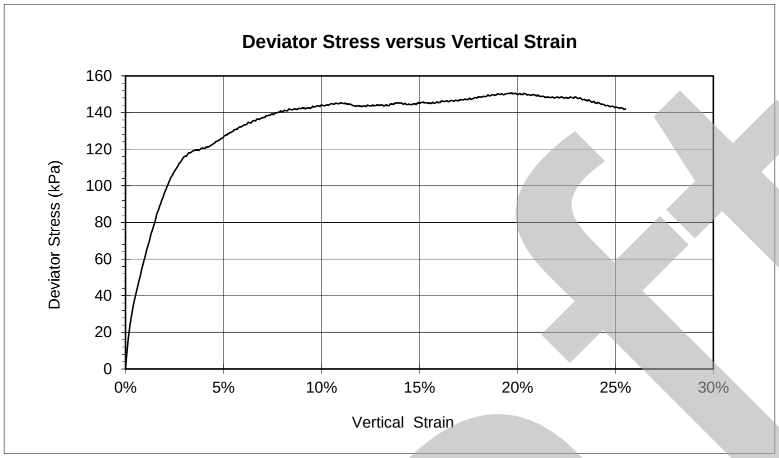
Project Name:	Saskatoon Bypass	**Test Name:**	Consolidated Undrained
Project No.	659183	**Soil Type:**	
Sample No.	NLB-1176 at 1.5-1.95m, BH-2-S1	**Test App.**	#2 New
Date:	2/2/2022	**Conducted by:**	MC
Confining Pressure:	16 kPa	**Checked By:**	KF

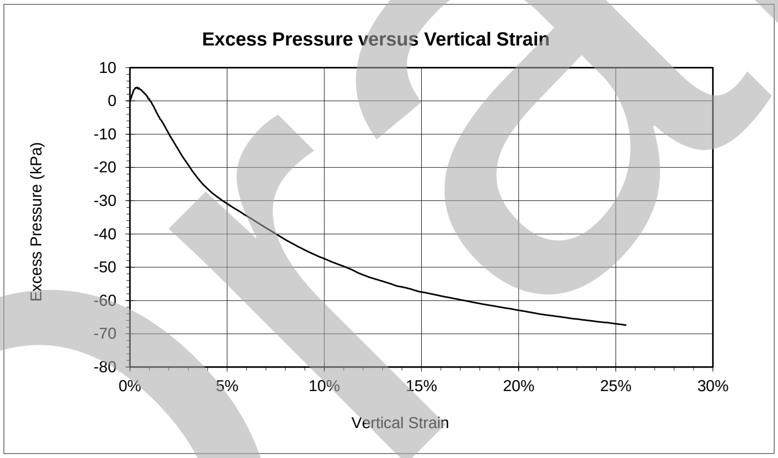


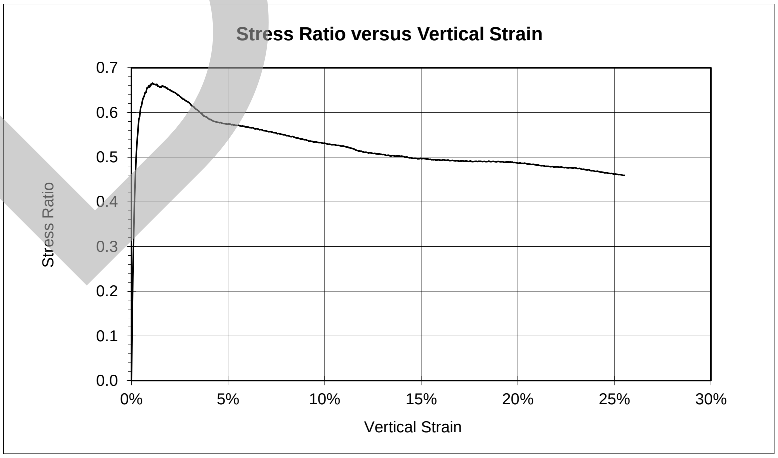


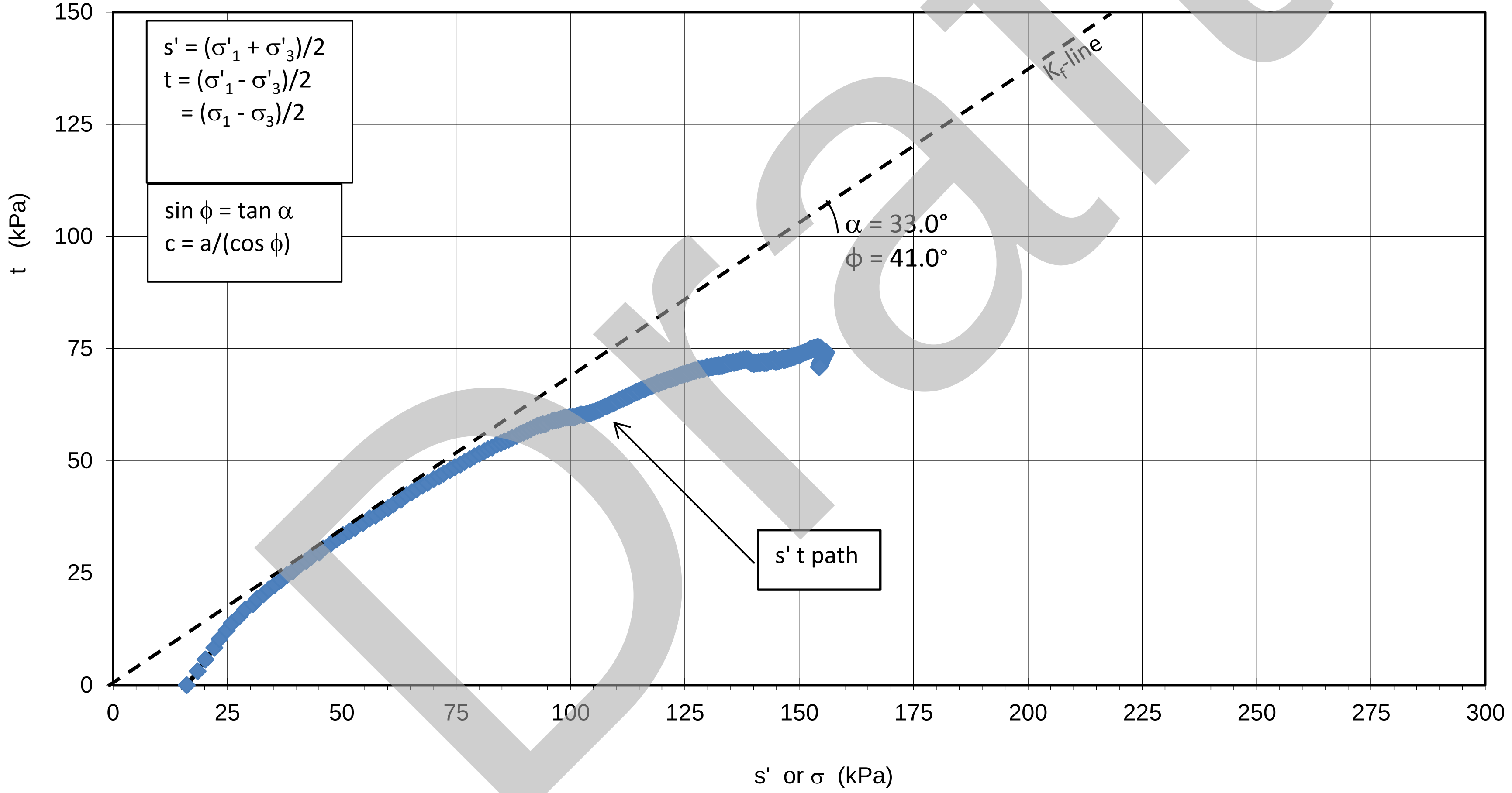
SNC·LAVALIN

Project Name:	Saskatoon Bypass	**Test Name:**	Consolidated Undrained
Project No.	659183	**Soil Type:**	
Sample No.	NLB-1176 at 1.5-1.95m, BH-2-S1	**Test App.**	#2 New
Date:	2/2/2022	**Conducted by:**	MC
Confining Pressure:	16 kPa	**Checked By:**	KF


Deviator Stress versus Vertical Strain


Excess Pressure versus Vertical Strain


Stress Ratio versus Vertical Strain



s' = (σ'$_1$ + σ'$_3$)/2
t = (σ'$_1$ - σ'$_3$)/2
= (σ$_1$ - σ$_3$)/2
sin ϕ = tan α
c = a/(cos ϕ)
K$_f$-line
α = 33.0°
ϕ = 41.0°
s' t path
150
125
100
75
50
25
0
t (kPa)
0
25
50
75
100
125
150
175
200
225
250
275
300
s' or σ (kPa)

SNC·LAVALIN

Consolidated Undrained Triaxial Test by ASTM D-4767

Client: Saskatoon Bypass
Project No. 659183
Checked by: KF
Date: 3/1/2022

SAMPLE NO.: NLB-1176 at 1.5-1.95m, BH-2-S1
CONFIGURATION SET-UP:
TEST APP: #2 New
Load Cell SN: DS-10Klb cap
Model: SN# 17D300116
DESCRIPTION:
Channel Box SN: New1-6574 SN4250
Transducer: #2 New 1000 kPa

Liquid Limit(%):	N/A		Gravel (%):	-
Plastic Limit(%):	N/A		Sand (%):	N/A
Plasticity Index (%):	N/A		Silt (%):	N/A
Specific Gravity:	2.65	(assumed)	Clay(%):	N/A

	AS SET UP	*AS TESTED*
Effective Confining Pressure (kPa):	32	32
Wet density (kg/m^3):	2189	2243
Dry density (kg/m^3):	1938	1970
Water content (	13.0%	13.9%
Void ratio:	0.37	0.37
Degree of saturation:	93.7%	100%
Strain rate (mm/min):	0.01	

COMMENTS:

Ver 5 - 2016/04/25

SNC·LAVALIN

Project Name:	Saskatoon Bypass	Test Name:	Consolidated Undrained
Project No.	659183	Sample Type:	Shelby
Sample No.:	NLB-1176 at 1.5-1.95m, BH-2-S1	Test App:	#2 New
Date:	3/1/2022	Conducted By:	MC
Confining Pressure:	32 kPa	Checked By:	KF

PHOTO OF SPECIMEN BEFORE TEST

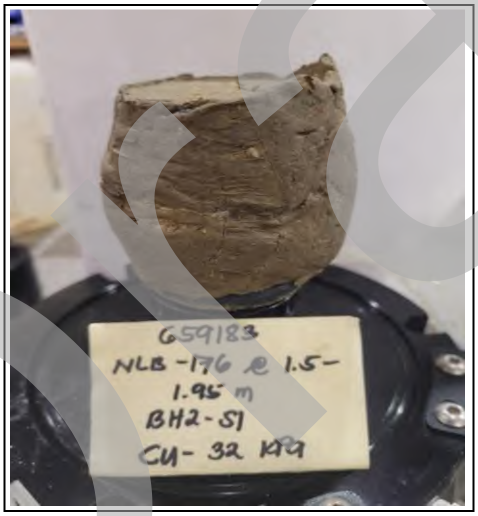


PHOTO OF SPECIMEN AFTER TEST

TEST EQUIPMENT

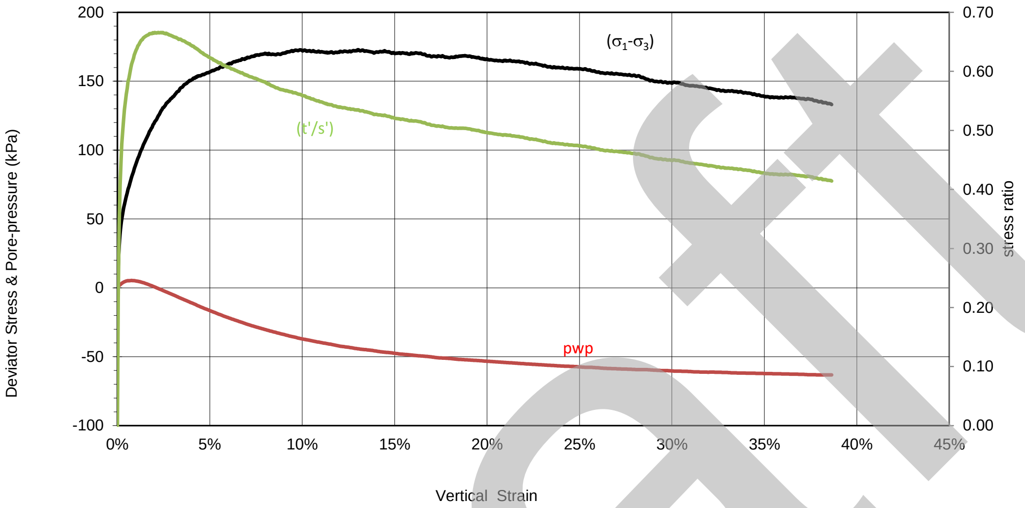
Karol Warner Constant Strain Loading Frame with a 10,000 lb. capacity.
Vertical Strains were measured by electronic displacement transducer.
Shear Stress were measured with an electronic load cell.
Cell and Pore pressure was applied with a compressed air-water system through a pressure control board.
Pressure were measured with electronic pressure transducers.

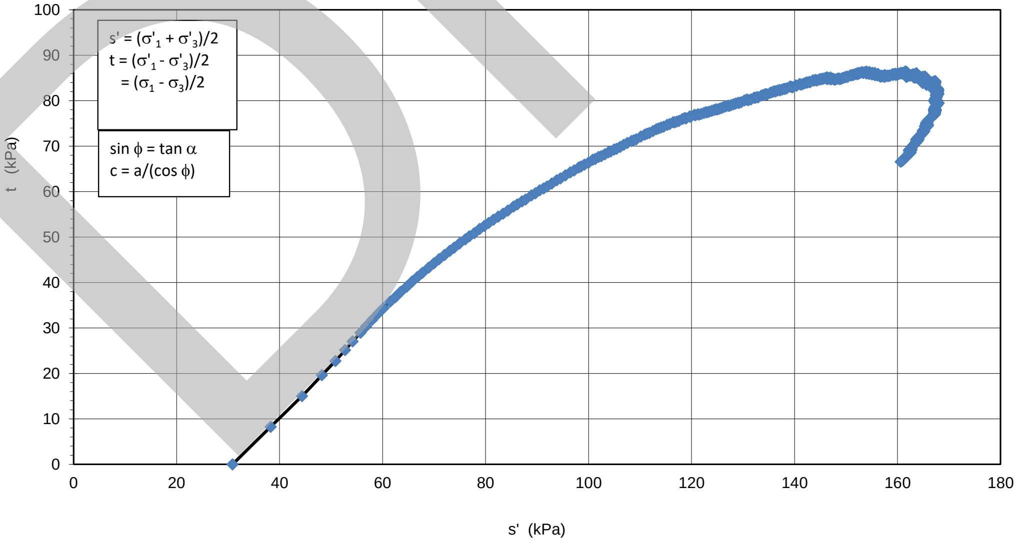
TEST PROCEDURE

This test was done in accordance with ASTM 4767-04 (Consolidated Undrained Triaxial Compression Test).

SNC·LAVALIN

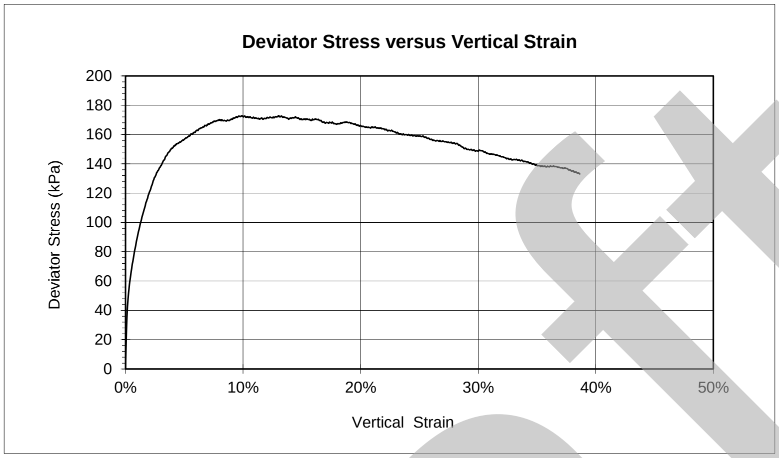
Project Name:	Saskatoon Bypass	**Test Name:**	Consolidated Undrained
Project No.	659183	**Soil Type:**	
Sample No.	NLB-1176 at 1.5-1.95m, BH-2-S1	**Test App.**	#2 New
Date:	3/1/2022	**Conducted by:**	MC
Confining Pressure:	32 kPa	**Checked By:**	KF

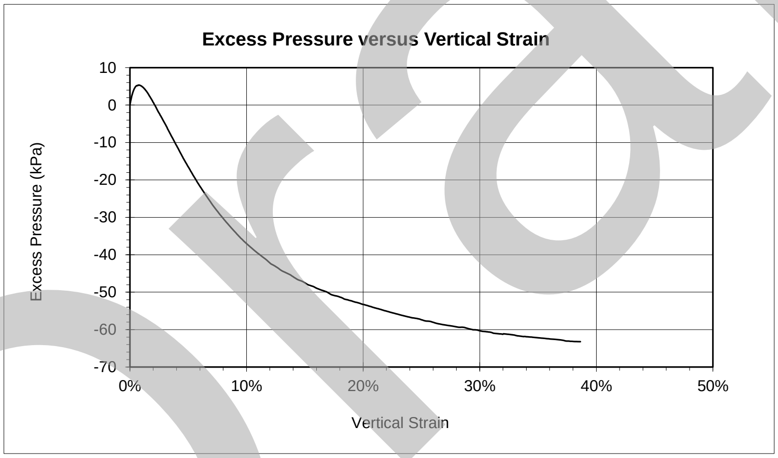


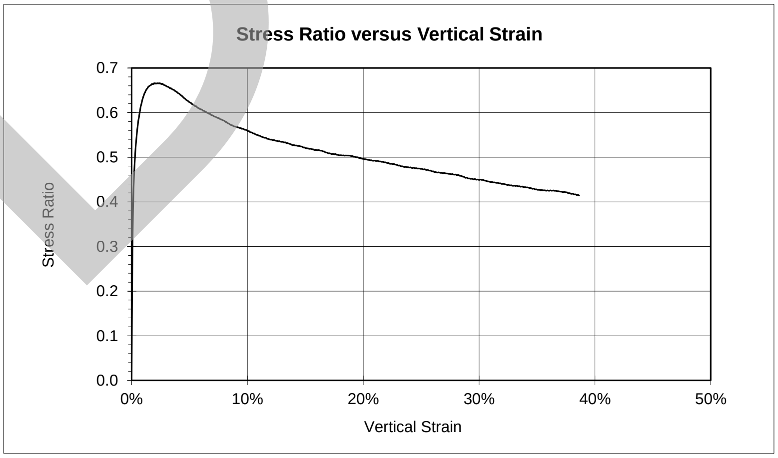


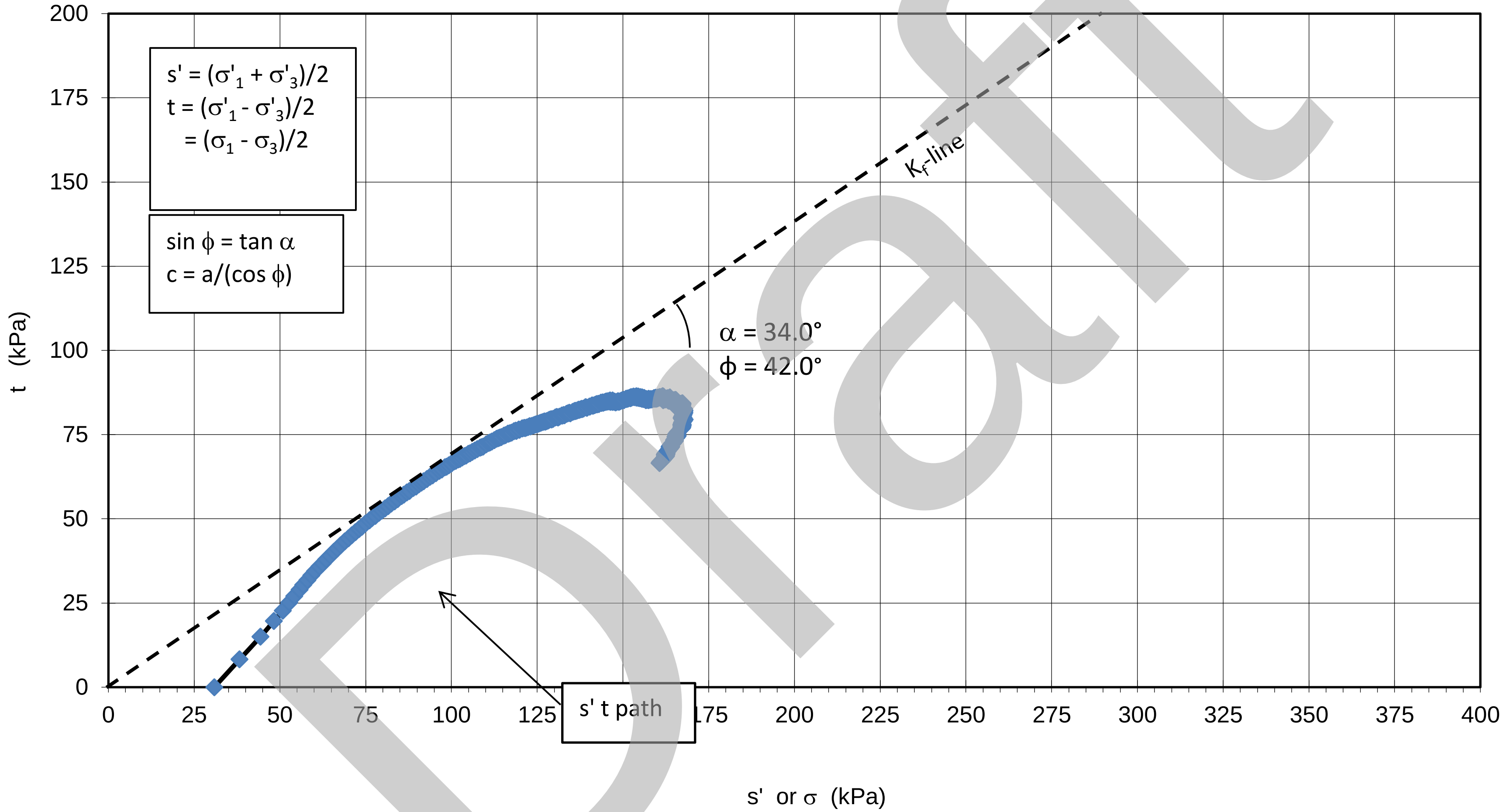
SNC·LAVALIN

Project Name:	Saskatoon Bypass	**Test Name:**	Consolidated Undrained
Project No.	659183	**Soil Type:**	
Sample No.	NLB-1176 at 1.5-1.95m, BH-2-S1	**Test App.**	#2 New
Date:	3/1/2022	**Conducted by:**	MC
Confining Pressure:	32 kPa	**Checked By:**	KF


Deviator Stress versus Vertical Strain


Excess Pressure versus Vertical Strain


Stress Ratio versus Vertical Strain



200
175
150
125
100
75
50
25
0
t (kPa)
s' = (σ'₁ + σ'₃)/2
t = (σ'₁ - σ'₃)/2
= (σ₁ - σ₃)/2
sin ϕ = tan α
c = a/(cos ϕ)
K_f-line
α = 34.0°
ϕ = 42.0°
s' t path
0
25
50
75
100
125
175
200
225
250
275
300
325
350
375
400
s' or σ (kPa)

SNC·LAVALIN

Consolidated Undrained Triaxial Test by ASTM D-4767

Client: Saskatoon Bypass
Project No. 659183
Checked by: KF
Date: 3/26/2026

SAMPLE NO.: NLB-1177 at 9.0-9.71m
CONFIGURATION SET-UP:
TEST APP: #2 New
Load Cell SN: DS-10Klb cap
Model: SN# 17D300116
DESCRIPTION:
Channel Box SN: New1-6574 SN4250
Transducer: #2 New 1000 kPa

Liquid Limit(%):	N/A		Gravel (%):	-
Plastic Limit(%):	N/A		Sand (%):	N/A
Plasticity Index (%):	N/A		Silt (%):	N/A
Specific Gravity:	2.65	(assumed)	Clay(%):	N/A

	AS SET UP	*AS TESTED*
Effective Confining Pressure (kPa):	75	75
Wet density (kg/m^3):	2046	2071
Dry density (kg/m^3):	1708	1743
Water content (	19.8%	18.8%
Void ratio:	0.55	0.50
Degree of saturation:	95.2%	100%
Strain rate (mm/min):	0.01	

COMMENTS:

Ver 5 - 2016/04/25

Project Name:	Saskatoon Bypass	Test Name:	Consolidated Undrained
Project No.	659183	Sample Type:	Shelby
Sample No.:	NLB-1177 at 9.0-9.71m	Test App:	#2 New
Date:	3/26/2026	Conducted By:	MC
Confining Pressure:	75 kPa	Checked By:	KF

PHOTO OF SPECIMEN BEFORE TEST

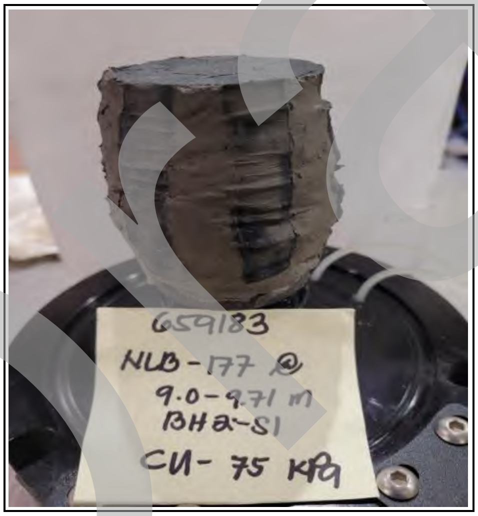


PHOTO OF SPECIMEN AFTER TEST

TEST EQUIPMENT

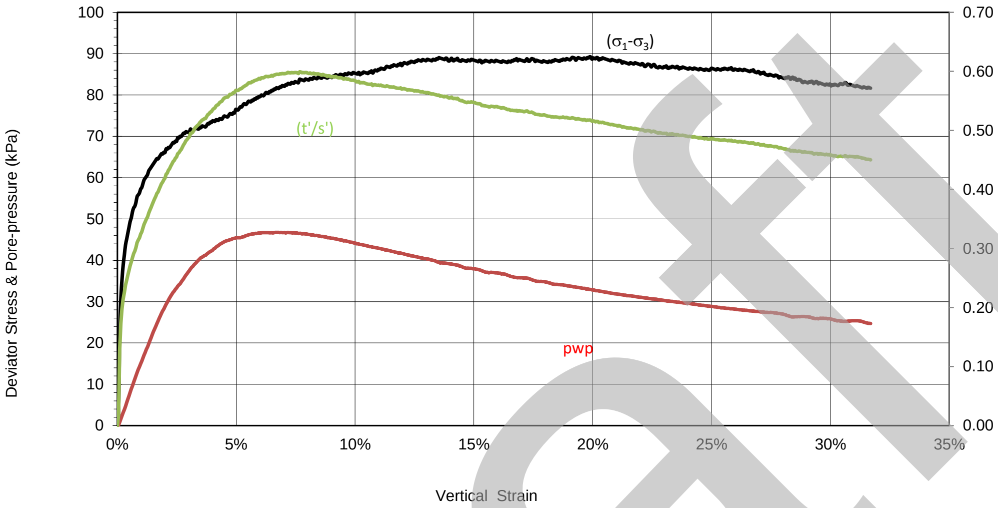
Karol Warner Constant Strain Loading Frame with a 10,000 lb. capacity.
Vertical Strains were measured by electronic displacement transducer.
Shear Stress were measured with an electronic load cell.
Cell and Pore pressure was applied with a compressed air-water system through a pressure control board.
Pressure were measured with electronic pressure transducers.

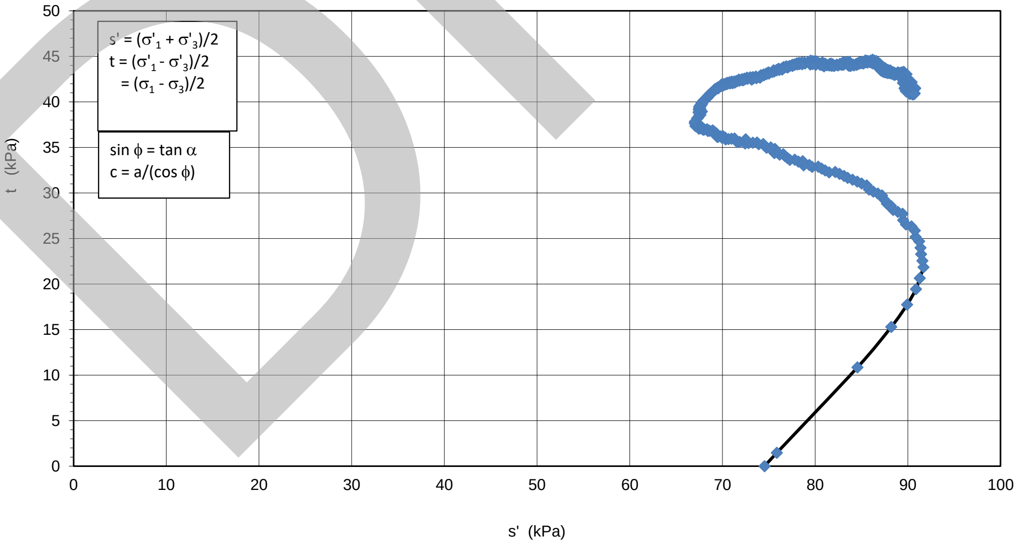
TEST PROCEDURE

This test was done in accordance with ASTM 4767-04 (Consolidated Undrained Triaxial Compression Test).

SNC·LAVALIN

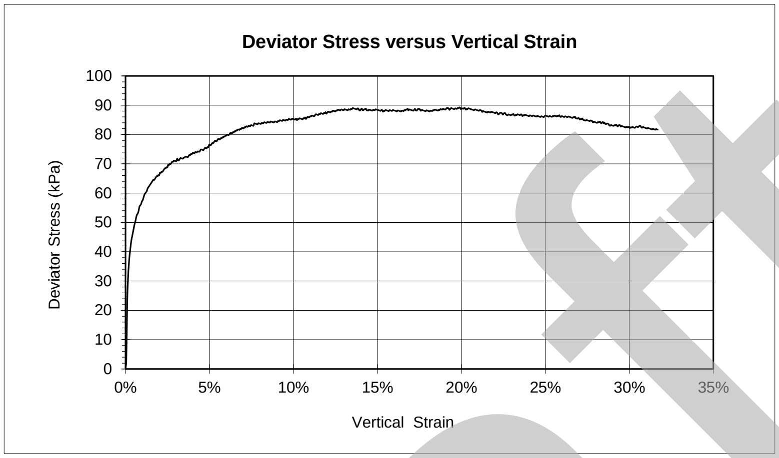
Project Name:	Saskatoon Bypass	**Test Name:**	Consolidated Undrained
Project No.	659183	**Soil Type:**	
Sample No.	NLB-1177 at 9.0-9.71m	**Test App.**	#2 New
Date:	3/26/2026	**Conducted by:**	MC
Confining Pressure:	75 kPa	**Checked By:**	KF

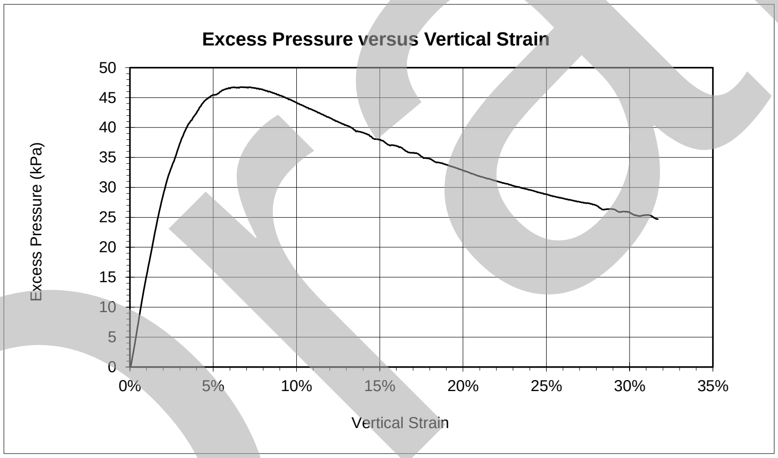


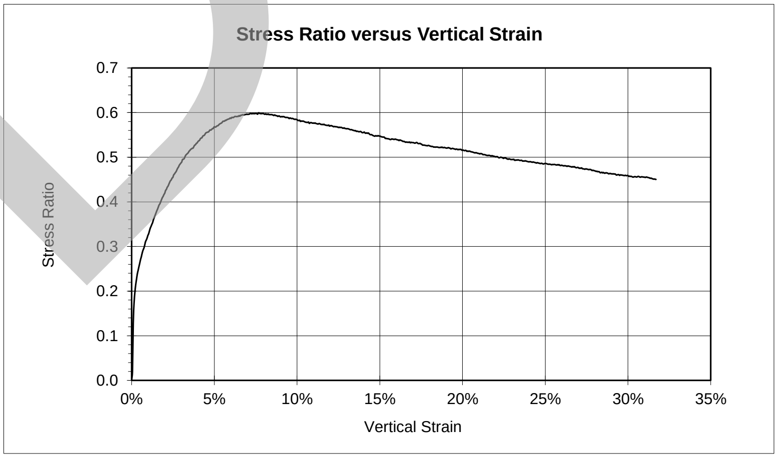


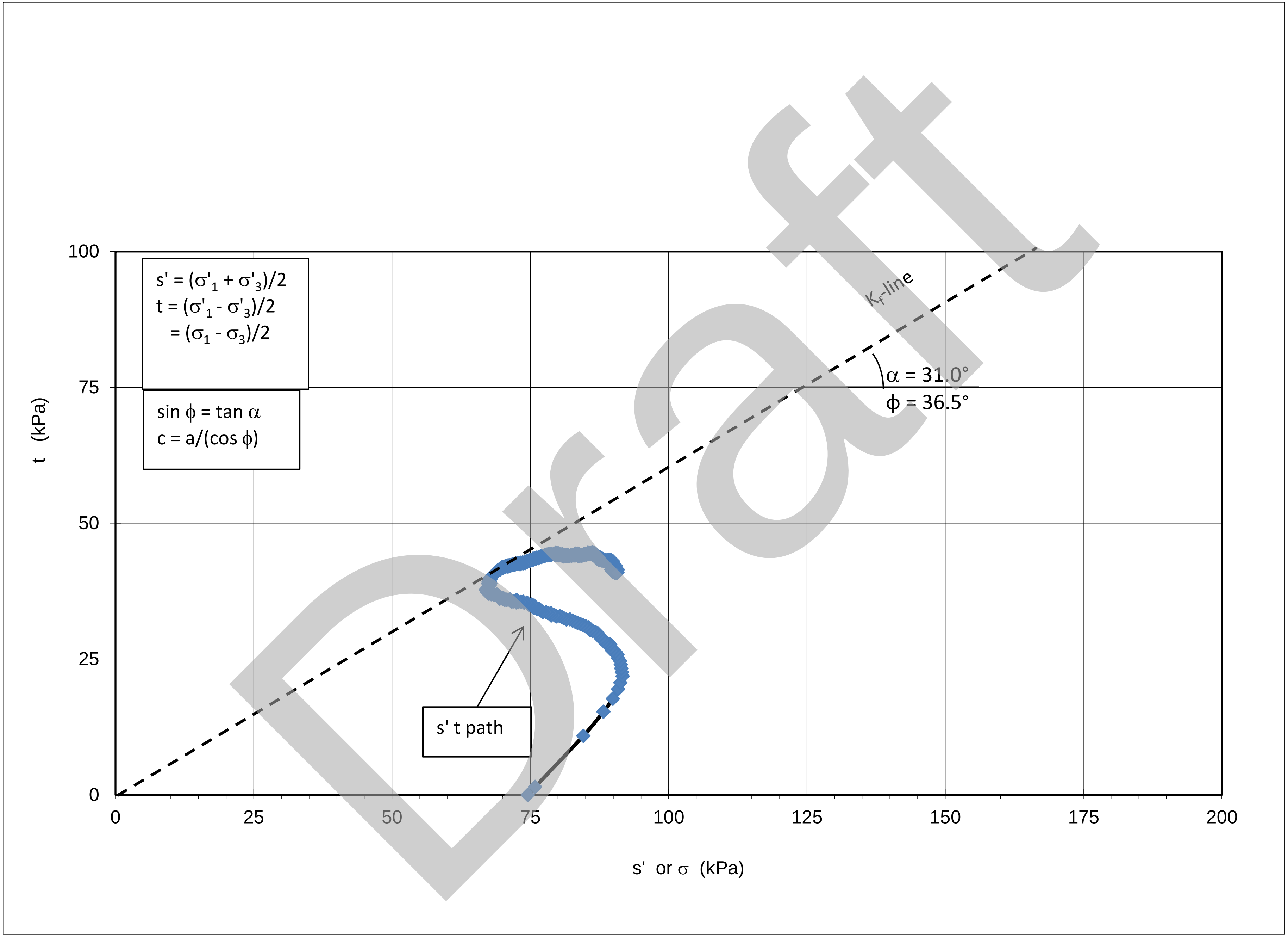
SNC·LAVALIN

Project Name:	Saskatoon Bypass	**Test Name:**	Consolidated Undrained
Project No.	659183	**Soil Type:**	
Sample No.	NLB-1177 at 9.0-9.71m	**Test App.**	#2 New
Date:	3/26/2026	**Conducted by:**	MC
Confining Pressure:	75 kPa	**Checked By:**	KF


Deviator Stress versus Vertical Strain


Excess Pressure versus Vertical Strain


Stress Ratio versus Vertical Strain


s' = (σ'1 + σ'3)/2
t = (σ'1 - σ'3)/2
= (σ1 - σ3)/2
sin ϕ = tan α
c = a/(cos ϕ)
Kf-line
α = 31.0°
ϕ = 36.5°
s' t path
t (kPa)
s' or σ (kPa)
0
25
50
75
100
125
150
175
200
0
25
50
75
100

SNC·LAVALIN

Consolidated Undrained Triaxial Test by ASTM D-4767

Client: Saskatoon Bypass
Project No. 659183
Checked by: KF
Date: 4/20/2022

SAMPLE NO.: NLB-1177 at 9.0- 9.71 m

CONFIGURATION SET-UP:

TEST APP:	#2 New	**Load Cell SN:**	DS-10Klb cap	**Model:**	SN# 17D300116
DESCRIPTION:		**Channel Box SN:**	New1-6574 SN4250	**Transducer:**	#2 New 1000 kPa

Liquid Limit(%):	N/A		Gravel (%):	-
Plastic Limit(%):	N/A		Sand (%):	N/A
Plasticity Index (%):	N/A		Silt (%):	N/A
Specific Gravity:	2.65	(assumed)	Clay(%):	N/A

	AS SET UP	***AS TESTED***
Effective Confining Pressure (kPa):	300	300
Wet density (kg/m^3):	2180	2188
Dry density (kg/m^3):	1809	1907
Water content (	20.5%	14.7%
Void ratio:	0.44	0.39
Degree of saturation:	100.0%	100%
Strain rate (mm/min):	0.01	

COMMENTS:

Ver 5 - 2016/04/25

Project Name:	Saskatoon Bypass	Test Name:	Consolidated Undrained
Project No.	659183	Sample Type:	Shelby
Sample No.:	NLB-1177 at 9.0- 9.71 m	Test App:	#2 New
Date:	4/20/2022	Conducted By:	MC
Confining Pressure:	300 kPa	Checked By:	KF

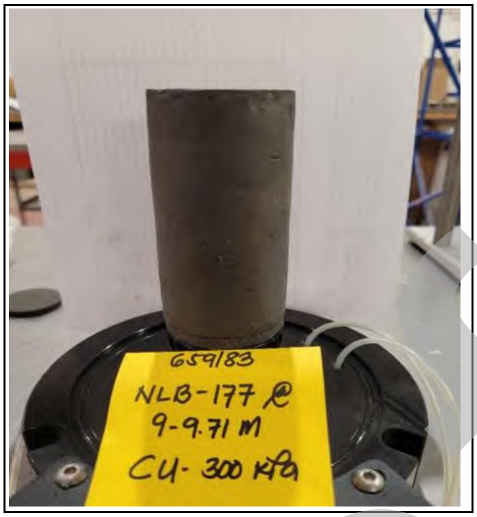


PHOTO OF SPECIMEN BEFORE TEST

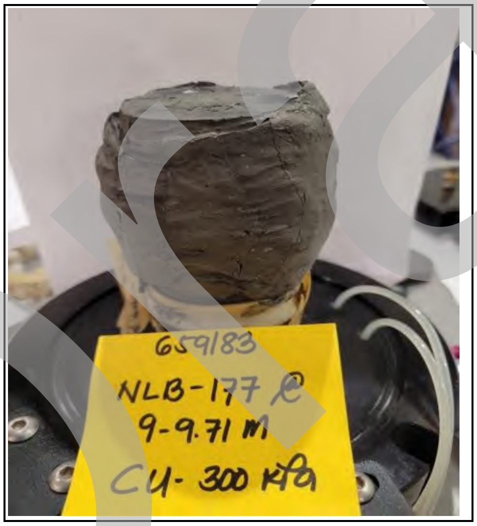


PHOTO OF SPECIMEN AFTER TEST

TEST EQUIPMENT

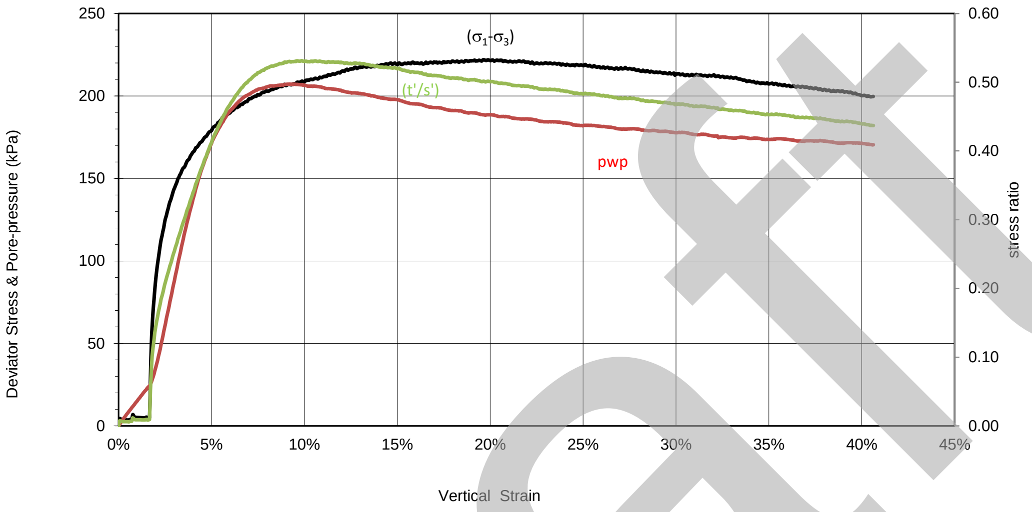
Karol Warner Constant Strain Loading Frame with a 10,000 lb. capacity.
Vertical Strains were measured by electronic displacement transducer.
Shear Stress were measured with an electronic load cell.
Cell and Pore pressure was applied with a compressed air-water system through a pressure control board.
Pressure were measured with electronic pressure transducers.

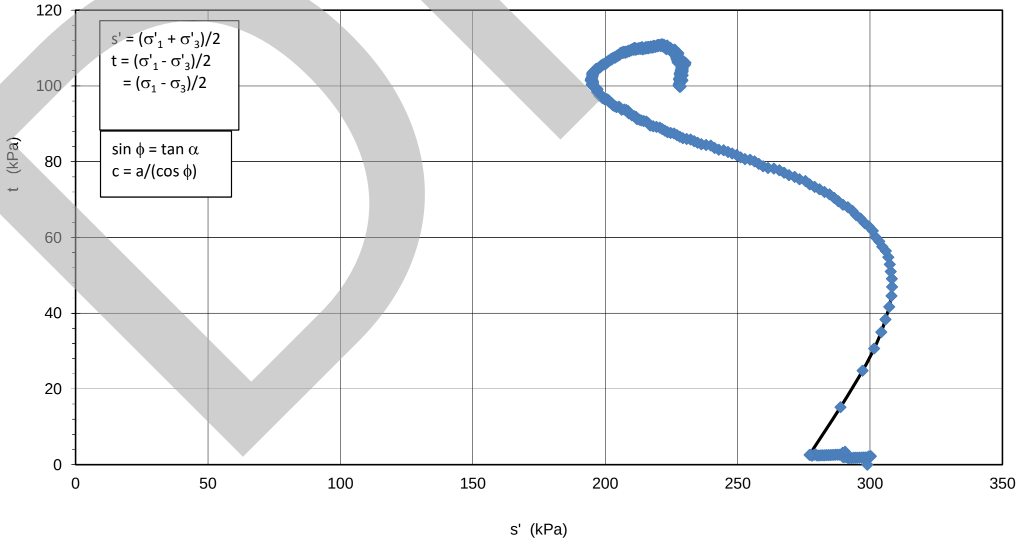
TEST PROCEDURE

This test was done in accordance with ASTM 4767-04 (Consolidated Undrained Triaxial Compression Test).

SNC·LAVALIN

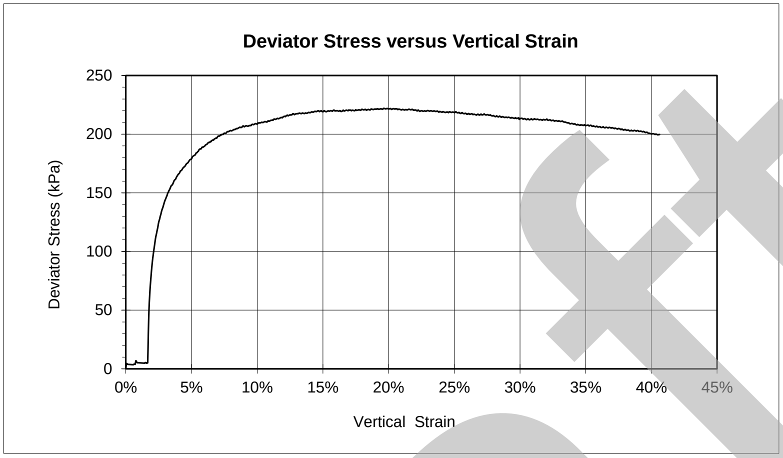
Project Name:	Saskatoon Bypass	**Test Name:**	Consolidated Undrained
Project No.	659183	**Soil Type:**	
Sample No.	NLB-1177 at 9.0- 9.71 m	**Test App.**	#2 New
Date:	4/20/2022	**Conducted by:**	MC
Confining Pressure:	300 kPa	**Checked By:**	KF

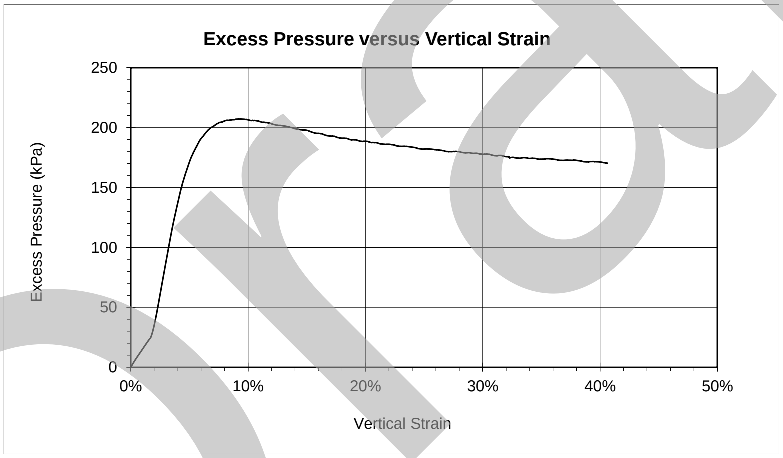


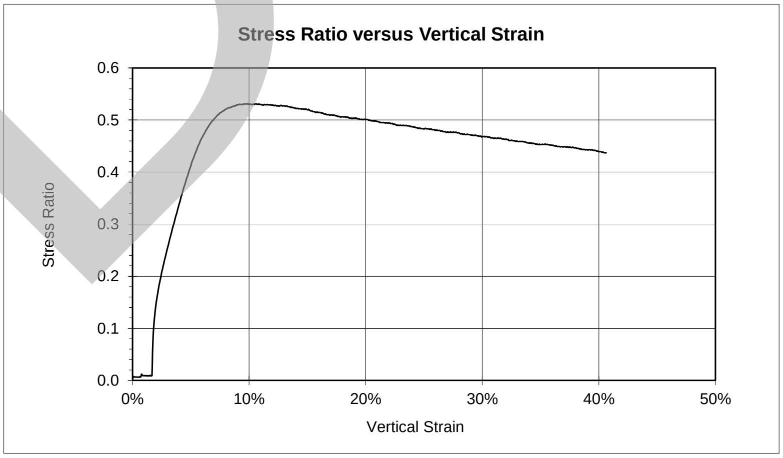


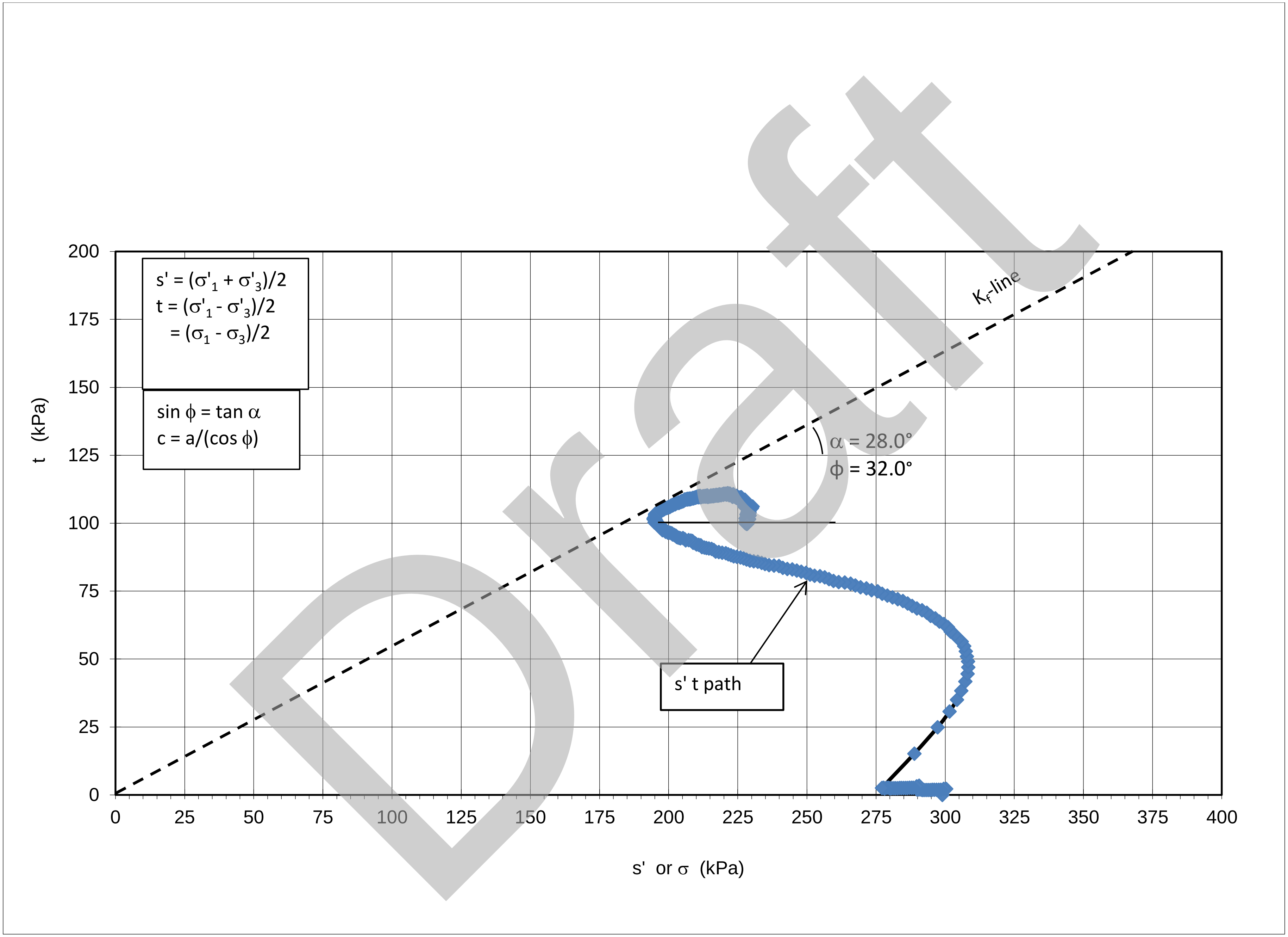
SNC·LAVALIN

Project Name:	Saskatoon Bypass	**Test Name:**	Consolidated Undrained
Project No.	659183	**Soil Type:**	
Sample No.	NLB-1177 at 9.0- 9.71 m	**Test App.**	#2 New
Date:	4/20/2022	**Conducted by:**	MC
Confining Pressure:	300 kPa	**Checked By:**	KF


Deviator Stress versus Vertical Strain


Excess Pressure versus Vertical Strain


Stress Ratio versus Vertical Strain


s' = (σ'1 + σ'3)/2
t = (σ'1 - σ'3)/2
= (σ1 - σ3)/2
sin ϕ = tan α
c = a/(cos ϕ)
Kf-line
α = 28.0°
ϕ = 32.0°
s' t path
t (kPa)
s' or σ (kPa)
0
25
50
75
100
125
150
175
200
0
25
50
75
100
125
150
175
200
225
250
275
300
325
350
375
400

Appendix VII (F)

Unconfined Compression Strength

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC • LAVALIN

Sample: NLB-1023 BH1 at 25m

Water Content %	10.9%
Mass of Test Specimen, g	876.7
Wet Density, kg/m^3	2123
Dry Density, kg/m^3	1915
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.72
Initial Diameter, D_o, cm	6.84
Initial Area, A_o, cm^2	36.76
Initial Height, L_o, cm	11.23
Initial Volume, V_o, cm^3	412.97

Average Pocket Pen Result		N/A
Stress	load/(corr. area)	
Corr. Area	$A_o/(1$ - unit strain)	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.64	
Strain Rate	1.78%	/min

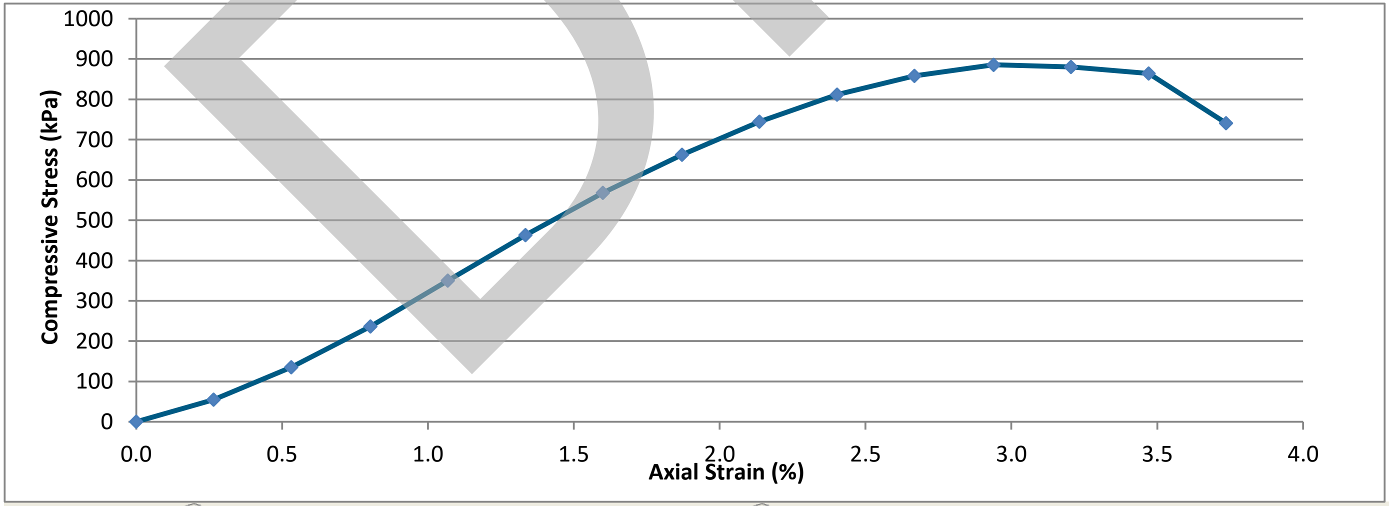
Unconfined Compressive Strength, q_u

889 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	9	0.00	0.0	0.00	0.003676	0.00
0.2	211	0.30	0.3	0.27	0.003686	54.80
0.3	509	0.60	0.6	0.53	0.003696	135.28
0.5	885	0.90	0.9	0.80	0.003706	236.36
0.6	1310	1.20	1.2	1.07	0.003716	350.10
0.8	1736	1.50	1.5	1.33	0.003726	463.48
0.9	2131	1.80	1.8	1.60	0.003736	567.96
1.1	2492	2.10	2.1	1.87	0.003747	662.75
1.2	2807	2.40	2.4	2.14	0.003757	744.81
1.4	3067	2.70	2.7	2.40	0.003767	811.80
1.5	3251	3.00	3.0	2.67	0.003777	858.31
1.7	3364	3.30	3.3	2.94	0.003788	885.75
1.8	3353	3.60	3.6	3.20	0.003798	880.43
2.0	3299	3.90	3.9	3.47	0.003809	863.83
2.1	2837	4.20	4.2	3.74	0.003819	740.49

Post Test



Checker: Don Hazelton **Reviewer:** Don Hazelton

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 14-Apr-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-1029 BH1 at 30-33m

Water Content %	10.9%
Mass of Test Specimen, g	793.7
Wet Density, kg/m^3	2141
Dry Density, kg/m^3	1930
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.74
Initial Diameter, D_o, cm	6.81
Initial Area, A_o, cm^2	36.46
Initial Height, L_o, cm	10.17
Initial Volume, V_o, cm^3	370.68

Average Pocket Pen Result		N/A
Stress	load/(corr. area)	
Corr. Area	$A_o/(1$ - unit strain)	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.49	
Strain Rate	1.97%	/min

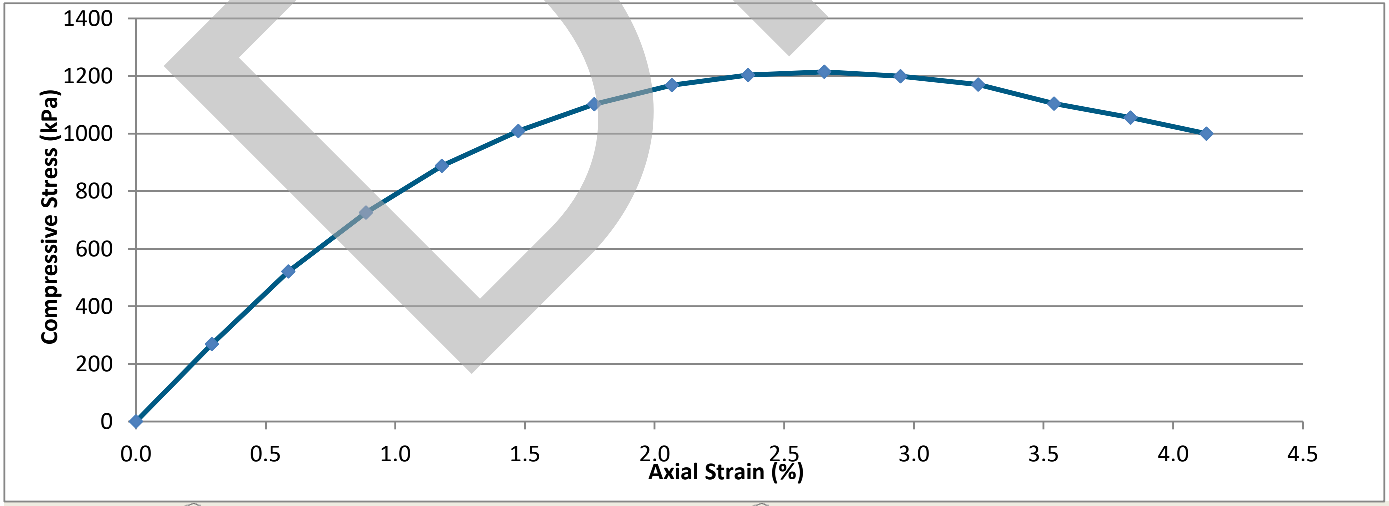
Unconfined Compressive Strength, q_u

1216 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.003646	0.00
0.2	984	0.30	0.3	0.29	0.003657	269.07
0.3	1912	0.60	0.6	0.59	0.003668	521.28
0.5	2670	0.90	0.9	0.89	0.003679	725.74
0.6	3279	1.20	1.2	1.18	0.003690	888.63
0.8	3736	1.50	1.5	1.47	0.003701	1009.47
0.9	4091	1.80	1.8	1.77	0.003712	1102.10
1.1	4350	2.10	2.1	2.07	0.003723	1168.30
1.2	4495	2.40	2.4	2.36	0.003735	1203.63
1.4	4549	2.70	2.7	2.65	0.003746	1214.42
1.5	4505	3.00	3.0	2.95	0.003757	1199.05
1.7	4411	3.30	3.3	3.25	0.003769	1170.40
1.8	4175	3.60	3.6	3.54	0.003780	1104.42
2.0	4002	3.90	3.9	3.84	0.003792	1055.43
2.1	3802	4.20	4.2	4.13	0.003803	999.63
2.3	3697	4.50	4.5	4.43	0.003815	968.98

Post Test



Checker: Don

Reviewer: Don

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 26-Apr-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-1034 BH1 at 37m

Water Content %	11.0%
Mass of Test Specimen, g	759.6
Wet Density, kg/m^3	2262
Dry Density, kg/m^3	2037
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.91
Initial Diameter, D_o, cm	6.43
Initial Area, A_o, cm^2	32.43
Initial Height, L_o, cm	10.36
Initial Volume, V_o, cm^3	335.86

Average Pocket Pen Result N/A

Stress load/(corr. area)

Corr. Area A_o/(1 - unit strain)

Unit Strain $\Delta L/L_o$

L_o/D_o 1.61

Strain Rate 1.93% /min

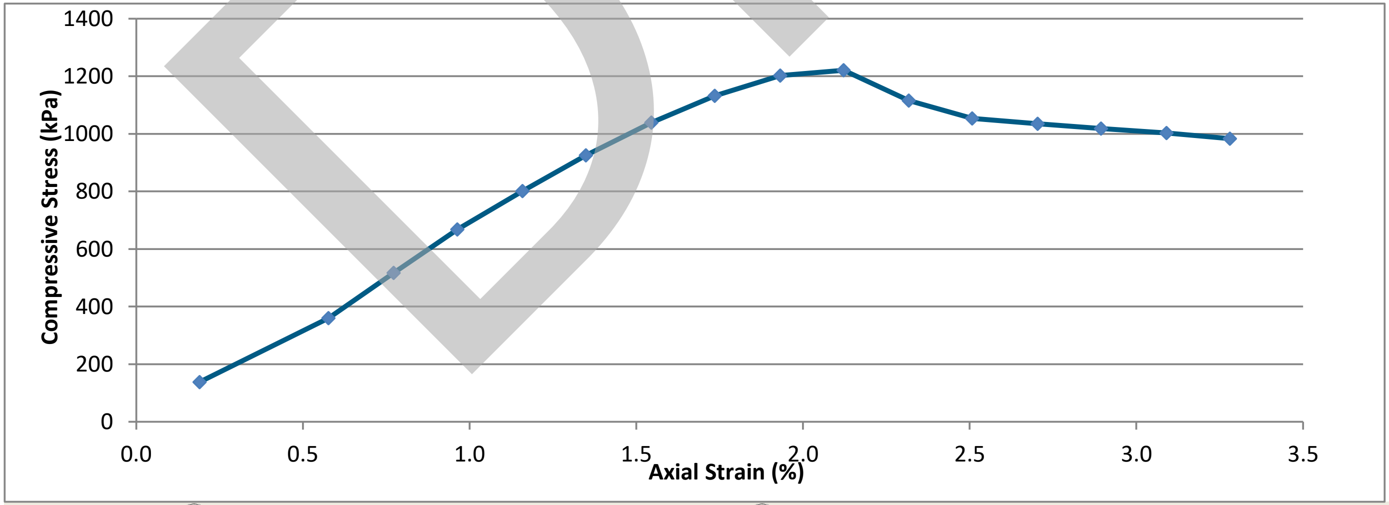
Unconfined Compressive Strength, q_u

1227 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.1	1	0.00	0.0	0.19	0.003243	138.17
0.3	1174	0.60	0.6	0.58	0.003262	359.57
0.4	1690	0.80	0.8	0.77	0.003269	516.72
0.5	2188	1.00	1.0	0.96	0.003275	667.79
0.6	2630	1.20	1.2	1.16	0.003281	801.17
0.7	3045	1.40	1.4	1.35	0.003288	925.85
0.8	3425	1.60	1.6	1.55	0.003294	1039.36
0.9	3738	1.80	1.8	1.74	0.003301	1132.18
1.0	3977	2.00	2.0	1.93	0.003307	1202.18
1.1	4047	2.20	2.2	2.12	0.003314	1220.98
1.2	3704	2.40	2.4	2.32	0.003320	1115.23
1.3	3508	2.60	2.6	2.51	0.003327	1054.14
1.4	3453	2.80	2.8	2.70	0.003334	1035.53
1.5	3404	3.00	3.0	2.89	0.003340	1018.83
1.6	3358	3.20	3.2	3.09	0.003347	1003.03
1.7	3300	3.40	3.4	3.28	0.003353	983.76

Post Test



Checker: Don

Reviewer: Don

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 19-Apr-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

Sample: NLB-1038 BH1 at 41m

SNC·LAVALIN

Water Content %	14.1%
Mass of Test Specimen, g	1081.08
Wet Density, kg/m^3	2117
Dry Density, kg/m^3	1856
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.84
Initial Diameter, D_o, cm	6.78
Initial Area, A_o, cm^2	36.09
Initial Height, L_o, cm	14.15
Initial Volume, V_o, cm^3	510.58

Average Pocket Pen Result	N/A
Stress	load/(corr. area)
Corr. Area	$A_o/(1 - \text{unit strain})$
Unit Strain	$\Delta L/L_o$
L_o/D_o	2.09
Strain Rate	1.41% /min

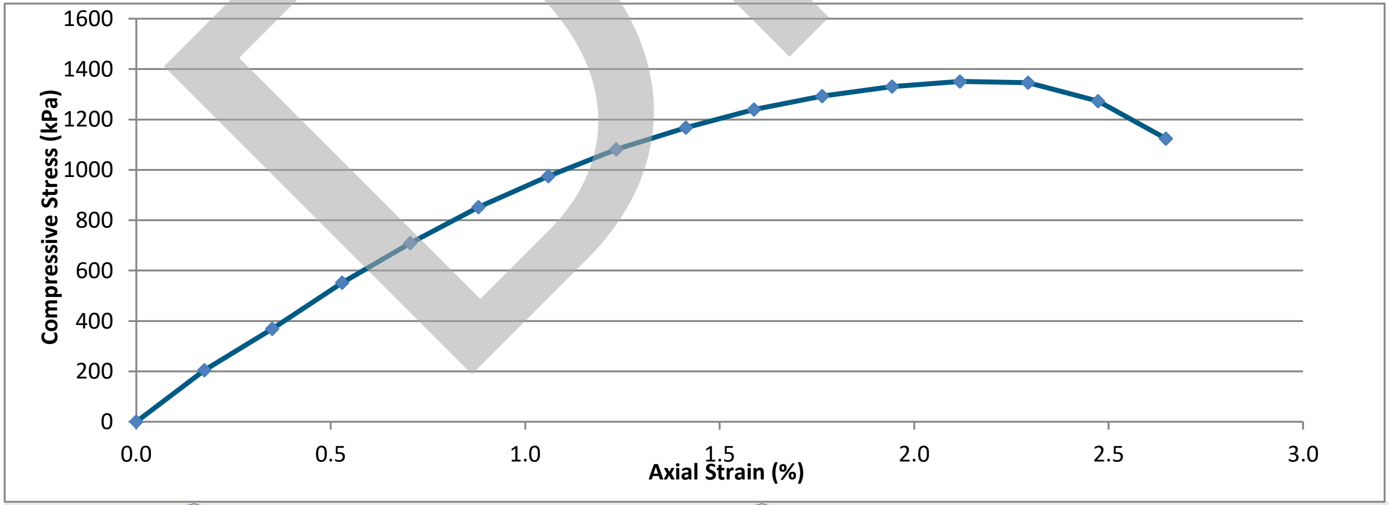
Unconfined Compressive Strength, q_u

1354 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.003609	0.00
0.1	740	0.25	0.2	0.18	0.003615	204.70
0.3	1335	0.50	0.5	0.35	0.003621	368.64
0.4	2001	0.75	0.7	0.53	0.003628	551.55
0.5	2579	1.00	1.0	0.70	0.003634	709.62
0.6	3102	1.25	1.2	0.88	0.003641	852.01
0.8	3555	1.50	1.5	1.06	0.003647	974.67
0.9	3949	1.75	1.7	1.23	0.003654	1080.78
1.0	4276	2.00	2.0	1.41	0.003660	1168.15
1.1	4547	2.25	2.2	1.59	0.003667	1239.97
1.3	4750	2.50	2.5	1.76	0.003674	1293.02
1.4	4896	2.75	2.8	1.94	0.003680	1330.33
1.5	4981	3.00	3.0	2.12	0.003687	1351.02
1.6	4971	3.25	3.2	2.29	0.003693	1345.89
1.8	4711	3.50	3.5	2.47	0.003700	1273.15
1.9	4166	3.75	3.7	2.65	0.003707	1123.85

Post Test



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 19-Apr-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-1041 BH1 at 44m

Water Content %	13.6%
Mass of Test Specimen, g	1126.78
Wet Density, kg/m^3	2089
Dry Density, kg/m^3	1839
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.78
Initial Diameter, D_o, cm	6.77
Initial Area, A_o, cm^2	36.02
Initial Height, L_o, cm	14.98
Initial Volume, V_o, cm^3	539.46

Average Pocket Pen Result		N/A
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	2.21	
Strain Rate	1.33%	/min

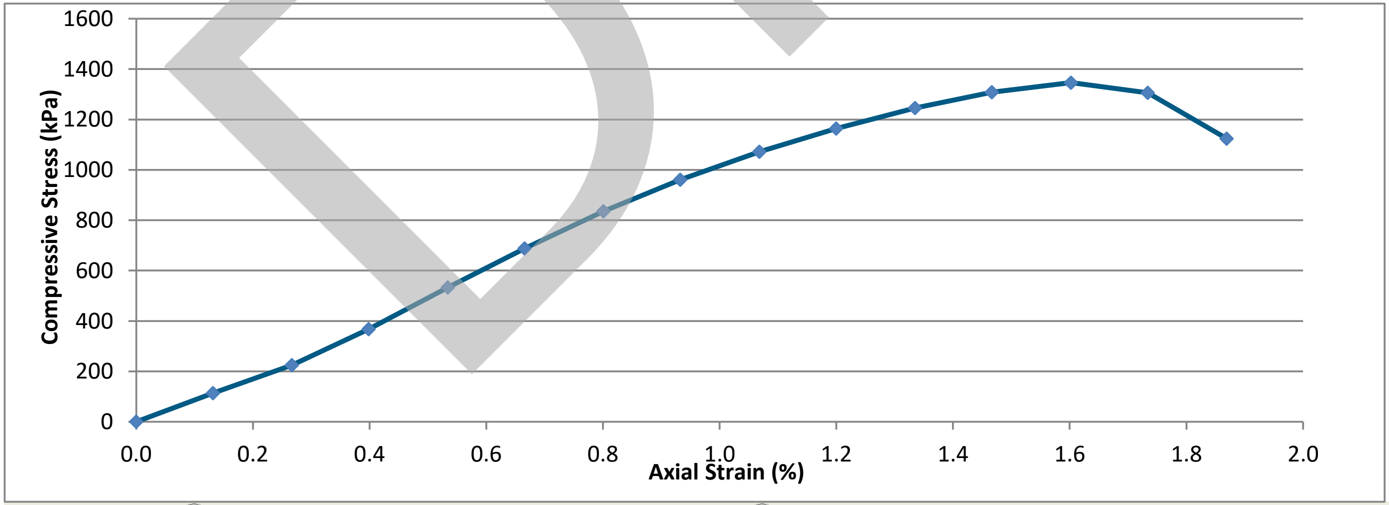
Unconfined Compressive Strength, q_u

1349 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.003602	0.00
0.1	410	0.20	0.2	0.13	0.003606	113.69
0.2	813	0.40	0.4	0.27	0.003611	225.13
0.3	1329	0.60	0.6	0.40	0.003616	367.54
0.4	1929	0.80	0.8	0.53	0.003621	532.74
0.5	2495	1.00	1.0	0.67	0.003626	688.14
0.6	3034	1.20	1.2	0.80	0.003631	835.66
0.7	3491	1.40	1.4	0.93	0.003635	960.26
0.8	3901	1.60	1.6	1.07	0.003640	1071.57
0.9	4244	1.80	1.8	1.20	0.003645	1164.24
1.0	4548	2.00	2.0	1.34	0.003650	1245.92
1.1	4781	2.20	2.2	1.47	0.003655	1308.01
1.2	4928	2.40	2.4	1.60	0.003660	1346.37
1.3	4787	2.60	2.6	1.73	0.003665	1306.10
1.4	4126	2.80	2.8	1.87	0.003670	1124.20

Post Test



Checker: Don [illegible] **Reviewer:** Don [illegible]

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	19-Apr-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

Sample: NLB-1095 BH1-SI at 47.55-47.93m

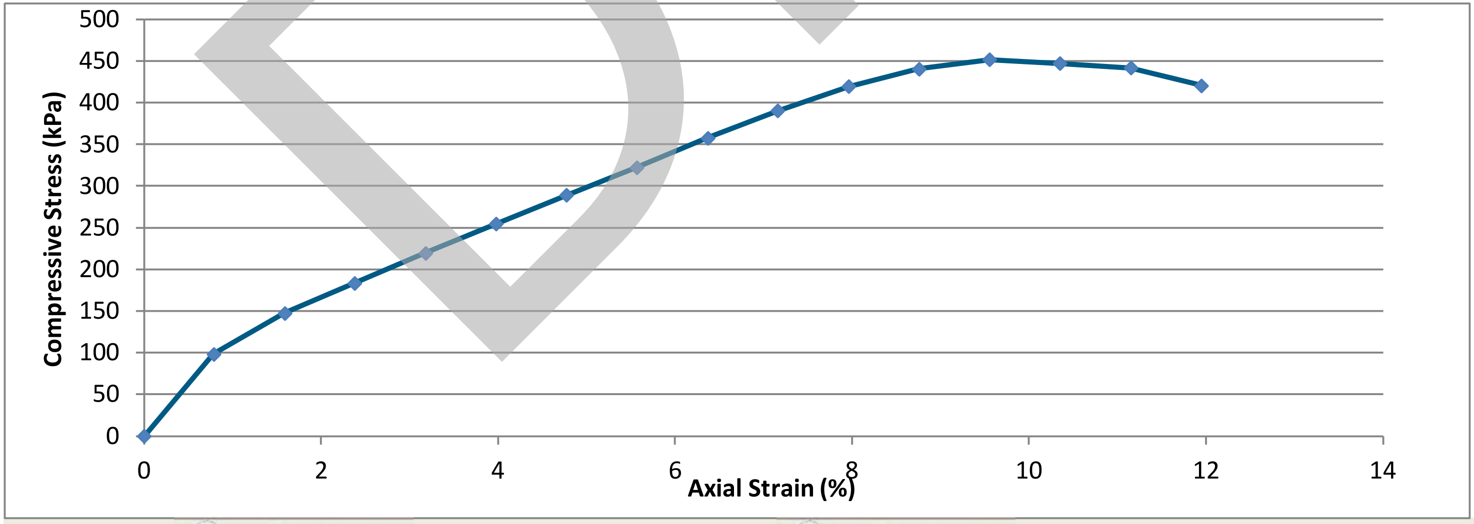
SNC·LAVALIN

Water Content %	16.6%	Average Pocket Pen Result	N/A
Mass of Test Specimen, g	1039.32	Stress	load/(corr. area)
Wet Density, kg/m^3	2053	Corr. Area	$A_o/(1 - \text{unit strain})$
Dry Density, kg/m^3	1760	Unit Strain	$\Delta L/L_o$
Specific Gravity (Assumed)	2.70	L_o/D_o	1.75
Degree of Saturation	0.84	Strain Rate	1.59% /min
Initial Diameter, D_o, cm	7.17		
Initial Area, A_o, cm^2	40.36	Unconfined Compressive Strength, q_u	
Initial Height, L_o, cm	12.54	**481**	**kPa**
Initial Volume, V_o, cm^3	506.27		

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	6	0.00	0.0	0.00	0.004036	0.00
0.5	406	0.98	1.0	0.78	0.004068	98.34
1.0	610	1.99	2.0	1.58	0.004101	147.29
1.5	765	2.98	3.0	2.38	0.004134	183.60
2.0	921	3.99	4.0	3.18	0.004168	219.52
2.5	1075	4.99	5.0	3.97	0.004203	254.36
3.0	1231	5.99	6.0	4.77	0.004238	289.05
3.5	1383	6.99	7.0	5.57	0.004274	322.21
4.0	1547	7.99	8.0	6.37	0.004310	357.53
4.5	1703	8.99	9.0	7.16	0.004347	390.38
5.0	1845	9.99	10.0	7.96	0.004385	419.40
5.5	1955	10.99	11.0	8.76	0.004423	440.65
6.0	2023	11.99	12.0	9.56	0.004462	452.03
6.5	2018	12.99	13.0	10.35	0.004502	446.94
7.0	2013	13.99	14.0	11.15	0.004542	441.86
7.5	1934	14.99	15.0	11.95	0.004583	420.67

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	19-Apr-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC • LAVALIN

Sample: NLB-171 FHII-03 at 53-53.5ft

Water Content %	16.5%
Mass of Test Specimen, g	530.35
Wet Density, kg/m^3	2355
Dry Density, kg/m^3	2022
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	5.53
Initial Area, A_o, cm^2	24.01
Initial Height, L_o, cm	9.38
Initial Volume, V_o, cm^3	225.20

Average Pocket Pen Result 4.5

Stress load/(corr. area)

Corr. Area $A_o/(1$ - unit strain$)$

Unit Strain $\Delta L/L_o$

L_o/D_o 1.70

Strain Rate 2.13% /min

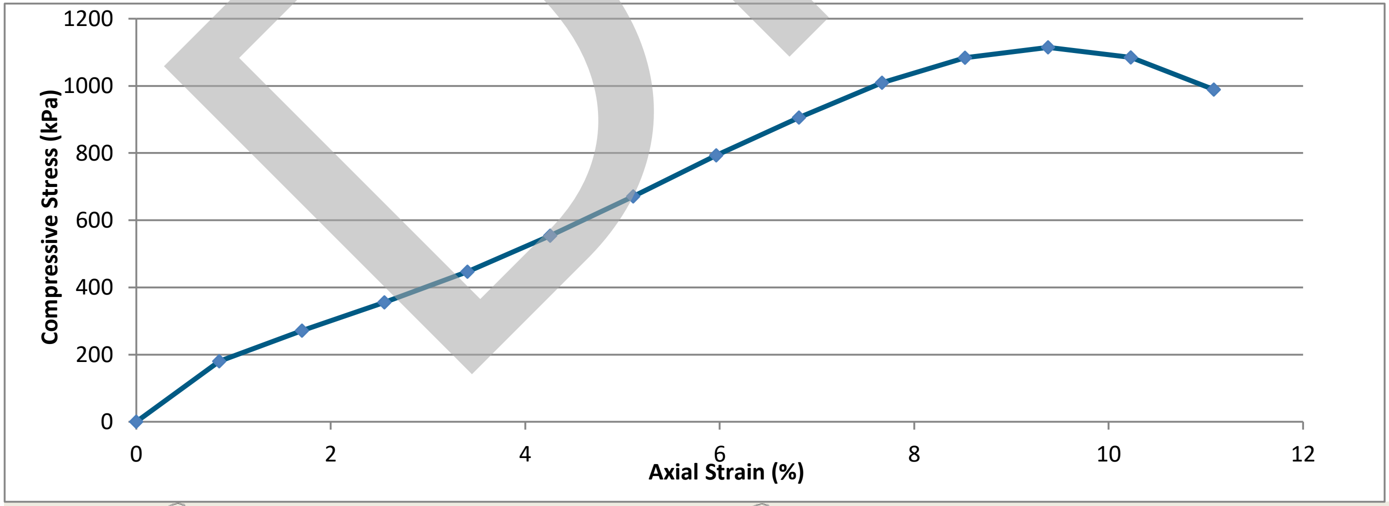
Unconfined Compressive Strength, q_u

1116 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.002401	0.00
0.4	437	0.80	0.8	0.85	0.002422	180.46
0.8	662	1.60	1.6	1.71	0.002443	271.02
1.2	875	2.39	2.4	2.55	0.002464	355.14
1.6	1111	3.19	3.2	3.41	0.002486	446.98
2.0	1389	3.99	4.0	4.26	0.002508	553.89
2.4	1698	4.79	4.8	5.11	0.002530	671.07
2.8	2025	5.59	5.6	5.96	0.002553	793.11
3.2	2335	6.39	6.4	6.82	0.002577	906.23
3.6	2624	7.20	7.2	7.67	0.002600	1009.06
4.0	2845	8.00	8.0	8.52	0.002625	1083.94
4.4	2953	8.80	8.8	9.38	0.002649	1114.60
4.8	2901	9.60	9.6	10.23	0.002675	1084.67
5.2	2670	10.40	10.4	11.08	0.002700	988.81

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-251 FHII-05 at 48-49.8ft

Water Content %	15.0%
Mass of Test Specimen, g	1343.1
Wet Density, kg/m^3	2227
Dry Density, kg/m^3	1936
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.23
Initial Area, A_o, cm^2	41.01
Initial Height, L_o, cm	14.71
Initial Volume, V_o, cm^3	603.06

Average Pocket Pen Result		4
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	2.04	
Strain Rate	1.36%	/min

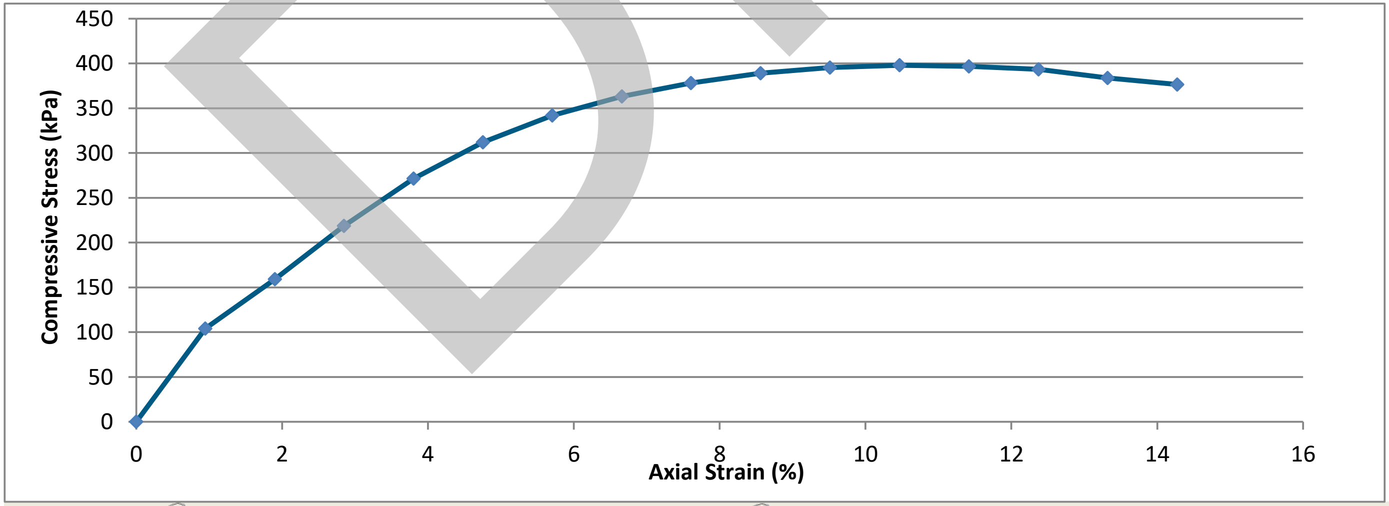
Unconfined Compressive Strength, q_u

399 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004101	0.00
0.7	431	1.39	1.4	0.95	0.004140	104.10
1.4	666	2.79	2.8	1.90	0.004180	159.32
2.1	923	4.19	4.2	2.85	0.004221	218.65
2.8	1158	5.59	5.6	3.80	0.004263	271.63
3.5	1344	6.99	7.0	4.75	0.004306	312.15
4.2	1487	8.39	8.4	5.70	0.004349	341.91
4.9	1596	9.79	9.8	6.66	0.004394	363.26
5.6	1679	11.19	11.2	7.61	0.004439	378.26
6.3	1746	12.59	12.6	8.56	0.004485	389.30
7.0	1793	13.99	14.0	9.51	0.004532	395.62
7.7	1823	15.39	15.4	10.47	0.004580	398.00
8.4	1837	16.79	16.8	11.42	0.004630	396.80
9.1	1842	18.19	18.2	12.37	0.004680	393.59
9.8	1816	19.59	19.6	13.32	0.004731	383.83
10.5	1802	20.99	21.0	14.28	0.004784	376.68

Post Test



Checker: **Reviewer:**

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-305 FHII-06 at 18-20ft

Water Content %	12.9%
Mass of Test Specimen, g	1371.68
Wet Density, kg/m^3	2291
Dry Density, kg/m^3	2028
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.26
Initial Area, A_o, cm^2	41.45
Initial Height, L_o, cm	14.45
Initial Volume, V_o, cm^3	598.79

Average Pocket Pen Result		2.75
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.99	
Strain Rate	1.38%	/min

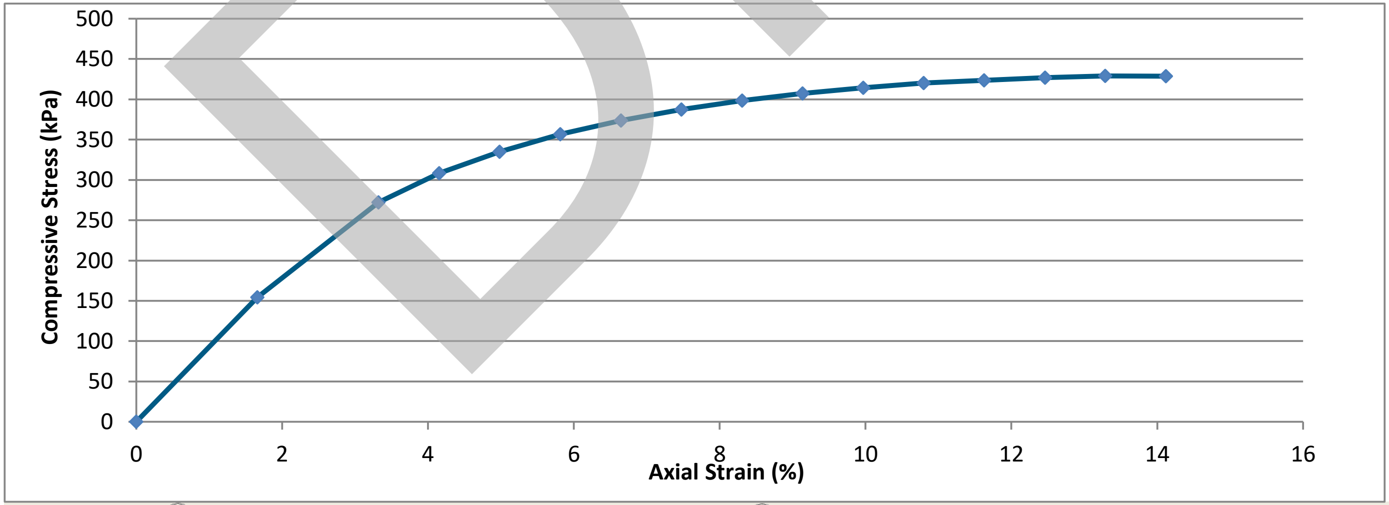
Unconfined Compressive Strength, q_u

430 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004145	0.00
1.2	651	2.40	2.4	1.66	0.004215	154.44
2.4	1167	4.80	4.8	3.32	0.004288	272.18
3.0	1334	6.00	6.0	4.15	0.004325	308.46
3.6	1461	7.20	7.2	4.98	0.004363	334.90
4.2	1570	8.40	8.4	5.82	0.004401	356.74
4.8	1660	9.60	9.6	6.65	0.004440	373.86
5.4	1735	10.80	10.8	7.48	0.004480	387.27
6.0	1801	12.00	12.0	8.31	0.004521	398.40
6.6	1859	13.20	13.2	9.14	0.004562	407.50
7.2	1907	14.40	14.4	9.97	0.004604	414.20
7.8	1953	15.60	15.6	10.80	0.004647	420.28
8.4	1987	16.80	16.8	11.63	0.004690	423.63
9.0	2021	18.00	18.0	12.46	0.004735	426.81
9.6	2051	19.20	19.2	13.29	0.004780	429.05
10.2	2070	20.40	20.4	14.12	0.004827	428.88

Post Test



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 2-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-359 FHII-09 at 38-40ft

Water Content %	11.8%
Mass of Test Specimen, g	1348.22
Wet Density, kg/m^3	2279
Dry Density, kg/m^3	2038
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.98
Initial Diameter, D_o, cm	7.30
Initial Area, A_o, cm^2	41.80
Initial Height, L_o, cm	14.15
Initial Volume, V_o, cm^3	591.61

Average Pocket Pen Result		4.25
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.94	
Strain Rate	1.41%	/min

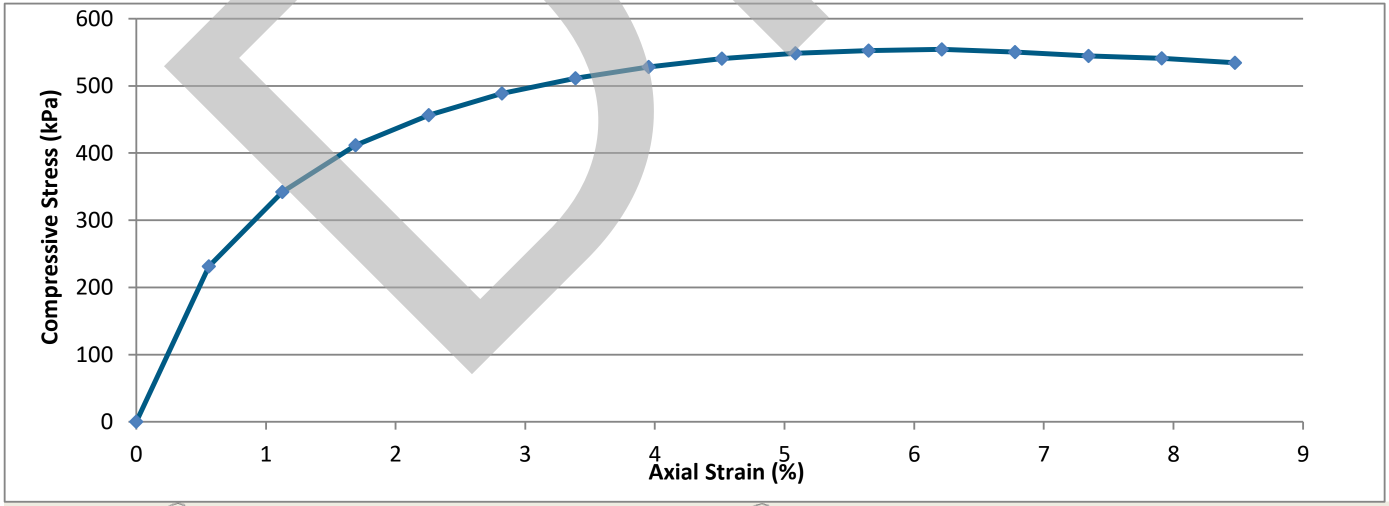
Unconfined Compressive Strength, q_u

555 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004180	0.00
0.4	972	0.79	0.8	0.56	0.004204	231.22
0.8	1447	1.59	1.6	1.13	0.004228	342.25
1.2	1750	2.39	2.4	1.69	0.004252	411.56
1.6	1952	3.19	3.2	2.26	0.004277	456.42
2.0	2103	3.99	4.0	2.82	0.004302	488.88
2.4	2213	4.79	4.8	3.39	0.004327	511.46
2.8	2299	5.59	5.6	3.95	0.004352	528.23
3.2	2367	6.39	6.4	4.52	0.004378	540.65
3.6	2417	7.20	7.2	5.08	0.004404	548.80
4.0	2448	8.00	8.0	5.65	0.004431	552.53
4.4	2471	8.80	8.8	6.21	0.004457	554.38
4.8	2468	9.60	9.6	6.78	0.004484	550.37
5.2	2457	10.40	10.4	7.34	0.004512	544.60
5.6	2456	11.20	11.2	7.91	0.004539	541.05
6.0	2440	12.00	12.0	8.48	0.004567	534.23

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-382 FHII-10 at 27-28.7ft

Water Content %	13.0%
Mass of Test Specimen, g	1402.26
Wet Density, kg/m^3	2313
Dry Density, kg/m^3	2047
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.22
Initial Area, A_o, cm^2	40.92
Initial Height, L_o, cm	14.82
Initial Volume, V_o, cm^3	606.33

Average Pocket Pen Result		2.25
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	2.05	
Strain Rate	1.35%	/min

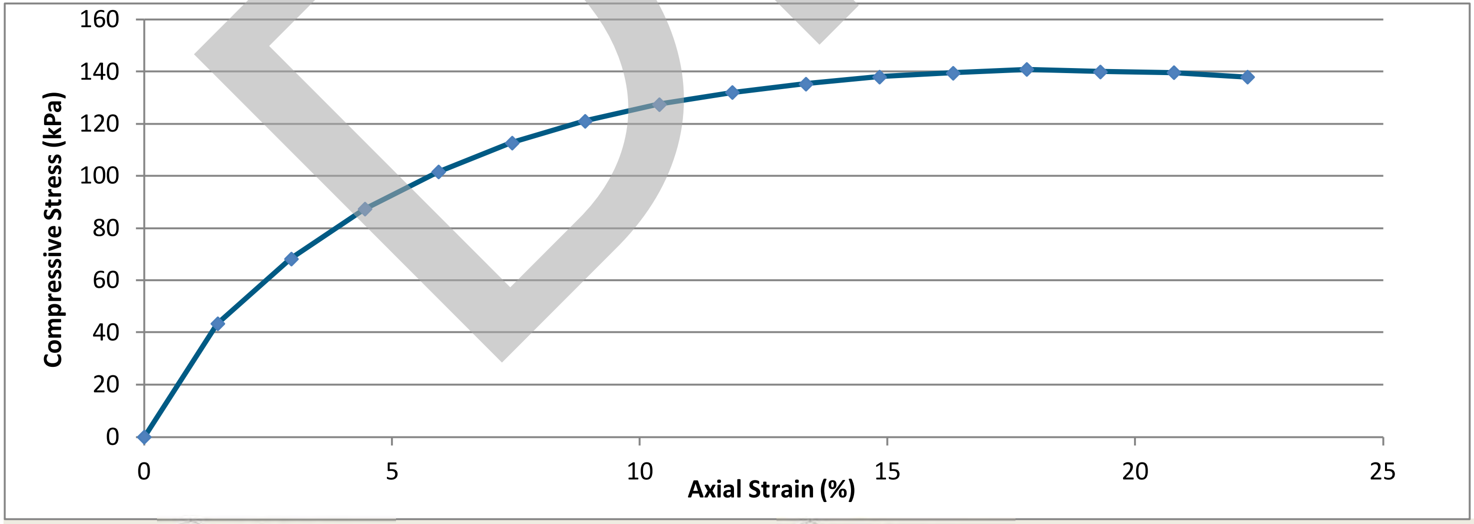
Unconfined Compressive Strength, q_u

138 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004092	0.00
1.1	180	2.19	2.2	1.48	0.004153	43.34
2.2	288	4.39	4.4	2.96	0.004217	68.30
3.3	374	6.59	6.6	4.45	0.004282	87.33
4.4	442	8.79	8.8	5.93	0.004350	101.61
5.5	498	10.99	11.0	7.42	0.004420	112.68
6.6	544	13.19	13.2	8.90	0.004492	121.11
7.7	582	15.39	15.4	10.39	0.004566	127.46
8.8	613	17.59	17.6	11.87	0.004643	132.03
9.9	639	19.79	19.8	13.36	0.004723	135.30
11.0	663	21.99	22.0	14.84	0.004805	137.98
12.1	682	24.19	24.2	16.32	0.004890	139.47
13.2	701	26.39	26.4	17.81	0.004979	140.80
14.3	710	28.59	28.6	19.29	0.005070	140.04
15.4	721	30.79	30.8	20.78	0.005165	139.59
16.5	726	32.99	33.0	22.26	0.005264	137.93

Post Test



Checker: Don

Reviewer: Don

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-446 FHII-11 at 22-23.25ft

Water Content %	12.6%
Mass of Test Specimen, g	1118.09
Wet Density, kg/m^3	2108
Dry Density, kg/m^3	1871
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.77
Initial Diameter, D_o, cm	7.08
Initial Area, A_o, cm^2	39.36
Initial Height, L_o, cm	13.48
Initial Volume, V_o, cm^3	530.48

Average Pocket Pen Result		1.75
Stress	load/(corr. area)	
Corr. Area	$A_o/(1$ - unit strain)	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.90	
Strain Rate	1.48%	/min

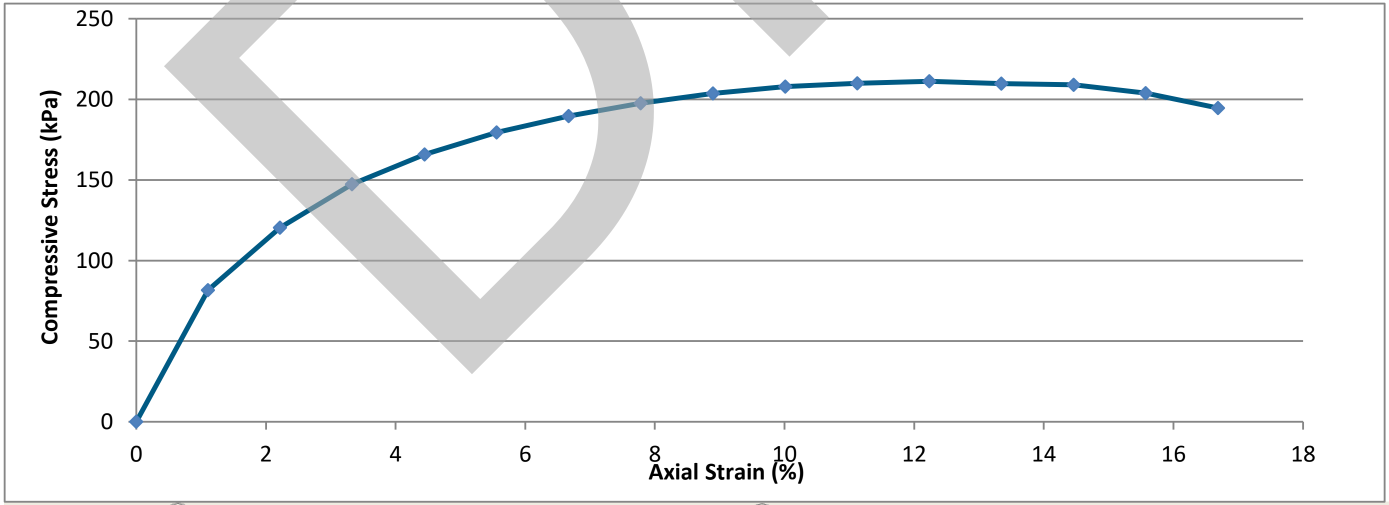
Unconfined Compressive Strength, q_u

212 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.003936	0.00
0.8	325	1.49	1.5	1.11	0.003980	81.66
1.5	485	2.99	3.0	2.22	0.004025	120.49
2.3	600	4.49	4.5	3.33	0.004071	147.37
3.0	683	5.99	6.0	4.45	0.004119	165.82
3.8	748	7.49	7.5	5.56	0.004167	179.48
4.5	800	8.99	9.0	6.67	0.004217	189.70
5.3	843	10.49	10.5	7.78	0.004268	197.52
6.0	880	12.00	12.0	8.90	0.004320	203.69
6.8	909	13.49	13.5	10.01	0.004374	207.83
7.5	930	14.99	15.0	11.12	0.004428	210.01
8.3	947	16.49	16.5	12.24	0.004484	211.17
9.0	953	17.99	18.0	13.35	0.004542	209.82
9.8	962	19.49	19.5	14.46	0.004601	209.07
10.5	950	20.99	21.0	15.58	0.004662	203.78
11.3	919	22.49	22.5	16.69	0.004724	194.53

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-508 FHII-08 at 43-44.5ft

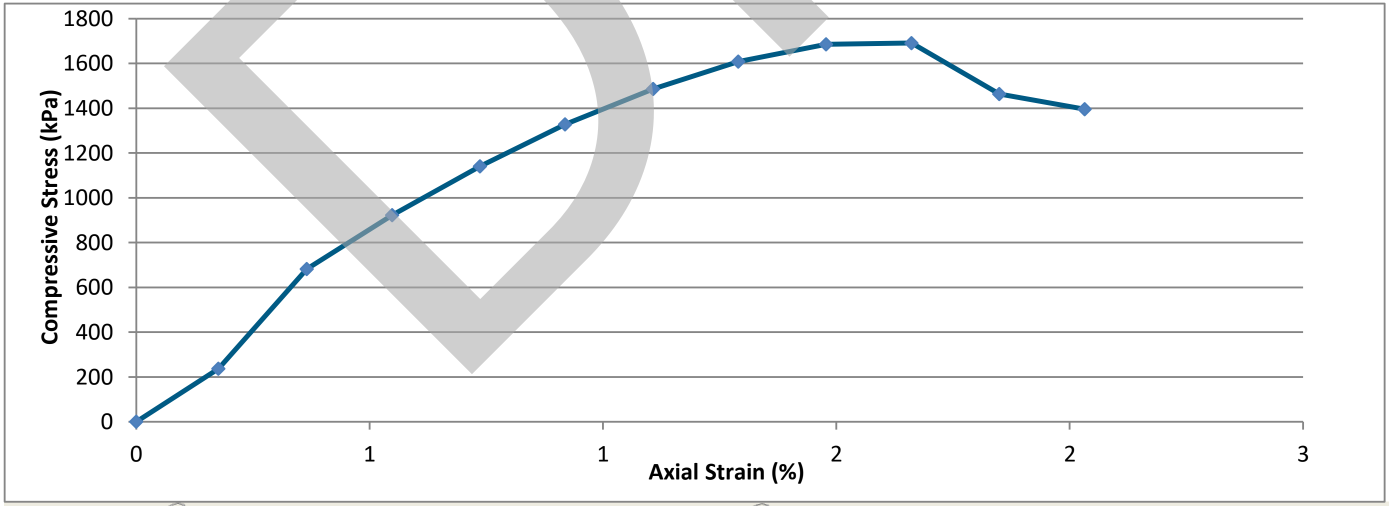
Water Content %	5.3%
Mass of Test Specimen, g	564.45
Wet Density, kg/m^3	2199
Dry Density, kg/m^3	2088
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.49
Initial Diameter, D_o, cm	5.51
Initial Area, A_o, cm^2	23.80
Initial Height, L_o, cm	10.78
Initial Volume, V_o, cm^3	256.63

Average Pocket Pen Result		4.5
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.96	
Strain Rate	1.85%	/min
Unconfined Compressive Strength, q_u		
1701	**kPa**	

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.002380	0.00
0.1	564	0.19	0.2	0.18	0.002384	236.54
0.2	1630	0.39	0.4	0.37	0.002389	682.33
0.3	2210	0.59	0.6	0.55	0.002393	923.42
0.4	2735	0.79	0.8	0.74	0.002398	1140.62
0.5	3191	0.99	1.0	0.92	0.002402	1328.35
0.6	3576	1.19	1.2	1.11	0.002407	1485.79
0.7	3878	1.39	1.4	1.29	0.002411	1608.29
0.8	4072	1.59	1.6	1.48	0.002416	1685.52
0.9	4094	1.79	1.8	1.66	0.002420	1691.49
1.0	3550	1.99	2.0	1.85	0.002425	1463.92
1.1	3390	2.19	2.2	2.03	0.002430	1395.34

Post Test



Checker: **Reviewer:**

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC • LAVALIN

Sample: NLB-528 FHII-12 at 18-19.6ft

Water Content %	38.5%
Mass of Test Specimen, g	1091.77
Wet Density, kg/m^3	1853
Dry Density, kg/m^3	1338
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.25
Initial Area, A_o, cm^2	41.31
Initial Height, L_o, cm	14.26
Initial Volume, V_o, cm^3	589.18

Average Pocket Pen Result		1.25
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.97	
Strain Rate	1.40%	/min

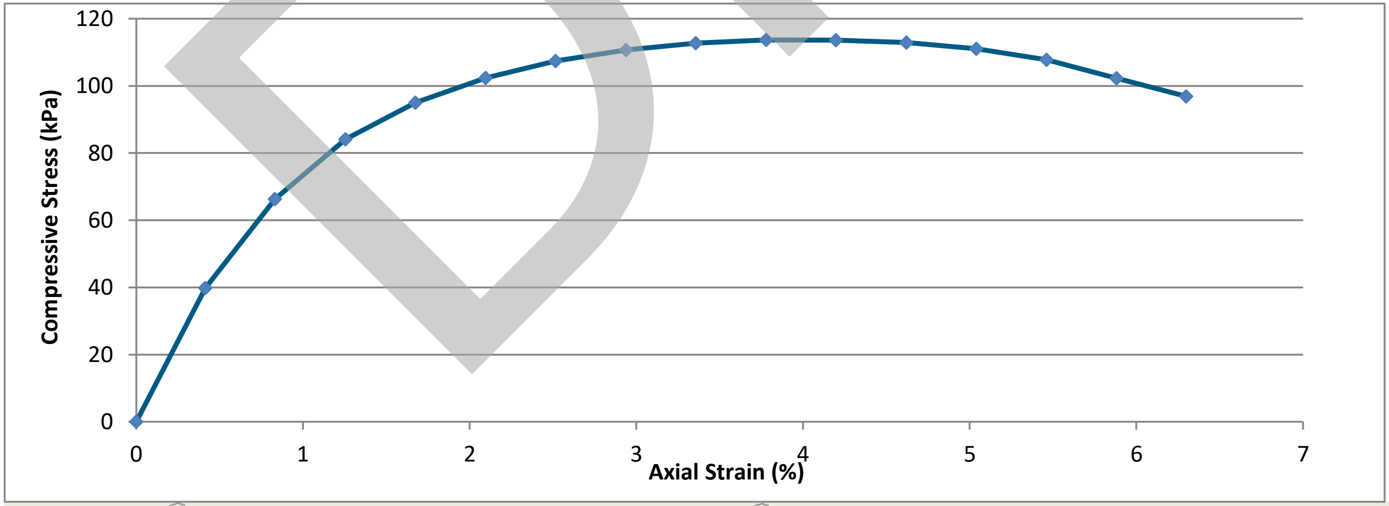
Unconfined Compressive Strength, q_u

114 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004131	0.00
0.3	165	0.59	0.6	0.41	0.004148	39.78
0.6	276	1.19	1.2	0.83	0.004165	66.26
0.9	352	1.79	1.8	1.26	0.004183	84.14
1.2	399	2.39	2.4	1.67	0.004201	94.97
1.5	432	2.99	3.0	2.10	0.004219	102.39
1.8	455	3.59	3.6	2.52	0.004237	107.38
2.1	471	4.19	4.2	2.94	0.004256	110.67
2.4	482	4.79	4.8	3.36	0.004274	112.77
2.7	488	5.39	5.4	3.78	0.004293	113.67
3.0	490	5.99	6.0	4.20	0.004312	113.64
3.3	489	6.59	6.6	4.62	0.004331	112.91
3.6	483	7.19	7.2	5.04	0.004350	111.03
3.9	471	7.79	7.8	5.46	0.004369	107.79
4.2	449	8.39	8.4	5.88	0.004389	102.30
4.5	427	8.99	9.0	6.30	0.004409	96.86

Post Test



Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 4-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-575 FHII-14 at 58-60ft

Water Content %	11.8%
Mass of Test Specimen, g	1477.84
Wet Density, kg/m^3	2349
Dry Density, kg/m^3	2101
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.34
Initial Area, A_o, cm^2	42.28
Initial Height, L_o, cm	14.88
Initial Volume, V_o, cm^3	629.15

Average Pocket Pen Result		4.5
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	2.03	
Strain Rate	1.34%	/min

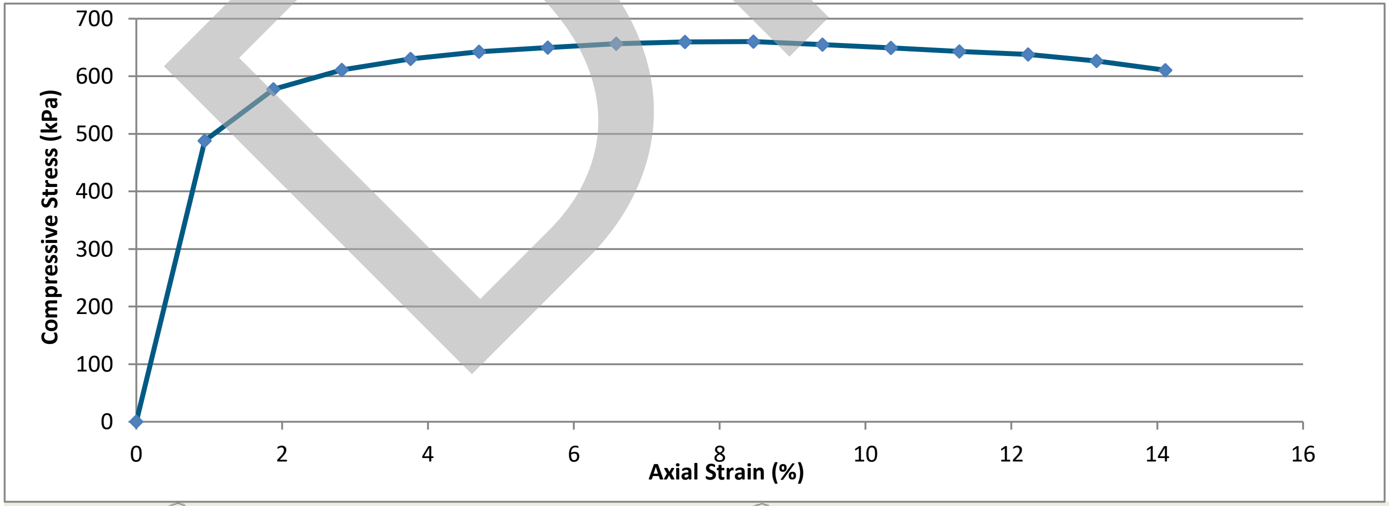
Unconfined Compressive Strength, q_u

662 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004228	0.00
0.7	2083	1.40	1.4	0.94	0.004268	488.05
1.4	2489	2.80	2.8	1.88	0.004309	577.63
2.1	2659	4.20	4.2	2.82	0.004351	611.18
2.8	2769	5.60	5.6	3.76	0.004393	630.28
3.5	2851	7.00	7.0	4.70	0.004437	642.61
4.2	2913	8.40	8.4	5.65	0.004481	650.09
4.9	2972	9.80	9.8	6.58	0.004526	656.66
5.6	3016	11.20	11.2	7.53	0.004572	659.66
6.3	3050	12.60	12.6	8.47	0.004619	660.32
7.0	3058	14.00	14.0	9.41	0.004667	655.23
7.7	3063	15.40	15.4	10.35	0.004716	649.50
8.4	3064	16.80	16.8	11.29	0.004766	642.91
9.1	3072	18.20	18.2	12.23	0.004817	637.74
9.8	3050	19.60	19.6	13.17	0.004869	626.40
10.5	3006	21.00	21.0	14.11	0.004923	610.66

Post Test



Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC • LAVALIN

Sample: NLB-588 FHII-19 at 13-15ft

Water Content %	20.5%
Mass of Test Specimen, g	1198.18
Wet Density, kg/m^3	2152
Dry Density, kg/m^3	1785
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.02
Initial Area, A_o, cm^2	38.70
Initial Height, L_o, cm	14.39
Initial Volume, V_o, cm^3	556.82

Average Pocket Pen Result		3.5
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	2.05	
Strain Rate	1.39%	/min

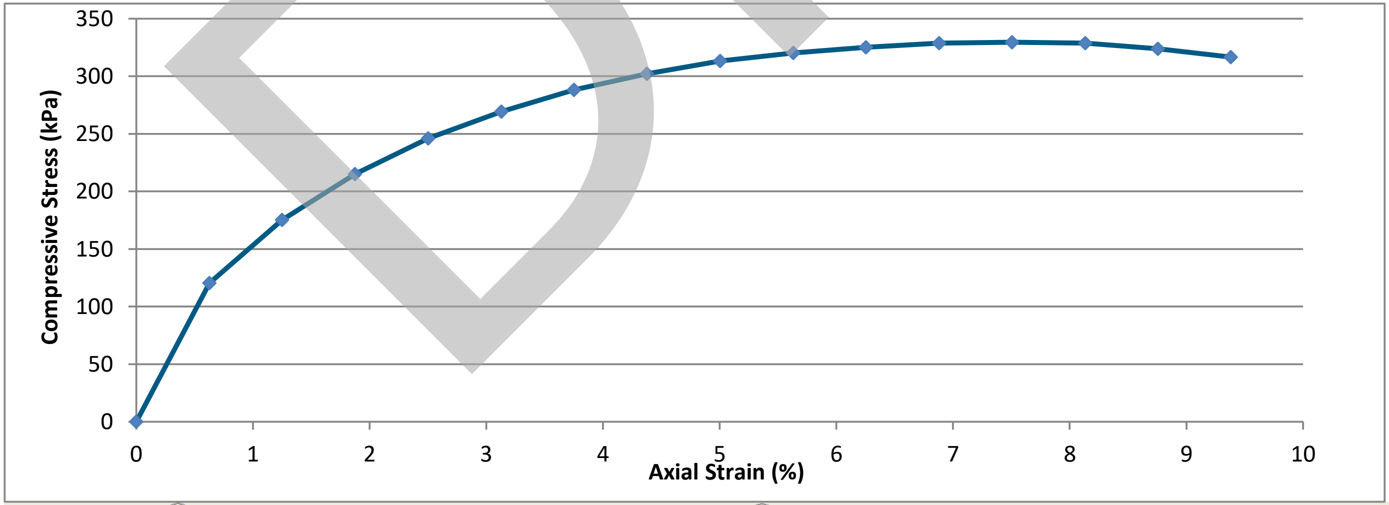
Unconfined Compressive Strength, q_u

330 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.003870	0.00
0.5	469	0.90	0.9	0.63	0.003894	120.43
0.9	687	1.80	1.8	1.25	0.003919	175.31
1.4	848	2.70	2.7	1.88	0.003944	215.02
1.8	977	3.60	3.6	2.50	0.003969	246.14
2.3	1076	4.50	4.5	3.13	0.003995	269.34
2.7	1159	5.40	5.4	3.75	0.004021	288.26
3.2	1223	6.30	6.3	4.38	0.004047	302.19
3.6	1276	7.20	7.2	5.00	0.004074	313.22
4.1	1313	8.10	8.1	5.63	0.004101	320.18
4.5	1342	9.00	9.0	6.25	0.004128	325.09
5.0	1366	9.90	9.9	6.88	0.004156	328.69
5.4	1379	10.80	10.8	7.51	0.004184	329.59
5.9	1385	11.70	11.7	8.13	0.004213	328.78
6.3	1374	12.60	12.6	8.76	0.004241	323.96
6.8	1352	13.50	13.5	9.38	0.004271	316.58

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-639 FHII-13 at 43-45ft

Water Content %	10.7%
Mass of Test Specimen, g	1310.46
Wet Density, kg/m^3	2262
Dry Density, kg/m^3	2044
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.90
Initial Diameter, D_o, cm	7.21
Initial Area, A_o, cm^2	40.83
Initial Height, L_o, cm	14.19
Initial Volume, V_o, cm^3	579.32

Average Pocket Pen Result		3.75
Stress	load/(corr. area)	
Corr. Area	$A_o/(1$ - unit strain)	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.97	
Strain Rate	1.41%	/min

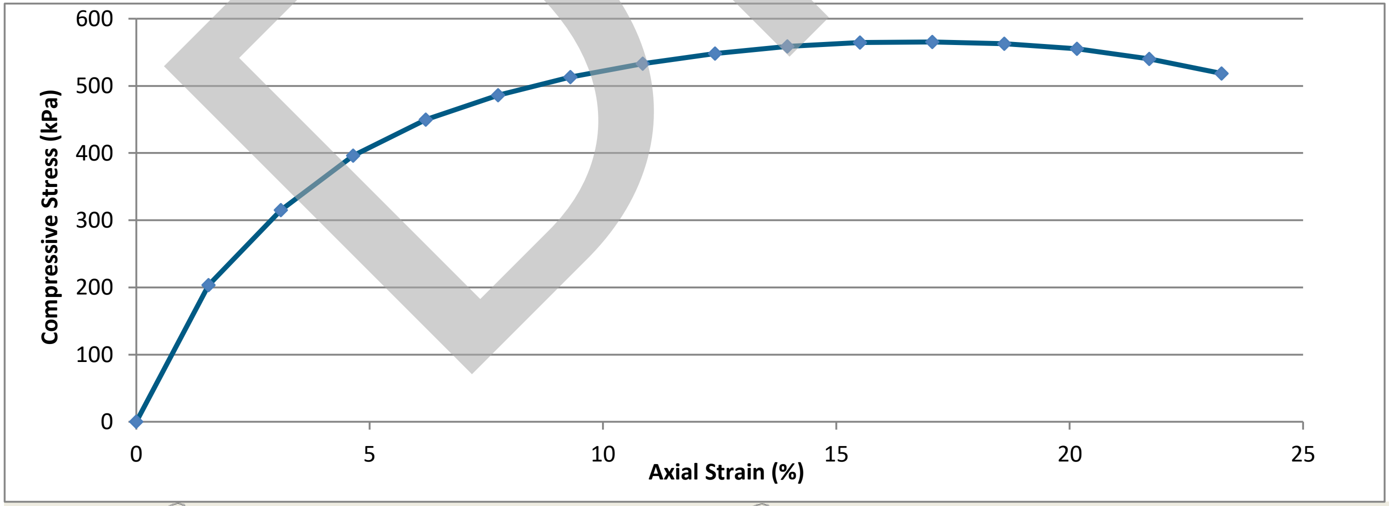
Unconfined Compressive Strength, q_u

567 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004083	0.00
1.1	843	2.20	2.2	1.55	0.004147	203.27
2.2	1327	4.40	4.4	3.10	0.004214	314.94
3.3	1697	6.60	6.6	4.65	0.004282	396.32
4.4	1958	8.80	8.8	6.20	0.004353	449.82
5.5	2151	11.00	11.0	7.75	0.004426	486.01
6.6	2311	13.20	13.2	9.30	0.004502	513.37
7.7	2442	15.40	15.4	10.85	0.004580	533.20
8.8	2555	17.60	17.6	12.41	0.004661	548.16
9.9	2651	19.80	19.8	13.95	0.004745	558.70
11.0	2727	22.00	22.0	15.51	0.004832	564.35
12.1	2783	24.20	24.2	17.06	0.004922	565.38
13.2	2823	26.40	26.4	18.60	0.005016	562.80
14.3	2839	28.60	28.6	20.16	0.005114	555.20
15.4	2816	30.80	30.8	21.70	0.005215	540.02
16.5	2759	33.00	33.0	23.26	0.005320	518.59

Post Test



Checker: **Reviewer:**

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	4-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-721 FHII-22 at 68-70.3ft

Water Content %	10.7%
Mass of Test Specimen, g	1368.63
Wet Density, kg/m^3	2292
Dry Density, kg/m^3	2071
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.95
Initial Diameter, D_o, cm	7.21
Initial Area, A_o, cm^2	40.86
Initial Height, L_o, cm	14.61
Initial Volume, V_o, cm^3	597.09

Average Pocket Pen Result		3.25
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	2.03	
Strain Rate	1.37%	/min

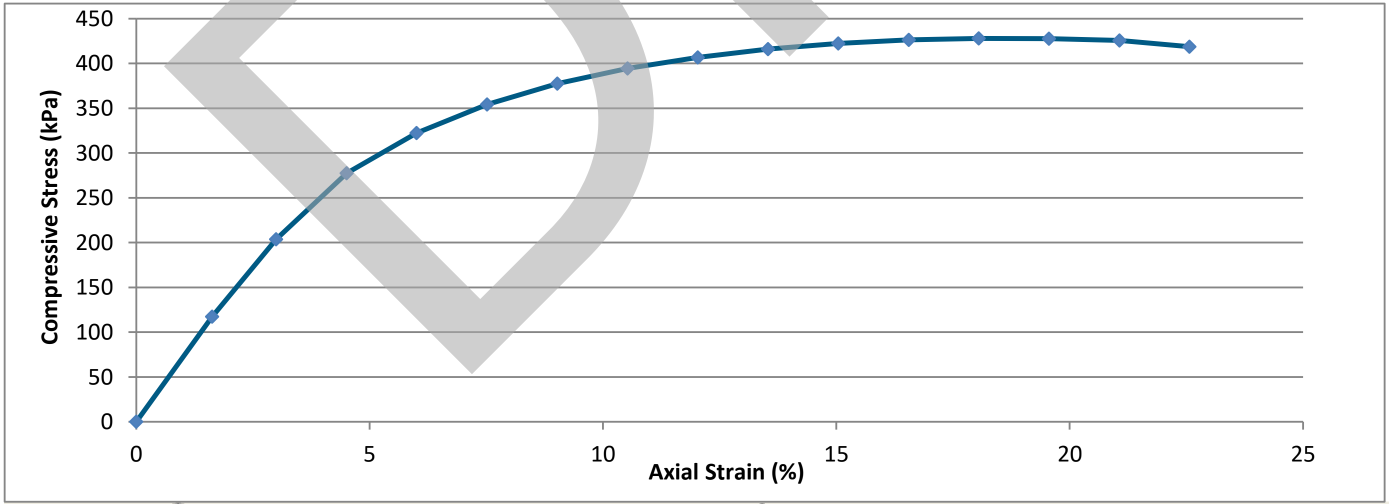
Unconfined Compressive Strength, q_u

429 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004086	0.00
1.2	487	2.38	2.4	1.63	0.004154	117.25
2.2	859	4.38	4.4	3.00	0.004212	203.93
3.3	1187	6.59	6.6	4.51	0.004279	277.42
4.4	1402	8.78	8.8	6.01	0.004347	322.51
5.5	1566	10.99	11.0	7.52	0.004418	354.46
6.6	1695	13.18	13.2	9.02	0.004491	377.41
7.7	1801	15.39	15.4	10.53	0.004567	394.37
8.8	1889	17.58	17.6	12.03	0.004645	406.69
9.9	1966	19.79	19.8	13.54	0.004726	416.01
11.0	2032	21.98	22.0	15.04	0.004809	422.50
12.1	2087	24.19	24.2	16.55	0.004896	426.24
13.2	2134	26.38	26.4	18.05	0.004986	427.98
14.3	2173	28.58	28.6	19.56	0.005079	427.81
15.4	2204	30.79	30.8	21.07	0.005176	425.78
16.5	2209	32.98	33.0	22.57	0.005277	418.61

Post Test



Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-768 FHII-20 at 64-66ft

Water Content %	35.0%
Mass of Test Specimen, g	1153.14
Wet Density, kg/m^3	1935
Dry Density, kg/m^3	1434
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.24
Initial Area, A_o, cm^2	41.16
Initial Height, L_o, cm	14.48
Initial Volume, V_o, cm^3	595.83

Average Pocket Pen Result		1.25
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	2.00	
Strain Rate	1.38%	/min

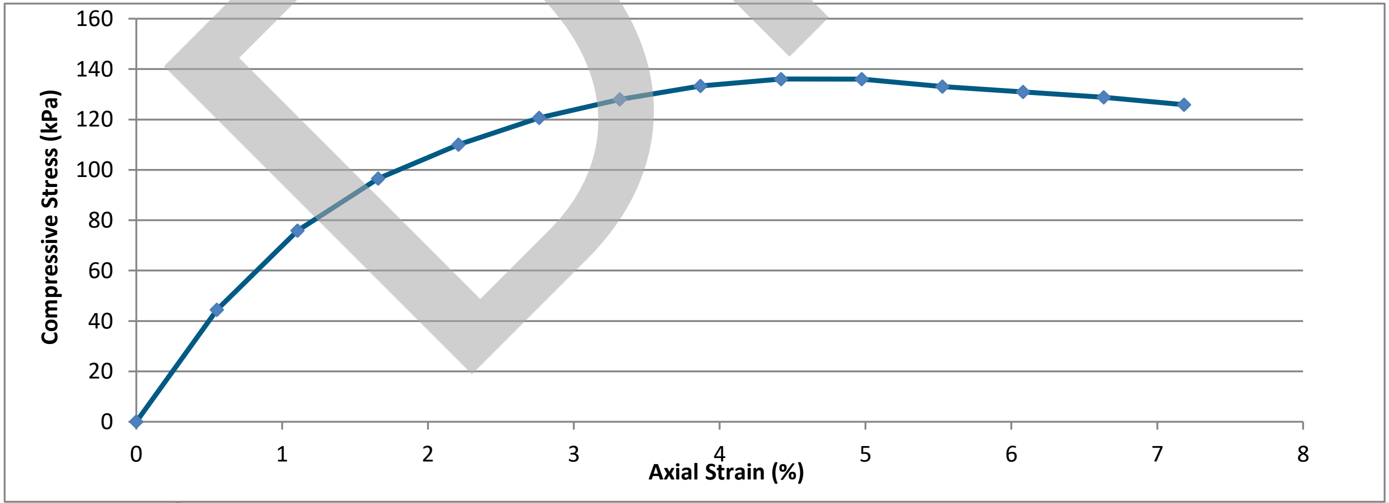
Unconfined Compressive Strength, q_u

136 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004116	0.00
0.4	184	0.80	0.8	0.55	0.004139	44.45
0.8	316	1.60	1.6	1.11	0.004162	75.92
1.2	404	2.40	2.4	1.66	0.004186	96.52
1.6	463	3.20	3.2	2.21	0.004209	109.99
2.0	511	4.00	4.0	2.76	0.004233	120.71
2.4	545	4.80	4.8	3.32	0.004258	128.01
2.8	571	5.60	5.6	3.87	0.004282	133.35
3.2	586	6.40	6.4	4.42	0.004307	136.07
3.6	589	7.20	7.2	4.97	0.004332	135.97
4.0	580	8.00	8.0	5.53	0.004357	133.11
4.4	574	8.80	8.8	6.08	0.004383	130.97
4.8	568	9.60	9.6	6.63	0.004409	128.84
5.2	558	10.40	10.4	7.19	0.004435	125.82

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	2-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-785 SHII-08 at 23-24.9ft

Water Content %	40.1%
Mass of Test Specimen, g	1094.67
Wet Density, kg/m^3	1914
Dry Density, kg/m^3	1366
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.20
Initial Area, A_o, cm^2	40.70
Initial Height, L_o, cm	14.06
Initial Volume, V_o, cm^3	572.02

Average Pocket Pen Result		1.25
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.95	
Strain Rate	1.42%	/min

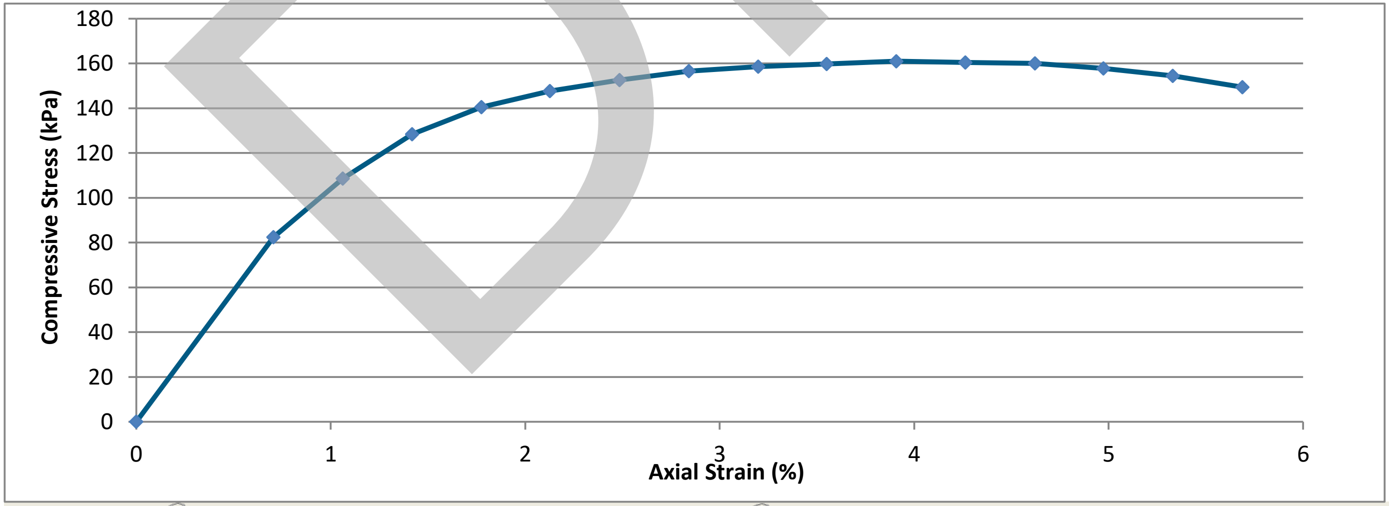
Unconfined Compressive Strength, q_u

161 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004070	0.00
0.5	338	0.99	1.0	0.71	0.004098	82.47
0.8	447	1.49	1.5	1.06	0.004113	108.67
1.0	530	1.99	2.0	1.42	0.004128	128.39
1.3	582	2.50	2.5	1.78	0.004143	140.47
1.5	614	2.99	3.0	2.13	0.004158	147.67
1.8	637	3.49	3.5	2.49	0.004173	152.64
2.0	656	3.99	4.0	2.84	0.004189	156.62
2.3	667	4.50	4.5	3.20	0.004204	158.66
2.5	674	4.99	5.0	3.55	0.004219	159.74
2.8	682	5.49	5.5	3.91	0.004235	161.04
3.0	682	5.99	6.0	4.26	0.004251	160.44
3.3	683	6.50	6.5	4.62	0.004267	160.08
3.5	676	6.99	7.0	4.97	0.004283	157.85
3.8	664	7.49	7.5	5.33	0.004299	154.47
4.0	645	8.00	8.0	5.69	0.004315	149.48

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	2-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

Sample: NLB-807 FHII-24 at 28-30ft

Water Content %	35.3%
Mass of Test Specimen, g	1096.44
Wet Density, kg/m^3	1878
Dry Density, kg/m^3	1388
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.25
Initial Area, A_o, cm^2	41.31
Initial Height, L_o, cm	14.14
Initial Volume, V_o, cm^3	583.85

Average Pocket Pen Result		0.75
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.95	
Strain Rate	1.41%	/min

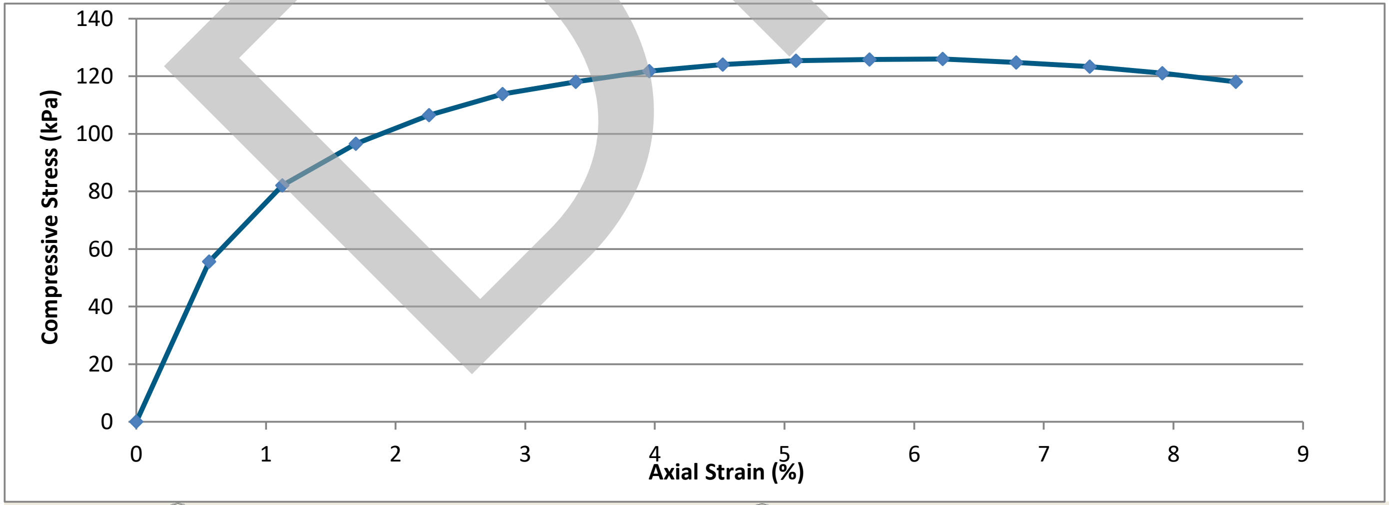
Unconfined Compressive Strength, q_u

127 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004131	0.00
0.4	231	0.79	0.8	0.56	0.004154	55.61
0.8	343	1.59	1.6	1.13	0.004178	82.10
1.2	406	2.39	2.4	1.69	0.004202	96.63
1.6	450	3.19	3.2	2.26	0.004226	106.48
2.0	484	3.99	4.0	2.83	0.004251	113.87
2.4	505	4.79	4.8	3.39	0.004276	118.11
2.8	524	5.59	5.6	3.96	0.004301	121.84
3.2	537	6.39	6.4	4.52	0.004326	124.13
3.6	546	7.20	7.2	5.09	0.004352	125.46
4.0	551	8.00	8.0	5.66	0.004378	125.85
4.4	555	8.80	8.8	6.22	0.004405	126.01
4.8	553	9.60	9.6	6.79	0.004431	124.79
5.2	550	10.40	10.4	7.35	0.004458	123.36
5.6	543	11.19	11.2	7.92	0.004486	121.05
6.0	533	11.99	12.0	8.48	0.004513	118.09

Post Test



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 2-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-868 FHII-23 at 93-95ft

Water Content %	11.8%
Mass of Test Specimen, g	1339.74
Wet Density, kg/m^3	2275
Dry Density, kg/m^3	2034
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.98
Initial Diameter, D_o, cm	7.26
Initial Area, A_o, cm^2	41.38
Initial Height, L_o, cm	14.23
Initial Volume, V_o, cm^3	588.94

Average Pocket Pen Result 2.75

Stress load/(corr. area)

Corr. Area $A_o/(1 - \text{unit strain})$

Unit Strain $\Delta L/L_o$

L_o/D_o 1.96

Strain Rate 1.41% /min

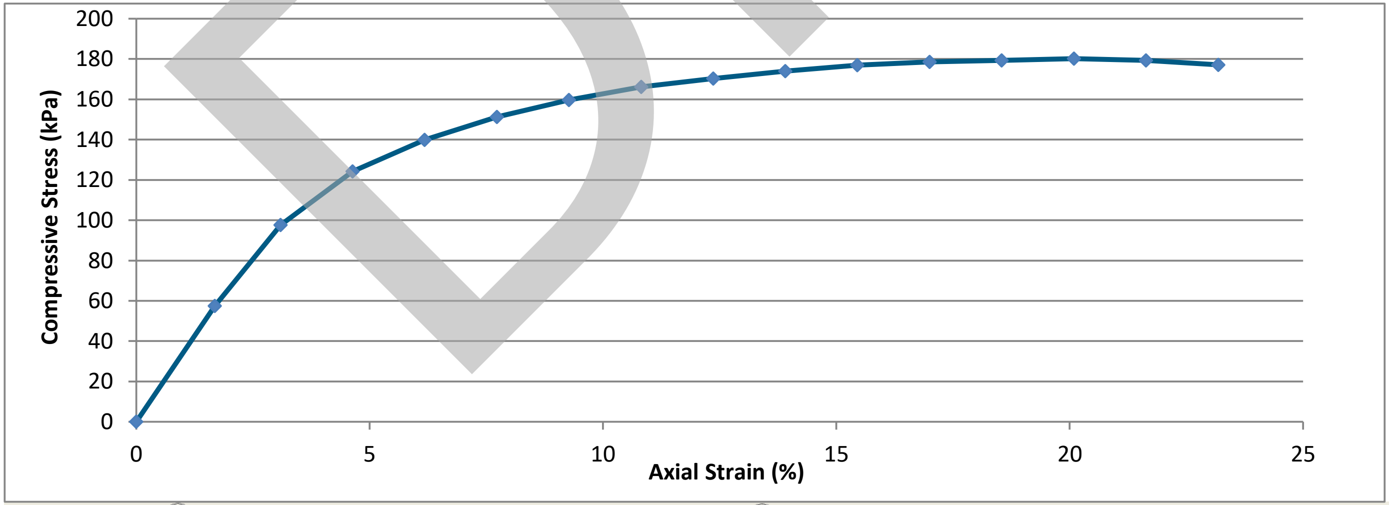
Unconfined Compressive Strength, q_u

181 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004138	0.00
1.2	242	2.40	2.4	1.69	0.004209	57.50
2.2	417	4.40	4.4	3.09	0.004270	97.67
3.3	539	6.60	6.6	4.64	0.004339	124.23
4.4	617	8.80	8.8	6.18	0.004410	139.90
5.5	678	11.00	11.0	7.73	0.004484	151.20
6.6	728	13.20	13.2	9.27	0.004560	159.63
7.7	771	15.40	15.4	10.82	0.004640	166.18
8.8	804	17.60	17.6	12.36	0.004721	170.29
9.9	836	19.80	19.8	13.91	0.004806	173.94
11.0	866	22.00	22.0	15.45	0.004894	176.95
12.1	890	24.20	24.2	17.00	0.004985	178.53
13.2	911	26.40	26.4	18.55	0.005080	179.34
14.3	933	28.60	28.6	20.09	0.005178	180.18
15.4	947	30.80	30.8	21.64	0.005280	179.35
16.5	954	33.00	33.0	23.19	0.005387	177.11

Post Test



Checker: **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-882 FHII-16 at 18-19.7ft

Water Content %	9.2%
Mass of Test Specimen, g	1315.74
Wet Density, kg/m^3	2266
Dry Density, kg/m^3	2075
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.83
Initial Diameter, D_o, cm	7.19
Initial Area, A_o, cm^2	40.65
Initial Height, L_o, cm	14.28
Initial Volume, V_o, cm^3	580.54

Average Pocket Pen Result		Max
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.99	
Strain Rate	#DIV/0!	/min

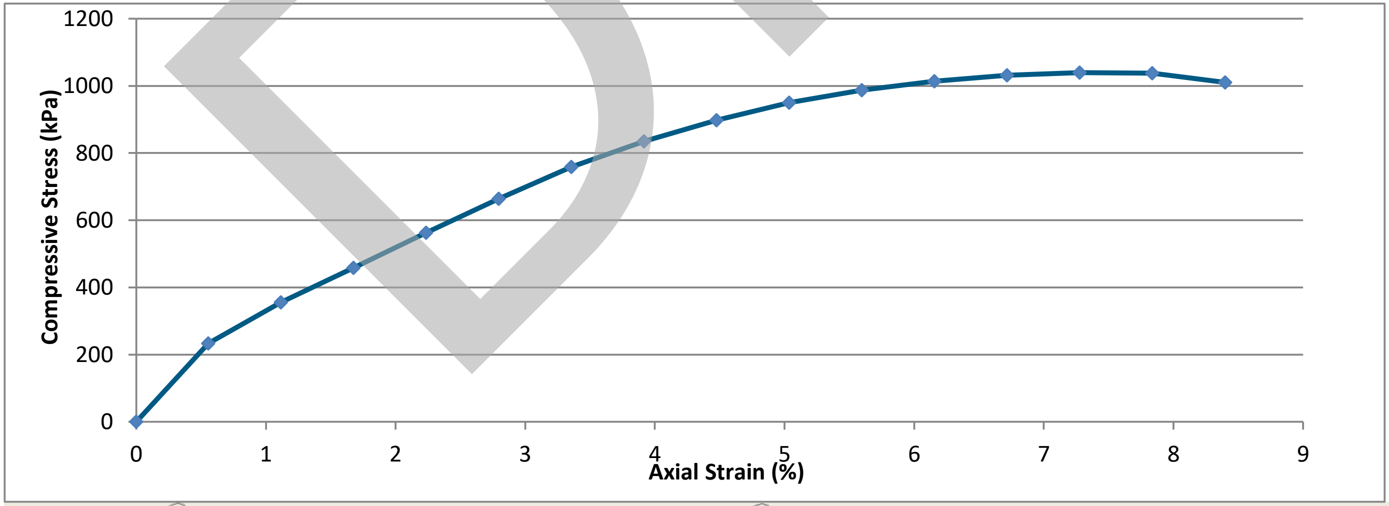
Unconfined Compressive Strength, q_u

1042 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004065	0.00
0.4	953	0.79	0.8	0.56	0.004087	233.15
0.8	1461	1.59	1.6	1.12	0.004111	355.42
1.2	1896	2.39	2.4	1.68	0.004134	458.63
1.6	2339	3.19	3.2	2.24	0.004158	562.57
2.0	2778	3.99	4.0	2.80	0.004182	664.33
2.4	3190	4.79	4.8	3.36	0.004206	758.46
2.8	3532	5.59	5.6	3.92	0.004230	834.91
3.2	3822	6.39	6.4	4.48	0.004255	898.19
3.6	4065	7.20	7.2	5.04	0.004280	949.69
4.0	4251	8.00	8.0	5.60	0.004306	987.29
4.4	4393	8.80	8.8	6.16	0.004331	1014.21
4.8	4496	9.60	9.6	6.72	0.004357	1031.79
5.2	4557	10.40	10.4	7.28	0.004384	1039.51
5.6	4576	11.20	11.2	7.84	0.004410	1037.54
6.0	4484	12.00	12.0	8.40	0.004437	1010.50

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	3-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

Sample: NLB-912 FHII-18 at 18-20ft

Water Content %	21.8%
Mass of Test Specimen, g	1295.58
Wet Density, kg/m^3	2133
Dry Density, kg/m^3	1751
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.26
Initial Area, A_o, cm^2	41.44
Initial Height, L_o, cm	14.65
Initial Volume, V_o, cm^3	607.32

Average Pocket Pen Result		1.25
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	2.02	
Strain Rate	1.36%	/min

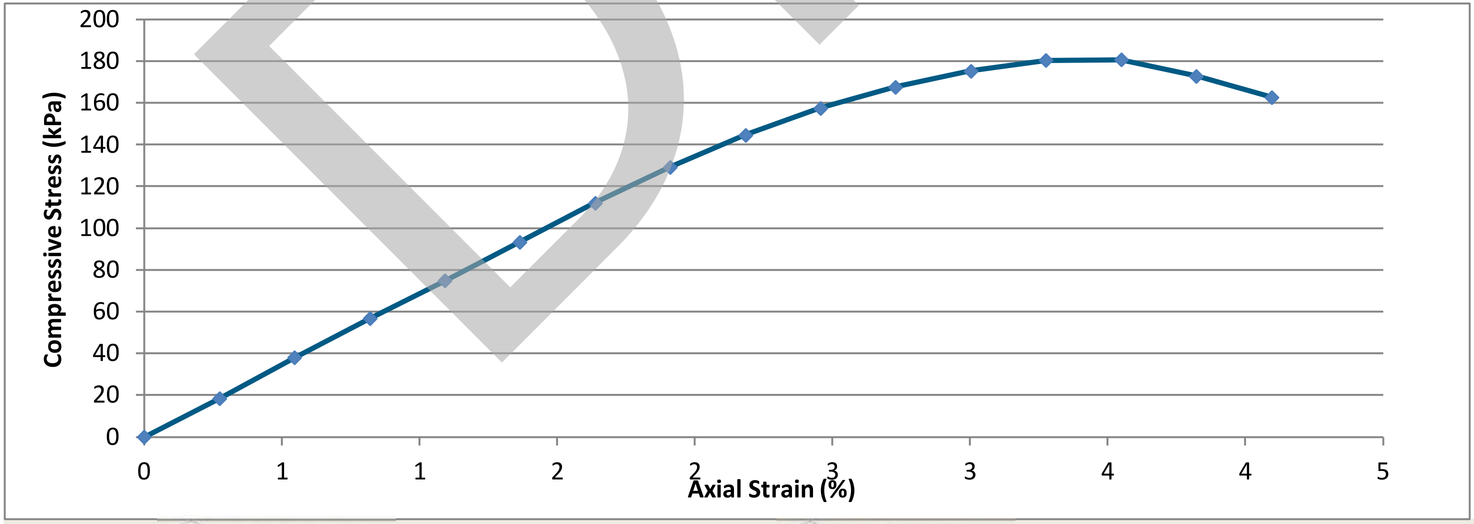
Unconfined Compressive Strength, q_u

182 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004144	0.00
0.2	76	0.40	0.4	0.27	0.004156	18.29
0.4	158	0.80	0.8	0.55	0.004167	37.91
0.6	237	1.20	1.2	0.82	0.004179	56.72
0.8	313	1.60	1.6	1.09	0.004190	74.70
1.0	392	2.00	2.0	1.36	0.004202	93.29
1.2	472	2.40	2.4	1.64	0.004214	112.02
1.4	546	2.80	2.8	1.91	0.004225	129.22
1.6	613	3.20	3.2	2.18	0.004237	144.68
1.8	669	3.60	3.6	2.46	0.004249	157.45
2.0	714	4.00	4.0	2.73	0.004261	167.57
2.2	749	4.40	4.4	3.00	0.004273	175.29
2.4	773	4.80	4.8	3.28	0.004285	180.40
2.6	777	5.20	5.2	3.55	0.004297	180.82
2.8	745	5.60	5.6	3.82	0.004309	172.89
3.0	703	6.00	6.0	4.10	0.004321	162.68

Post Test



Checker: Don

Reviewer: Don

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	4-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-922 FHII-18 at 43-45ft

Water Content %	12.8%
Mass of Test Specimen, g	1368.49
Wet Density, kg/m^3	2289
Dry Density, kg/m^3	2030
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.27
Initial Area, A_o, cm^2	41.53
Initial Height, L_o, cm	14.40
Initial Volume, V_o, cm^3	597.94

Average Pocket Pen Result		2.25
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	1.98	
Strain Rate	1.39%	/min

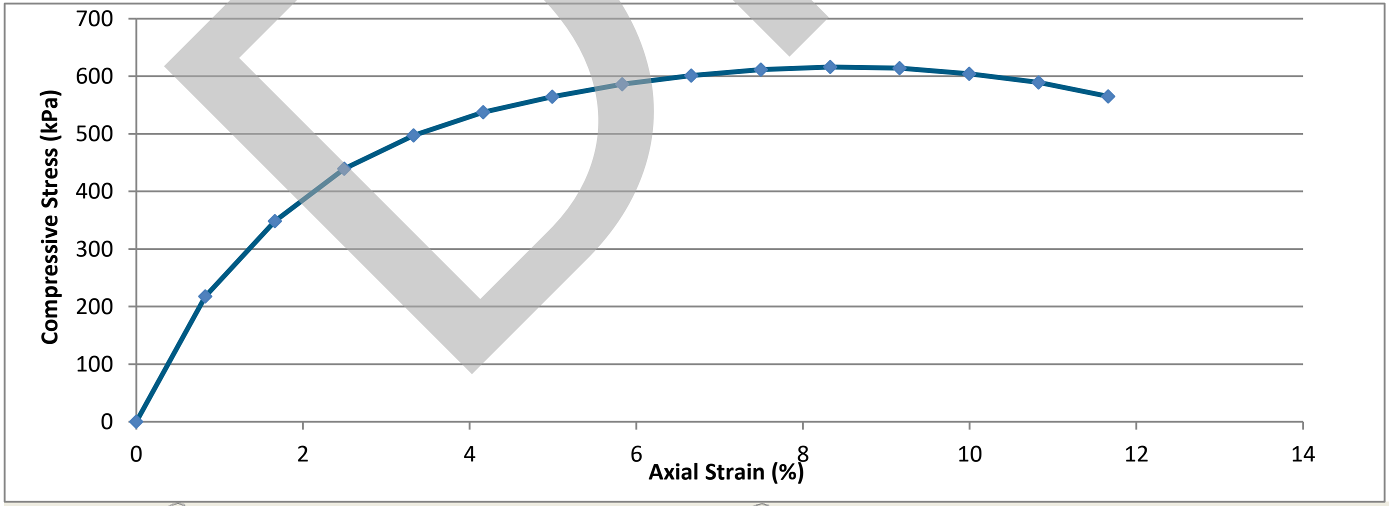
Unconfined Compressive Strength, q_u

617 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004153	0.00
0.6	912	1.19	1.2	0.83	0.004188	217.78
1.2	1471	2.39	2.4	1.66	0.004223	348.31
1.8	1873	3.59	3.6	2.50	0.004259	439.74
2.4	2137	4.79	4.8	3.33	0.004296	497.43
3.0	2329	5.99	6.0	4.16	0.004333	537.44
3.6	2468	7.19	7.2	4.99	0.004371	564.59
4.2	2585	8.40	8.4	5.83	0.004410	586.14
4.8	2676	9.59	9.6	6.66	0.004449	601.43
5.4	2745	10.79	10.8	7.49	0.004489	611.43
6.0	2791	11.99	12.0	8.33	0.004530	616.07
6.6	2807	13.19	13.2	9.16	0.004572	613.97
7.2	2788	14.39	14.4	9.99	0.004614	604.22
7.8	2745	15.59	15.6	10.83	0.004657	589.39
8.4	2656	16.79	16.8	11.66	0.004701	564.95

Post Test



Checker: **Reviewer:**

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	4-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

SNC·LAVALIN

Sample: NLB-946 FHII-17 at 13-15ft

Water Content %	21.4%
Mass of Test Specimen, g	1116.67
Wet Density, kg/m^3	1983
Dry Density, kg/m^3	1634
Specific Gravity (Assumed)	2.70
Degree of Saturation	0.88
Initial Diameter, D_o, cm	7.24
Initial Area, A_o, cm^2	41.19
Initial Height, L_o, cm	13.67
Initial Volume, V_o, cm^3	563.13

Average Pocket Pen Result	1.25
Stress	load/(corr. area)
Corr. Area	$A_o/(1 - \text{unit strain})$
Unit Strain	$\Delta L/L_o$
L_o/D_o	1.89
Strain Rate	1.46% /min

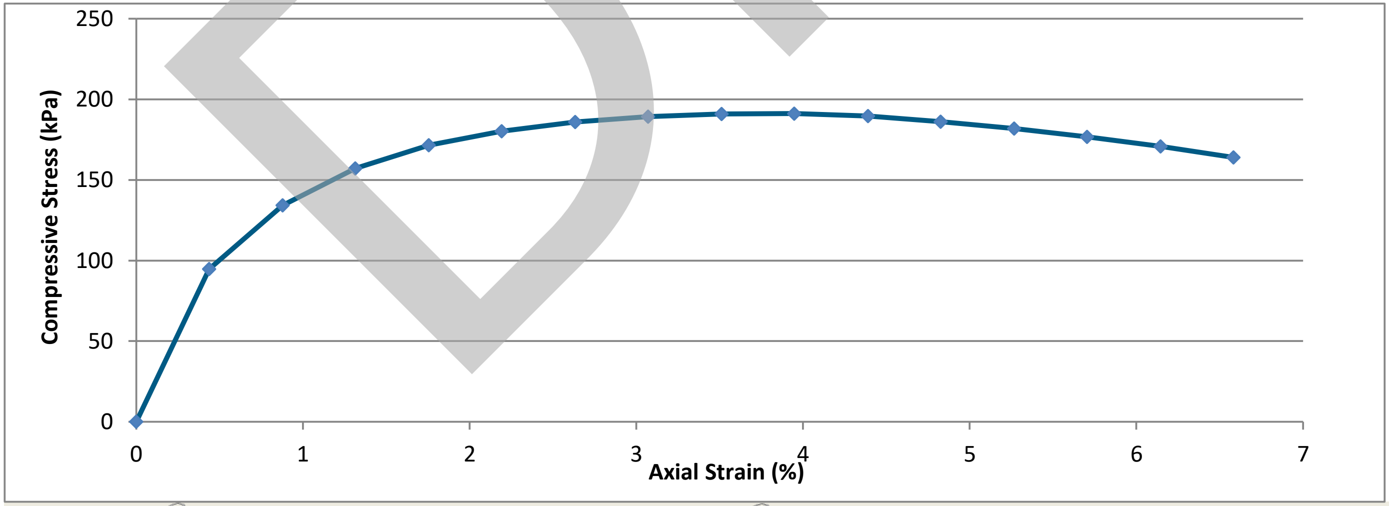
Unconfined Compressive Strength, q_u

192 kPa

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004119	0.00
0.3	392	0.60	0.6	0.44	0.004137	94.74
0.6	558	1.20	1.2	0.88	0.004156	134.27
0.9	656	1.80	1.8	1.31	0.004174	157.15
1.2	719	2.40	2.4	1.76	0.004193	171.47
1.5	759	3.00	3.0	2.19	0.004212	180.21
1.8	787	3.60	3.6	2.63	0.004231	186.01
2.1	804	4.20	4.2	3.07	0.004250	189.18
2.4	815	4.80	4.8	3.51	0.004269	190.89
2.7	820	5.40	5.4	3.95	0.004289	191.20
3.0	817	6.00	6.0	4.39	0.004309	189.62
3.3	806	6.60	6.6	4.83	0.004328	186.21
3.6	791	7.20	7.2	5.27	0.004348	181.90
3.9	772	7.80	7.8	5.70	0.004369	176.71
4.2	750	8.40	8.4	6.15	0.004389	170.88
4.5	723	9.00	9.0	6.58	0.004410	163.96

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	4-May-2022

Geoscience & Materials

UNCONFINED COMPRESSION TEST REPORT

(Test Reference: ASTM D 2166)

Sample: NLB-959 FHII-17 at 48-49.25ft

Water Content %	12.4%
Mass of Test Specimen, g	1391.93
Wet Density, kg/m^3	2322
Dry Density, kg/m^3	2066
Specific Gravity (Assumed)	2.70
Degree of Saturation	1.00
Initial Diameter, D_o, cm	7.21
Initial Area, A_o, cm^2	40.81
Initial Height, L_o, cm	14.69
Initial Volume, V_o, cm^3	599.33

Average Pocket Pen Result		2.25
Stress	load/(corr. area)	
Corr. Area	$A_o/(1 - \text{unit strain})$	
Unit Strain	$\Delta L/L_o$	
L_o/D_o	2.04	
Strain Rate	1.36%	/min

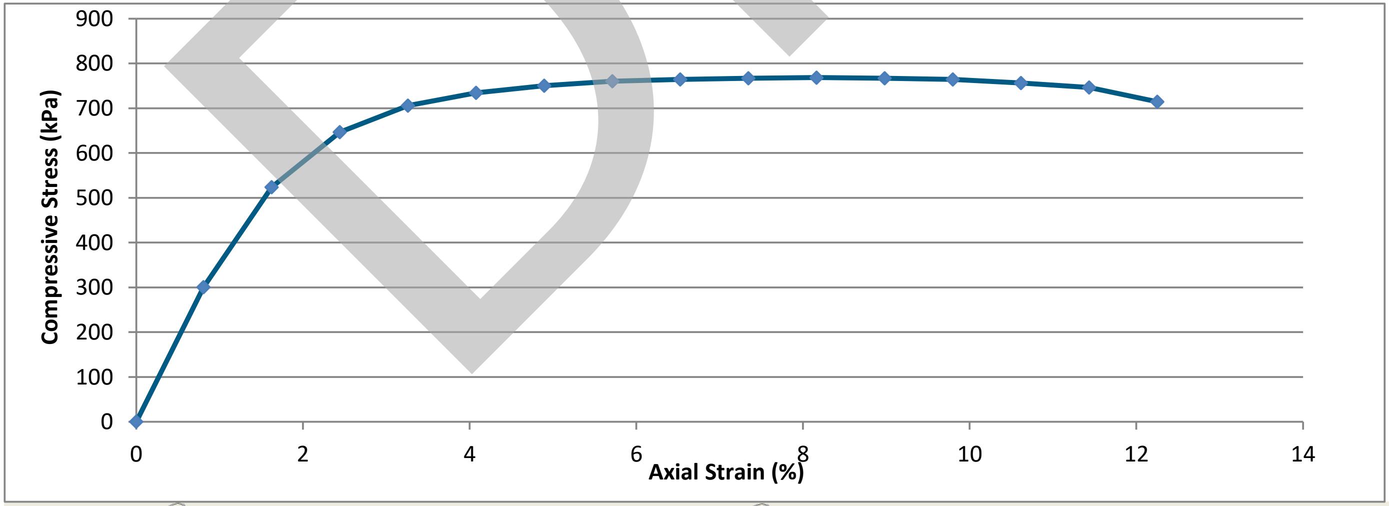
Unconfined Compressive Strength, q_u

769 **kPa**

Consistency	q_u, kPa
Very soft	0-24
Soft	24-48
Medium	48-96
Stiff	96-192
Very stiff	192-383
Hard	>383

Elapsed Time,min	Axial Load,N	LVDT, mm	Total Deviation	Unit Strain, %	Corrected Area, cm2	Stress, kPa
0.0	0	0.00	0.0	0.00	0.004081	0.00
0.6	1237	1.19	1.2	0.81	0.004114	300.65
1.2	2174	2.39	2.4	1.63	0.004149	524.03
1.8	2706	3.59	3.6	2.44	0.004183	646.85
2.4	2977	4.79	4.8	3.26	0.004219	705.67
3.0	3126	5.99	6.0	4.08	0.004255	734.73
3.6	3220	7.19	7.2	4.89	0.004291	750.38
4.2	3290	8.39	8.4	5.71	0.004328	760.11
4.8	3337	9.59	9.6	6.53	0.004366	764.28
5.4	3380	10.79	10.8	7.35	0.004405	767.36
6.0	3416	11.99	12.0	8.16	0.004444	768.69
6.6	3439	13.19	13.2	8.98	0.004484	766.98
7.2	3458	14.39	14.4	9.80	0.004524	764.29
7.8	3454	15.59	15.6	10.62	0.004566	756.50
8.4	3439	16.79	16.8	11.43	0.004608	746.32
9.0	3323	17.99	18.0	12.25	0.004651	714.49

Post Test



Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	3-May-2022

Geoscience & Materials

Appendix VII (G)

Consolidation

SNC · LAVALIN

One-Dimensional Consolidation Test - ASTM D 2435

Project #:	659183	**Project :**	Saskatoon Freeway Functional Pla
Client:	SMHI	**Tech:**	JA
Sample Name:	NLB-1027 BH1	**Date:**	15-May-22
Depth:	28.5 -30.0m	**Checked by:**	KF

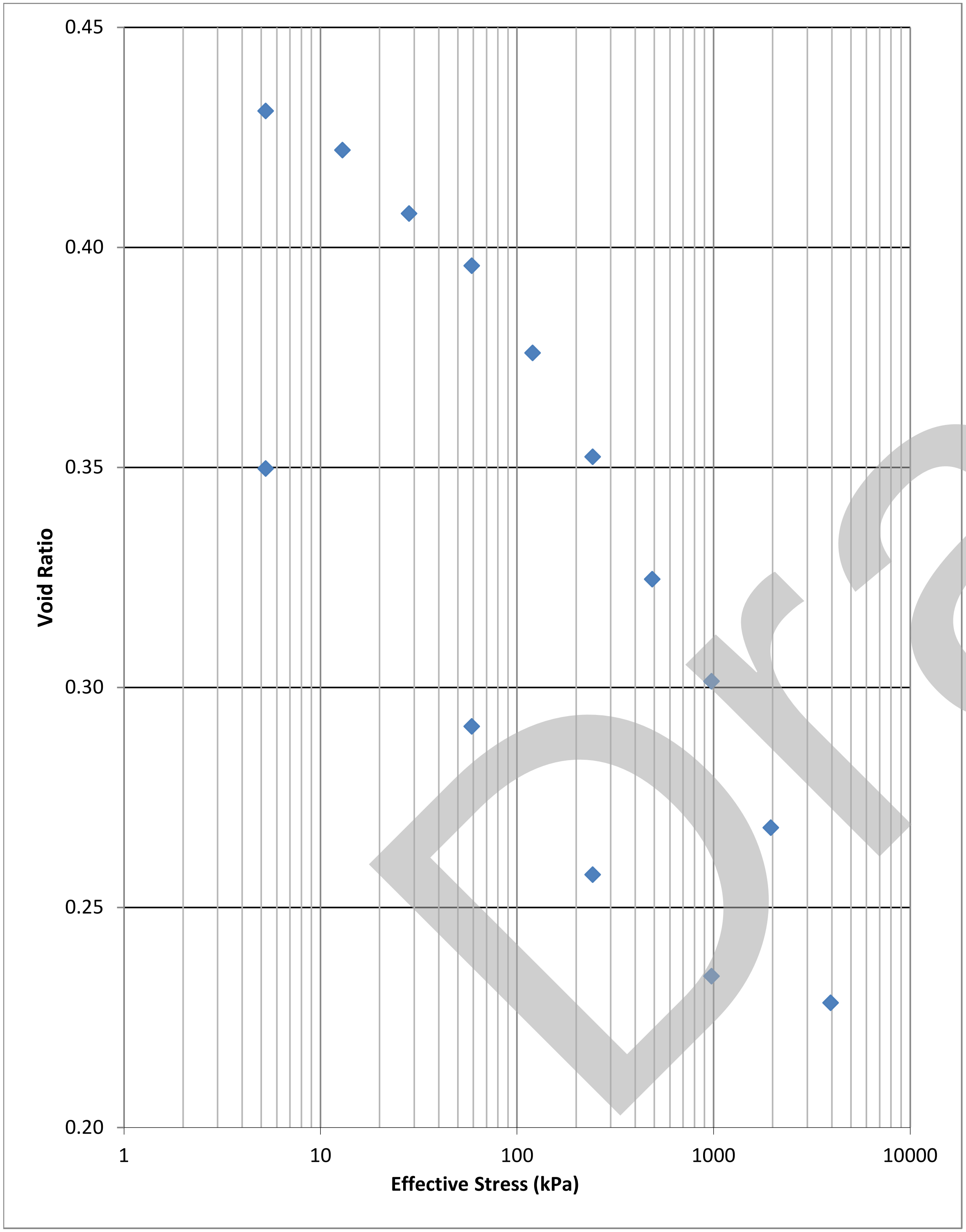
Test Procedure: Trimmed from shelby specimen

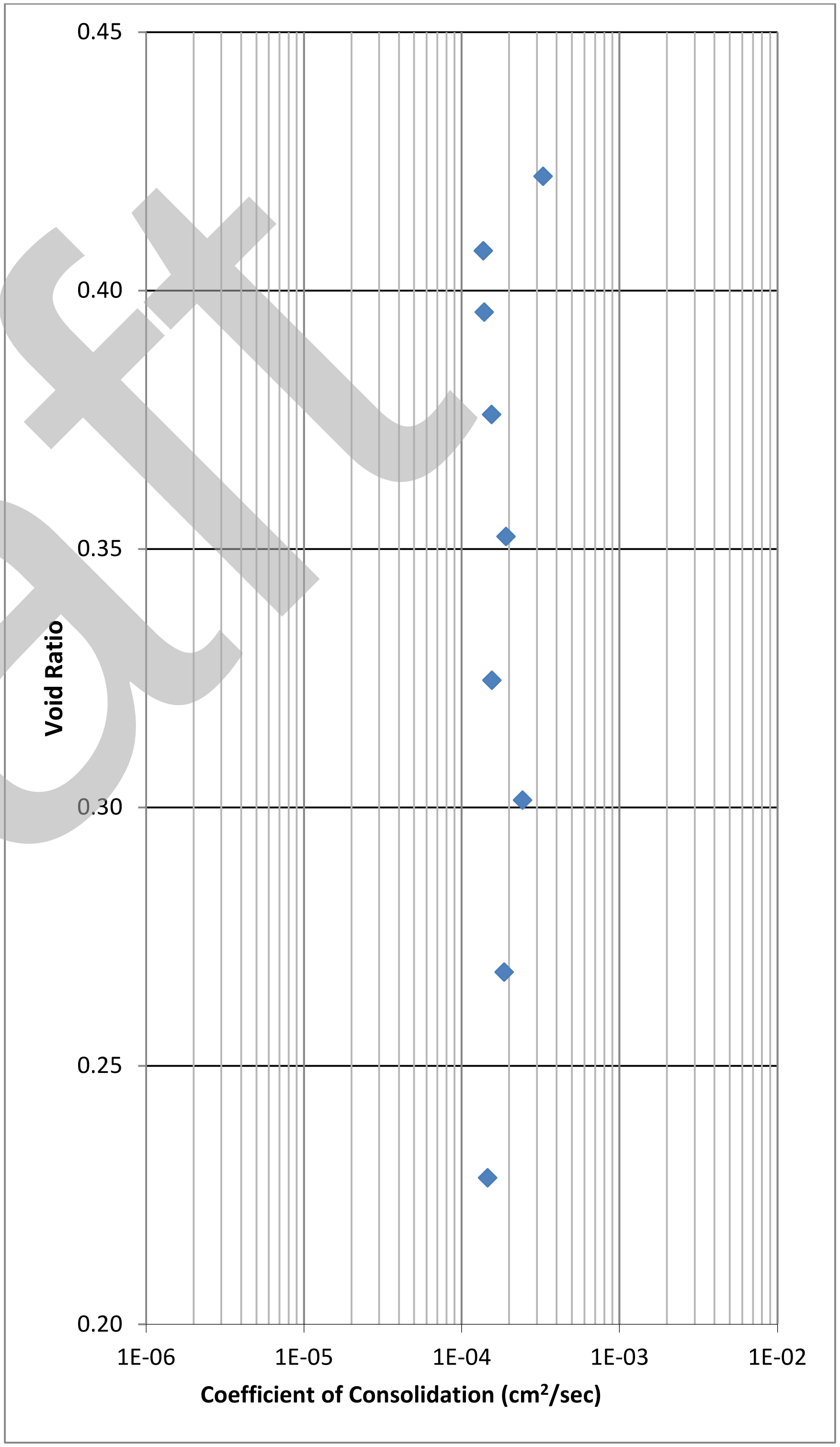
Method of testing: Method B **Condition of test:** Natural Moisture

Sample Calculations:

	Cross-sectional area:	32.04	cm^2	0.003204 m^2			
	Volume of solids:	53.07	cc	5.31E-05 m^3			
(Prior to loading)	Total volume:	75.94	cc	Specific Gravity:	2.7	
(Prior to loading)	Volume of voids:	22.87	cc	Initial wet density:	2177	kg/m^3
(Prior to loading)	Initial void ratio:	0.43		Initial dry density:	1887	kg/m^3
	Post-test Dry mass of solids:	143.28	g	Initial Dial reading:	12.306	

		At End of Primary Consolidation							Coefficient of Consolidation				
Loading Increment	Pressure (kPa)	R_{100} (mm)	Uncorrected Sample Height (mm)	Equipment Compressibility (mm)	Corrected Sample Height (mm)	Volume of Sample (cc)	Volume of Voids (cc)	Void Ratio	R_{50} (mm)	Corrected Sample Height at R_{50} (mm)	H_{D50} (mm)	time50 (sec)	Coefficient of Consolidation c_v (cm^2/s)
Initial	5.3							0.43					
1	13.0	12.1550	23.5490	0.004	23.5530	75.47	22.40	0.42	12.21	23.61	11.81	840	3.27E-04
2	28.3	11.9140	23.3080	0.006	23.3140	74.70	21.63	0.41	12.00	23.40	11.70	1980	1.36E-04
3	58.9	11.7080	23.1020	0.016	23.1180	74.07	21.01	0.40	11.79	23.20	11.60	1920	1.38E-04
4	120.1	11.3720	22.7660	0.024	22.7900	73.02	19.96	0.38	11.50	22.92	11.46	1680	1.54E-04
5	242.6	10.9710	22.3650	0.034	22.3990	71.77	18.70	0.35	11.12	22.55	11.27	1320	1.90E-04
6	487.5	10.4960	21.8900	0.048	21.9380	70.29	17.23	0.32	10.67	22.12	11.06	1560	1.54E-04
7	977.4	10.0920	21.4860	0.068	21.5540	69.06	16.00	0.30	10.24	21.70	10.85	960	2.42E-04
8	1957.1	9.5110	20.9050	0.098	21.0030	67.30	14.23	0.27	9.71	21.21	10.60	1200	1.85E-04
9	3939.1	8.8060	20.2000	0.144	20.3440	65.19	12.12	0.23	9.06	20.60	10.30	1440	1.45E-04
10	977.4	8.9660	20.3600	0.084	20.4440	65.51	12.44	0.23					
11	242.6	9.3760	20.7700	0.056	20.8260	66.73	13.66	0.26					
12	58.9	9.9500	21.3440	0.040	21.3840	68.52	15.45	0.29					
13	5.3	10.9380	22.3320	0.022	22.3540	71.63	18.56	0.35					


0.45
0.40
0.35
0.30
0.25
0.20
Void Ratio
1
10
100
1000
10000
Effective Stress (kPa)


0.45
0.40
0.35
0.30
0.25
0.20
Void Ratio
1E-06
1E-05
1E-04
1E-03
1E-02
Coefficient of Consolidation (cm²/sec)

SNC·LAVALIN

One-Dimensional Consolidation Test - ASTM D 2435

Project #:	659183	**Project :**	Saskatoon Freeway Functional Plar
Client:	SMHI	**Tech:**	JA
Sample Name:	NLB-1093 BH1-SI	**Date:**	11-May-22
Depth:	28 - 28.38m	**Checked by:**	KF

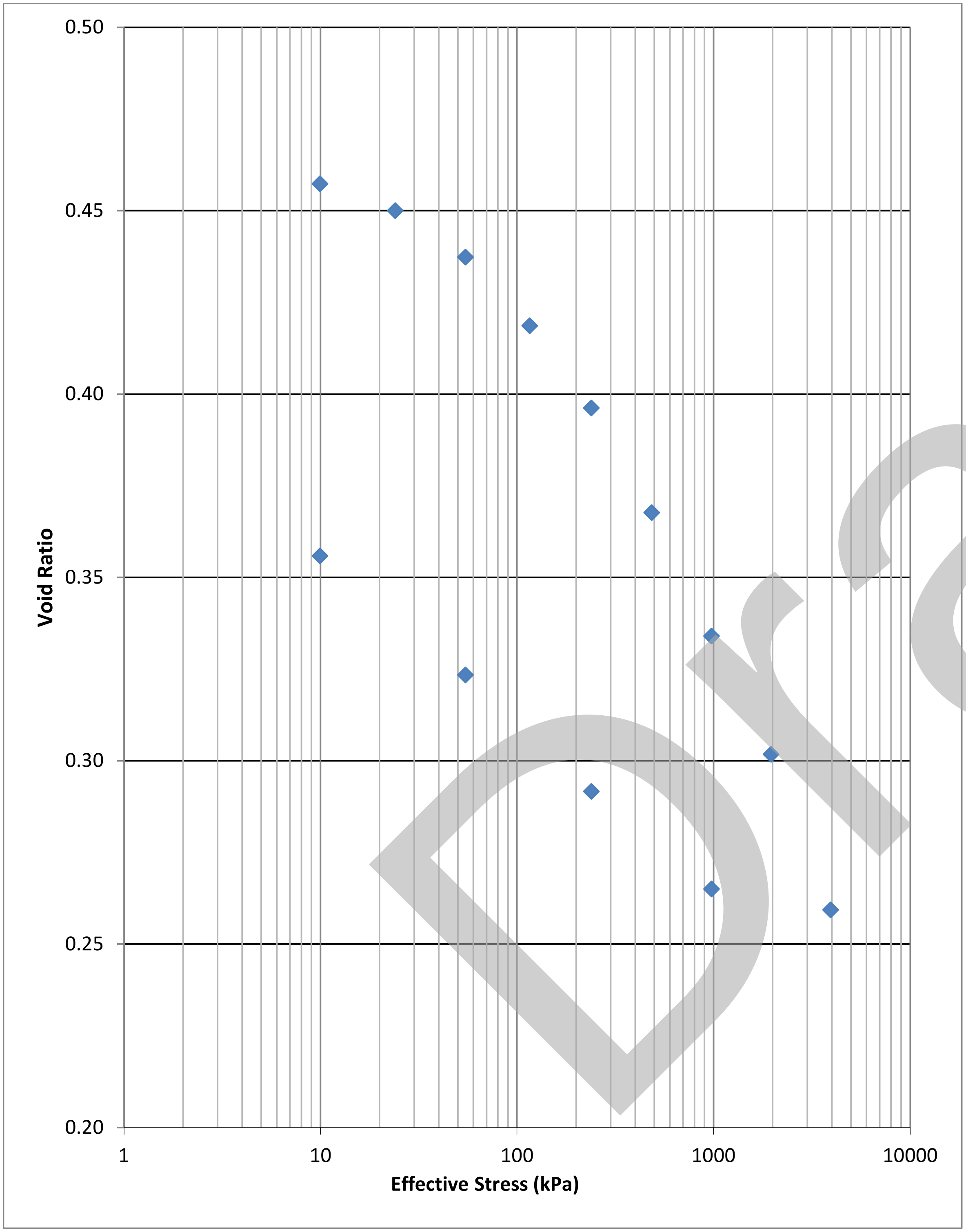
Test Procedure: Trimmed from shelby specimen

Method of testing: Method B **Condition of test:** Natural Moisture

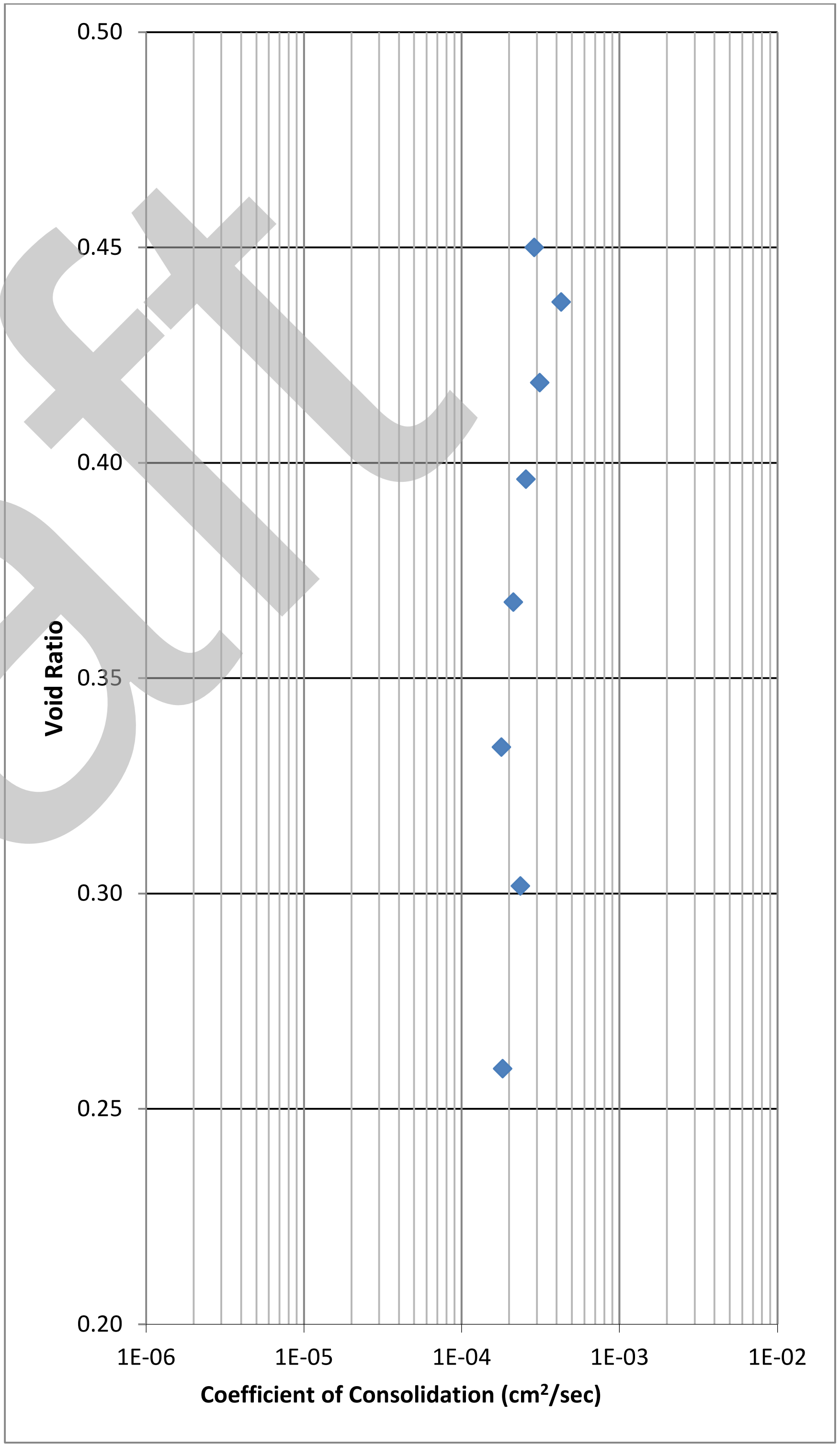
Sample Calculations:

	Cross-sectional area:	31.92	cm^2	0.003192 m^2		
	Volume of solids:	55.11	cc	5.51E-05 m^3		
(Prior to loading)	Total volume:	80.31	cc	Specific Gravity:	2.7	
(Prior to loading)	Volume of voids:	25.20	cc	Initial wet density:	2152	kg/m^3
(Prior to loading)	Initial void ratio:	0.46		Initial dry density:	1853	kg/m^3
	Post-test Dry mass of solids:	148.79	g	Initial Dial reading:	12.682	

		At End of Primary Consolidation							Coefficient of Consolidation				
Loading Increment	Pressure (kPa)	R_{100} (mm)	Uncorrected Sample Height (mm)	Equipment Compressibility (mm)	Corrected Sample Height (mm)	Volume of Sample (cc)	Volume of Voids (cc)	Void Ratio	R_{50} (mm)	Corrected Sample Height at R_{50} (mm)	H_{D50} (mm)	time50 (sec)	Coefficient of Consolidation c_v (cm^2/s)
Initial	10.0							0.46					
1	24.0	12.5500	25.0280	0.006	25.0340	79.91	24.80	0.45	12.61	25.09	12.54	1080	2.87E-04
2	54.8	12.3270	24.8050	0.010	24.8150	79.21	24.10	0.44	12.42	24.91	12.45	720	4.24E-04
3	116.2	11.9860	24.4640	0.028	24.4920	78.18	23.07	0.42	12.10	24.61	12.30	960	3.11E-04
4	239.2	11.5830	24.0610	0.044	24.1050	76.94	21.83	0.40	11.73	24.25	12.12	1140	2.54E-04
5	485.0	11.0660	23.5440	0.068	23.6120	75.37	20.26	0.37	11.25	23.79	11.90	1320	2.11E-04
6	976.8	10.4570	22.9350	0.096	23.0310	73.51	18.41	0.33	10.68	23.25	11.63	1500	1.78E-04
7	1960.3	9.8650	22.3430	0.132	22.4750	71.74	16.63	0.30	10.09	22.70	11.35	1080	2.35E-04
8	3948.0	9.0880	21.5660	0.176	21.7420	69.40	14.29	0.26	9.36	22.02	11.01	1320	1.81E-04
9	976.8	9.2400	21.7180	0.122	21.8400	69.71	14.60	0.27					
10	239.2	9.7340	22.2120	0.088	22.3000	71.18	16.07	0.29					
11	54.8	10.3120	22.7900	0.058	22.8480	72.93	17.82	0.32					
12	10.0	10.8880	23.3660	0.042	23.4080	74.72	19.61	0.36					



0.50
0.45
0.40
0.35
0.30
0.25
0.20
Void Ratio
1
10
100
1000
10000
Effective Stress (kPa)



0.50
0.45
0.40
0.35
0.30
0.25
0.20
Void Ratio
1E-06
1E-05
1E-04
1E-03
1E-02
Coefficient of Consolidation (cm²/sec)

SNC·LAVALIN

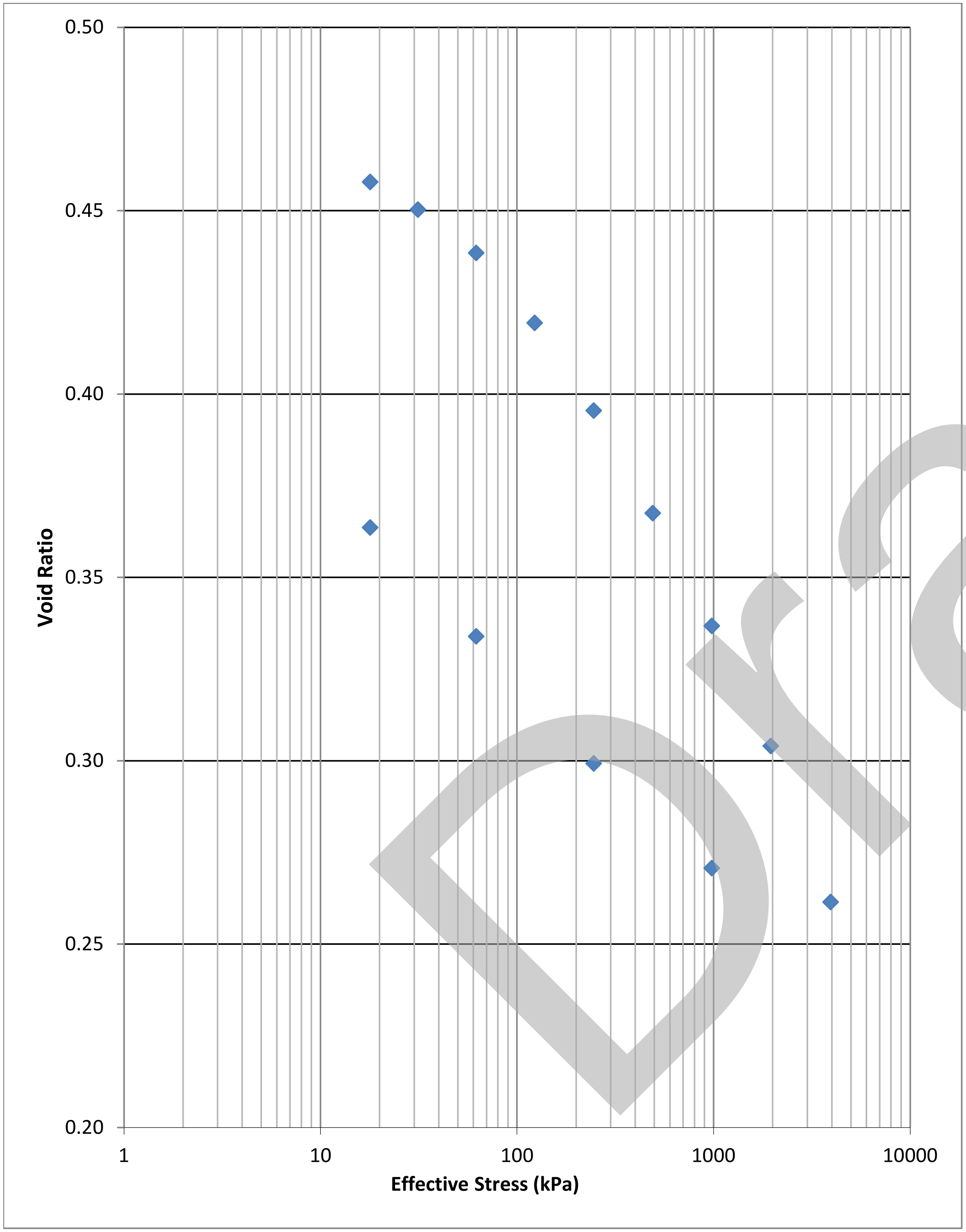
One-Dimensional Consolidation Test - ASTM D 2435

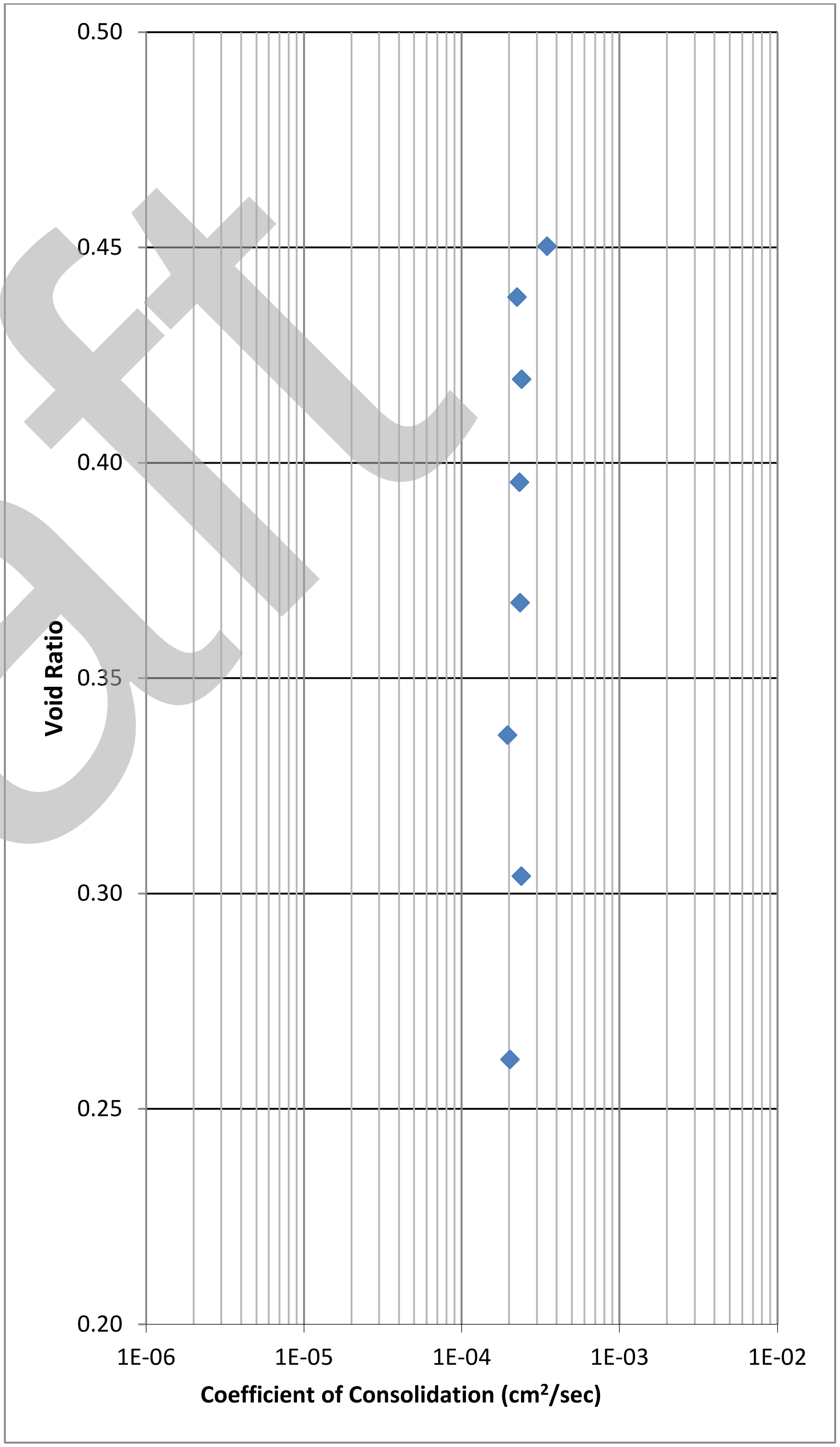
Project #:	659183	**Project :**	Saskatoon Freeway Functional Pla
Client:	SMHI	**Tech:**	JA
Sample Name:	NLB-1094 BH1-SI	**Date:**	11-May-22
Depth:	41.55 - 42.03m	**Checked by:**	KF
Test Procedure:			Trimmed from shelby specimen
Method of testing:	Method B	**Condition of test:**	Natural Moisture

Sample Calculations:

	Cross-sectional area:	32.08	cm^2	0.003208 m^2			
	Volume of solids:	55.52	cc	5.55E-05 m^3			
(Prior to loading)	Total volume:	80.94	cc	Specific Gravity:	2.7	
(Prior to loading)	Volume of voids:	25.42	cc	Initial wet density:	2155	kg/m^3
(Prior to loading)	Initial void ratio:	0.46		Initial dry density:	1852	kg/m^3
	Post-test Dry mass of solids:	149.90	g	Initial Dial reading:	12.004	

		At End of Primary Consolidation							Coefficient of Consolidation				
Loading Increment	Pressure (kPa)	R_{100} (mm)	Uncorrected Sample Height (mm)	Equipment Compressibility (mm)	Corrected Sample Height (mm)	Volume of Sample (cc)	Volume of Voids (cc)	Void Ratio	R_{50} (mm)	Corrected Sample Height at R_{50} (mm)	H_{D50} (mm)	time50 (sec)	Coefficient of Consolidation c_v (cm^2/s)
Initial	17.9							0.46					
1	31.3	11.8580	25.0840	0.016	25.1000	80.52	25.00	0.45	11.92	25.16	12.58	900	3.46E-04
2	61.9	11.6370	24.8630	0.032	24.8950	79.86	24.34	0.44	11.73	24.99	12.49	1380	2.23E-04
3	123.1	11.2850	24.5110	0.054	24.5650	78.80	23.28	0.42	11.43	24.71	12.35	1260	2.39E-04
4	245.4	10.8540	24.0800	0.072	24.1520	77.48	21.96	0.40	11.03	24.32	12.16	1260	2.31E-04
5	490.0	10.3480	23.5740	0.094	23.6680	75.93	20.41	0.37	10.54	23.86	11.93	1200	2.34E-04
6	979.3	9.7800	23.0060	0.130	23.1360	74.22	18.70	0.34	10.00	23.35	11.68	1380	1.95E-04
7	1957.9	9.1670	22.3930	0.176	22.5690	72.40	16.88	0.30	9.40	22.81	11.40	1080	2.37E-04
8	3939.9	8.3800	21.6060	0.226	21.8320	70.04	14.52	0.26	8.68	22.13	11.07	1200	2.01E-04
9	979.3	8.6100	21.8360	0.156	21.9920	70.55	15.03	0.27					
10	245.4	9.1580	22.3840	0.102	22.4860	72.13	16.61	0.30					
11	61.9	9.7860	23.0120	0.074	23.0860	74.06	18.54	0.33					
12	17.9	10.3260	23.5520	0.048	23.6000	75.71	20.19	0.36					


0.50
0.45
0.40
0.35
0.30
0.25
0.20
Void Ratio
1
10
100
1000
10000
Effective Stress (kPa)


0.50
0.45
0.40
0.35
0.30
0.25
0.20
Void Ratio
1E-06
1E-05
1E-04
1E-03
1E-02
Coefficient of Consolidation (cm²/sec)

SNC·LAVALIN

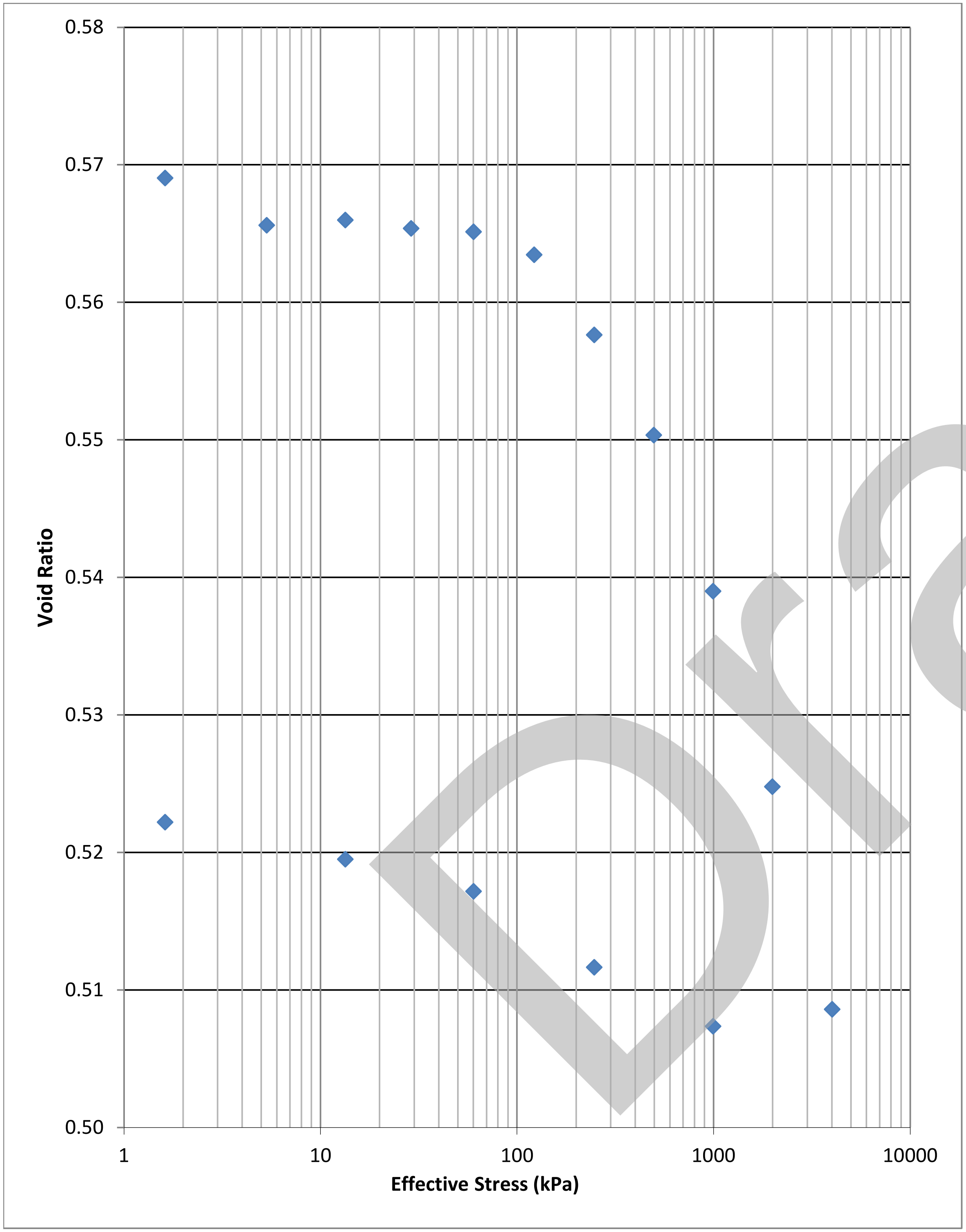
One-Dimensional Consolidation Test - ASTM D 2435

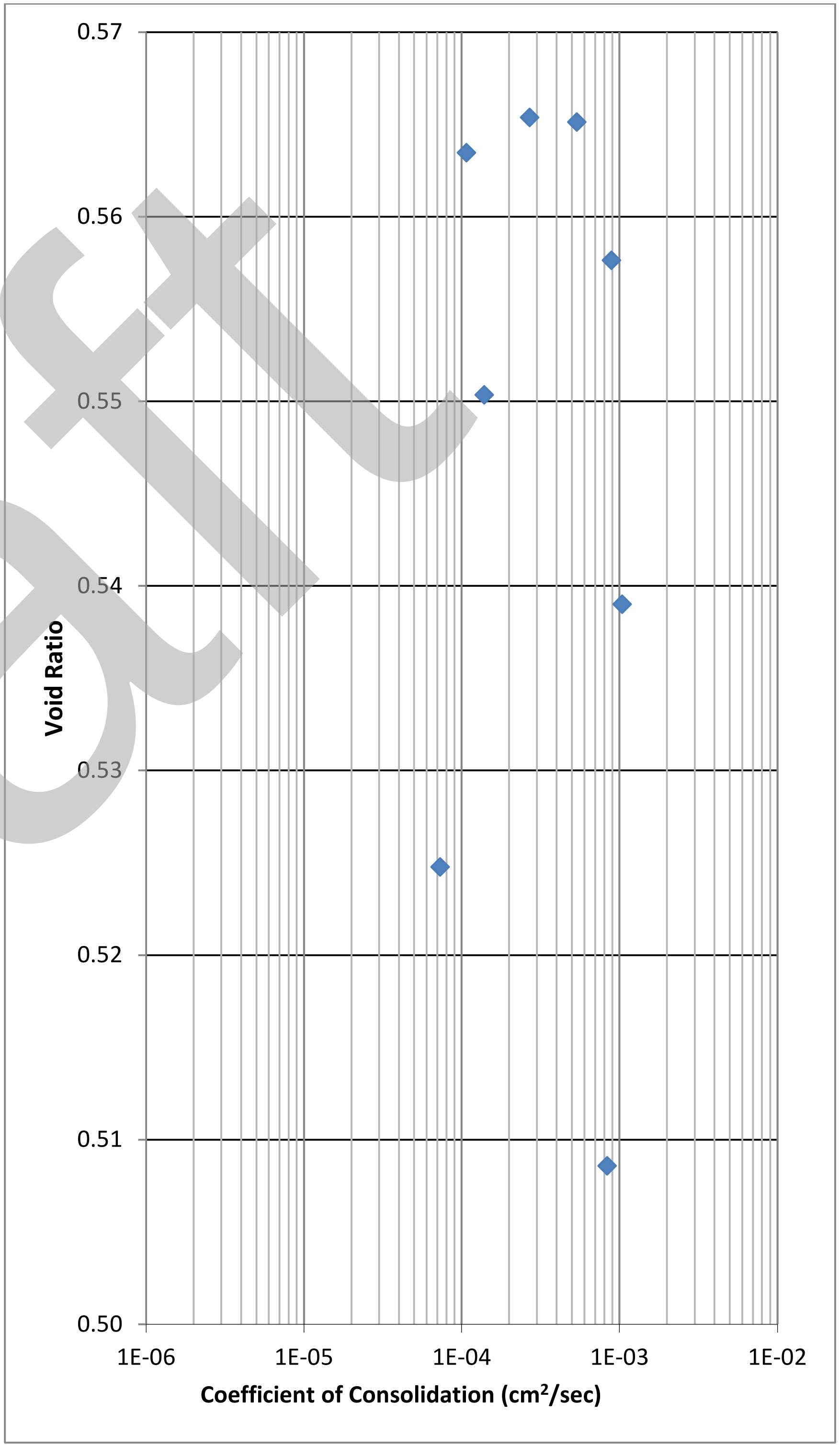
Project #:	659183	**Project :**	Saskatoon Freeway Functional Pla
Client:	SMHI	**Tech:**	JA
Sample Name:	NLB-1101 BH2	**Date:**	11-May-22
Depth:	4.5 - 4.98m	**Checked by:**	KF
Test Procedure:			Trimmed from shelby specimen
Method of testing:	Method B	**Condition of test:**	Natural Moisture

Sample Calculations:

	Cross-sectional area:	31.47	cm^2	0.003147 m^2		
	Volume of solids:	51.33	cc	5.13E-05 m^3		
(Prior to loading)	Total volume:	80.53	cc	Specific Gravity:	2.7	
(Prior to loading)	Volume of voids:	29.21	cc	Initial wet density:	2064	kg/m^3
(Prior to loading)	Initial void ratio:	0.57		Initial dry density:	1721	kg/m^3
	Post-test Dry mass of solids:	138.58	g	Initial Dial reading:	15.636	

		At End of Primary Consolidation							Coefficient of Consolidation				
Loading Increment	Pressure (kPa)	R_{100} (mm)	Uncorrected Sample Height (mm)	Equipment Compressibility (mm)	Corrected Sample Height (mm)	Volume of Sample (cc)	Volume of Voids (cc)	Void Ratio	R_{50} (mm)	Corrected Sample Height at R_{50} (mm)	H_{D50} (mm)	time50 (sec)	Coefficient of Consolidation c_v (cm^2/s)
Initial	1.6							0.57					
1	5.3	15.5800	25.5340	0.000	25.5340	80.36	29.03	0.57	15.58	25.53	12.77	6	5.35E-02
2	13.4	15.5680	25.5220	0.018	25.5400	80.37	29.05	0.57	15.57	25.54	12.77	6	5.35E-02
3	29.0	15.5480	25.5020	0.028	25.5300	80.34	29.02	0.57	15.55	25.53	12.77	1200	2.68E-04
4	60.2	15.5080	25.4620	0.064	25.5260	80.33	29.01	0.57	15.51	25.53	12.76	600	5.35E-04
5	122.5	15.4530	25.4070	0.092	25.4990	80.25	28.92	0.56	15.46	25.51	12.75	3000	1.07E-04
6	247.2	15.3300	25.2840	0.120	25.4040	79.95	28.62	0.56	15.35	25.42	12.71	360	8.84E-04
7	496.6	15.1890	25.1430	0.142	25.2850	79.57	28.25	0.55	15.20	25.30	12.65	2280	1.38E-04
8	995.3	14.9700	24.9240	0.176	25.1000	78.99	27.66	0.54	14.98	25.11	12.56	300	1.04E-03
9	1992.9	14.6880	24.6420	0.226	24.8680	78.26	26.93	0.52	14.72	24.90	12.45	4200	7.27E-05
10	4010.9	14.3400	24.2940	0.310	24.6040	77.43	26.10	0.51	14.37	24.64	12.32	360	8.30E-04
11	995.3	14.3840	24.3380	0.246	24.5840	77.37	26.04	0.51					
12	247.2	14.4840	24.4380	0.216	24.6540	77.59	26.26	0.51					
13	60.2	14.5920	24.5460	0.198	24.7440	77.87	26.54	0.52					
14	13.4	14.6340	24.5880	0.194	24.7820	77.99	26.66	0.52					
15	1.6	14.6820	24.6360	0.190	24.8260	78.13	26.80	0.52					


Void Ratio
0.58
0.57
0.56
0.55
0.54
0.53
0.52
0.51
0.50
1
10
100
1000
10000
Effective Stress (kPa)


Void Ratio
0.57
0.56
0.55
0.54
0.53
0.52
0.51
0.50
1E-06
1E-05
1E-04
1E-03
1E-02
Coefficient of Consolidation (cm²/sec)

Appendix VII (H)

Unit Weight

BULK DENSITY TEST REPORT

(Wet Waxed Method)

SNC·LAVALIN

BULK DENSITY RESULTS

Sample #	Test Hole	Depth (m)	M/C (%)	Density, Wet (kg/m^3)	Density, Dry (kg/m^3)
NLB-1001	BH1	1.5 - 1.9	12.45	**Too Disturbed to test**	
NLB-1007	BH1	6 - 6.45	7.88	**2356**	**2184**
NLB-1009	BH1	7.5 - 7.95	5.59	**2061**	**1952**
NLB-1011	BH1	10.5 - 10.95	10.50	**Too Disturbed to test**	
NLB-1013	BH1	13.5 - 13.95	12.94	**Too Disturbed to test**	
NLB-1018	BH1	19.5 - 19.65	18.33	**Too Disturbed to test**	
NLB-1020	BH1	22.5 - 22.8	12.84	**Too Disturbed to test**	
NLB-1025	BH1	27 - 27.45	15.92	**2201**	**1899**
NLB-1033	BH1	36 - 36.45	14.61	**2234**	**1950**
NLB-1036	BH1	39 - 39.45	15.69	**2217**	**1916**
NLB-1039	BH1	42 - 42.45	15.30	**2214**	**1920**
NLB-1042	BH1	45 - 45.45	16.79	**2188**	**1874**
NLB-1047	BH1	51 - 51.45	14.63	**2228**	**1944**
NLB-1052	BH1	57 - 57.45	12.88	**2284**	**2023**
NLB-1057	BH1	63 - 63.45	12.92	**2276**	**2015**
NLB-1062	BH1	69 - 69.45	12.13	**2291**	**2043**
NLB-1067	BH1	73.0	23.47	**1963**	**1590**
NLB-1083	BH1	93-93.15	27.10	**1942**	**1528**
NLB-1089	BH1	100 - 100.25	25.44	**1865**	**1486**
NLB-1096	BH2	0 - 1.5	14.94	**Too Disturbed to test**	
NLB-1101	BH2	4.5 - 4.98	20.10	**Too Disturbed to test**	
NLB-1104	BH2	6 - 7.5	9.59	**Too Disturbed to test**	
NLB-1112	BH2	13.0	11.55	**Too Disturbed to test**	
NLB-1121	BH2	20.5	13.17	**2240**	**1980**
NLB-1131	BH2	29.0	13.24	**2232**	**1971**
NLB-1139	BH2	38.0	15.25	**2232**	**1937**
NLB-1147	BH2	48 - 48.45	9.70	**2376**	**2166**
NLB-1155	BH2	58.5	9.07	**2328**	**2134**
NLB-1163	BH2	68.5	9.95	**2298**	**2090**

Checker: **Reviewer:**

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	2022-01-30

Geoscience & Materials

BULK DENSITY TEST REPORT

(Wet Waxed Method)

SNC·LAVALIN

BULK DENSITY RESULTS

Sample #	Test Hole	Depth (ft)	M/C (%)	Density, Wet (kg/m^3)	Density, Dry (kg/m^3)
NLB-010	SHII 1	18 - 19.5	14.15	**2293**	**2009**
NLB-125	SHII 2	10.5	11.43	**2223**	**1995**
NLB-141	SHII 2	43.0	10.52	**2284**	**2066**
NLB-145	PHII 2	9.0	29.61	**1911**	**1474**
NLB-025	FHII 1	12.0	9.04	**2425**	**2224**
NLB-038	FHII 1	37.5 - 38.5		Too Disturbed	
NLB-266	FHII 2	11.0	12.52	**2174**	**1932**
NLB-277	FHII 2	33 - 34	11.36	**2304**	**2069**
NLB-148	FHII 3	7.0	22.37	**1994**	**1630**
NLB-158	FHII 3	25.5	13.68	**2154**	**1895**
NLB-170	FHII 3	50.5	10.00	**2213**	**2012**
NLB-188	FHII 3	102.0	13.52	**2226**	**1961**
NLB-195	FHII 4	17 - 18.5	11.93	**2387**	**2132**
NLB-209	FHII 4	45.0	8.22	**2384**	**2203**
NLB-226	FHII 4	97-98	15.43	**2327**	**2016**
NLB-234	FHII 5	11.0	11.93	**2277**	**2034**
NLB-256	FHII 5	65.5	15.34	**2226**	**1930**
NLB-061	SHII 4	8 - 9.5	15.13	**2192**	**1904**
NLB-070	SHII 4	28 - 29.5	15.32	**2247**	**1948**
NLB-307	FHII 6	23 - 24.5	11.33	**2373**	**2131**
NLB-412	FHII 7	20.5	13.02	**2281**	**2018**
NLB-430	FHII 7	68 - 69.5	9.83	**2369**	**2157**
NLB-503	FHII 8	31.0	12.95	**2261**	**2002**
NLB-346	FHII 9	10.5	17.38	**2139**	**1823**
NLB-356	FHII 9	30.5	9.79	**2311**	**2104**
NLB-362	FHII 9	45.5	11.95	**2293**	**2048**
NLB-370	FHII 9	70.5	8.49	**2331**	**2149**
NLB-380	FHII 10	20.0	14.18	**2253**	**1973**
NLB-394	FHII 10	57 - 58.5	10.36	**2323**	**2105**
NLB-115	PHII 4	12.0	18.30	**2175**	**1839**
NLB-109	PHII 5	7.0	27.47	**1844**	**1447**
NLB-477	SHII 6	20.5	16.73	**2192**	**1878**
NLB-485	SHII 6	38 - 39.5	20.55	**2138**	**1774**
NLB-488	SHII 6	45 - 46.5		Too Disturbed	

Checker:

Reviewer:

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 5-May-22

Geoscience & Materials

BULK DENSITY TEST REPORT

(Wet Waxed Method)

SNC·LAVALIN

BULK DENSITY RESULTS

Sample #	Test Hole	Depth (ft)	M/C (%)	Density, Wet (kg/m^3)	Density, Dry (kg/m^3)
NLB-447	FHII 11	25.0	16.59	**2198**	**1886**
NLB-102	PHII 6	3.0	8.52	**2187**	**2015**
NLB-106	PHII 6	17.0	10.92	**2282**	**2057**
NLB-083	SHII 7	8 - 9.5	13.85	**2282**	**2005**
NLB-093	SHII 7	33 - 34.5	19.69	**2197**	**1836**
NLB-564	FHII 14	28 - 29.5	11.96	**2280**	**2036**
NLB-885	FHII 16	25.0	13.27	**2266**	**2000**
NLB-890	FHII 16	36.0	10.78	**2359**	**2130**
NLB-902	FHII 16	68 - 69.5	12.34	**2298**	**2046**
NLB-531	FHII 12	25.5	39.79	**1902**	**1361**
NLB-538	FHII 12	43 - 44.5	14.04	**2333**	**2046**
NLB-548	FHII 12	68 - 69.3	11.77	**2357**	**2109**
NLB-628	FHII 13	16.0	36.11	**1888**	**1387**
NLB-631	FHII 13	23 - 24.3	32.31	**1919**	**1451**
NLB-636	FHII 13	36.0	15.92	**2195**	**1893**
NLB-644	FHII 13	57.0	13.67	**2279**	**2005**
NLB-947	FHII 17	15.5	33.13	**1896**	**1424**
NLB-960	FHII 17	51.0	12.23	**2288**	**2038**
NLB-914	FHII 18	23 - 25	24.24	**2127**	**1712**
NLB-923	FHII 18	46.0	12.64	**2286**	**2030**
NLB-591	FHII 19	22.0	15.81	**2220**	**1917**
NLB-606	FHII 19	63.0	17.90	**2166**	**1837**
NLB-753	FHII 20	27.0		Too Disturbed	
NLB-767	FHII 20	63.0	42.72	**1913**	**1340**
NLB-772	FHII 20	70.0	36.49	**1989**	**1457**
NLB-779	SHII 8	11.5		Too Disturbed	
NLB-789	SHII 8	33 - 34.5	40.38	**1974**	**1406**
NLB-662	FHII 21	20.5	36.19	**1880**	**1381**
NLB-680	FHII 21	68 - 69.25		Too Disturbed	
NLB-701	FHII 22	21.0	28.34	**1984**	**1546**
NLB-716	FHII 22	55.5	36.45	**1902**	**1394**
NLB-724	FHII 22	75.5	11.71	**2295**	**2055**
NLB-732	SHII 9	18 - 19.5		Too Disturbed	
NLB-739	SHII 9	37.0	37.45	**1874**	**1364**

Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	23-Apr-22

Geoscience & Materials

BULK DENSITY TEST REPORT

(Wet Waxed Method)

SNC·LAVALIN

BULK DENSITY RESULTS

Sample #	Test Hole	Depth (ft)	M/C (%)	Density, Wet (kg/m^3)	Density, Dry (kg/m^3)
NLB-832	FHII 23	8 - 9.5		Too Disturbed	
NLB-854	FHII 23	62.0	23.66	**2095**	**1694**
NLB-818	FHII 24	55.5	32.33	**1918**	**1449**
NLB-825	FHII 24	74.0	12.99	**2342**	**2073**

Checker: Don [illegible]

Reviewer: Don [illegible]

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 5-May-22

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Appendix VII (I)

Carbonate Content

CALCIUM CARBONATE TEST REPORT

(Test Reference: ASTM D4373)

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Calcium Carbonate Results

Sample Name	BH #	Depth (m)	% Calcite	% Dolomite	Calcite: Dolomite	CO_2 (ml) from Calcite	CO_2 (ml) from Dolomite	Total CO_2 (ml/g)
NLB-1016	BH-01	17.5 - 18	8.9	8.2	1.1	20	20	40
NLB-1018	BH-01	19.5 - 19.65	8.0	0.6	14.1	19	1	20
NLB-1019	BH-01	21 - 21.15	7.3	4.0	1.8	17	10	27
NLB-1020	BH-01	22.5 - 22.8	5.9	5.4	1.1	13	13	27
NLB-1103	BH-02	6 - 6.45	9.0	9.0	1.0	21	23	43
NLB-1105	BH-02	7.5 - 7.95	8.3	6.6	1.3	19	17	36
NLB-1108	BH-02	10	6.8	3.6	1.9	16	9	25
NLB-1111	BH-02	12 - 12.45	8.7	5.3	1.6	20	13	33
NLB-1113	BH-02	13.5 - 13.95	9.2	5.1	1.8	21	13	33

Checker: Don Hazelton **Reviewer:**

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 2022-04-26

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CALCIUM CARBONATE TEST REPORT

(Test Reference: ASTM D4373)

SNC • LAVALIN

Calcium Carbonate Results

Sample Name	BH #	Depth (ft)	% Calcite	% Dolomite	Calcite: Dolomite	CO_2 (ml) from Calcite	CO_2 (ml) from Dolomite	Total CO_2 (ml/g)
NLB-028	FHII 1	17	6.5	6.7	1.0	15	17	32
NLB-037	FHII 1	37	7.3	5.3	1.4	17	13	30
NLB-045	FHII 1	54	0.0	8.5	0.0	0	21	21
NLB-053	FHII 1	72.5-74	3.8	9.2	0.4	9	22	31
NLB-269	FHII 2	17	2.9	5.1	0.6	7	13	20
NLB-279	FHII 2	38-39.25	4.4	3.7	1.2	10	9	19
NLB-295	FHII 2	86	5.6	5.2	1.1	13	13	26
NLB-154	FHII 3	17	5.3	10.2	0.5	12	25	37
NLB-164	FHII 3	36	4.5	2.7	1.6	10	7	17
NLB-192	FHII 4	7-8.2	0.0	6.7	0.0	0	17	17
NLB-235	FHII 5	13-14.5	4.5	8.3	0.5	10	21	31
NLB-336	FHII 6	98-99.5	1.5	11.1	0.1	3	27	31
NLB-414	FHII 7	25.5	2.2	7.9	0.3	5	19	24
NLB-428	FHII 7	60.5	4.2	8.0	0.5	10	20	30
NLB-493	FHII 8	7	3.8	4.1	0.9	9	10	19
NLB-506	FHII 8	38-39.5	4.1	6.7	0.6	9	17	26
NLB-516	FHII 8	66	1.5	12.5	0.1	3	31	34
NLB-348	FHII 9	13-14	3.2	10.6	0.3	8	27	34
NLB-358	FHII 9	35.5	6.5	10.6	0.6	15	27	42
NLB-361	FHII 9	43-44.5	3.7	11.5	0.3	8	28	37
NLB-381	FHII 10	25	1.9	8.1	0.2	4	20	24
NLB-395	FHII 10	60	3.6	9.3	0.4	8	23	32
NLB-445	FHII 11	20	3.7	6.5	0.6	9	16	25
NLB-464	FHII 11	64	4.7	7.3	0.7	11	18	29
NLB-563	FHII 14	25.5	5.1	9.7	0.5	12	24	36
NLB-574	FHII 14	55.5	5.2	11.2	0.5	12	28	39
NLB-884	FHII 16	23-24.5	4.6	8.4	0.5	10	21	31
NLB-890	FHII 16	36	4.9	9.7	0.5	11	24	36
NLB-901	FHII 16	65	3.3	12.9	0.3	8	33	40
NLB-524	FHII 12	8-9.5	5.1	4.7	1.1	12	12	23
NLB-529	FHII 12	20.5	1.9	4.2	0.5	4	10	14
NLB-537	FHII 12	40.5	1.5	10.2	0.1	3	26	29

Checker:

Reviewer:

The testing services reported here have been performed in accordance with accepted local industry standards.
The results presented are for the sole use of the designated client only.
This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.
Engineering interpretation will be provided by SNC Lavalin upon request

Client: SMHI
Project: Saskatoon Freeway Functional Planning
Project #: 659183
Date: 2022-05-06

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CALCIUM CARBONATE TEST REPORT

(Test Reference: ASTM D4373)

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Calcium Carbonate Results

Sample Name	BH #	Depth (ft)	% Calcite	% Dolomite	Calcite: Dolomite	CO_2 (ml) from Calcite	CO_2 (ml) from Dolomite	Total CO_2 (ml/g)
NLB-552	FHII-12	80-81	5.0	4.6	1.1	11	11	23
NLB-631	FHII-13	23-24.3	0.0	3.5	0.0	0	9	9
NLB-644	FHII-13	57	3.7	10.7	0.4	9	27	35
NLB-650	FHII-13	71	4.3	7.6	0.6	10	19	29
NLB-949	FHII-17	20.5	4.2	7.7	0.5	10	19	29
NLB-958	FHII-17	46	4.6	9.9	0.5	10	24	34
NLB-915	FHII-18	25.5	4.2	4.2	1.0	10	11	20
NLB-925	FHII-18	51	5.5	8.9	0.6	13	23	36
NLB-589	FHII-19	17	4.0	6.4	0.6	9	16	25
NLB-597	FHII-19	36	3.3	6.5	0.5	8	16	23
NLB-605	FHII-19	58	1.5	11.5	0.1	3	28	32
NLB-611	FHII-19	72	4.5	10.7	0.4	10	27	37
NLB-749	FHII-20	17	2.9	2.7	1.1	7	7	13
NLB-765	FHII-20	56	0.0	4.8	0.0	0	12	12
NLB-773	FHII-20	72	3.2	7.8	0.4	7	19	27
NLB-660	FHII-21	15.5	0.0	4.4	0.0	0	11	11
NLB-681	FHII-21	71	No sample					
NLB-688A	FHII-21	88-89	1.5	5.6	0.3	3	14	17
NLB-690	FHII-21	96	3.8	5.8	0.7	9	14	23
NLB-699	FHII-22	17	4.3	5.6	0.8	10	14	24
NLB-703	FHII-22	27	3.0	2.1	1.4	7	5	12
NLB-714	FHII-22	52.2	2.8	3.2	0.9	7	8	14
NLB-722	FHII-22	70.5	4.7	7.7	0.6	11	19	30
NLB-854	FHII-23	62	3.2	3.3	1.0	8	8	16
NLB-862	FHII-23	78	5.1	5.7	0.9	12	14	26
NLB-869	FHII-23	96	5.3	4.9	1.1	12	12	24
NLB-818	FHII-24	55.5	4.7	5.6	0.8	11	14	25
NLB-825	FHII-24	74	1.5	9.6	0.2	3	24	28

Checker:

Reviewer:

Client:	SMHI
Project:	Saskatoon Freeway Functional Planning
Project #:	659183
Date:	2022-05-06

Geoscience & Materials

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Saskatoon, Saskatchewan, Canada S7K 1K3
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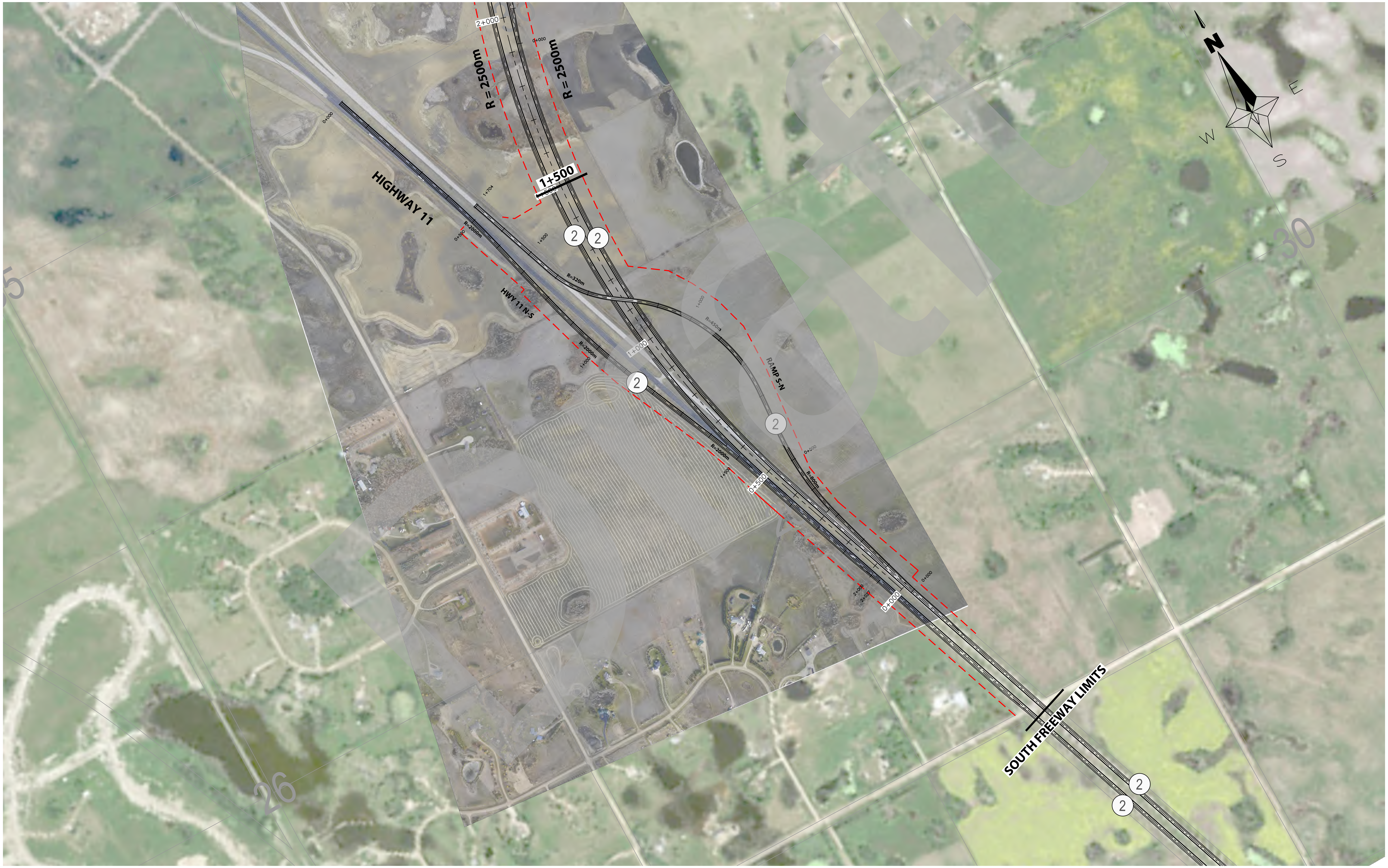
APPENDIX K

Functional Design Plans and Profiles

REVISIONS			CS	N/A	TAB NO	A1_11
NO	DATE	SIGNATURE	PHOTO DATE	N/A	SHEET	1 OF 11
			DRAWN BY	S. SCHNEIDER	DATE	22/2/13
			DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

SCALE
1: 5 000 HORIZONTAL

PHASE 2 INTERCHANGE TEMPLATE
STA. 0+000 TO STA. 1+500
SASKATOON FREEWAY PROJECT
HIGHWAY 11 INTERCHANGE



ACAD DWG: C3D_PHASE 2 SOUTH_HWY 11_W FLORAL_PARALLEL ENT – V4.DWG
LAST REV DATE: February 13, 2022

Saskatoon Freeway

Saskatchewan

SCALE
1: 5 000 HORIZONTAL

REVISIONS		
NO	DATE	SIGNATURE

CS	N/A	TAB NO	A2_Floral
PHOTO DATE	N/A	SHEET	2 OF 11
DRAWN BY	S. SCHNEIDER	DATE	22/2/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 1+500 TO STA. 4+250
SASKATOON FREEWAY PROJECT
FLORAL ROAD INTERCHANGE

ACAD DWG: C3D_PHASE 2 SOUTH_HWY 11_W FLORAL_PARALLEL ENT – V4.DWG
LAST REV DATE: February 13, 2022

Saskatoon Freeway

Saskatchewan

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1: 5 000 HORIZONTAL

REVISIONS						
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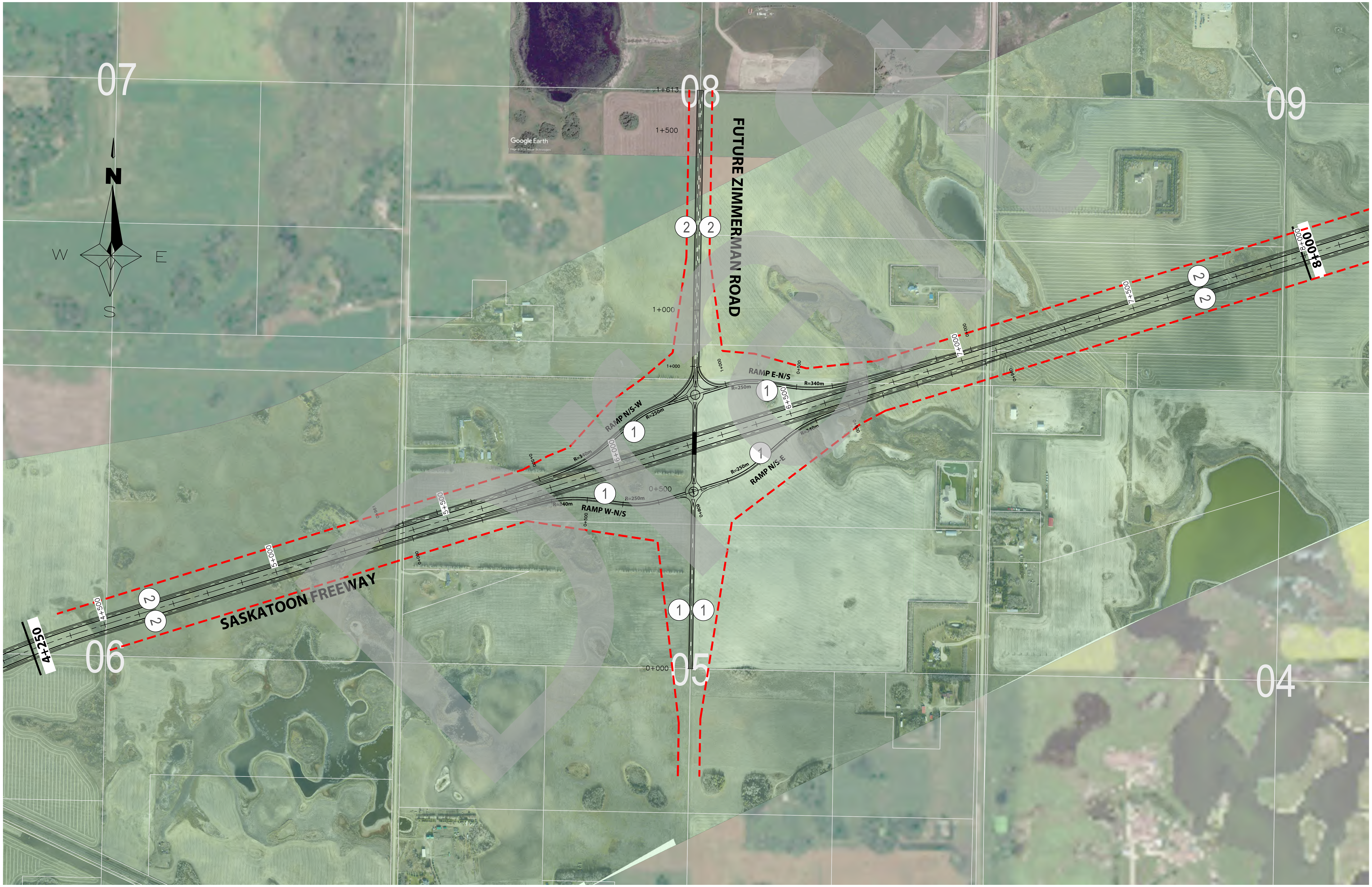
			PHOTO DATE	N/A	SHEET	3 OF 11
			DRAWN BY		DATE	
			DESIGNED BY		DATE	

PHASE 2 INTERCHANGE TEMPLATE

STA. 4+250 TO STA. 8+000
SASKATOON FREEWAY PROJECT
ZIMMERMAN ROAD INTERCHANGE



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LAST REV DATE: March 20, 2023

Saskatoon Freeway

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SCALE
1: 5 000 HORIZONTAL

REVISIONS		
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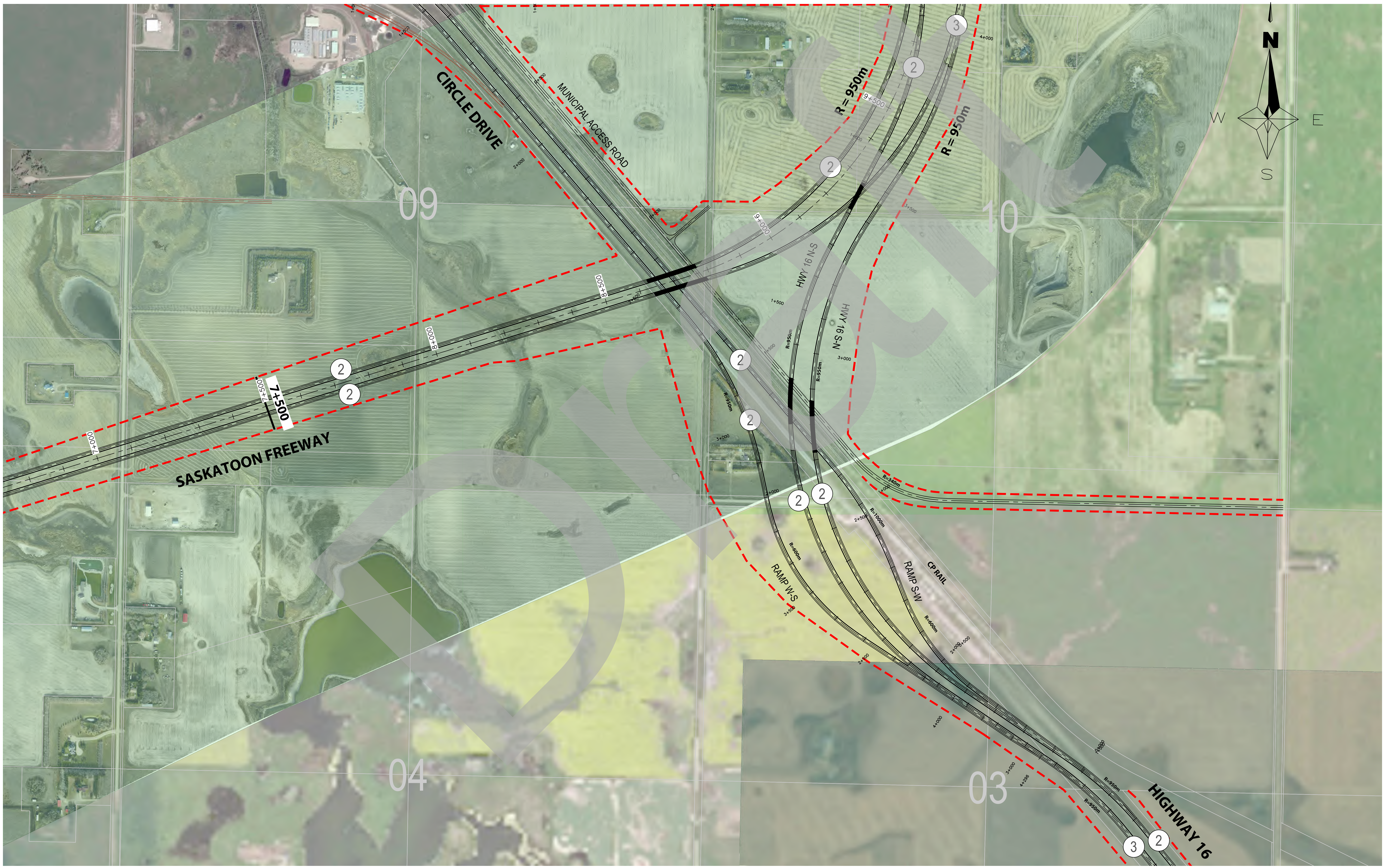
PHOTO DATE	N/A	SHEET	4 OF 11
DRAWN BY	S. SCHNEIDER	DATE	22/02/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 7+500 TO STA. 9+500
SASKATOON FREEWAY PROJECT
HIGHWAY 16 INTERCHANGE



ACAD DWG: C3D_PHASE 2 SOUTH_HWY 16_V5.DWG
LAST REV DATE: October 19, 2022

Saskatoon Freeway

Saskatchewan

SCALE
1: 5 000 HORIZONTAL

REVISIONS		
NO	DATE	SIGNATURE

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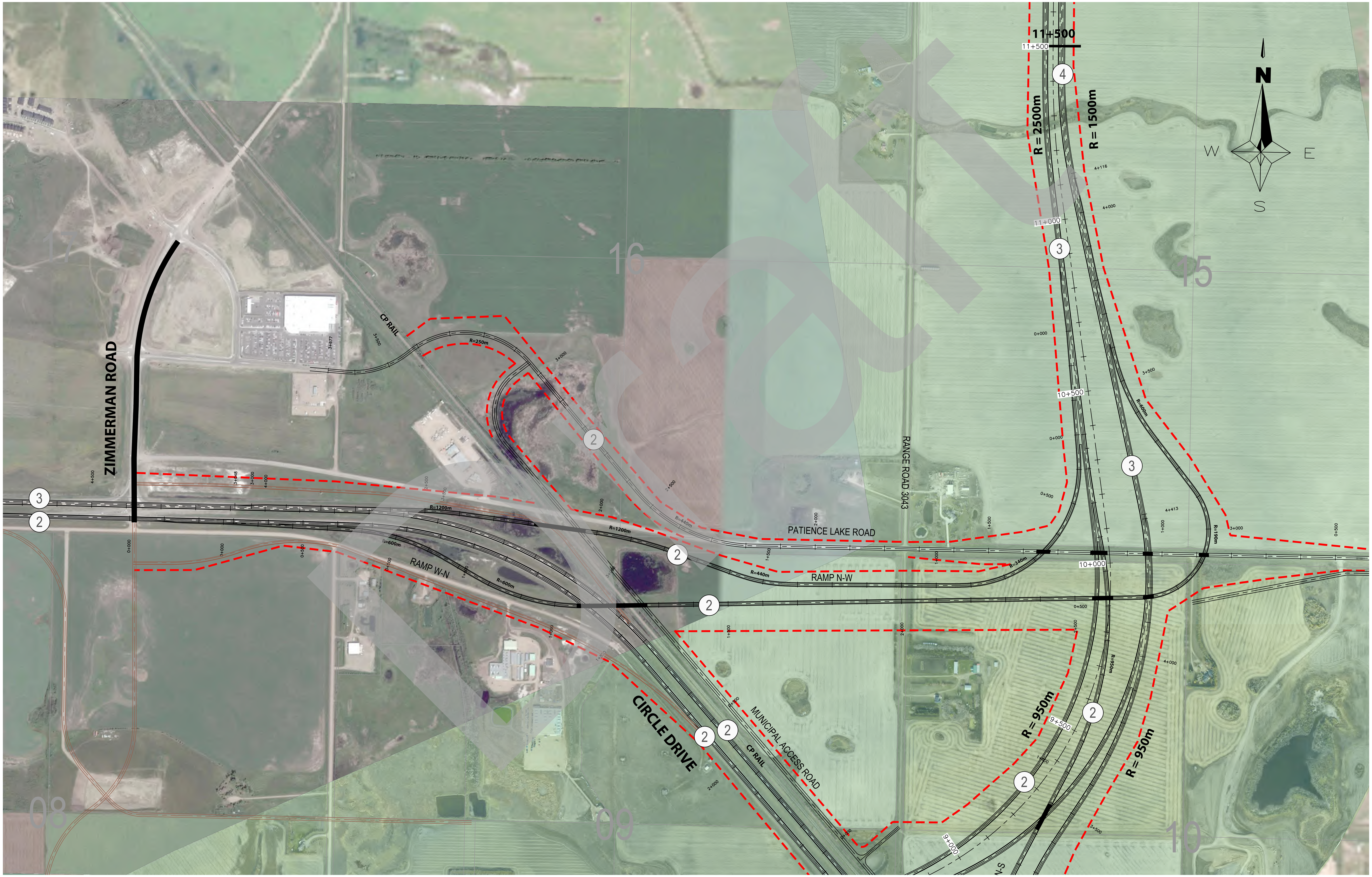
PHOTO DATE	N/A	SHEET	5 OF 11
DRAWN BY	S. SCHNEIDER	DATE	22/2/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 9+500 TO STA. 11+500
SASKATOON FREEWAY PROJECT
HIGHWAY 16 INTERCHANGE



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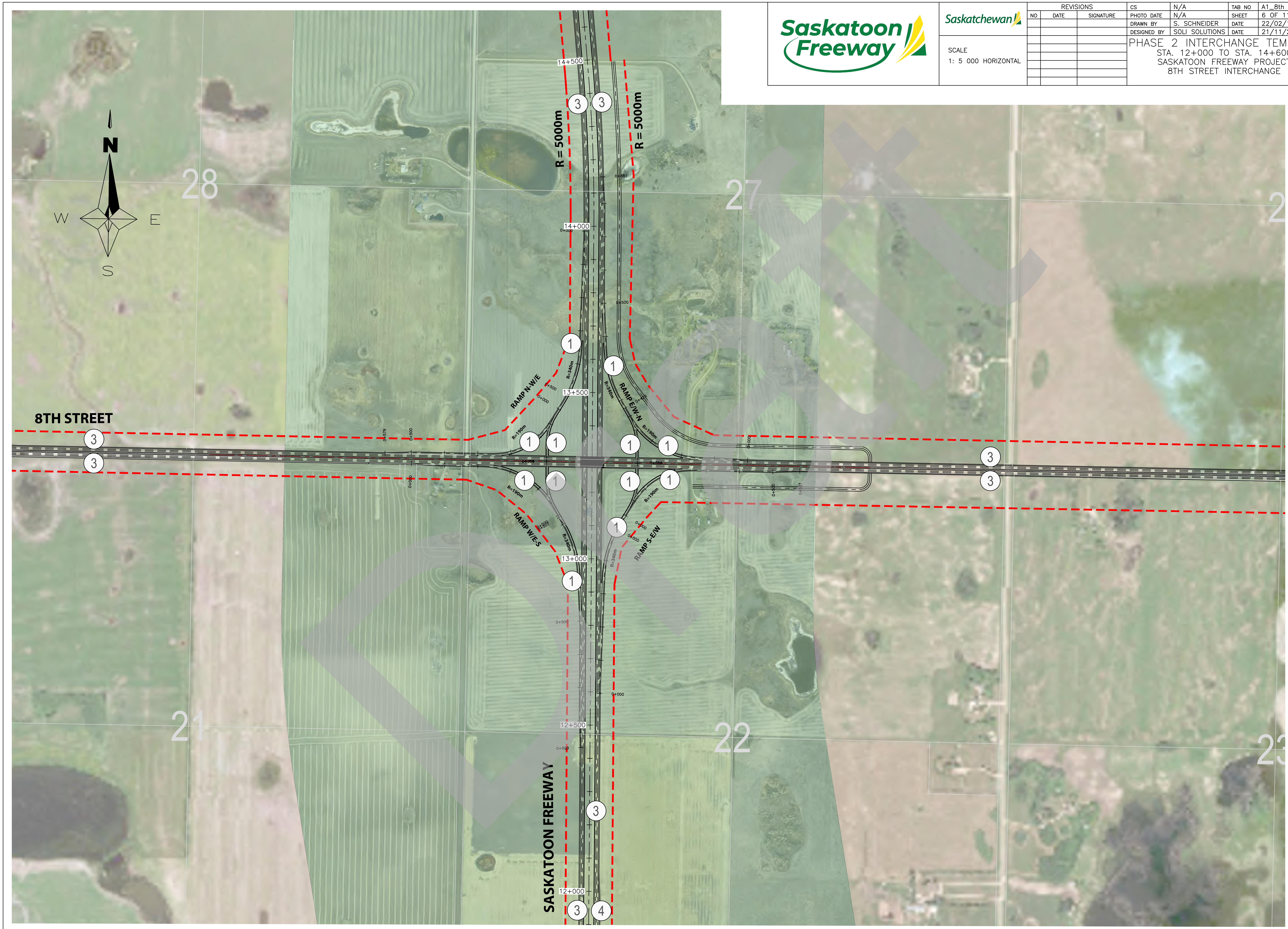
LAST REV DATE: February 13, 2022



Saskatoon Freeway

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1: 5 000 HORIZONTAL

REVISIONS		
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PHOTO DATE	N/A	SHEET	6 OF 11
DRAWN BY	S. SCHNEIDER	DATE	22/02/11
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 12+000 TO STA. 14+600
SASKATOON FREEWAY PROJECT
8TH STREET INTERCHANGE

ACAD DWG: C3D_PHASE 2 SOUTH_8TH_ZIMM_PARALLEL ENT – V2.DWG
LAST REV DATE: January 4, 2022

Saskatoon Freeway

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1: 5 000 HORIZONTAL

REVISIONS		
NO	DATE	SIGNATURE

CS	N/A	TAB NO	A1_Hwy5
PHOTO DATE	N/A	SHEET	7 OF 11
DRAWN BY	J. GREENE	DATE	22/01/10
DESIGNED BY	AECOM	DATE	22/01/10

HIGHWAY 5 INTERCHANGE
STA. 14+600 TO STA. 17+700
SASKATOON FREEWAY PROJECT

ACAD DWG:PHASE 2 DESIGN PLATES.DWG
LAST REV DATE: January 17, 2022

Saskatoon Freeway

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1: 5 000 HORIZONTAL

REVISIONS		
NO	DATE	SIGNATURE

CS	N/A	TAB NO	A1_Hwy41
PHOTO DATE	N/A	SHEET	8 OF 11
DRAWN BY	J. GREENE	DATE	22/01/10
DESIGNED BY	AECOM	DATE	22/01/10

HIGHWAY 41 FLYOVER
STA. 17+700 TO STA. 20+700
SASKATOON FREEWAY PROJECT

ACAD DWG:PHASE 2 DESIGN PLATES.DWG
LAST REV DATE: January 17, 2022

Saskatoon Freeway

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1: 5 000 HORIZONTAL

REVISIONS		
NO	DATE	SIGNATURE

CS	N/A	TAB NO	A1_Blackley
PHOTO DATE	N/A	SHEET	9 OF 11
DRAWN BY	J. GREENE	DATE	22/01/10
DESIGNED BY	AECOM	DATE	22/01/10

BLACKLEY ROAD INTERCHANGE
STA. 20+700 TO STA. 24+800
SASKATOON FREEWAY PROJECT

ACAD DWG:PHASE 2 DESIGN PLATES.DWG
LAST REV DATE: January 17, 2022

Saskatoon Freeway	Saskatchewan	REVISIONS			CS	N/A	TAB NO	A1_Hwy41Realign
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					DRAWN BY	J. GREENE	DATE	22/01/10
					DESIGNED BY	AECOM	DATE	22/01/10
	SCALE 1: 5 000 HORIZONTAL				HWY 41 REALIGNMENT STA. 0+000 TO STA. 4+200 SASKATOON FREEWAY PROJECT			

ACAD DWG:PHASE 2 DESIGN PLATES.DWG
LAST REV DATE: January 17, 2022

Saskatoon Freeway

Saskatchewan

SCALE
1: 5 000 HORIZONTAL

REVISIONS		
NO	DATE	SIGNATURE

CS	N/A	TAB NO	A1_Central
PHOTO DATE	N/A	SHEET	11 OF 11
DRAWN BY	J. GREENE	DATE	22/01/10
DESIGNED BY	AECOM	DATE	22/01/10

CENTRAL AVE INTERCHANGE
STA. 24+800 TO STA. 28+380
SASKATOON FREEWAY PROJECT

ACAD DWG:PHASE 2 DESIGN PLATES.DWG
LAST REV DATE: January 27, 2022

Saskatoon Freeway

Saskatchewan

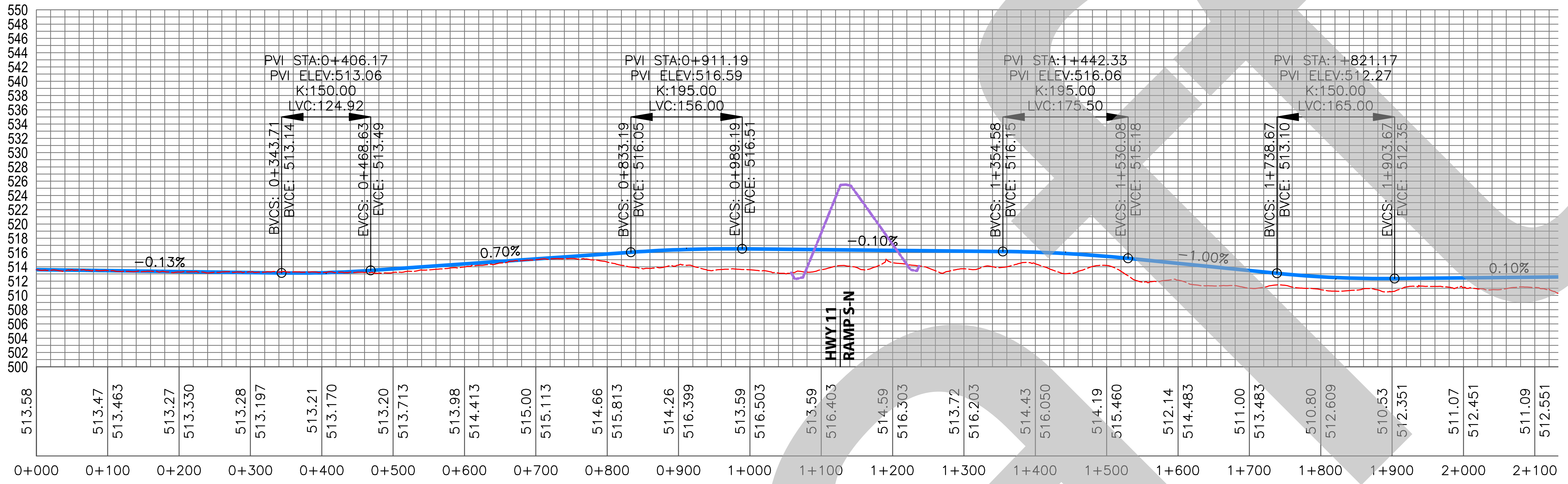
REVISIONS		
NO	DATE	SIGNATURE

CS	N/A	TAB NO	Profile_01
PHOTO DATE	N/A	SHEET	1 of 1
DRAWN BY	S. SCHNEIDER	DATE	22/2/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

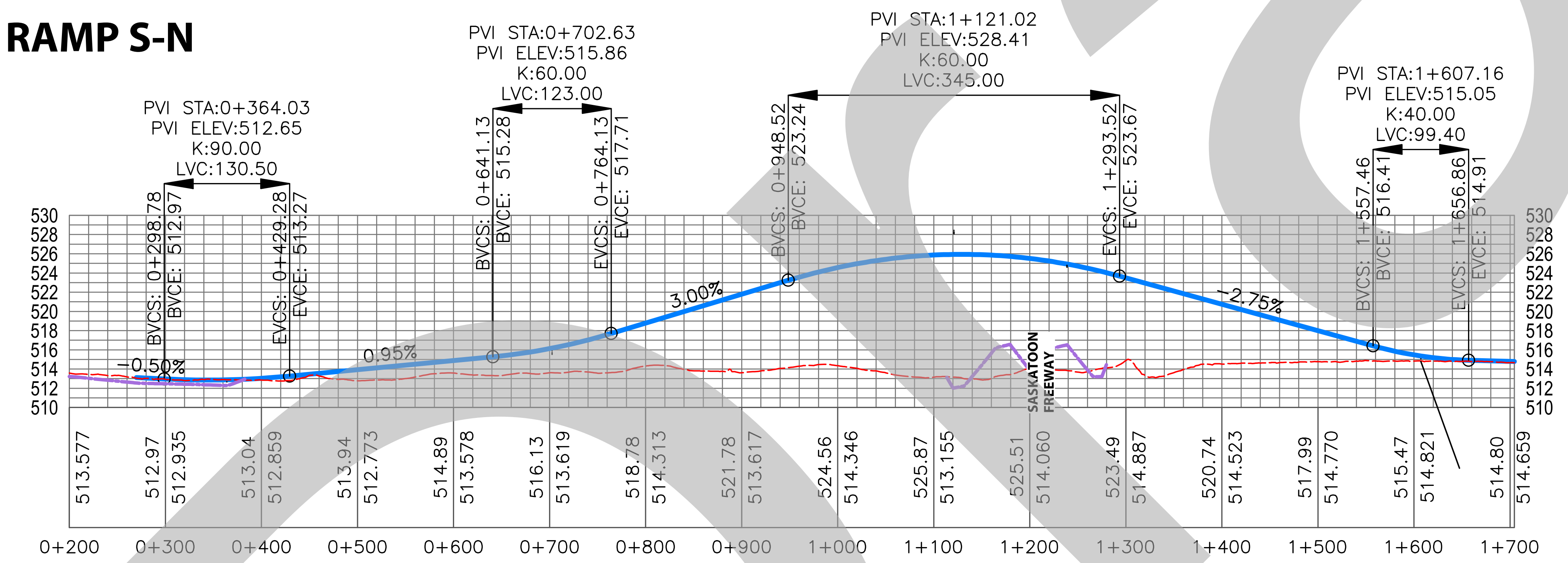
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

PHASE 2 INTERCHANGE TEMPLATE
STA. 0+000 TO STA. 2+000
SASKATOON FREEWAY PROJECT
HIGHWAY 11 INTERCHANGE

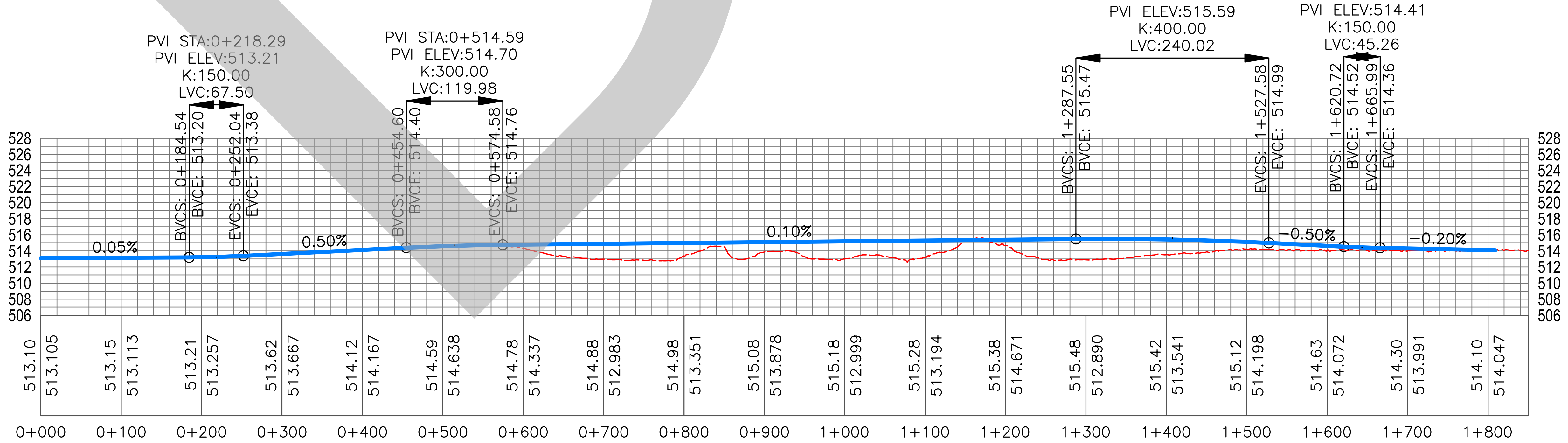
MAINLINE FREEWAY PROFILE



RAMP S-N



HWY 11 N-S



ACAD DWG: C3D_PHASE 2 SOUTH_HWY 11_W FLORAL_PARALLEL ENT - V4.DWG
LAST REV DATE: February 13, 2022

Saskatoon Freeway

Saskatchewan

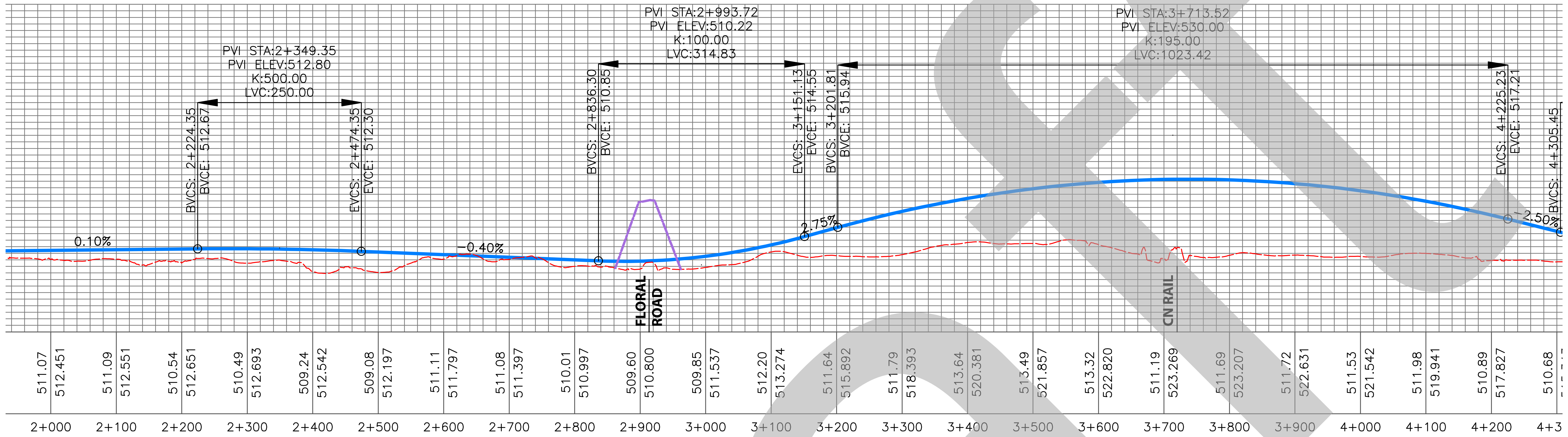
REVISIONS		
NO	DATE	SIGNATURE

CS	N/A	TAB NO	Profile_01
PHOTO DATE	N/A	SHEET	1 OF 1
DRAWN BY	S. SCHNEIDER	DATE	22/02/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

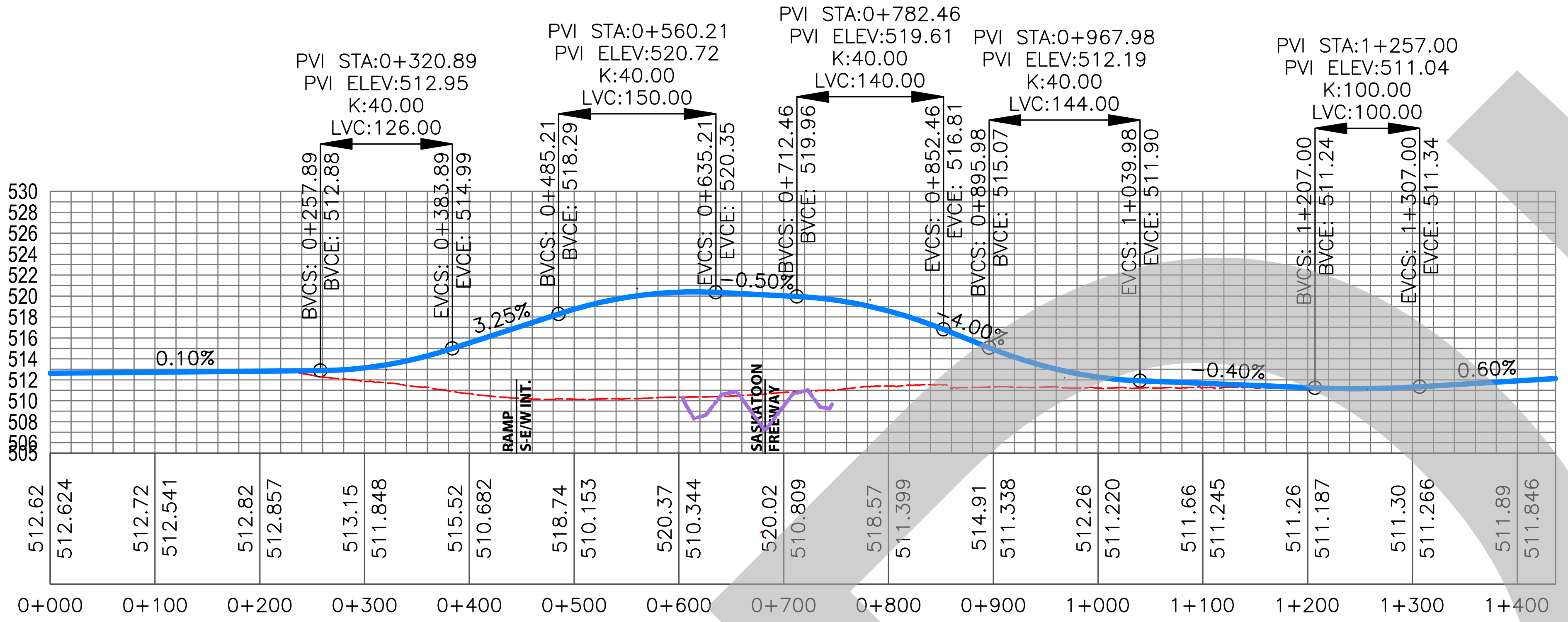
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

PHASE 2 INTERCHANGE TEMPLATE
STA. 2+000 TO STA. 4+250
SASKATOON FREEWAY PROJECT
FLORAL ROAD INTERCHANGE

MAINLINE FREEWAY PROFILE



FLORAL ROAD PROFILE



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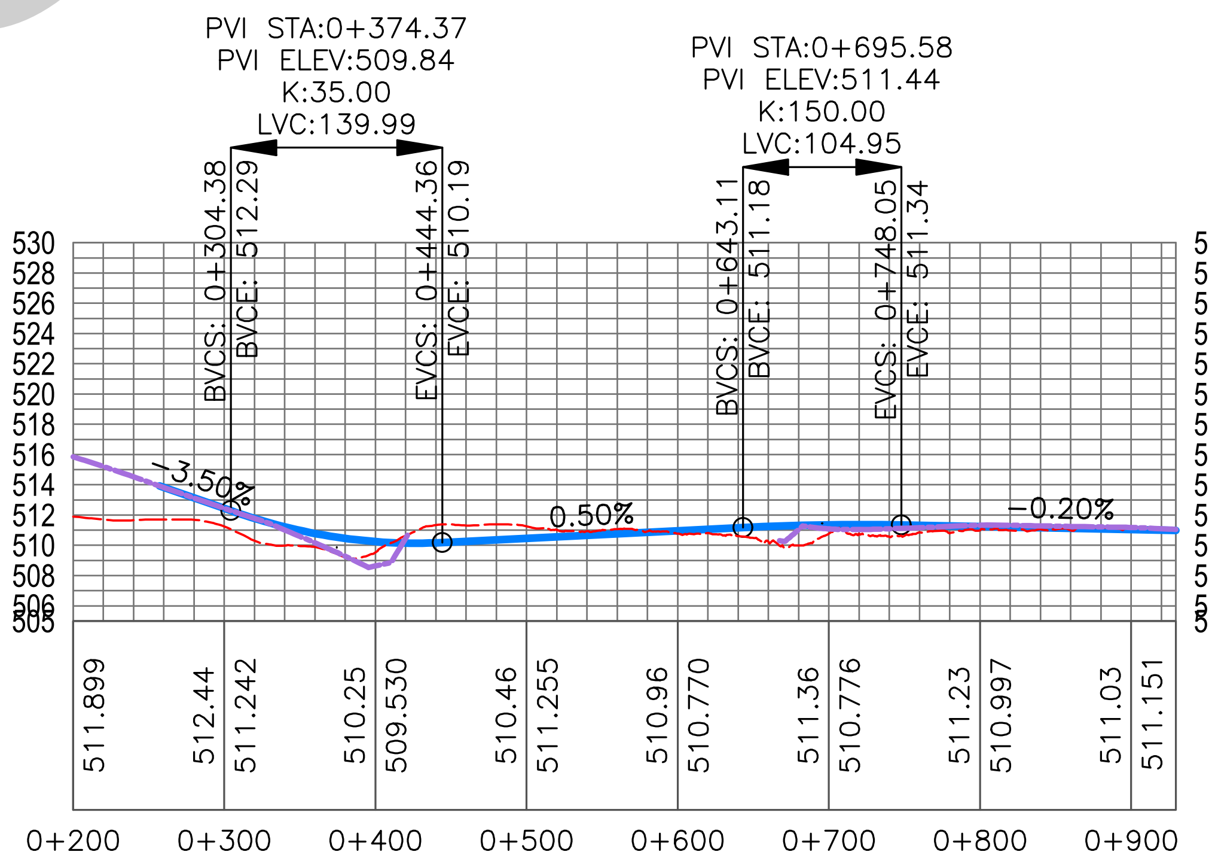

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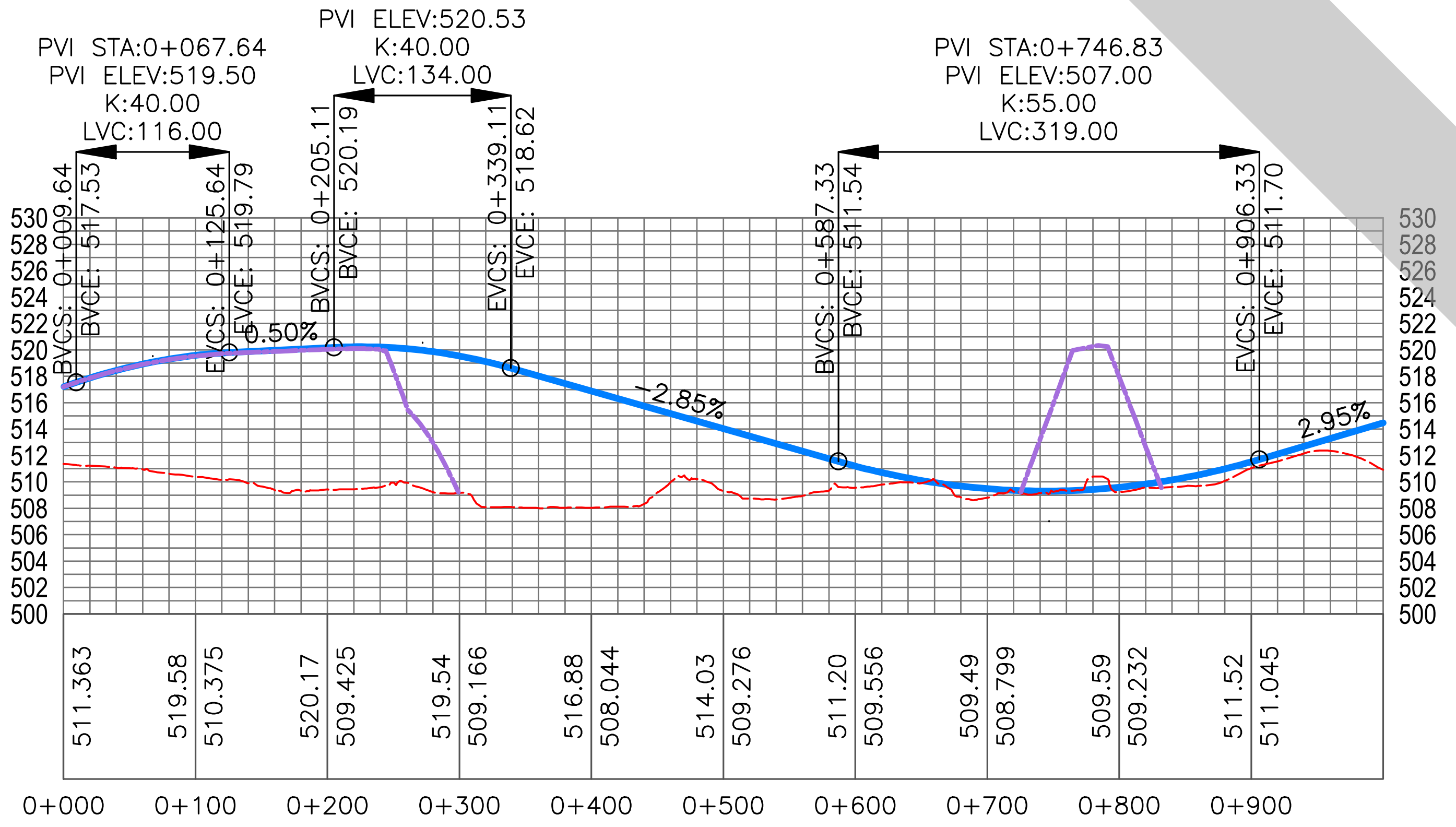
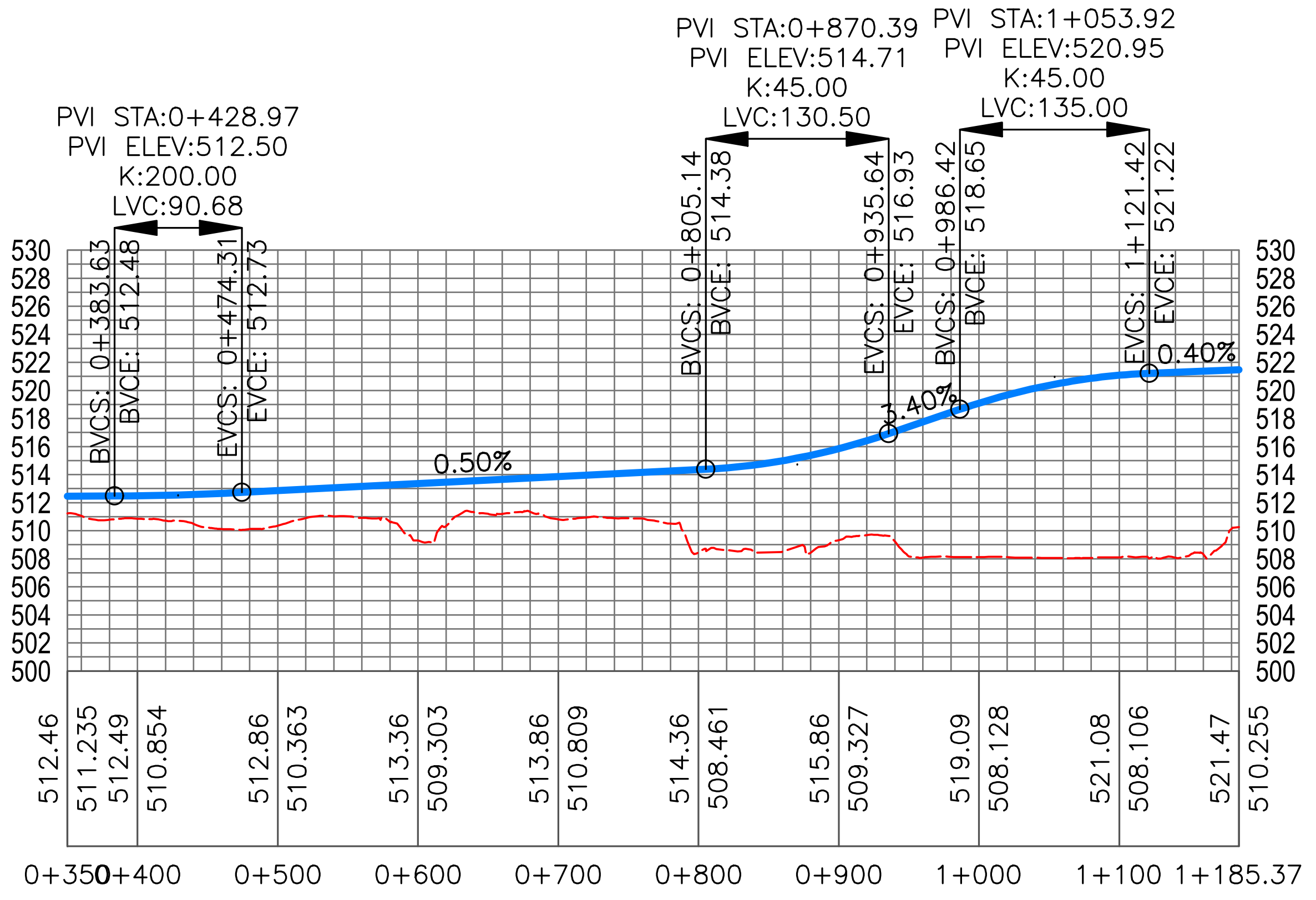


RAMP S-E/W



ACAD DWG: C3D_PHASE 2 SOUTH_HWY 11_W FLORAL_PARALLEL ENT - V4.DWG
LAST REV DATE: February 13, 2022

Saskatoon Freeway

Saskatchewan

SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

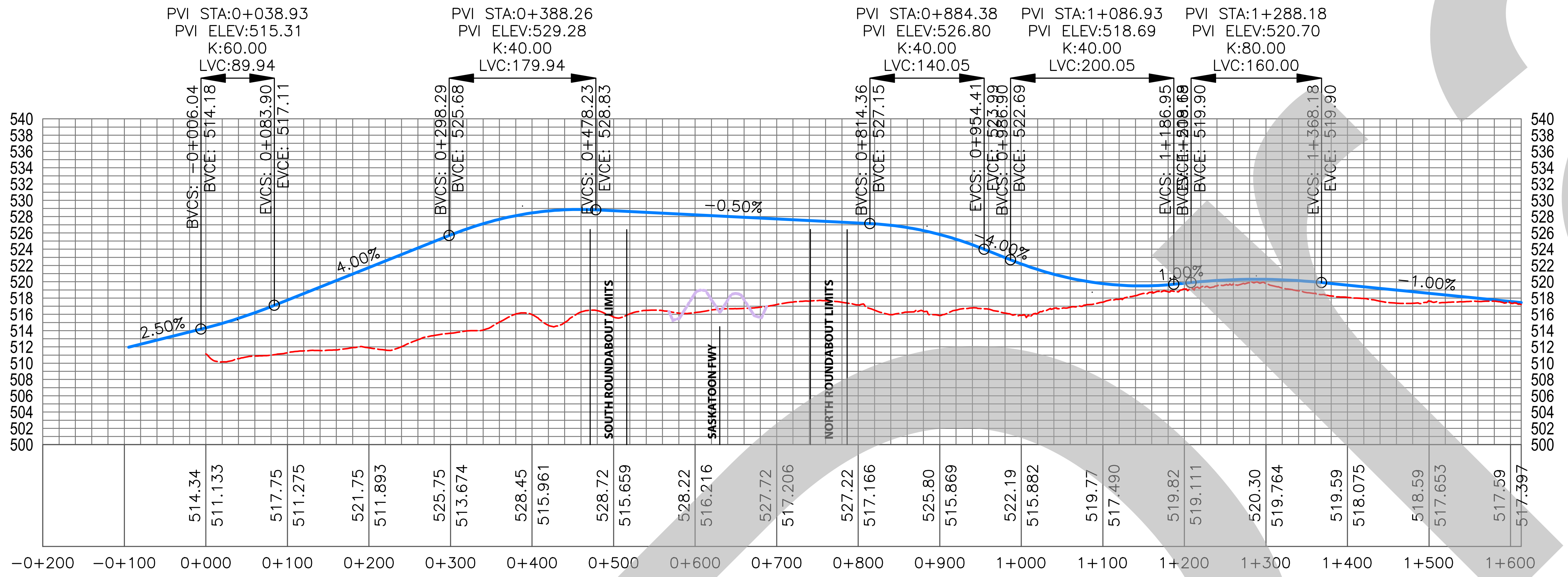
REVISIONS		
NO	DATE	SIGNATURE

CS	N/A	TAB NO	Profiles_01
PHOTO DATE	N/A	SHEET	1 OF 1
DRAWN BY	S. SCHNEIDER	DATE	22/02/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

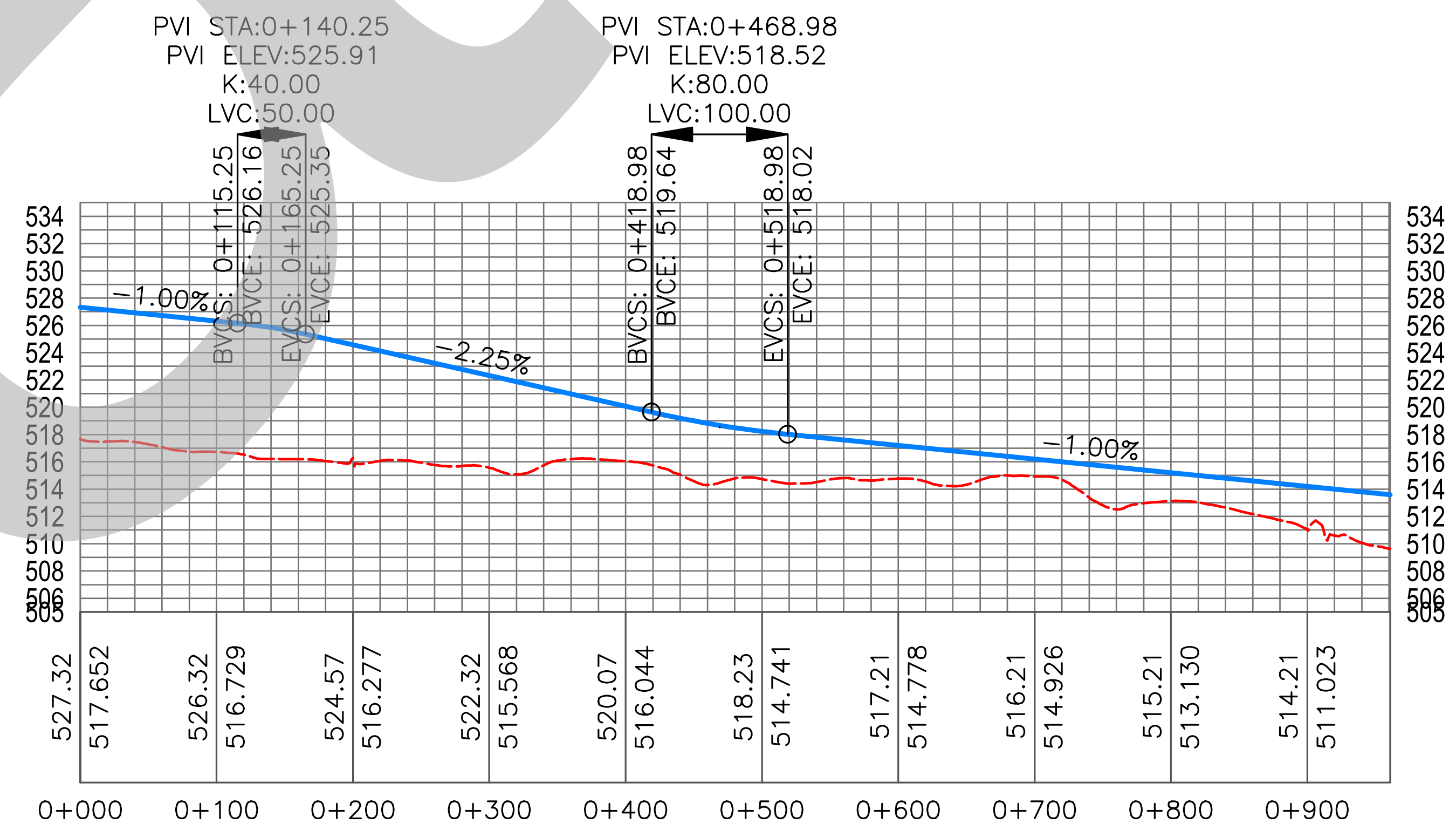
PHASE 2 INTERCHANGE TEMPLATE
STA. 4+250 TO STA. 8+000
SASKATOON FREEWAY PROJECT
ZIMMERMAN ROAD INTERCHANGE

MAINLINE PROFILE

ZIMMERMAN ROAD PROFILE



RAMP N/S-W PROFILE



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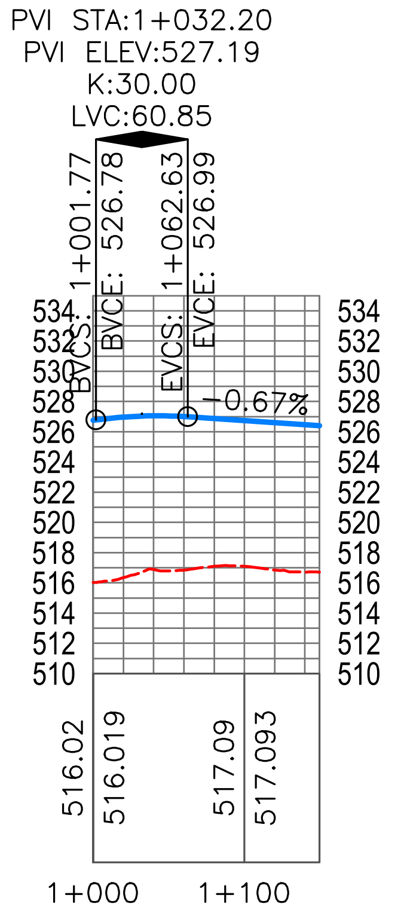
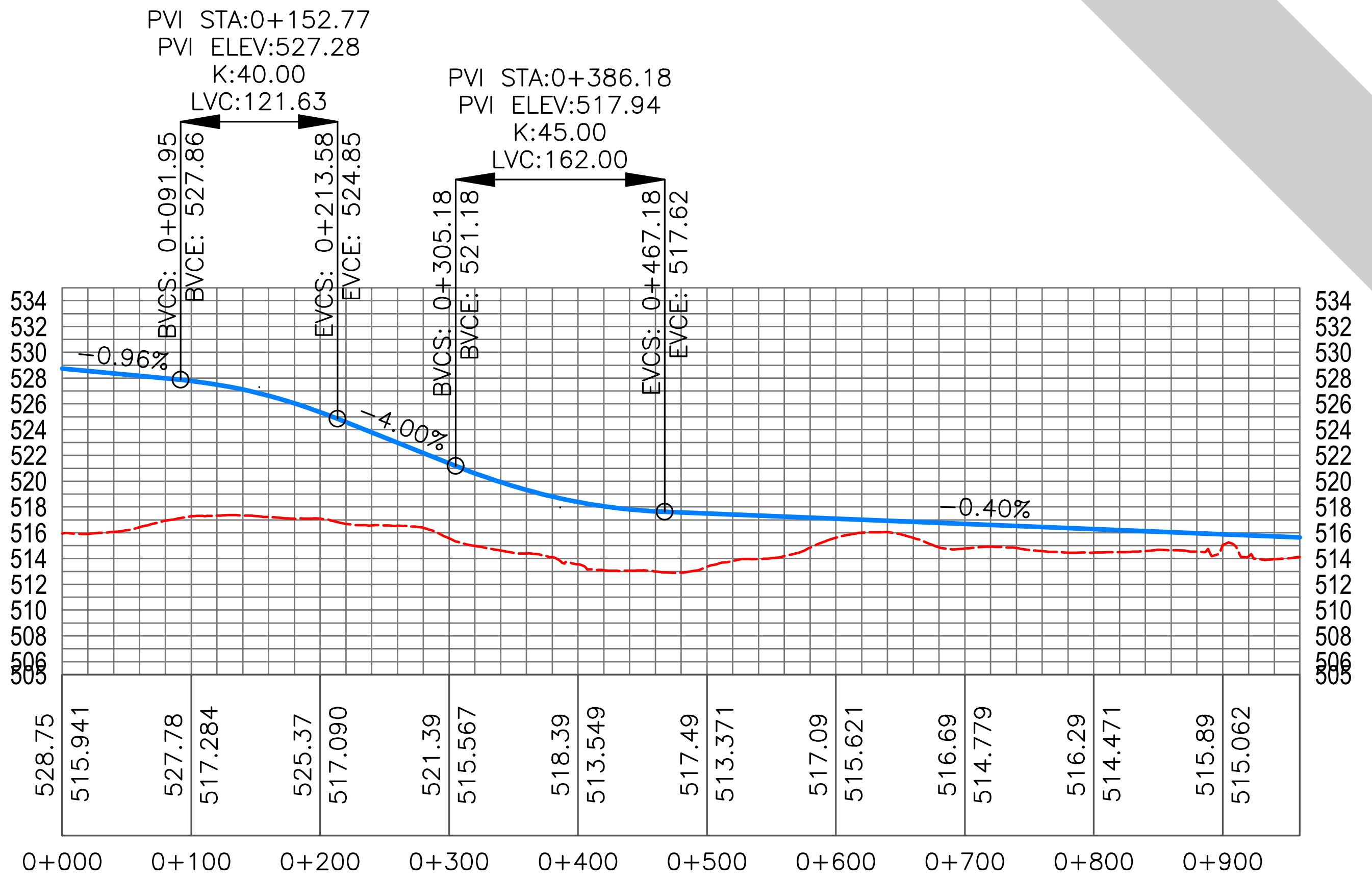


RAMP N/S-E PROFILE



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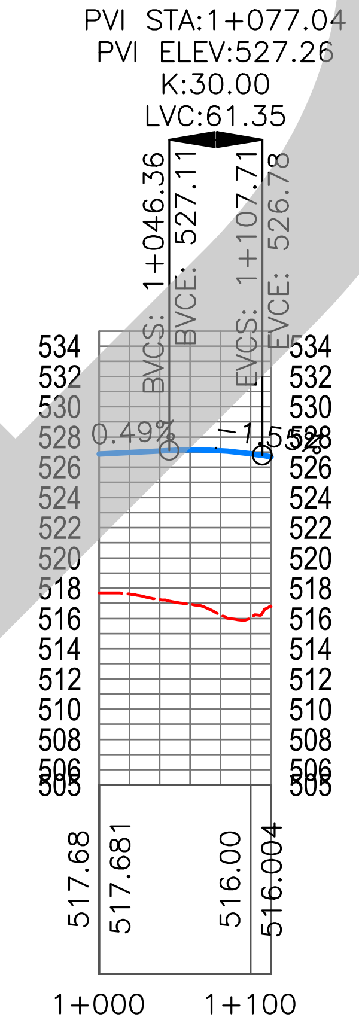

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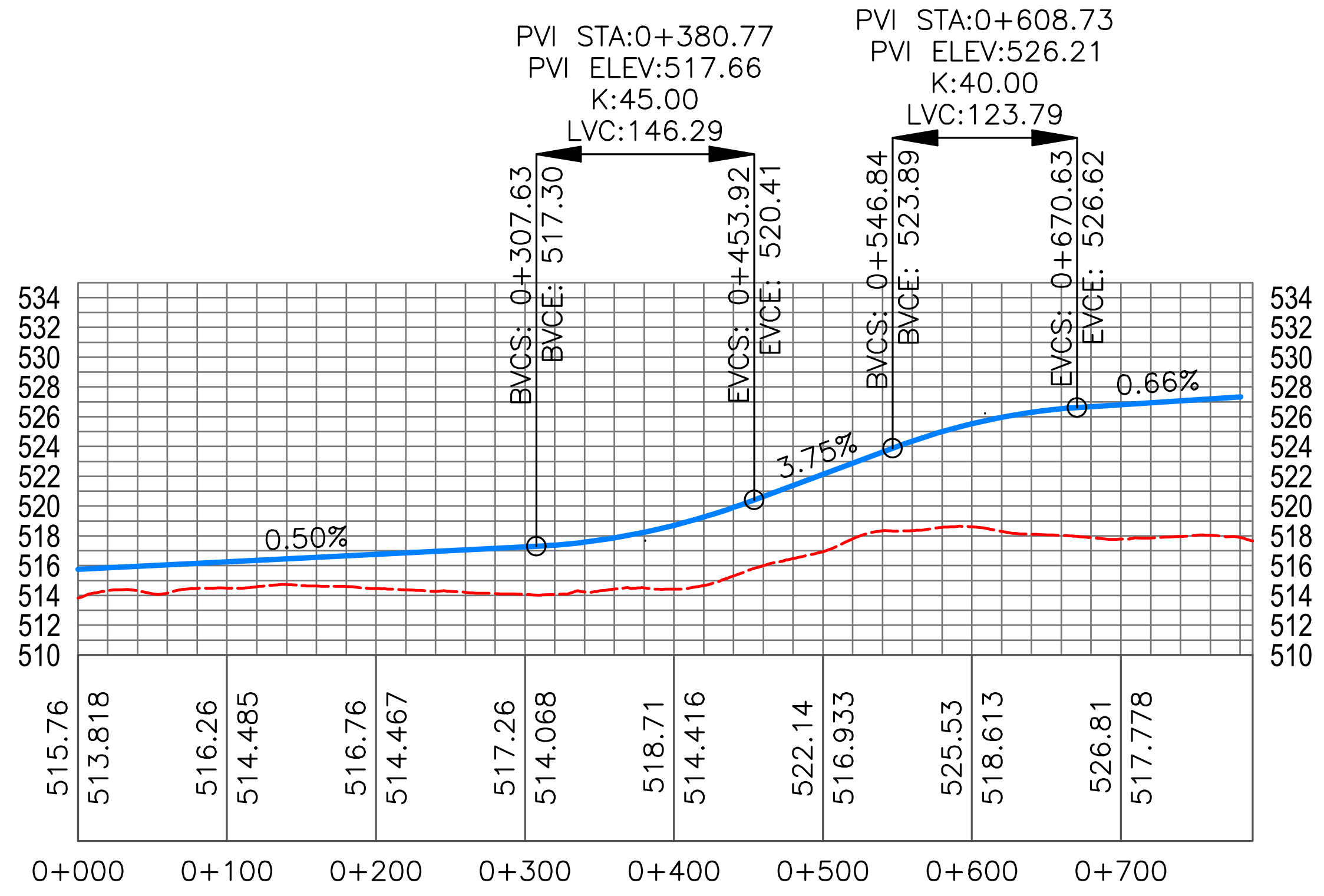
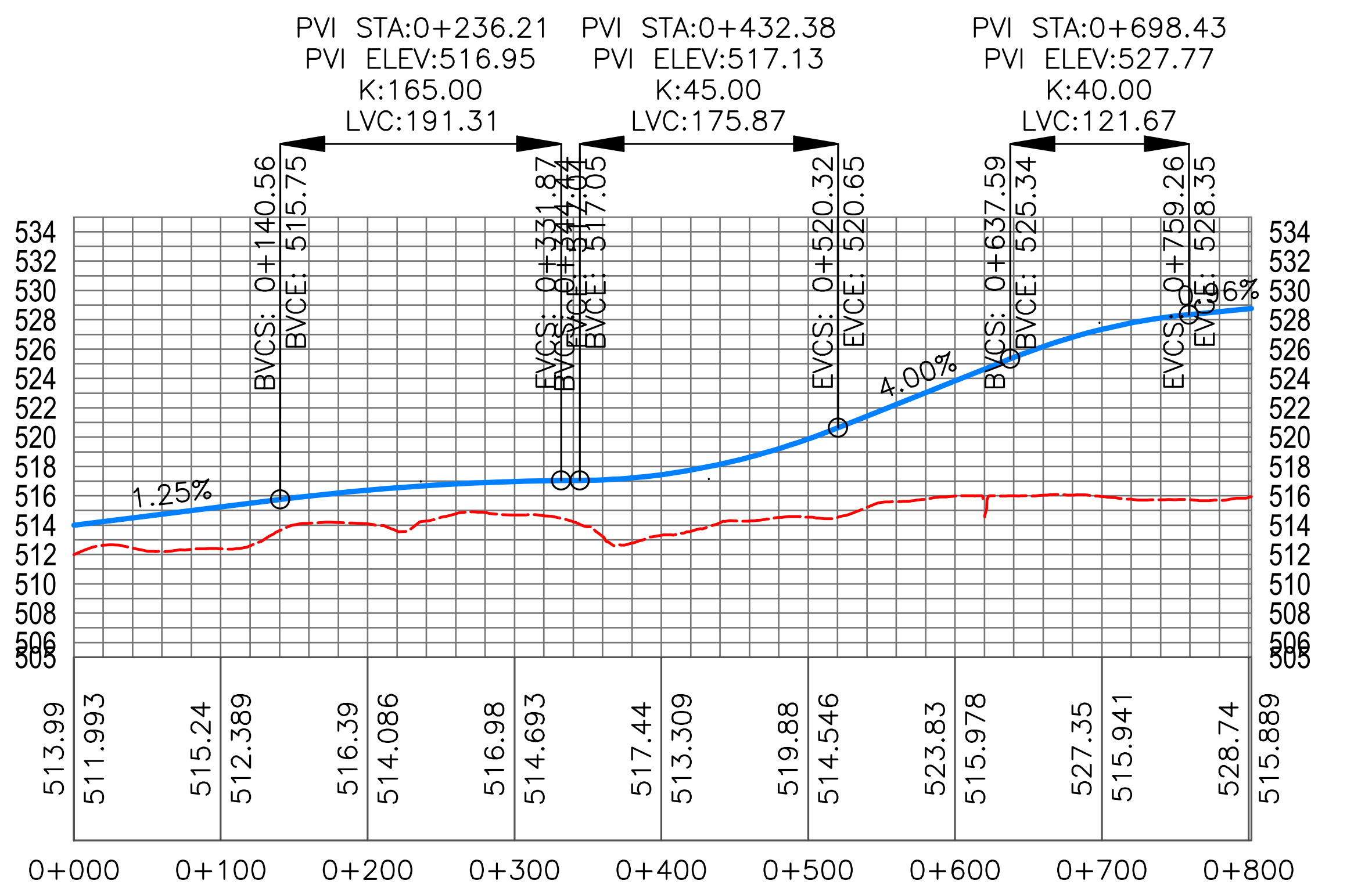


RAMP W-N/S PROFILE



ACAD DWG: C3D_PHASE 2_SOUTH_8TH_ZIMM_PARALLEL ENT - V2_W RT BYPASS.DWG
LAST REV DATE: March 20, 2023

Saskatoon Freeway

Saskatchewan

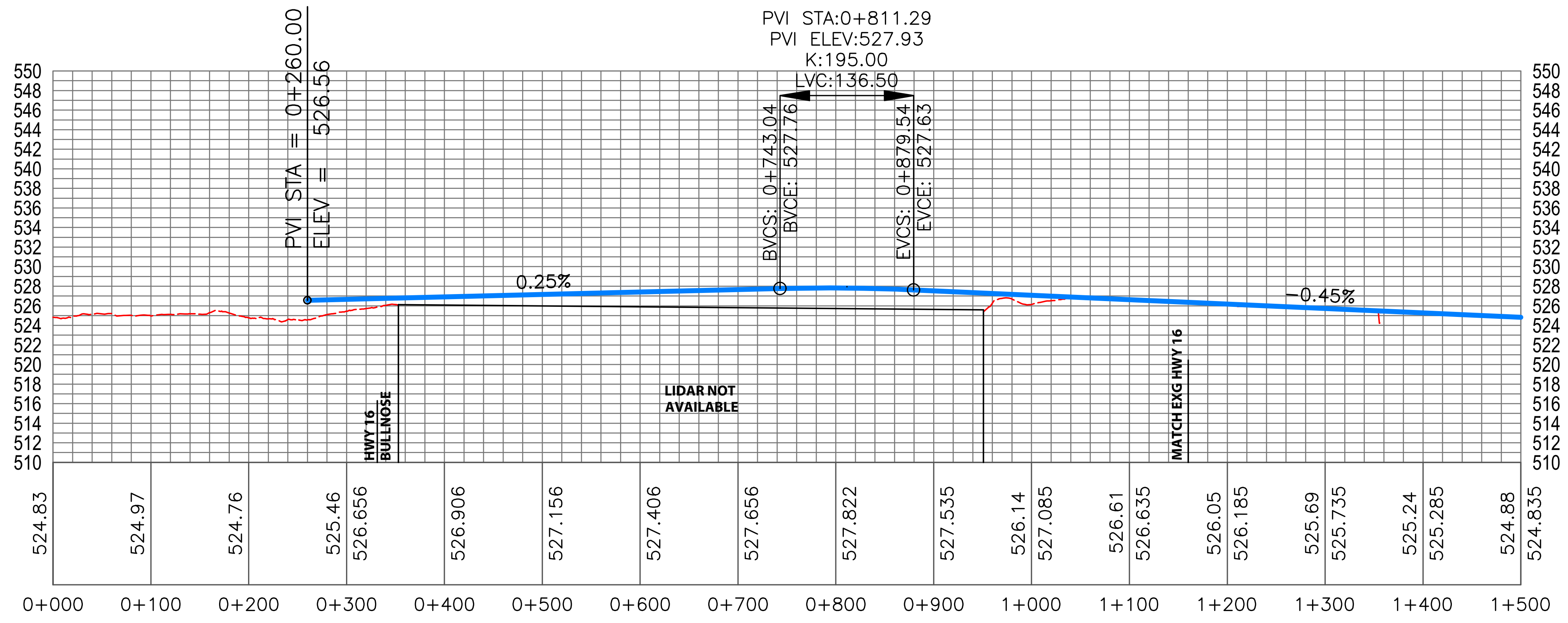
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

REVISIONS		
NO	DATE	SIGNATURE

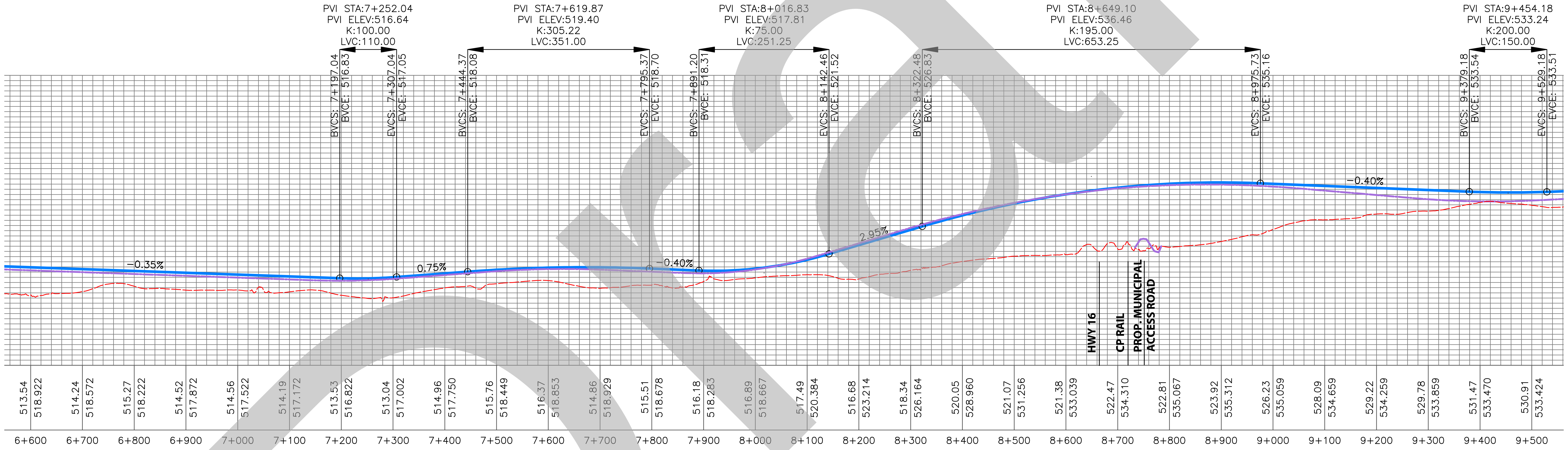
CS	N/A	TAB NO	Profile_01
PHOTO DATE	N/A	SHEET	1 OF 5
DRAWN BY	S. SCHNEIDER	DATE	22/2/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 7+500 TO STA. 9+500
SASKATOON FREEWAY PROJECT
HIGHWAY 16 INTERCHANGE

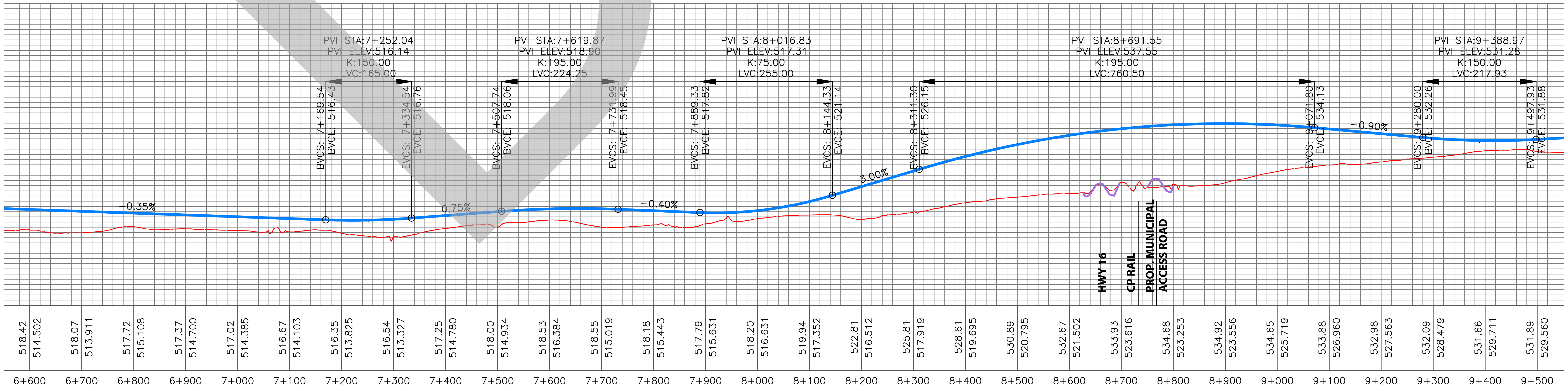
Ramp S-W Profile



NB Mainline Freeway Profile



SB Mainline Freeway Profile



ACAD DWG: C3D_PHASE 2 SOUTH_HWY 16_V4.DWG
LAST REV DATE: February 13, 2022

Saskatoon Freeway

Saskatchewan

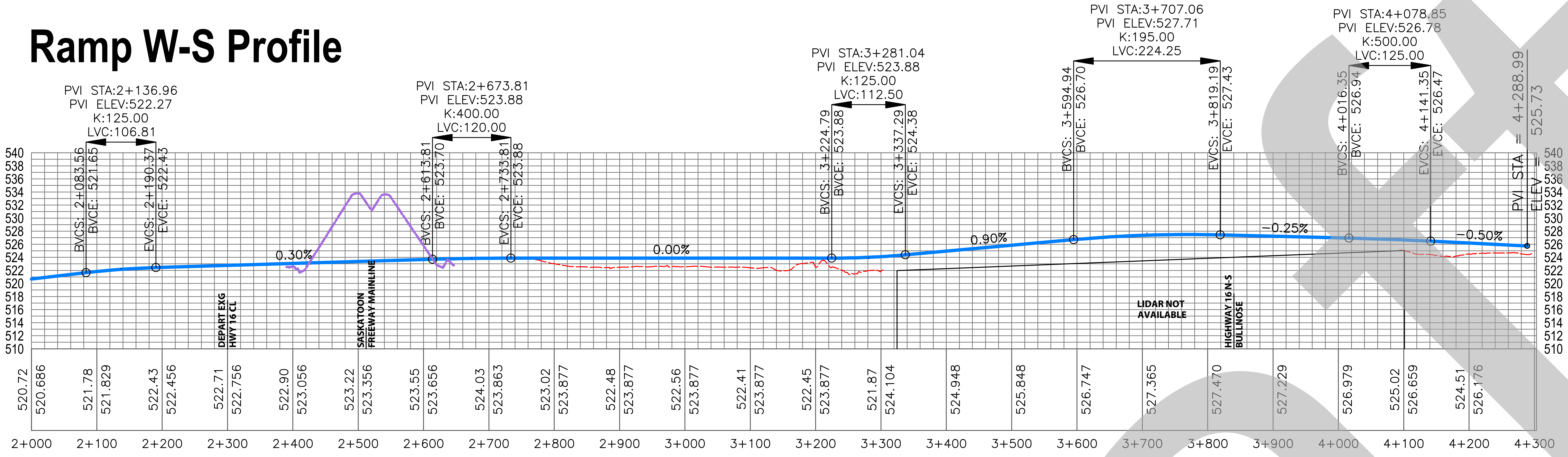
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

REVISIONS		
NO	DATE	SIGNATURE

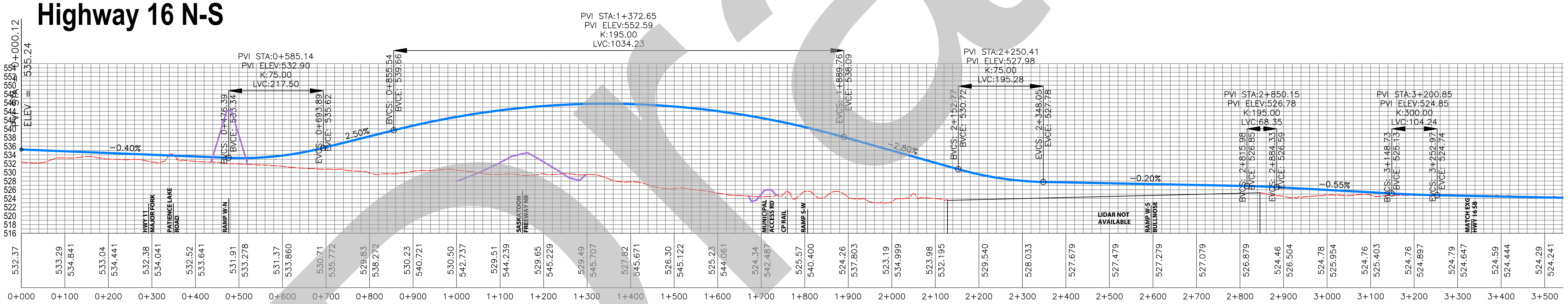
CS	N/A	TAB NO	Profile_02
PHOTO DATE	N/A	SHEET	2 OF 5
DRAWN BY	S. SCHNEIDER	DATE	22/2/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 7+500 TO STA. 9+500
SASKATOON FREEWAY PROJECT
HIGHWAY 16 INTERCHANGE

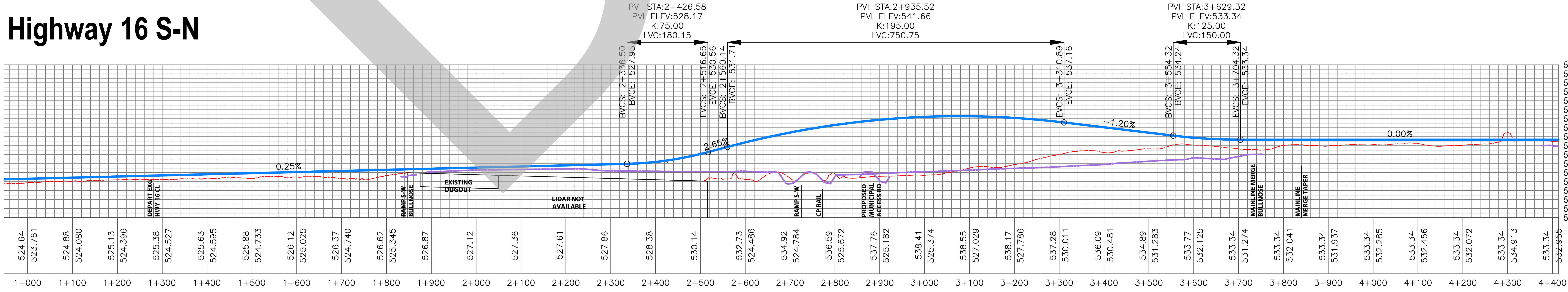
Ramp W-S Profile



Highway 16 N-S



Highway 16 S-N



ACAD DWG: C3D_PHASE 2 SOUTH_HWY 16_V4.DWG
LAST REV DATE: February 13, 2022

Saskatoon Freeway

Saskatchewan

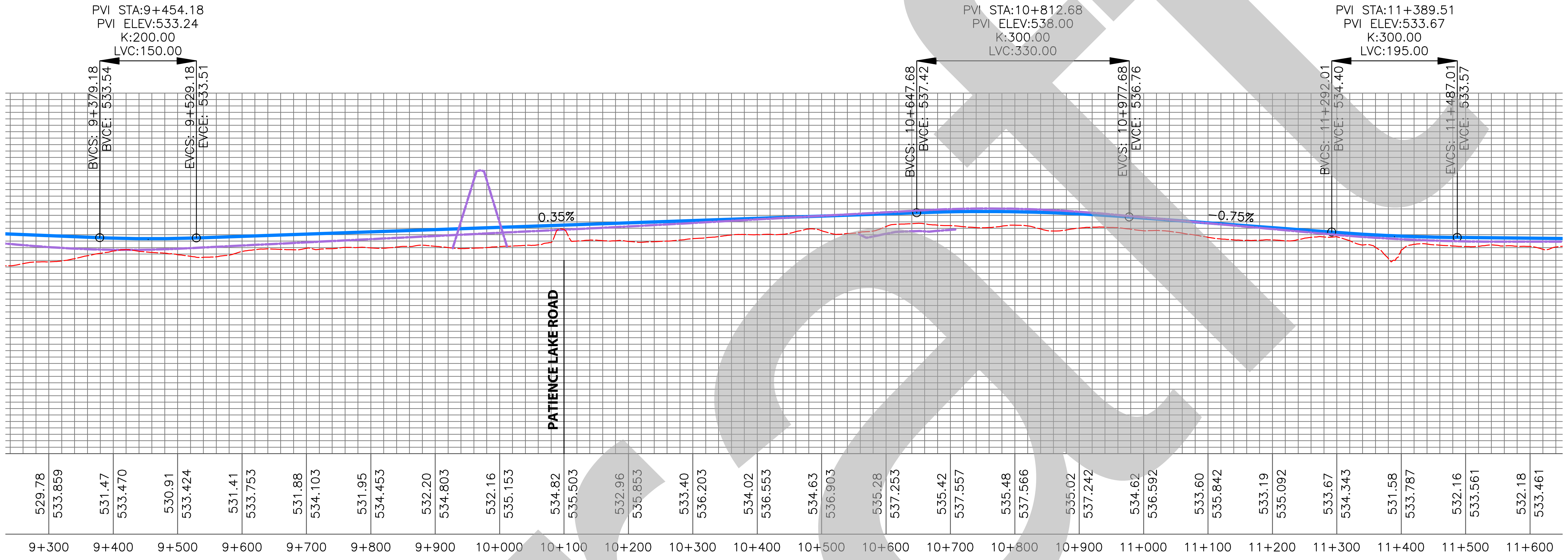
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

REVISIONS		
NO	DATE	SIGNATURE

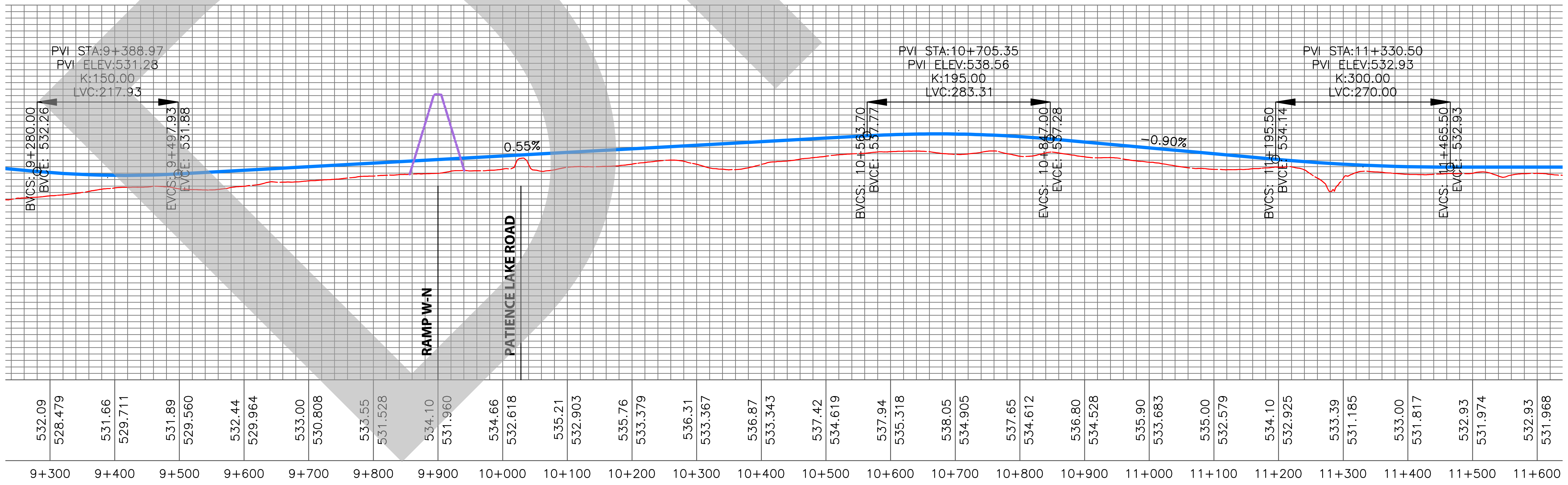
CS	N/A	TAB NO	Profile_03
PHOTO DATE	N/A	SHEET	3 OF 5
DRAWN BY	S. SCHNEIDER	DATE	22/2/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 9+500 TO STA. 11+500
SASKATOON FREEWAY PROJECT
HIGHWAY 16 INTERCHANGE

NB Mainline Freeway Profile



SB Mainline Freeway Profile



ACAD DWG: C3D_PHASE 2 SOUTH_HWY 16_V4.DWG
LAST REV DATE: February 13, 2022

Saskatoon Freeway

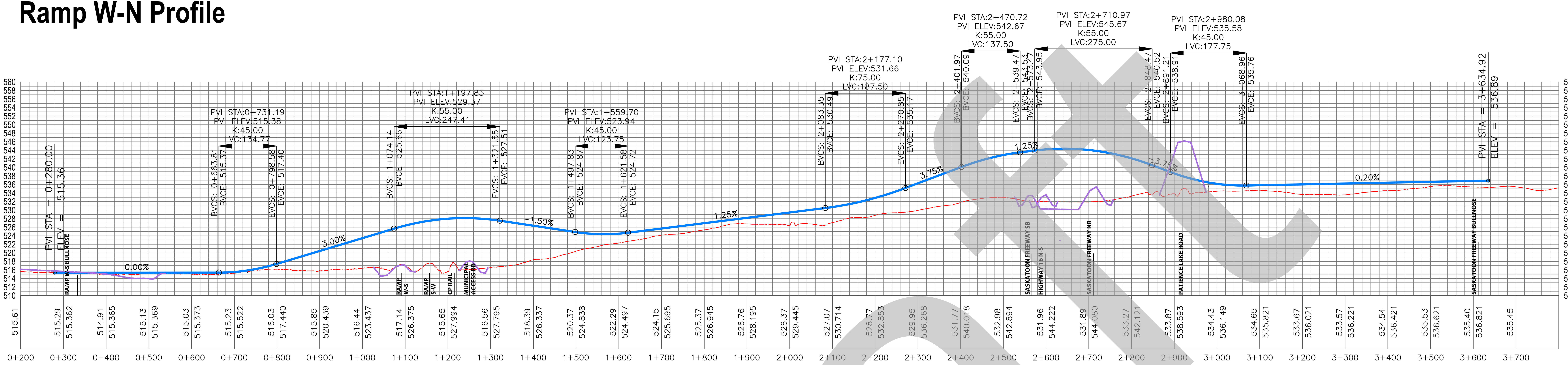
Saskatchewan

SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

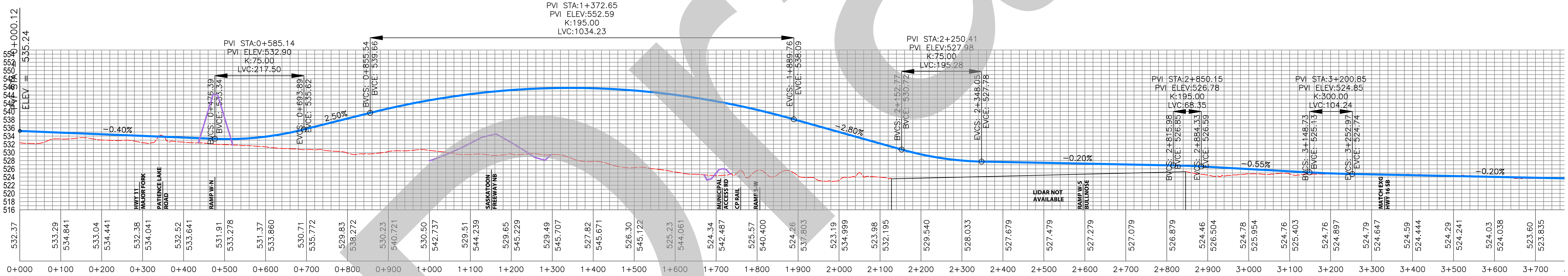
REVISIONS						
NO	DATE	SIGNATURE	CS	N/A	TAB NO	Profile_04
			PHOTO DATE	N/A	SHEET	4 OF 5
			DRAWN BY	S. SCHNEIDER	DATE	22/2/13
			DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 9+500 TO STA. 11+500
SASKATOON FREEWAY PROJECT
HIGHWAY 16 INTERCHANGE

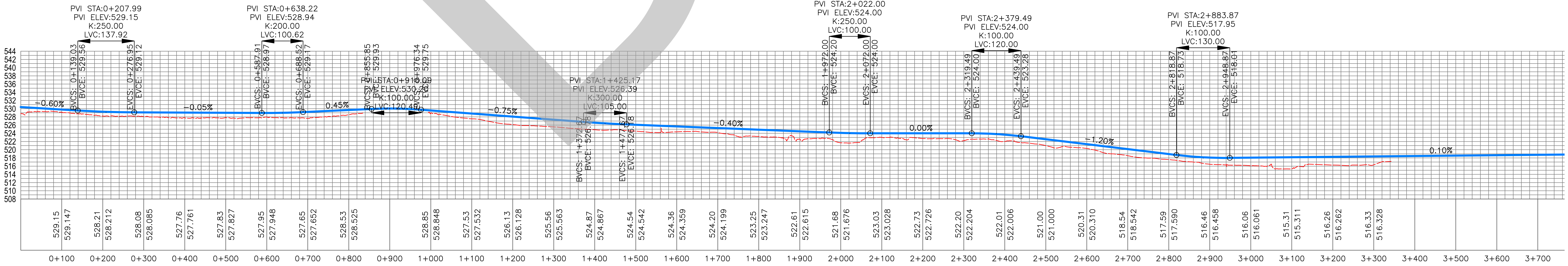
Ramp W-N Profile



Highway 16 N-S Profile



Municipal Access Road Profile



Saskatoon Freeway

Saskatchewan

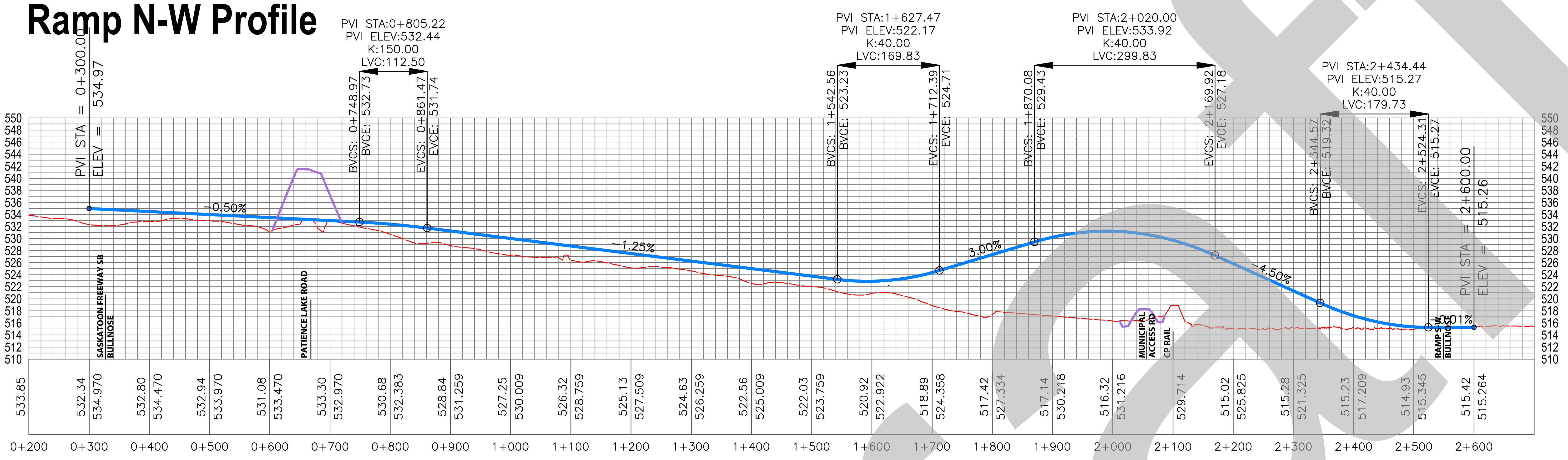
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

REVISIONS		
NO	DATE	SIGNATURE

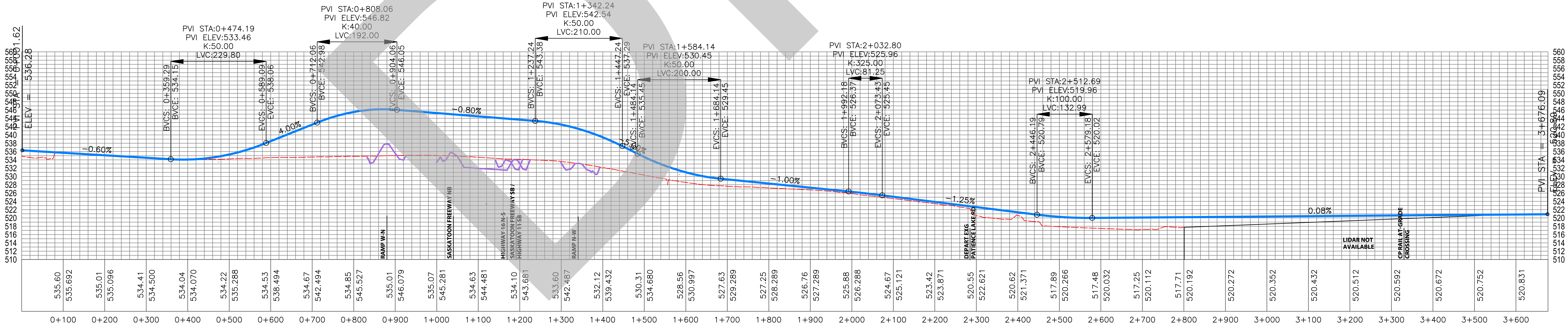
CS	N/A	TAB NO	Profile_05
PHOTO DATE	N/A	SHEET	5 OF 5
DRAWN BY	S. SCHNEIDER	DATE	22/2/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 9+500 TO STA. 11+500
SASKATOON FREEWAY PROJECT
HIGHWAY 16 INTERCHANGE

Ramp N-W Profile



Patience Lake Road Profile



ACAD DWG: C3D_PHASE 2 SOUTH_HWY 16_V4.DWG
LAST REV DATE: February 13, 2022

REVISIONS			CS	N/A	TAB NO	Profile_01
NO	DATE	SIGNATURE	PHOTO DATE	N/A	SHEET	1 OF 2
			DRAWN BY	S. SCHNEIDER	DATE	22/02/13
			DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

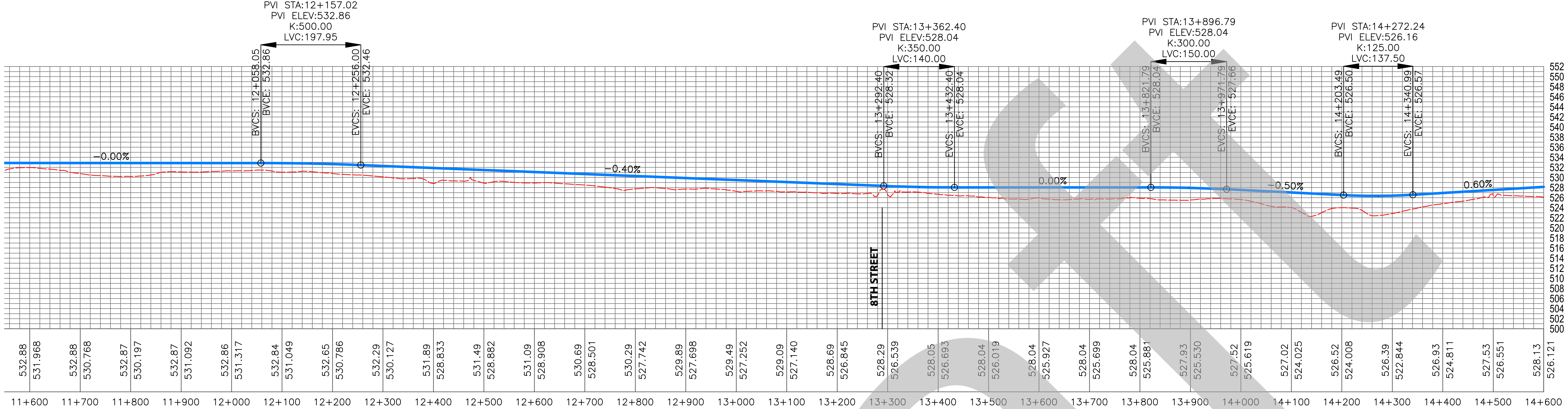
Saskatoon Freeway

Saskatchewan

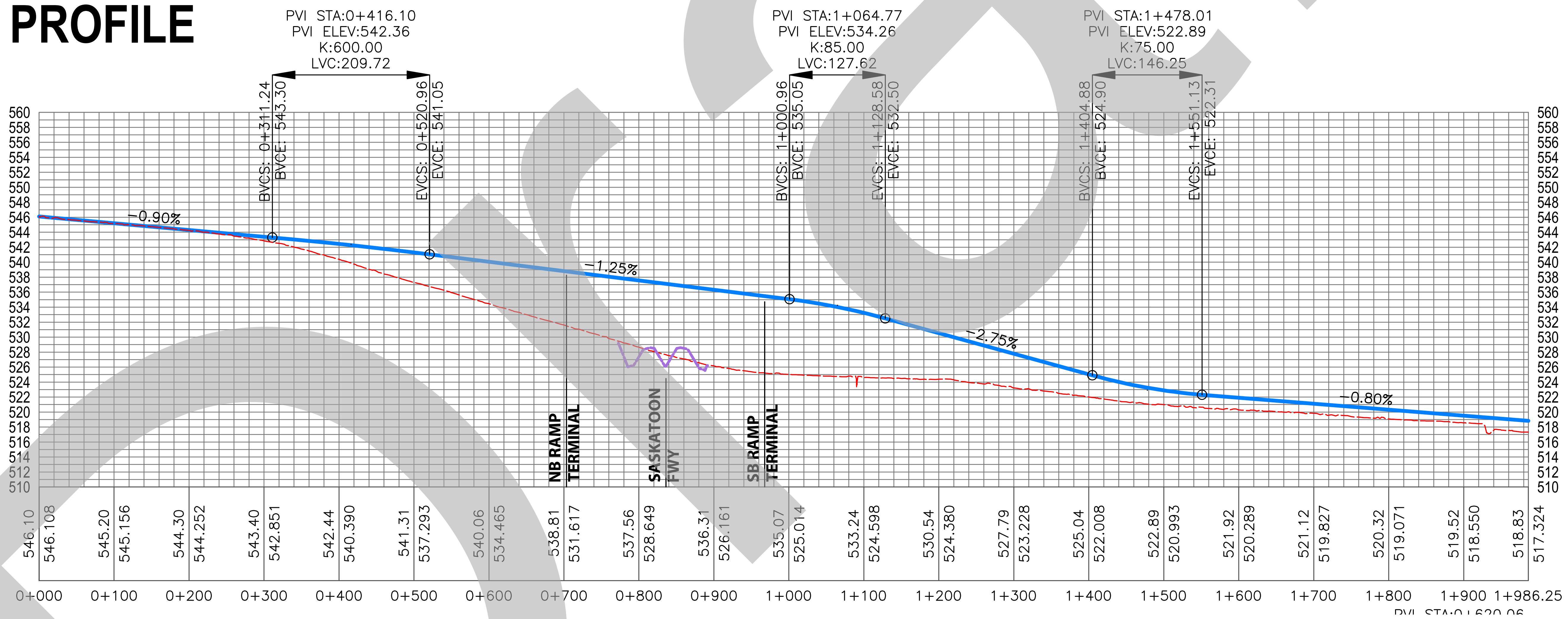
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

PHASE 2 INTERCHANGE TEMPLATE
STA. 11+500 TO STA. 14+600
SASKATOON FREEWAY PROJECT
8TH STREET INTERCHANGE

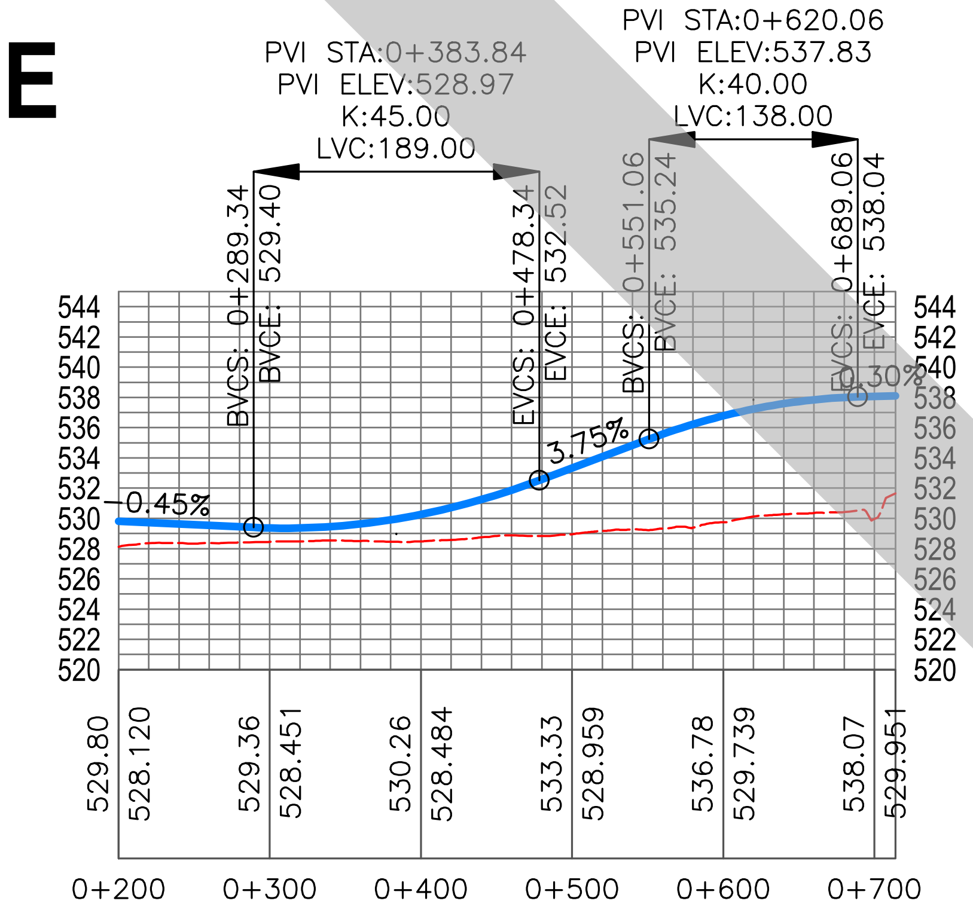
MAINLINE PROFILE



8TH STREET PROFILE



RAMP S-E/W PROFILE



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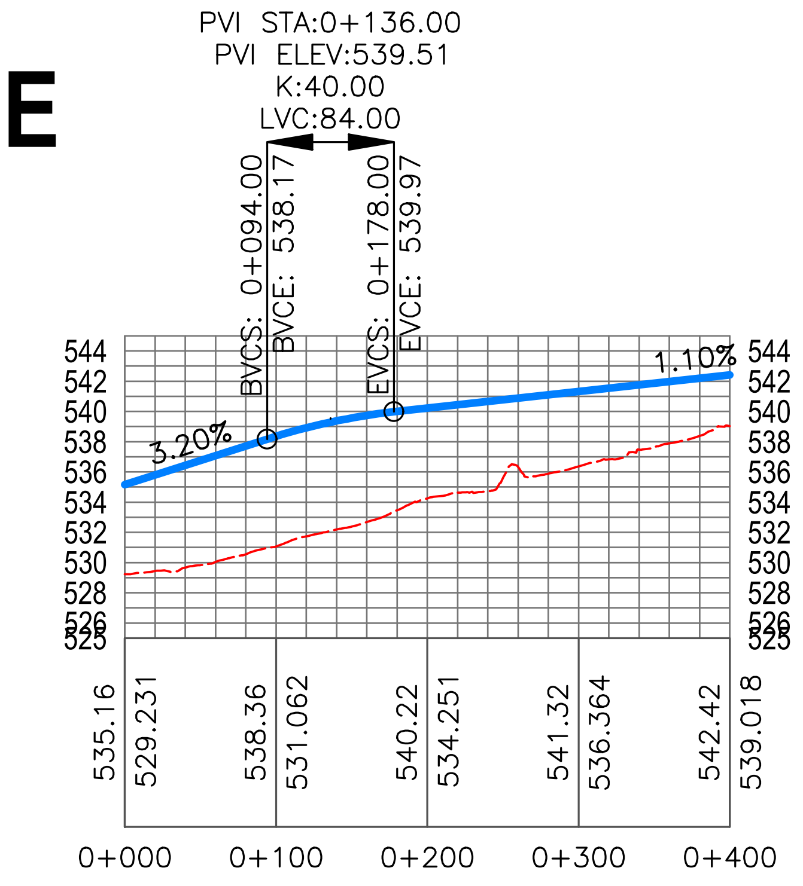


ACAD DWG: C3D_PHASE 2 SOUTH_8TH_ZIMM_PARALLEL ENT – V2.DWG
LAST REV DATE: January 4, 2022

Saskatoon Freeway | **Saskatchewan**

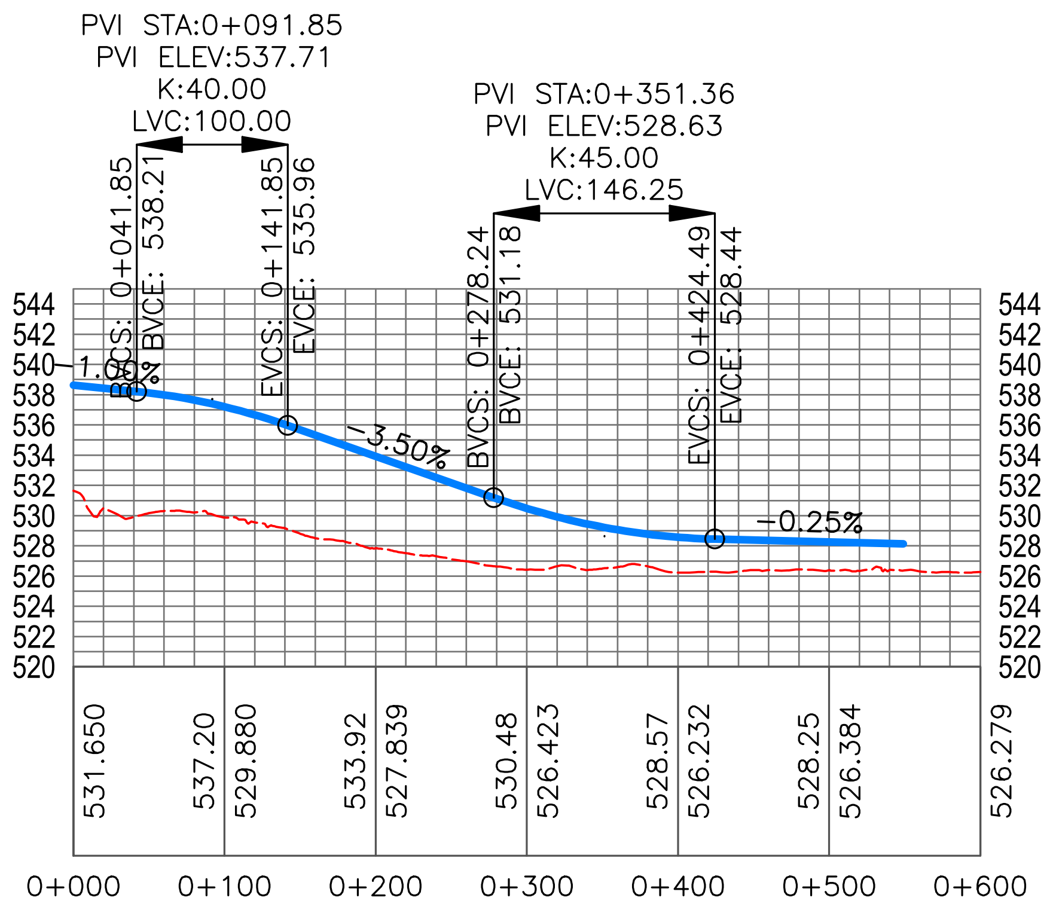
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

REVISIONS		
NO	DATE	SIGNATURE

CS	N/A	TAB NO	Profile_02
PHOTO DATE	N/A	SHEET	2 OF 2
DRAWN BY	S. SCHNEIDER	DATE	22/02/13
DESIGNED BY	SOLI SOLUTIONS	DATE	21/11/26

PHASE 2 INTERCHANGE TEMPLATE
STA. 11+500 TO STA. 15+000
SASKATOON FREEWAY PROJECT
8TH STREET INTERCHANGE

RAMP E/W-N PROFILE



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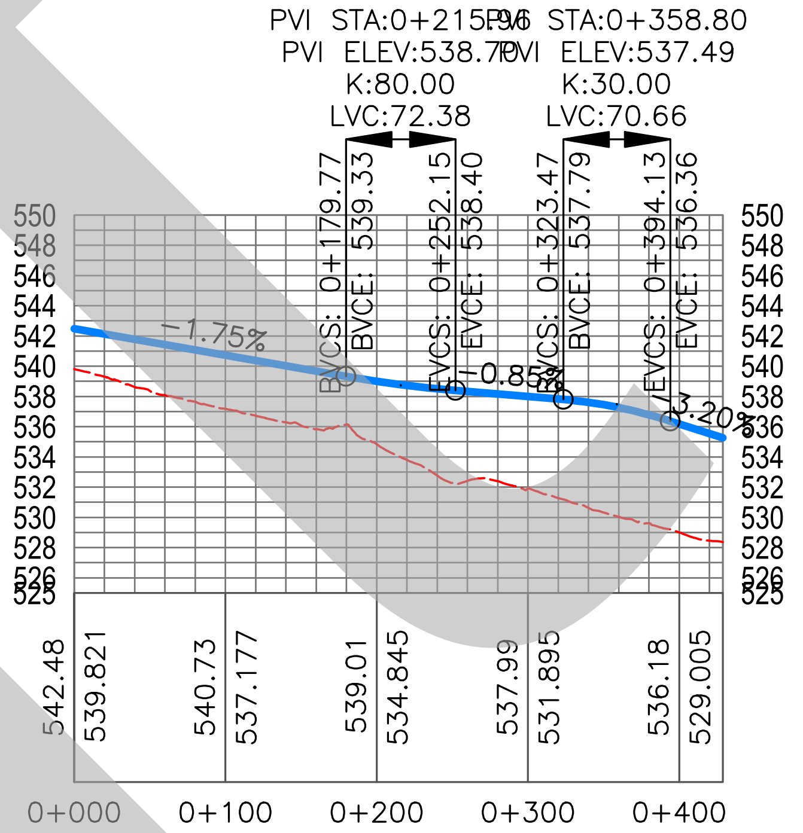
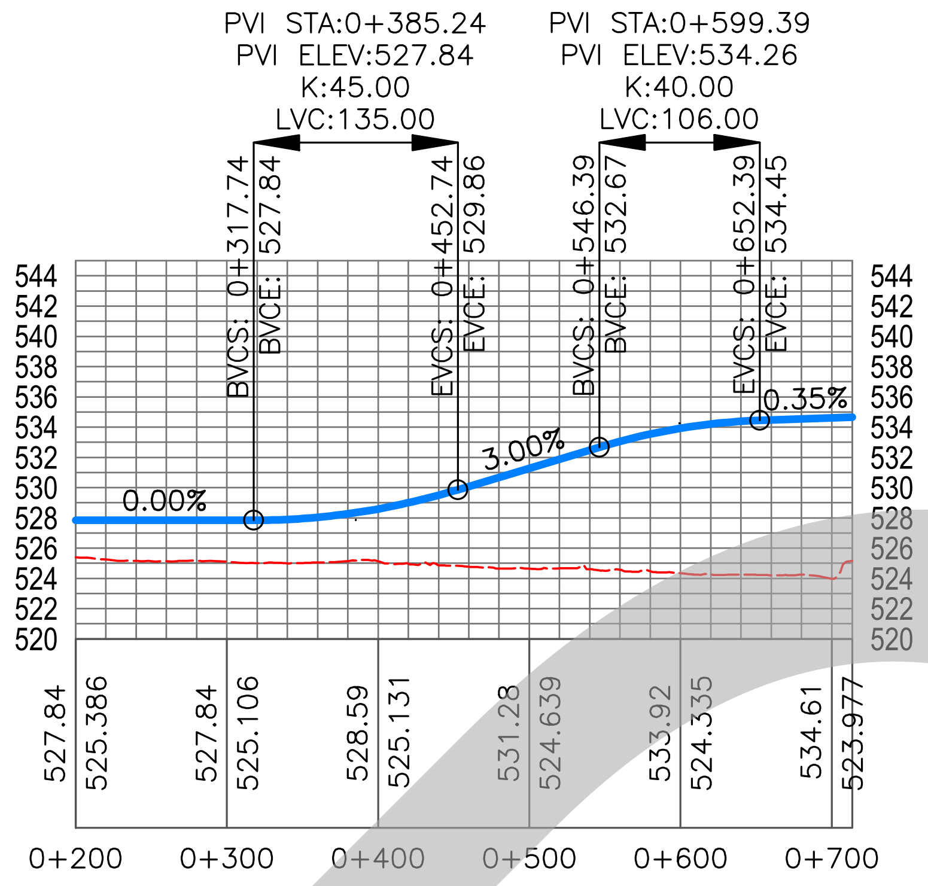


RAMP N-W/E PROFILE



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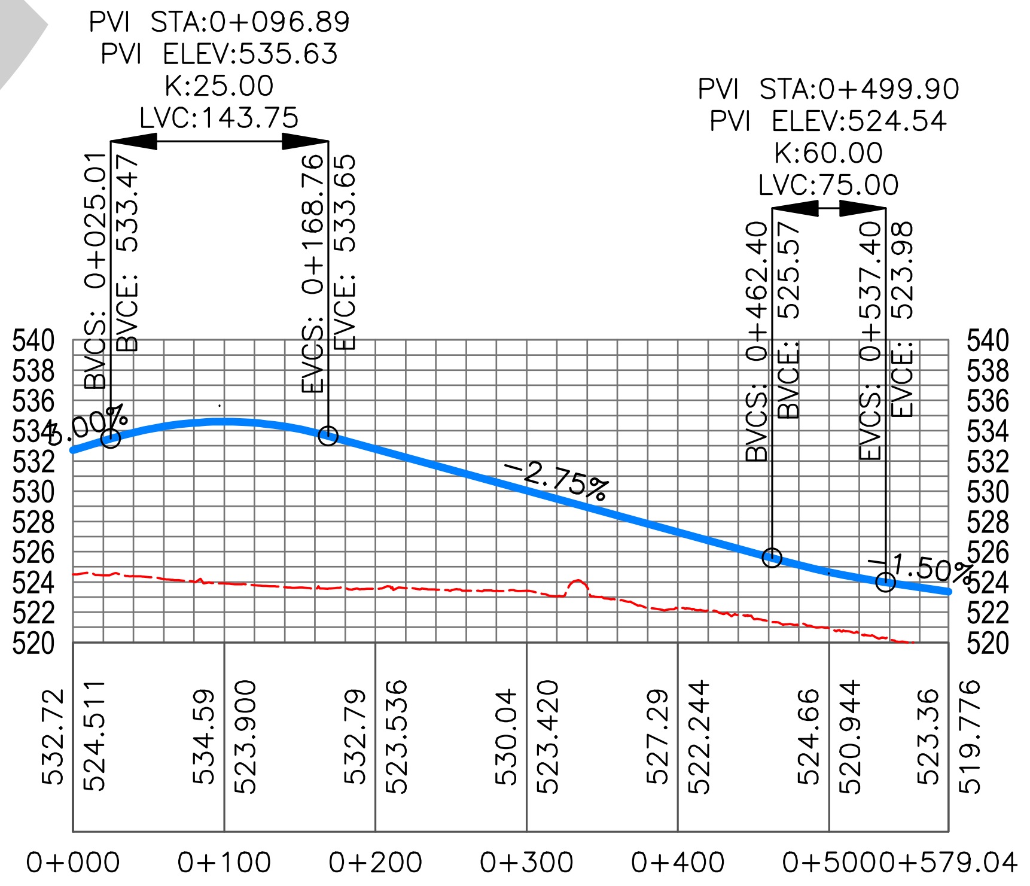
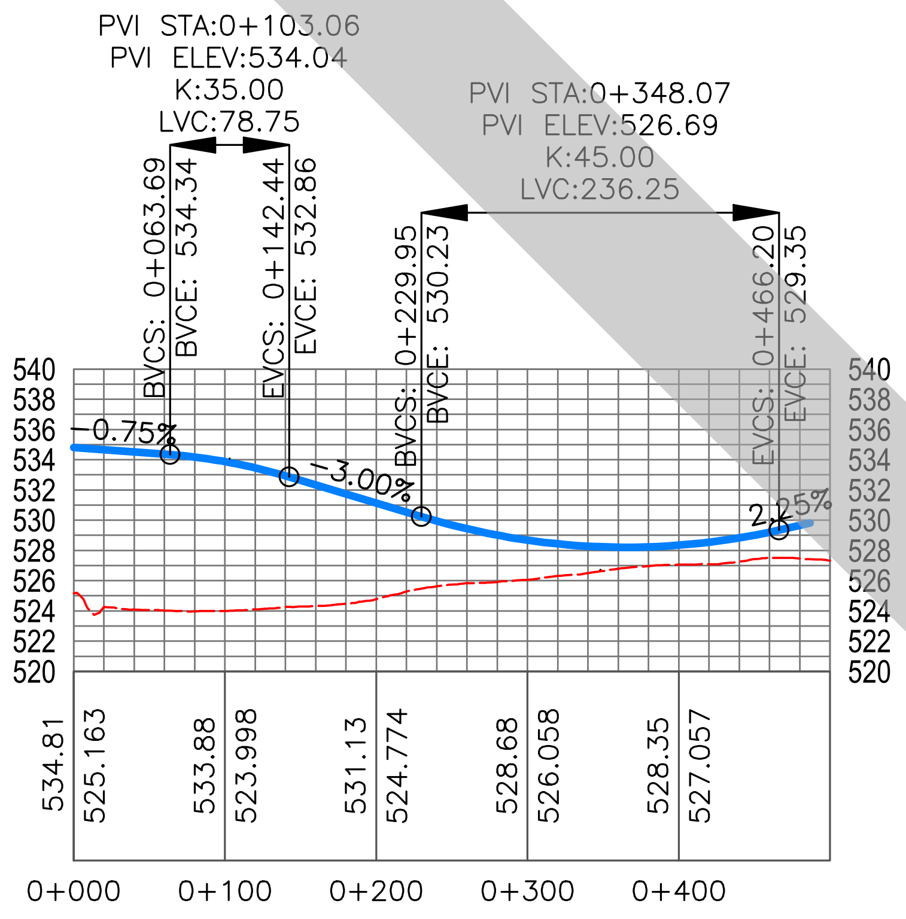
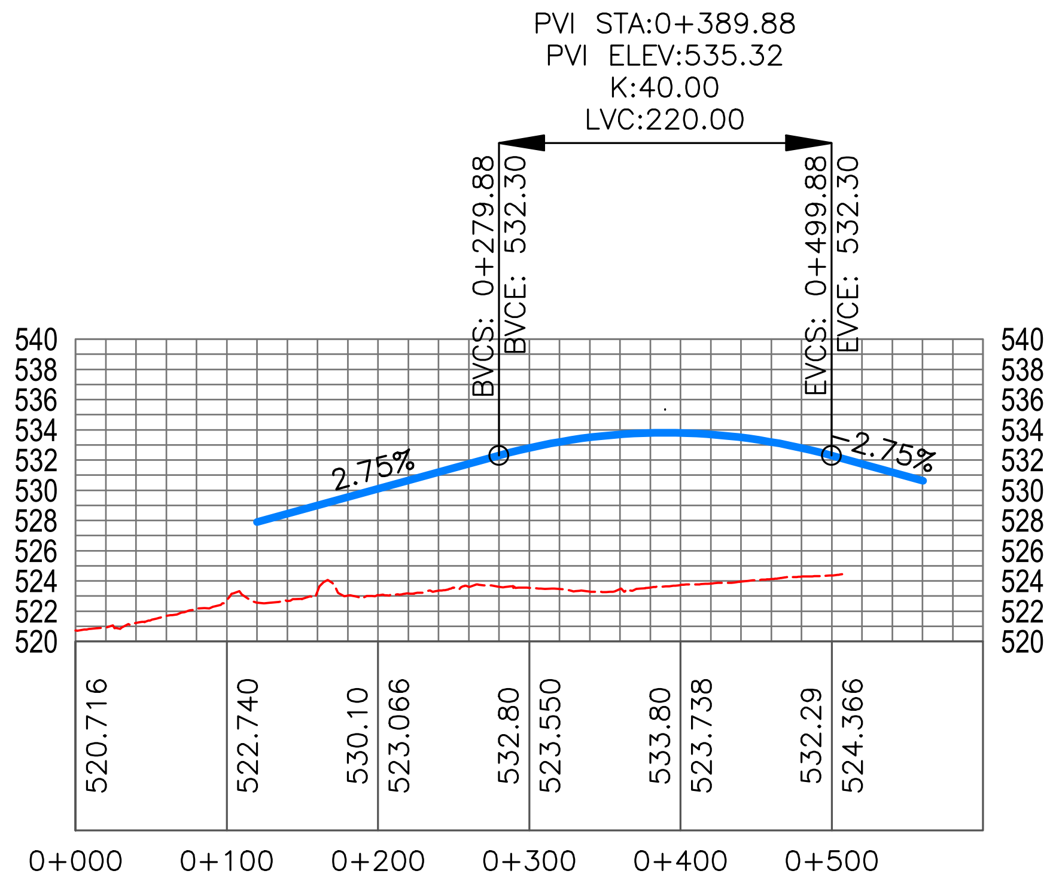


RAMP W/E-S PROFILE



RAMP W-S PROFILE



ACAD DWG: C3D_PHASE 2 SOUTH_8TH_ZIMM_PARALLEL ENT – V2.DWG
LAST REV DATE: January 4, 2022

Saskatoon Freeway

Saskatchewan

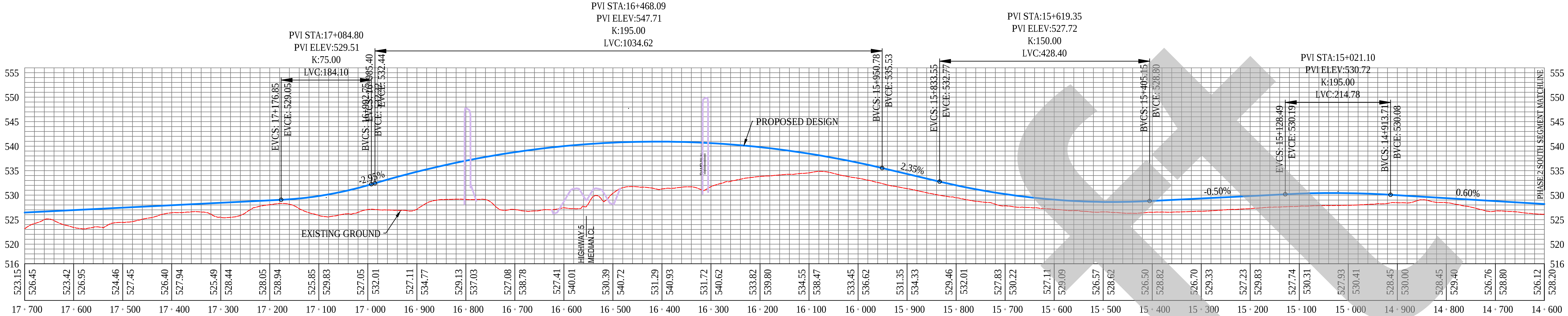
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

REVISIONS		
NO	DATE	SIGNATURE

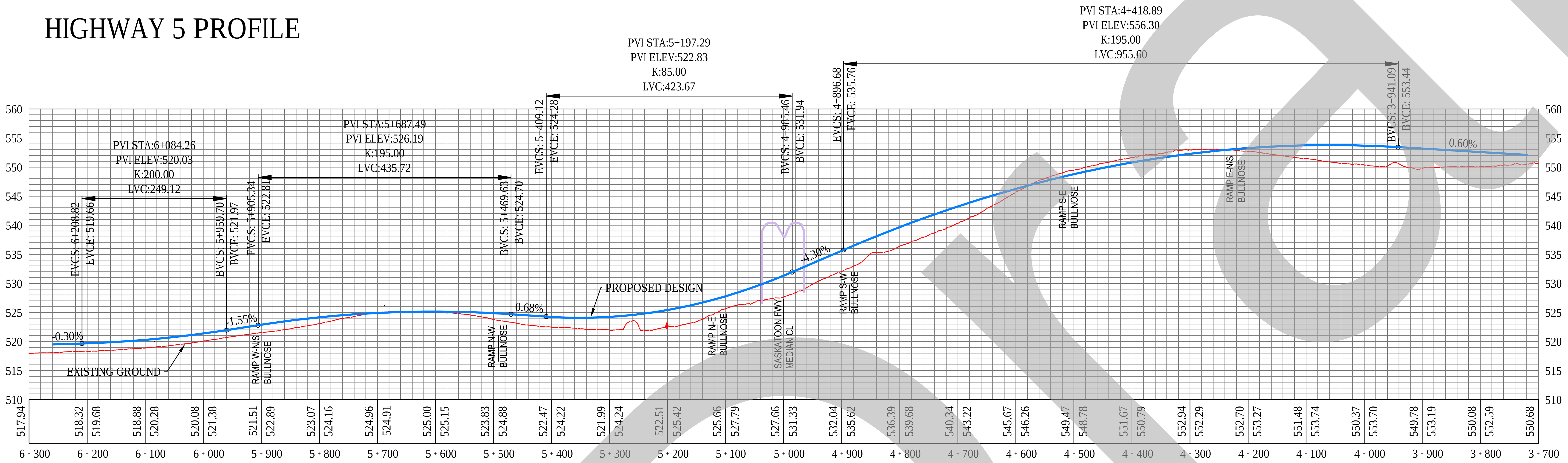
CS	N/A	TAB NO	Profiles_01
PHOTO DATE	N/A	SHEET	1 OF 2
DRAWN BY	J. GREENE	DATE	22/01/10
DESIGNED BY	AECOM	DATE	22/01/10

HIGHWAY 5 INTERCHANGE
PROFILES
SASKATOON FREEWAY PROJECT

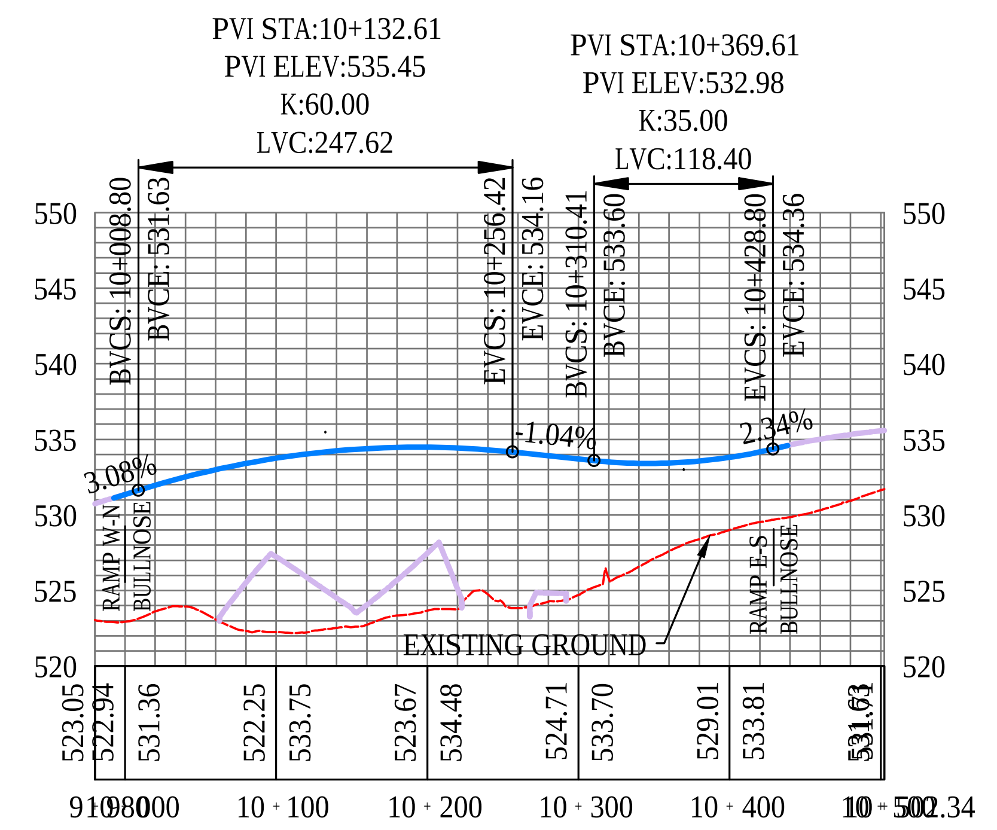
SASKATOON FREEWAY MAINLINE PROFILE



HIGHWAY 5 PROFILE

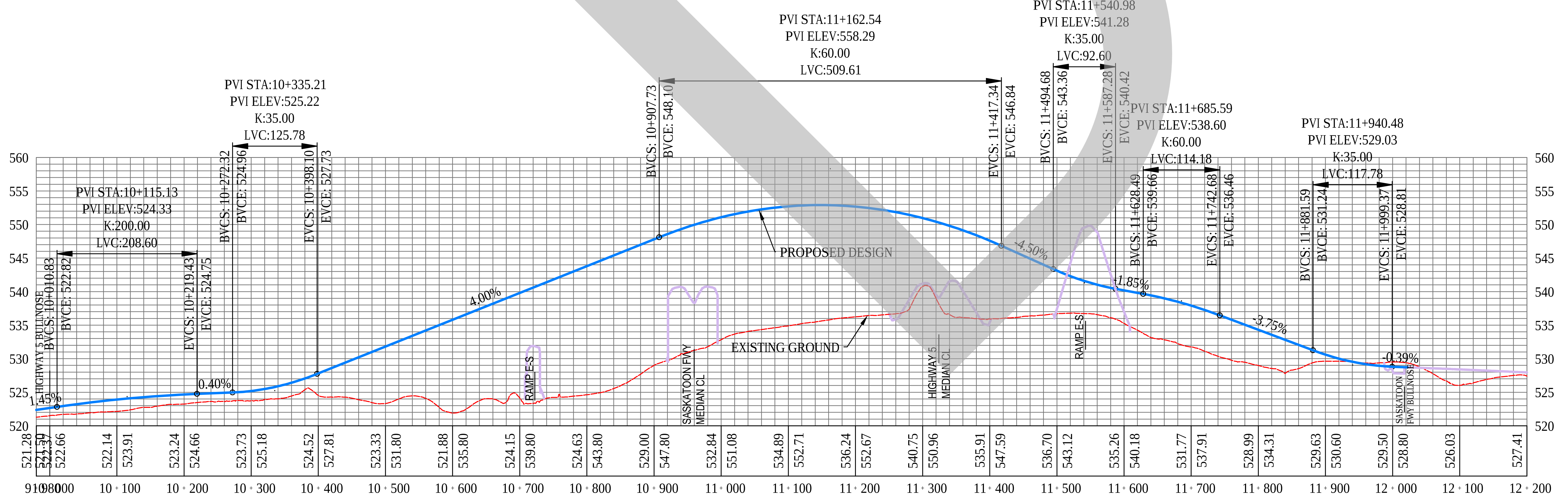


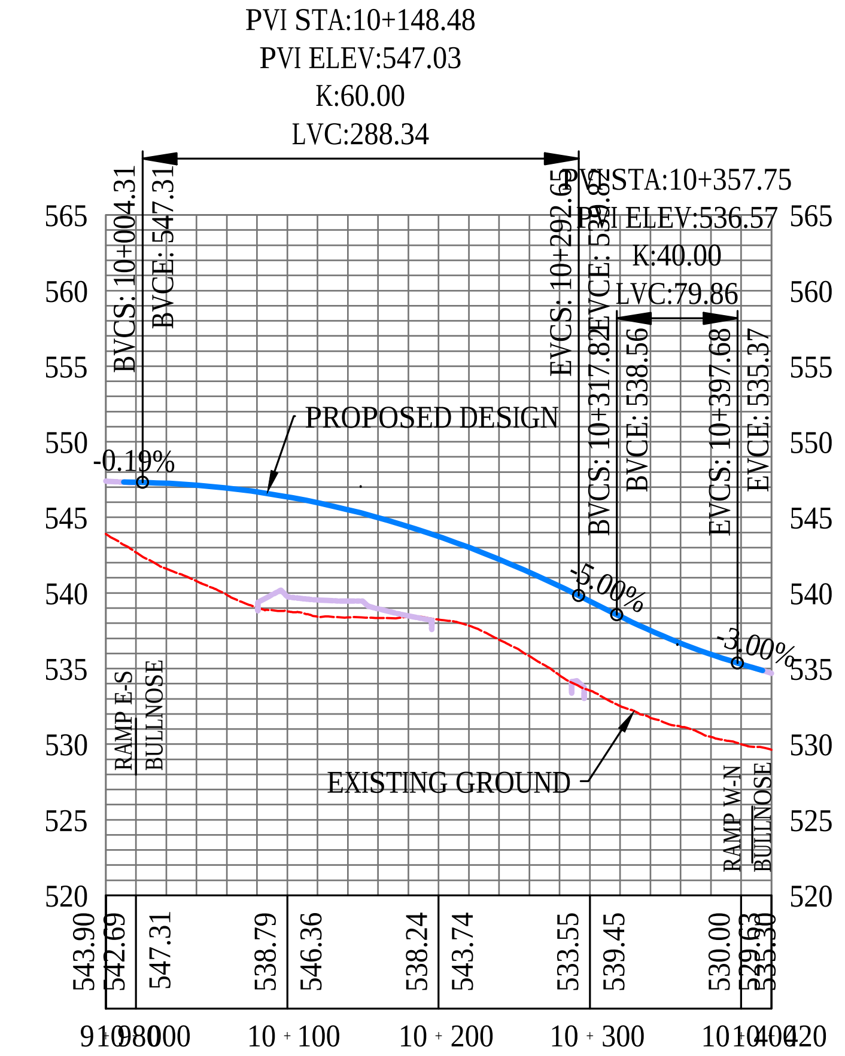
HIGHWAY 5 W-S RAMP PROFILE



HIGHWAY 5 E-N RAMP PROFILE

HIGHWAY 5 W-N RAMP PROFILE





ACAD DWG:X_HWY 5 IC_ALIGNMENT AND PROFILE.DWG
LAST REV DATE: January 10, 2022

Saskatoon Freeway

Saskatchewan

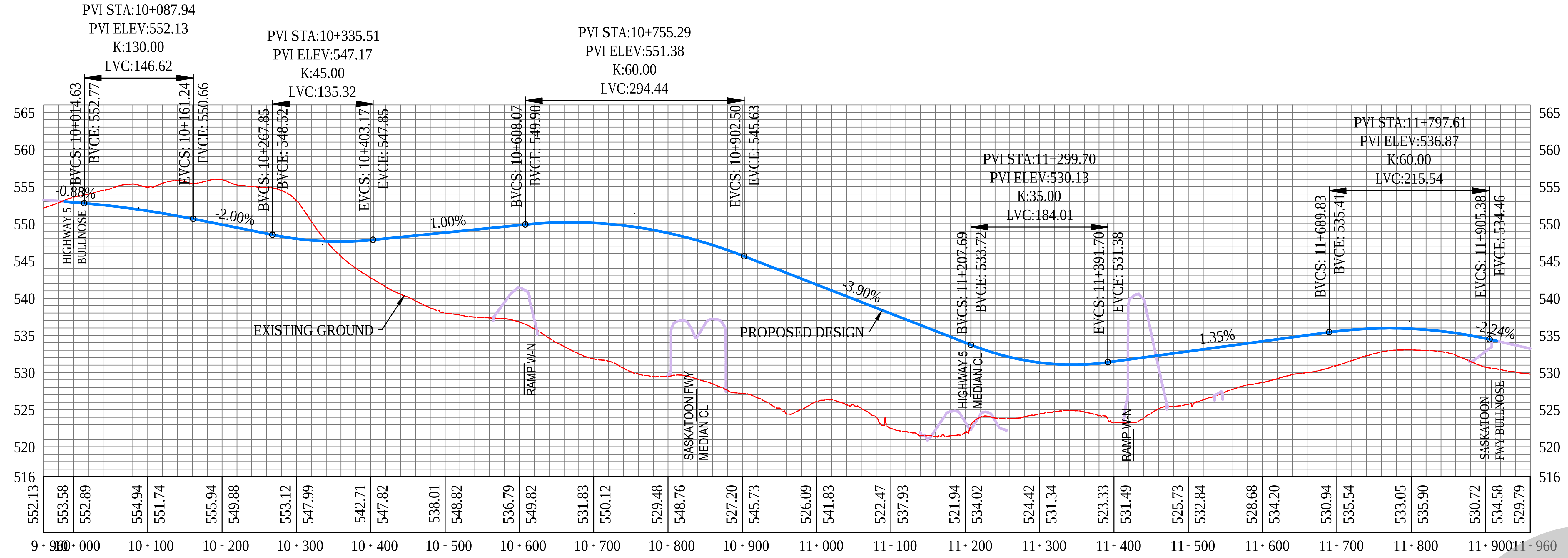
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

REVISIONS		
NO	DATE	SIGNATURE

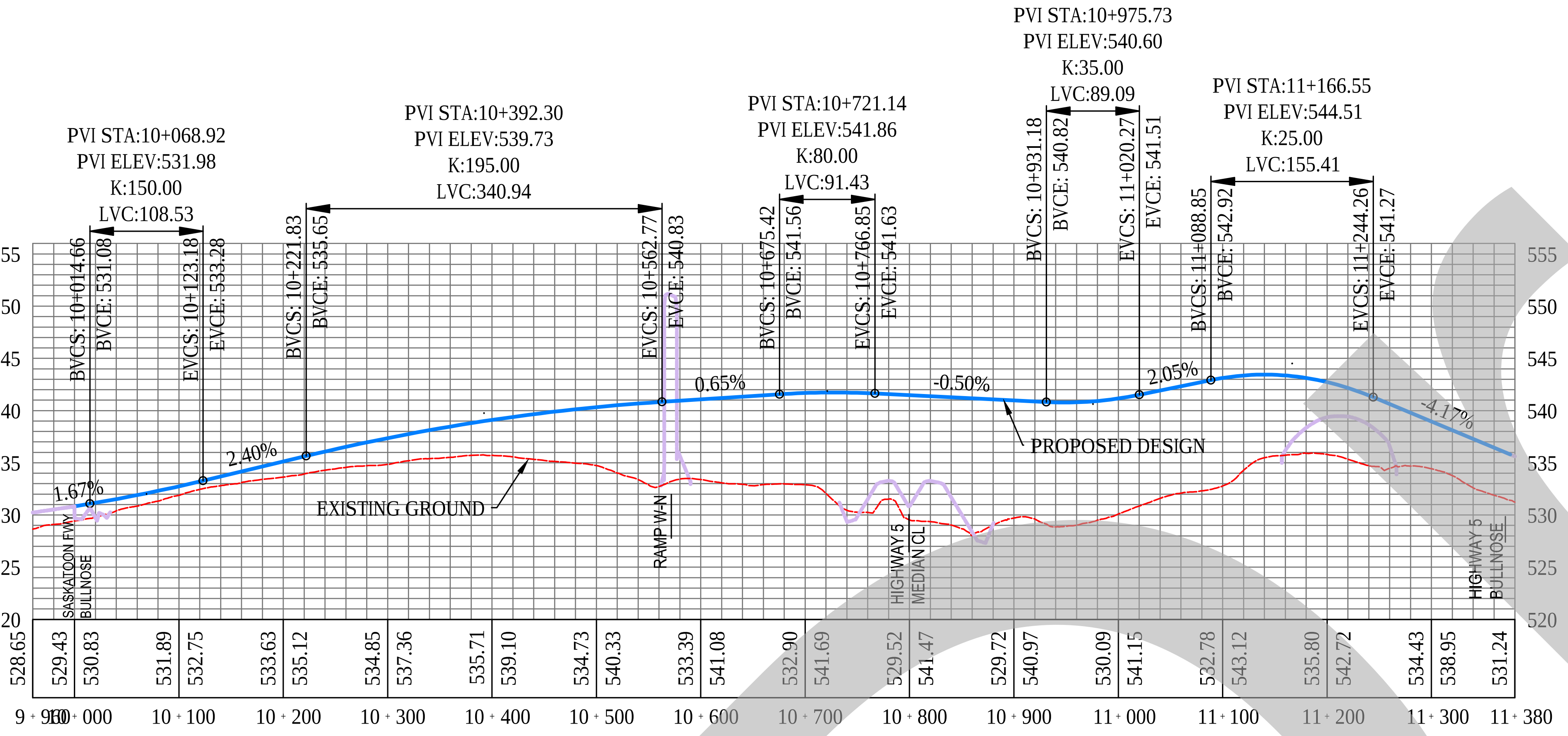
CS	N/A	TAB NO	Profiles_02
PHOTO DATE	N/A	SHEET	2 OF 2
DRAWN BY	J. GREENE	DATE	22/01/10
DESIGNED BY	AECOM	DATE	22/01/10

HIGHWAY 5 INTERCHANGE
PROFILES
SASKATOON FREEWAY PROJECT

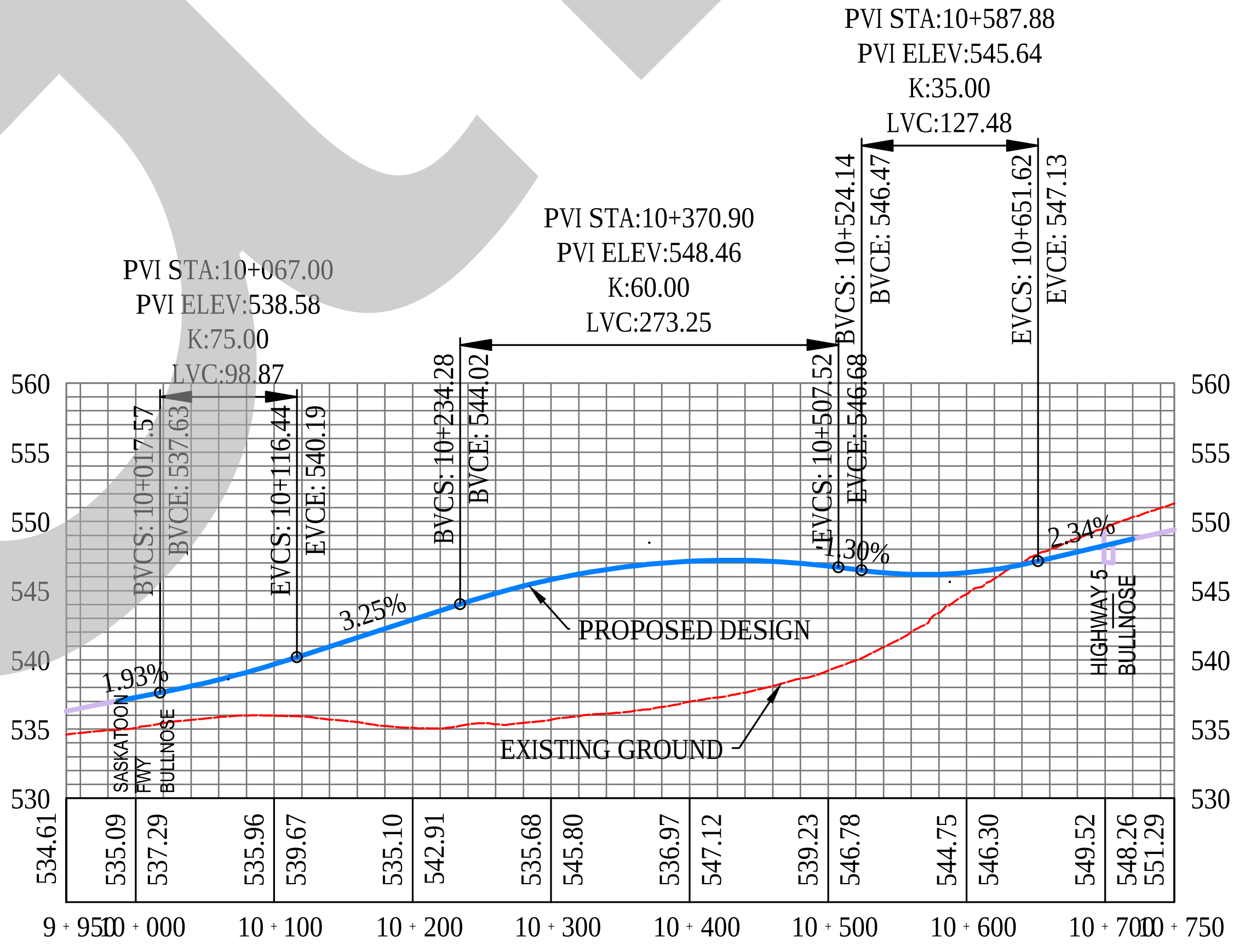
HIGHWAY 5 E-S RAMP PROFILE



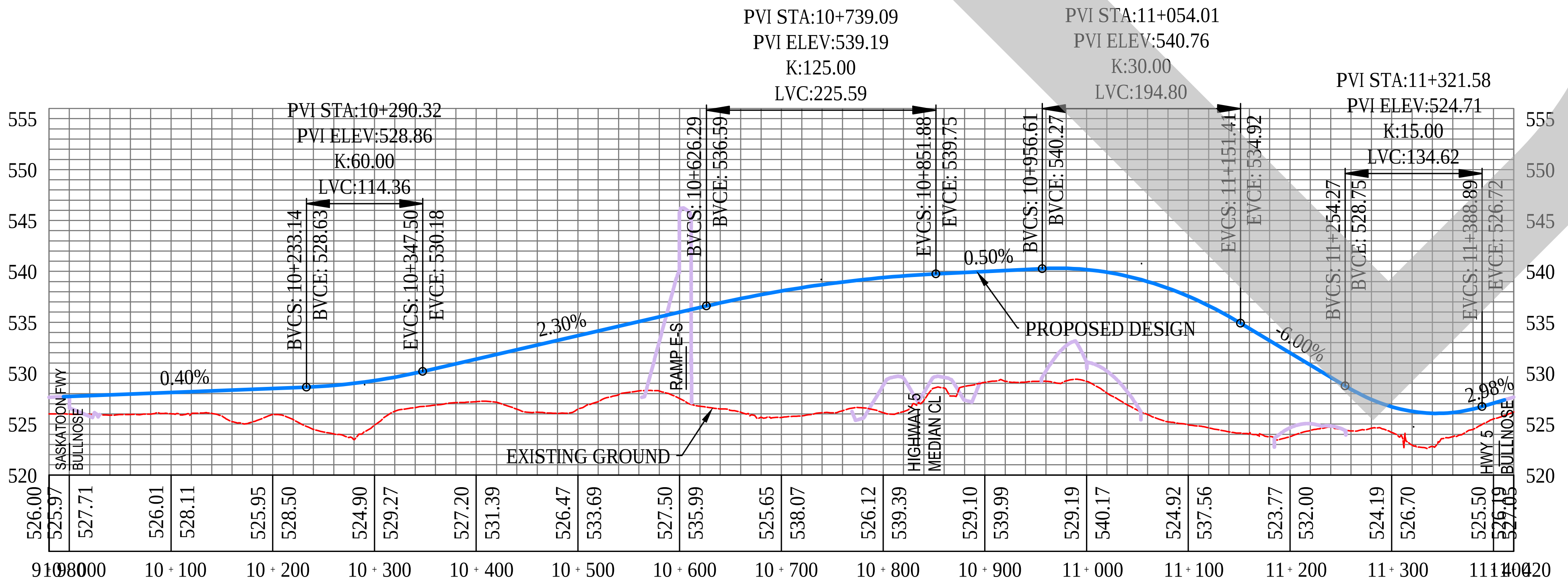
HIGHWAY 5 S-W RAMP PROFILE



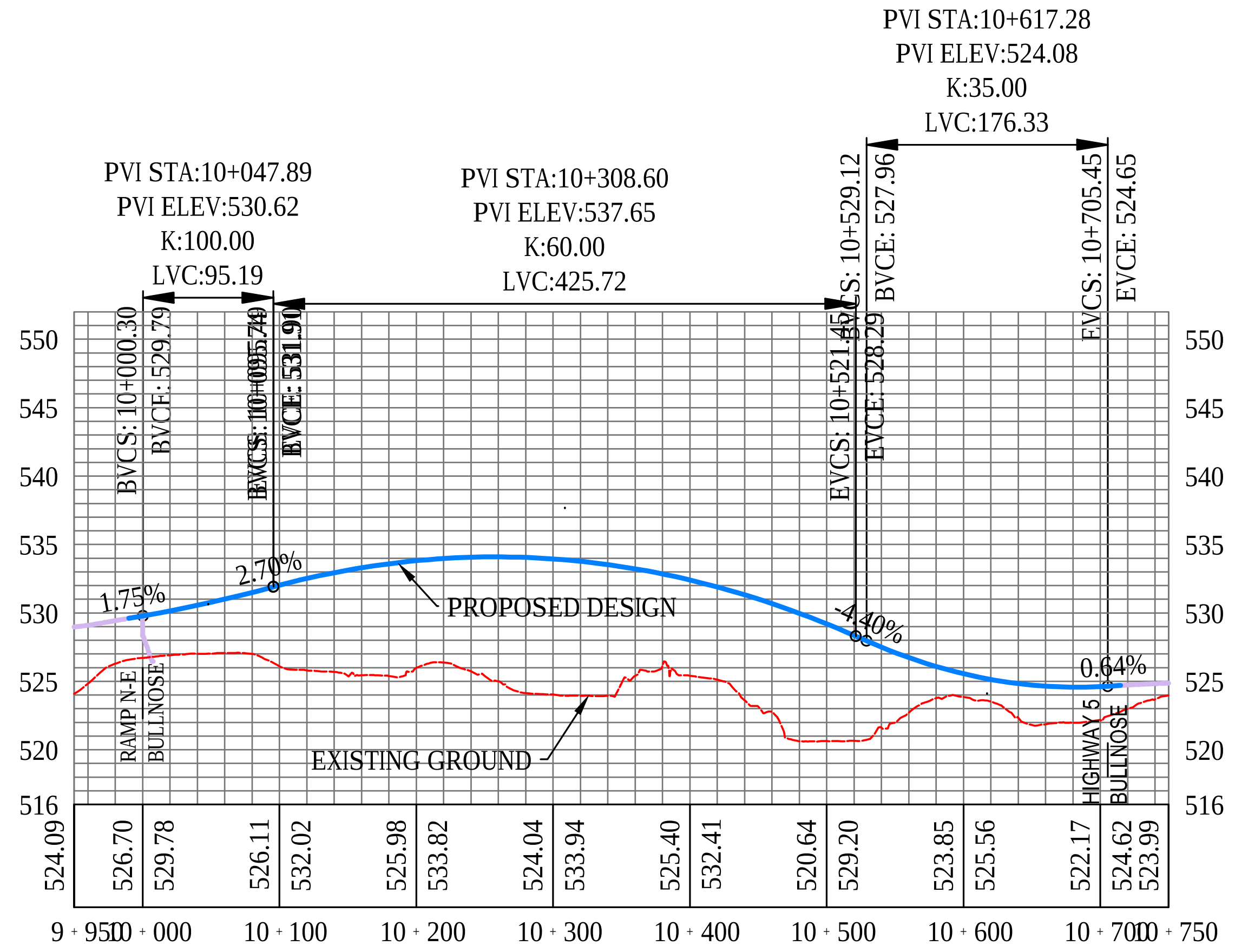
HIGHWAY 5 S-E RAMP PROFILE



HIGHWAY 5 N-E RAMP PROFILE



HIGHWAY 5 N-W RAMP PROFILE



ACAD DWG: X_HWY 5 IC_ALIGNMENT AND PROFILE.DWG
LAST REV DATE: January 10, 2022

Saskatoon Freeway

Saskatchewan

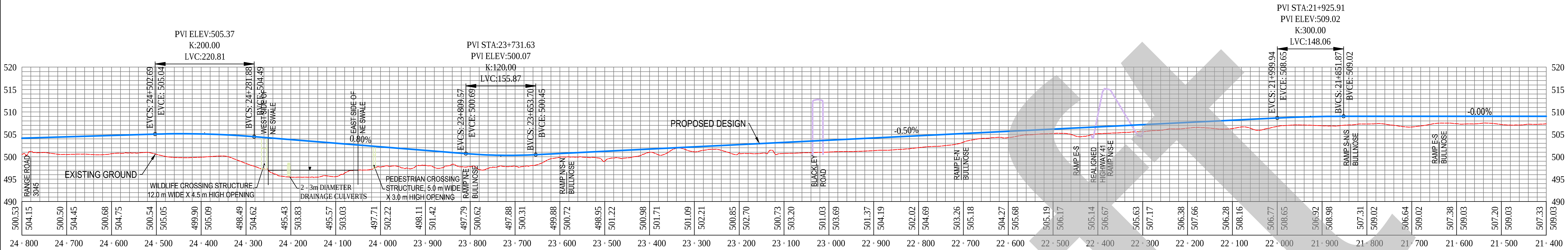
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

REVISIONS		
NO	DATE	SIGNATURE

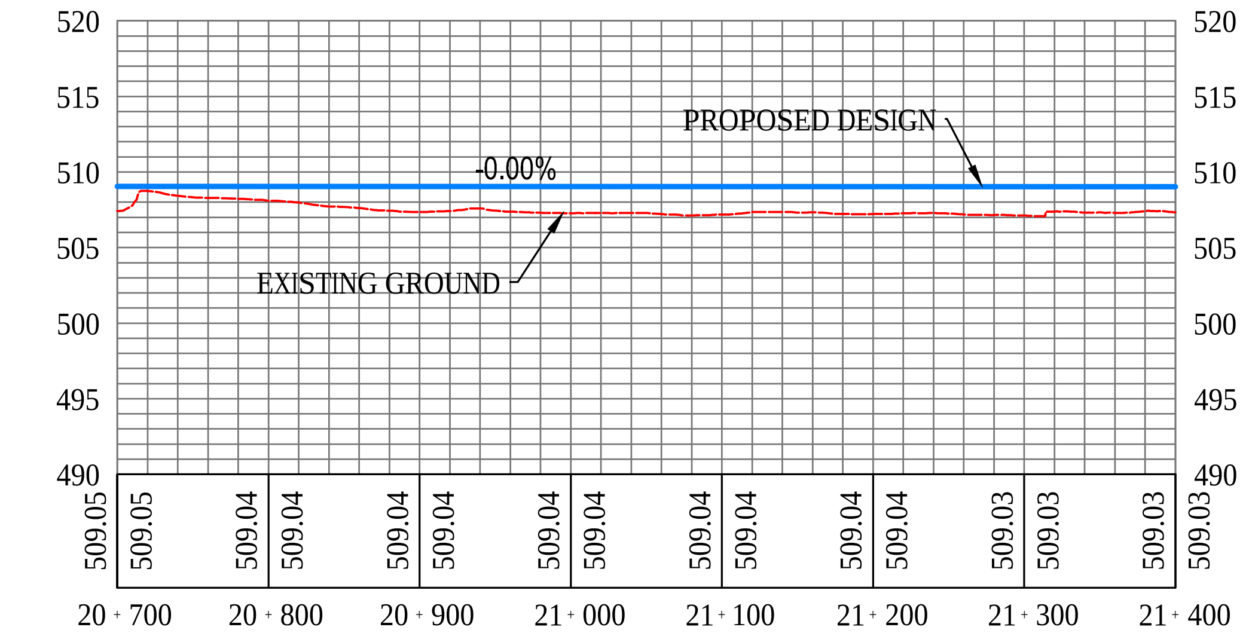
CS	N/A	TAB NO	Profiles_01
PHOTO DATE	N/A	SHEET	1 OF 2
DRAWN BY	J. GREENE	DATE	22/01/10
DESIGNED BY	AECOM	DATE	22/01/10

BLACKLEY ROAD INTERCHANGE
PROFILES
SASKATOON FREEWAY PROJECT

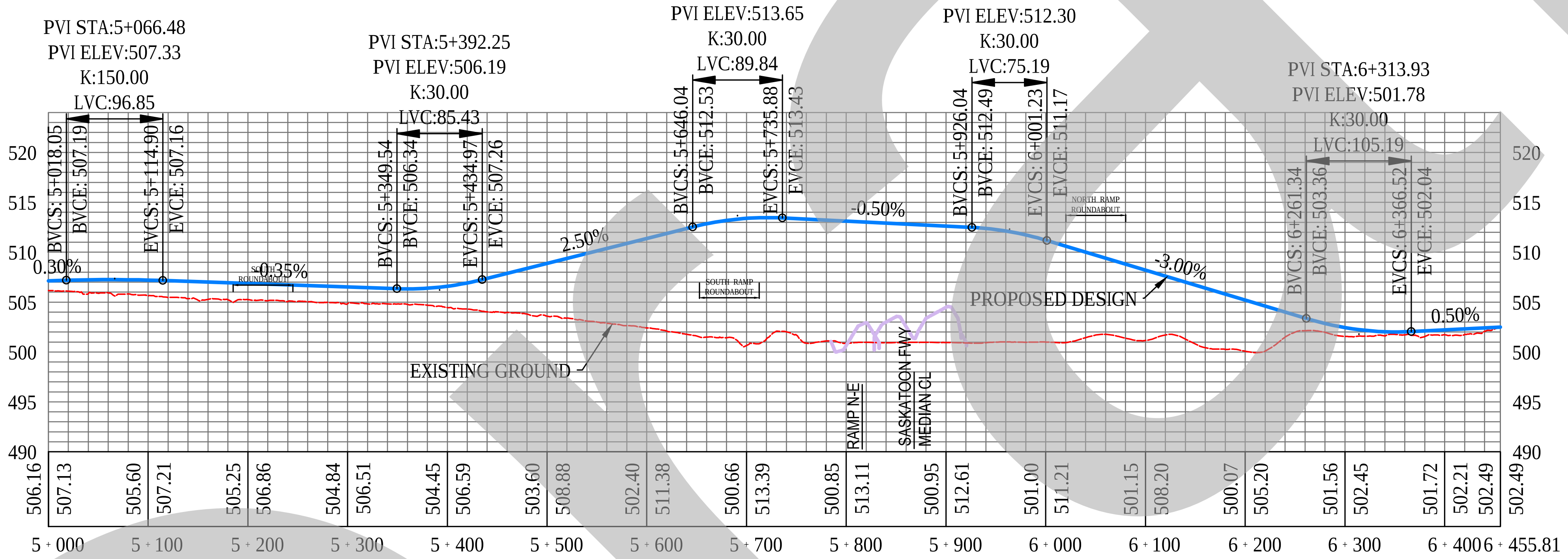
SASKATOON FREEWAY MAINLINE PROFILE



SASKATOON FREEWAY MAINLINE PROFILE



BLACKLEY ROAD PROFILE



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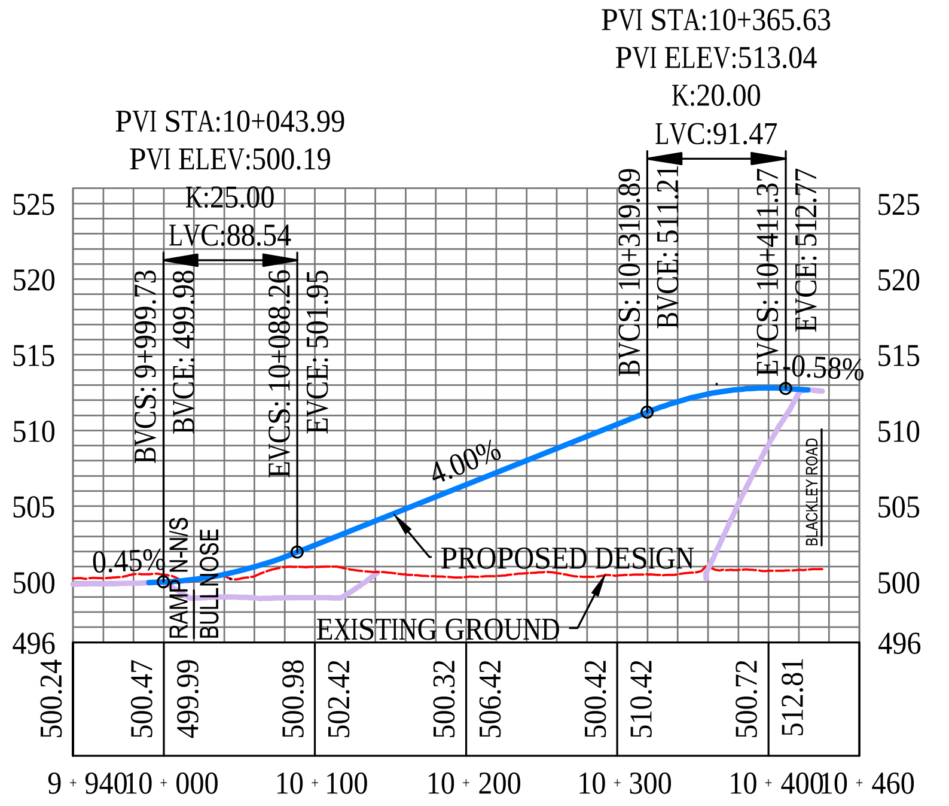
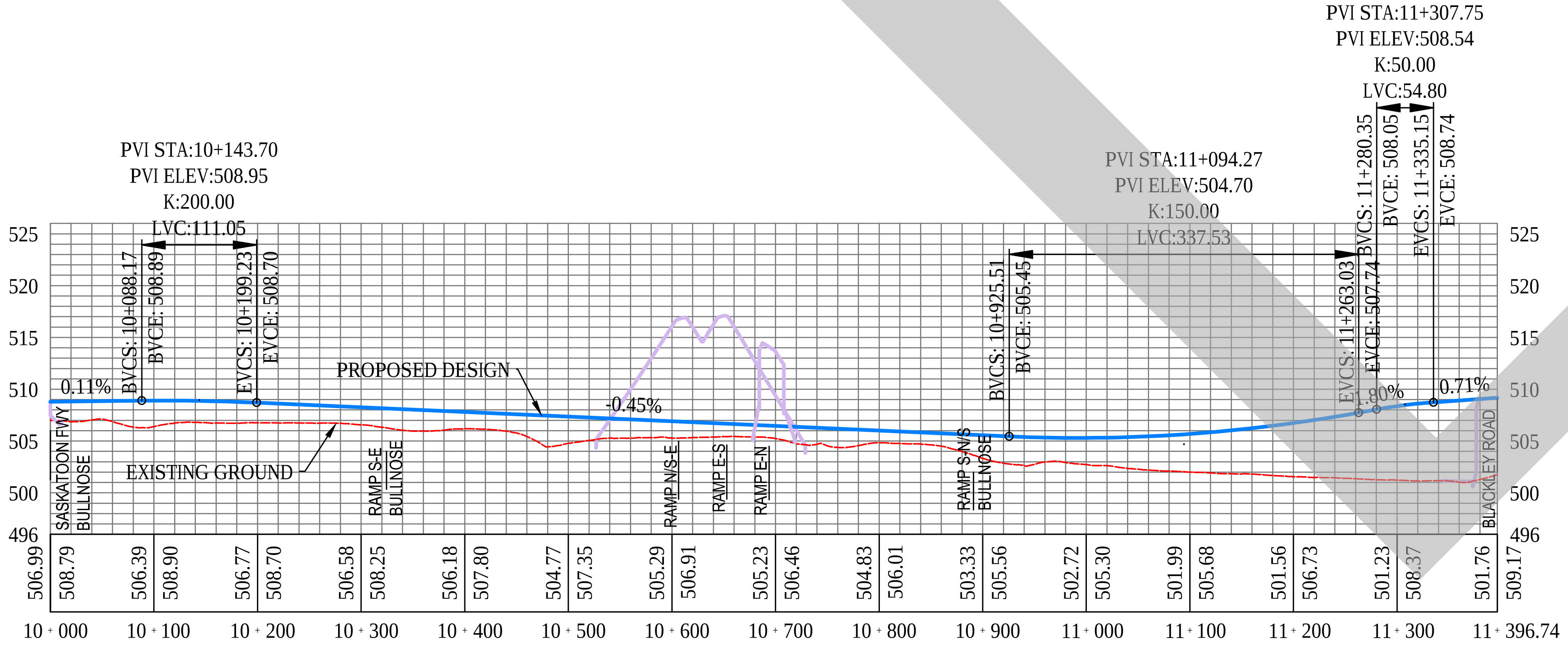


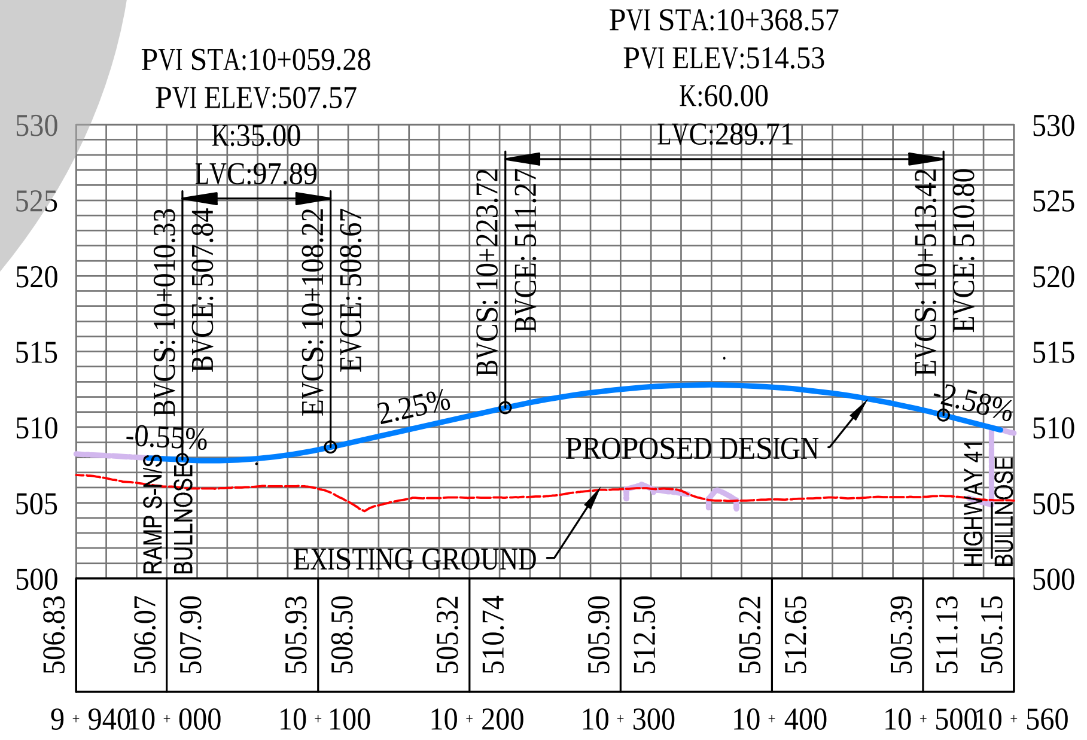
BLACKLEY ROAD S-N/S RAMP PROFILE

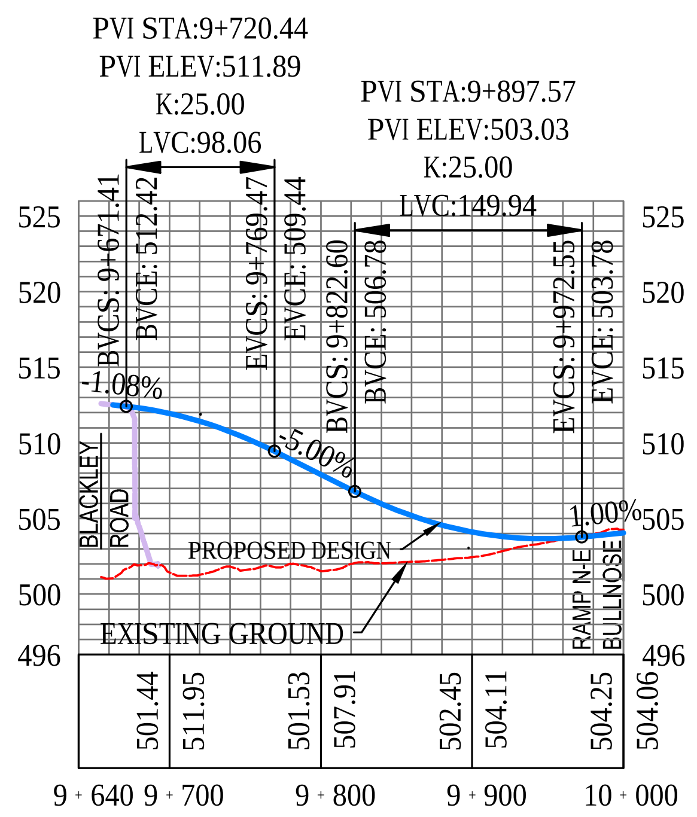
BLACKLEY ROAD S-E RAMP PROFILE

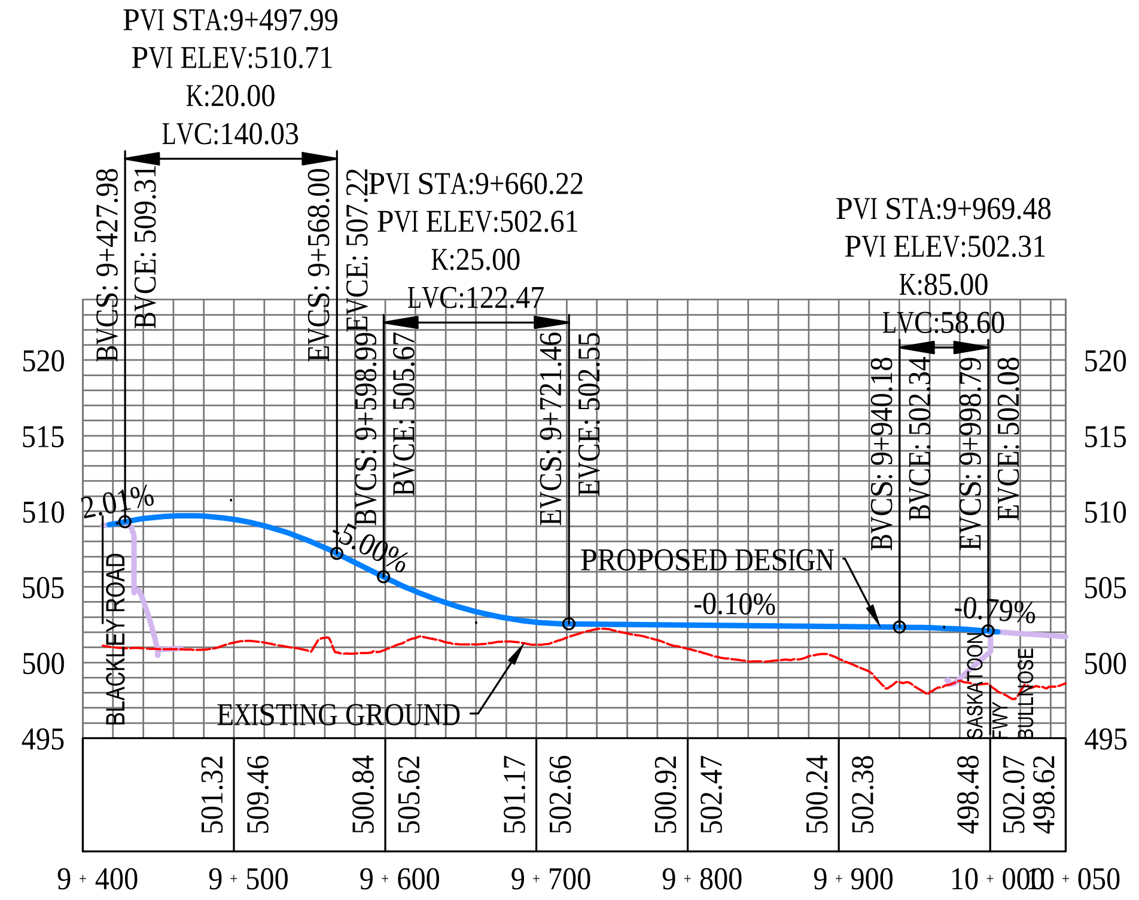
BLACKLEY ROAD N/S-E RAMP PROFILE

BLACKLEY ROAD N/S-N RAMP PROFILE









ACAD DWG:X_BLACKLEY RD IC_ALIGNMENT AND PROFILE.DWG
LAST REV DATE: January 10, 2022

Saskatoon Freeway

Saskatchewan

SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

REVISIONS		
NO	DATE	SIGNATURE

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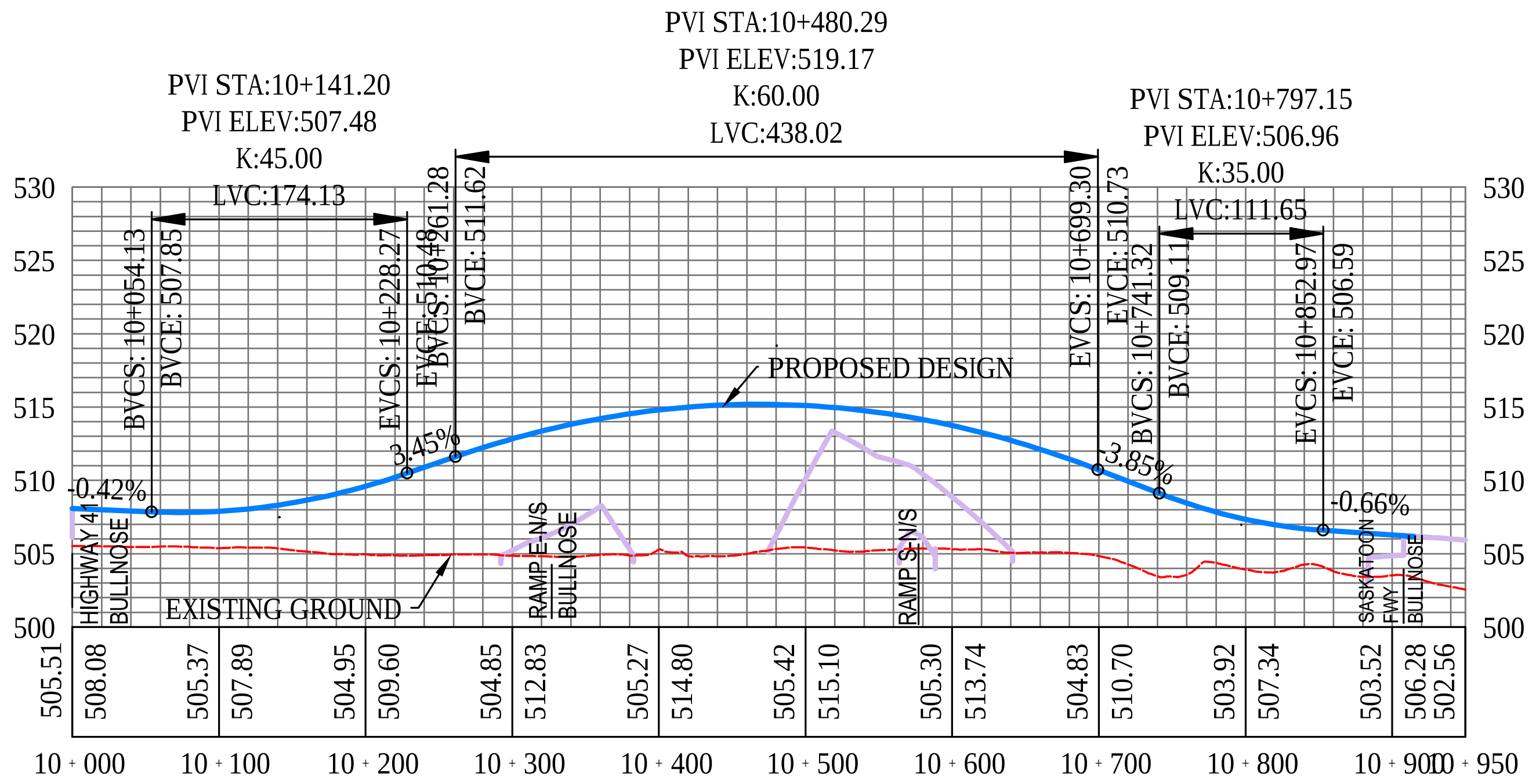
PHOTO DATE	N/A	SHEET	2 OF 2
DRAWN BY	J. GREENE	DATE	22/01/10
DESIGNED BY	AECOM	DATE	22/01/10

BLACKLEY ROAD INTERCHANGE
PROFILES
SASKATOON FREEWAY PROJECT

BLACKLEY ROAD E-N RAMP PROFILE



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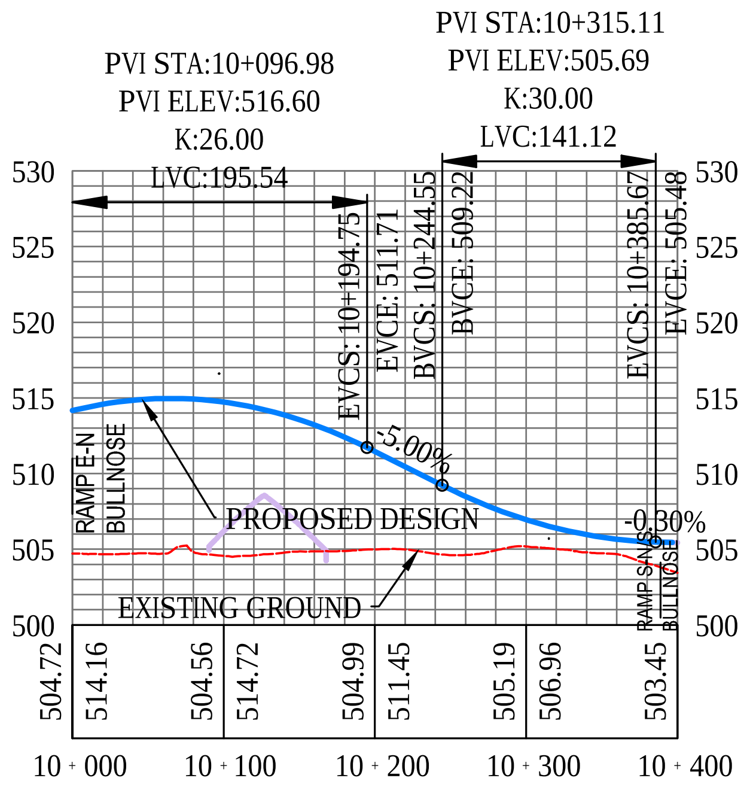

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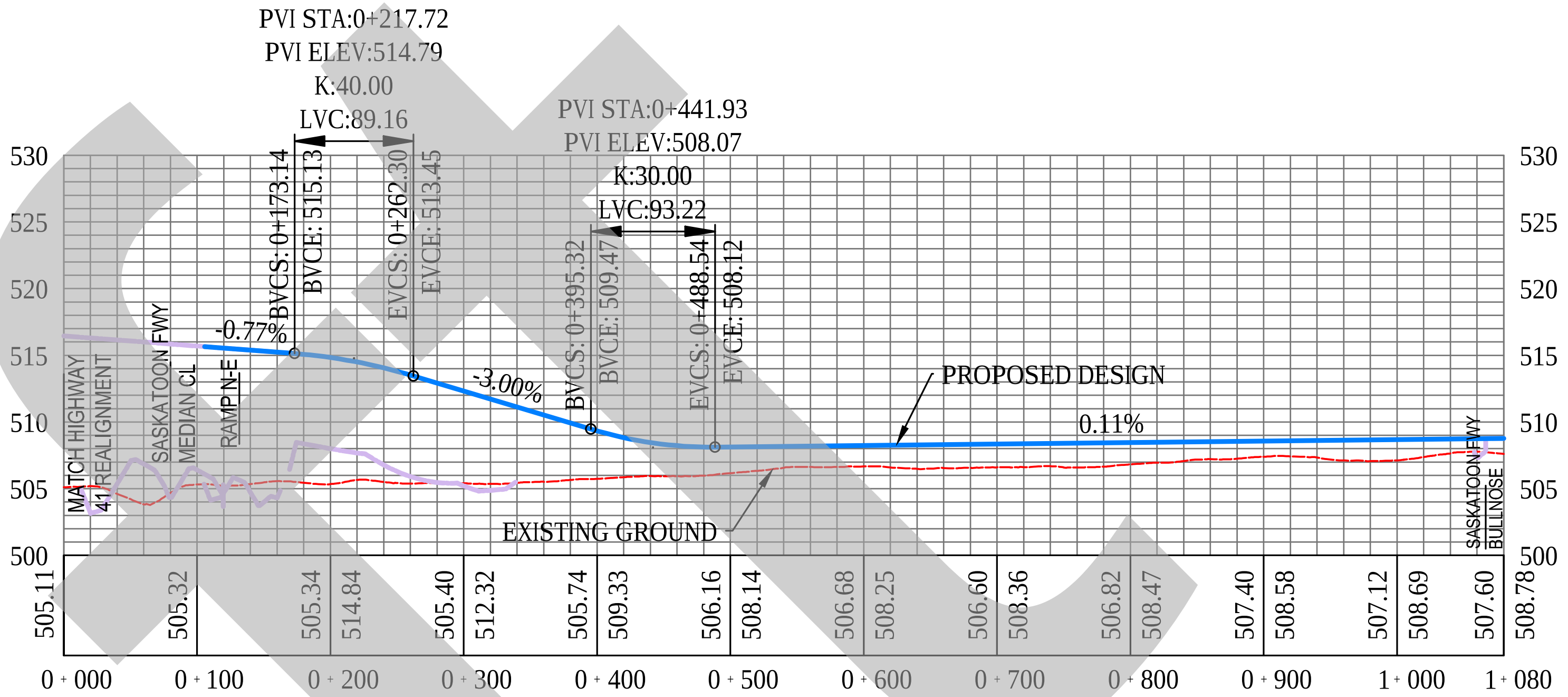

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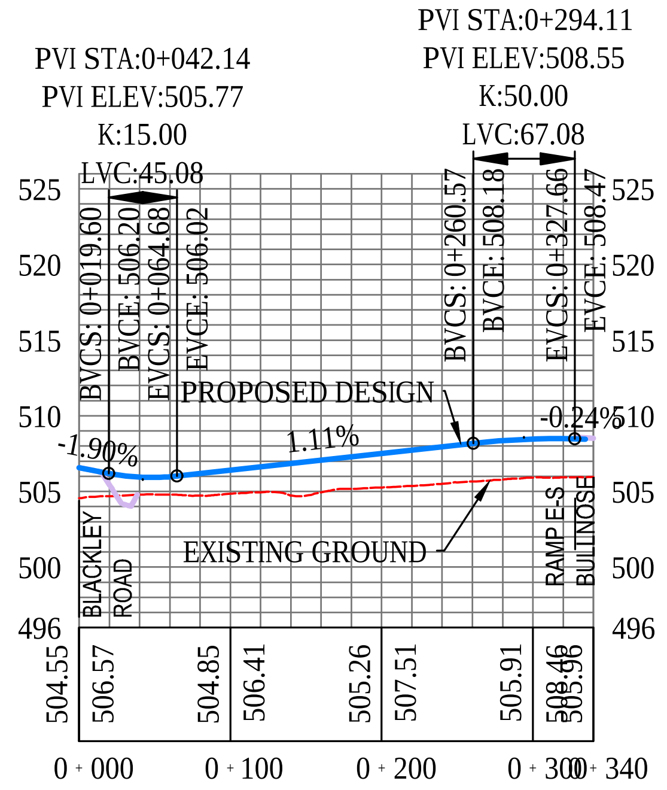

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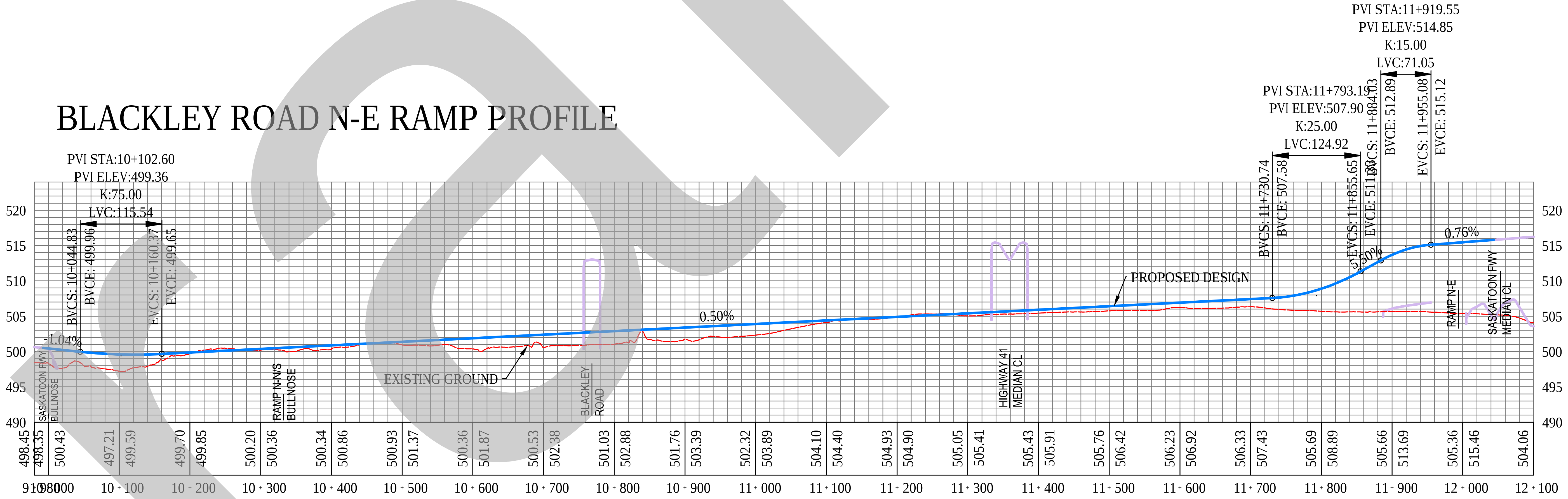
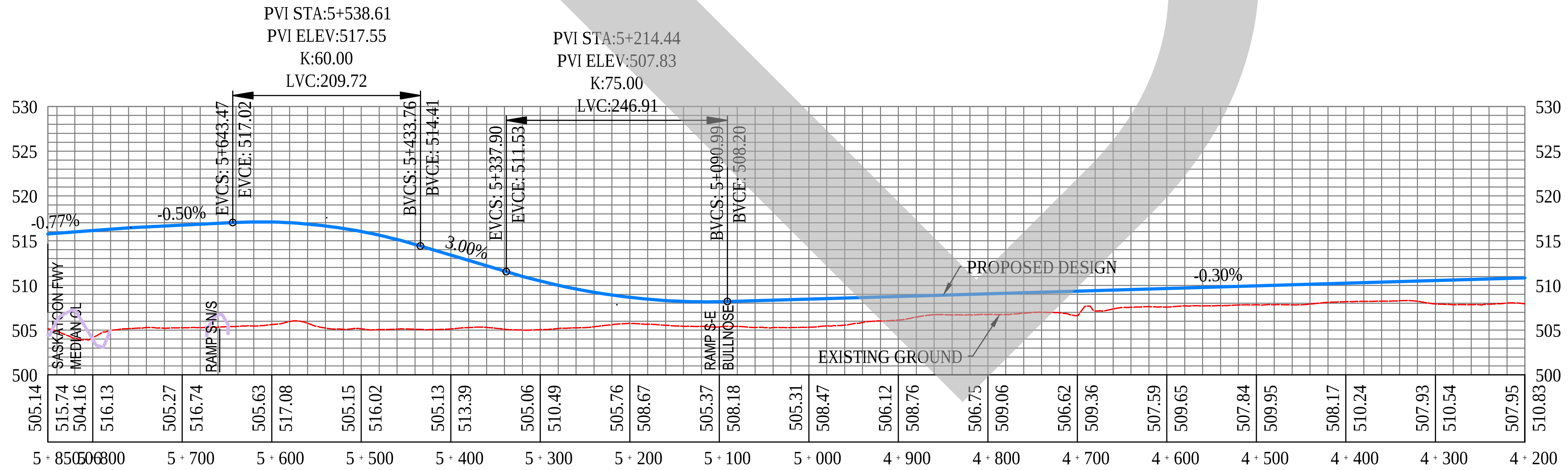


HIGHWAY 41 REALIGNMENT PROFILE



ACAD DWG:X_BLACKLEY RD IC_ALIGNMENT AND PROFILE.DWG
LAST REV DATE: January 10, 2022

Saskatoon Freeway	Saskatchewan	REVISIONS			CS	N/A	TAB NO	Profiles_01
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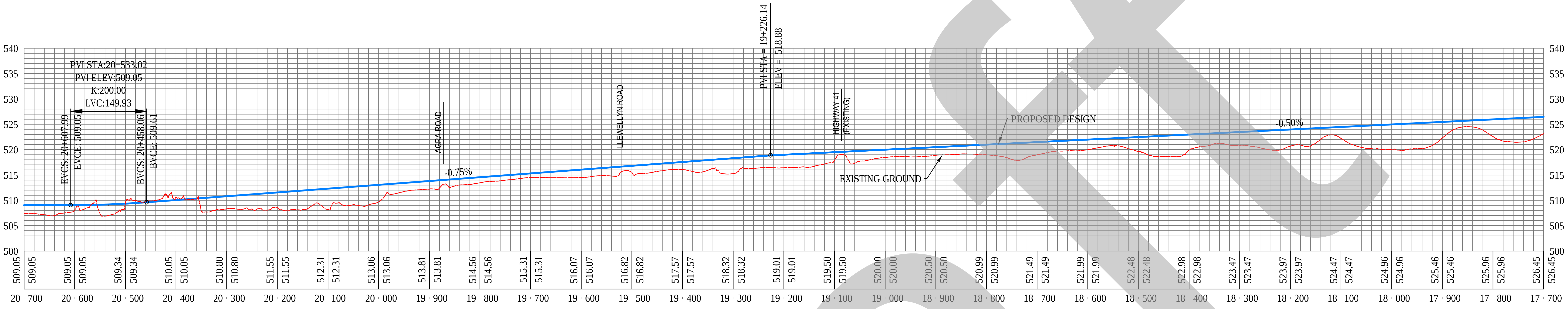
					DRAWN BY	J. GREENE	DATE	22/01/10
					DESIGNED BY	AECOM	DATE	22/01/10

SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

HWY 41 REALIGNMENT
PROFILES
SASKATOON FREEWAY PROJECT

SASKATOON FREEWAY MAINLINE PROFILE



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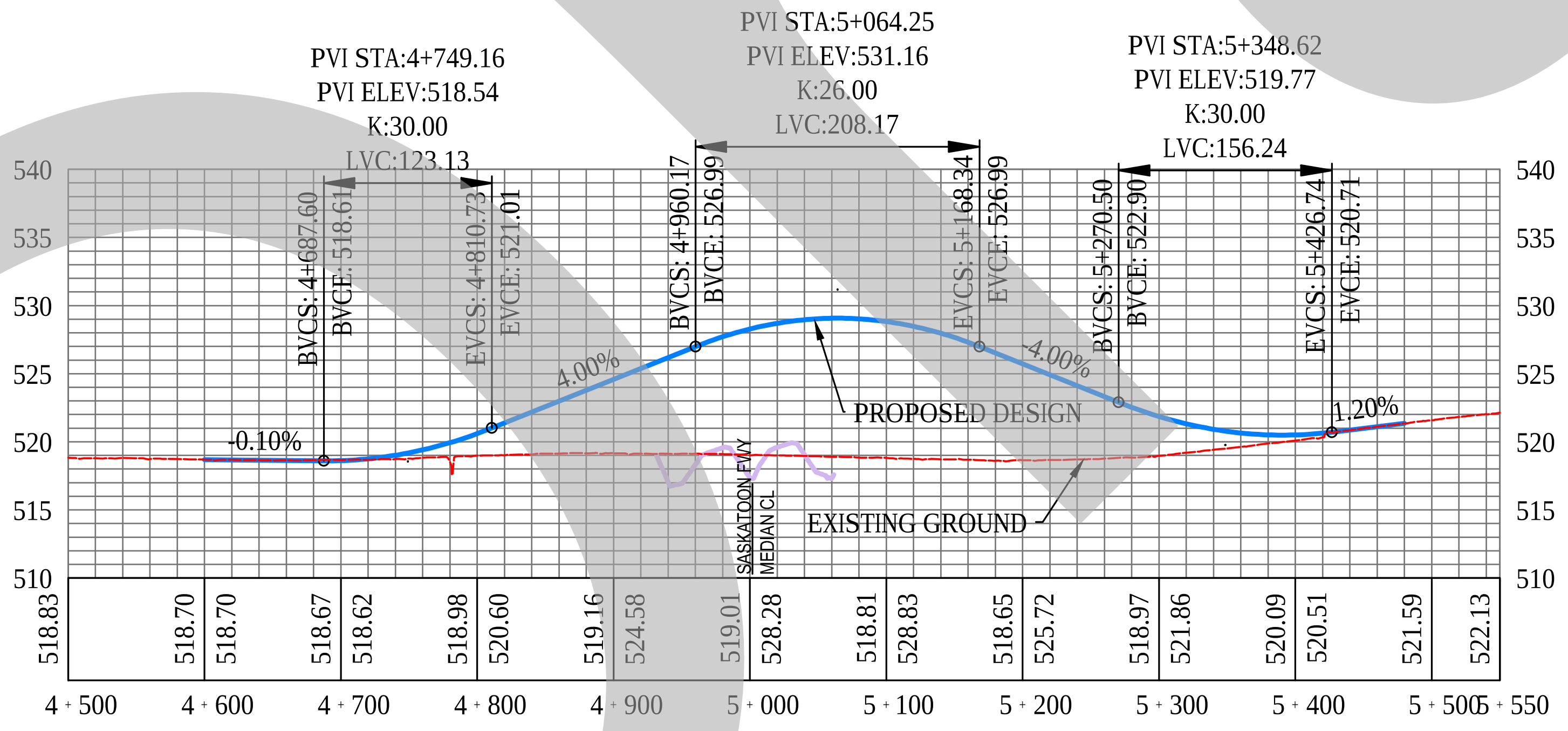

ACAD DWG: X_HWY 41 REALIGNMENT IC_ALIGNMENT AND PROFILE.DWG
LAST REV DATE: January 10, 2022

Saskatoon Freeway	Saskatchewan	REVISIONS			CS	N/A	TAB NO	Profiles_02
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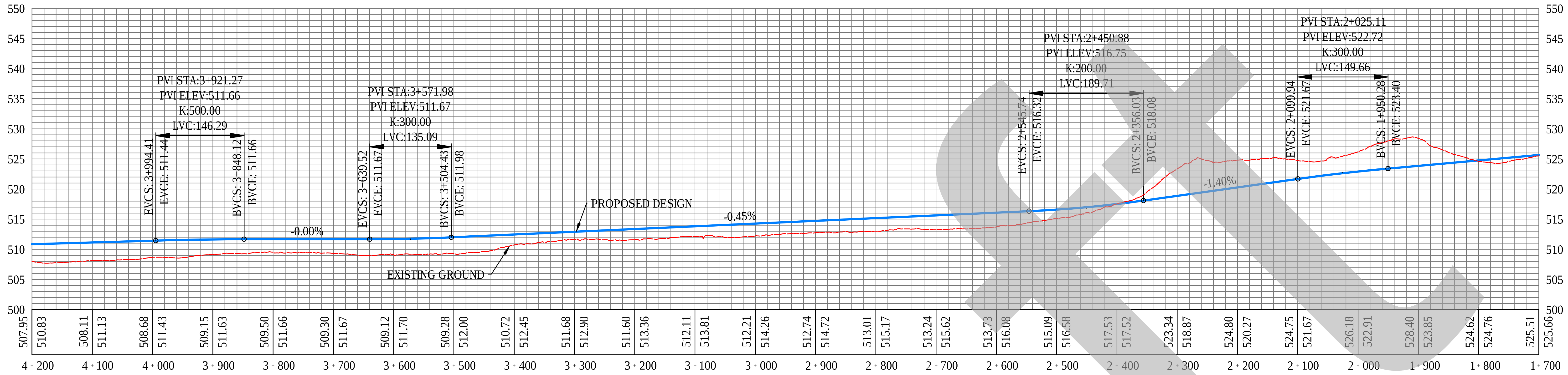
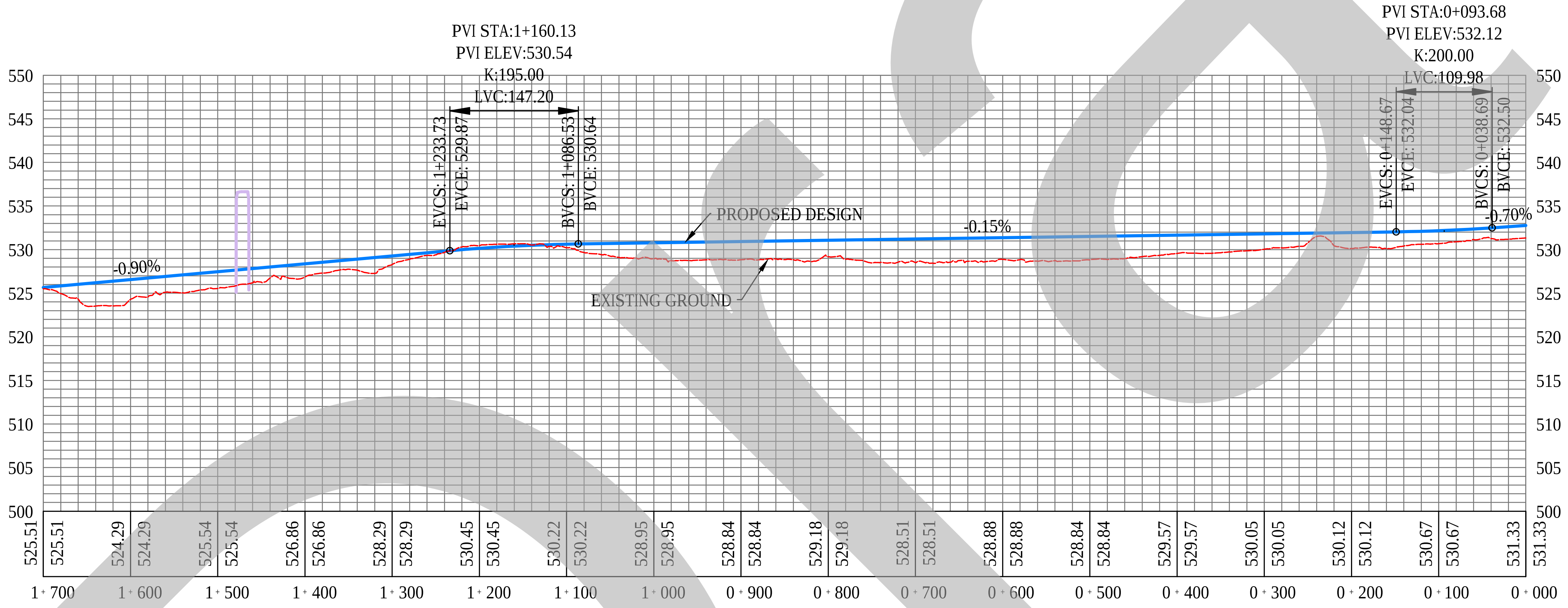
					DRAWN BY	J. GREENE	DATE	22/01/10
					DESIGNED BY	AECOM	DATE	22/01/10
	SCALE 1: 5 000 HORIZONTAL 1: 50 000 VERTICAL				HWY 41 REALIGNMENT PROFILES SASKATOON FREEWAY PROJECT			

HIGHWAY 41 REALIGNMENT PROFILE



HIGHWAY 41 REALIGNMENT PROFILE



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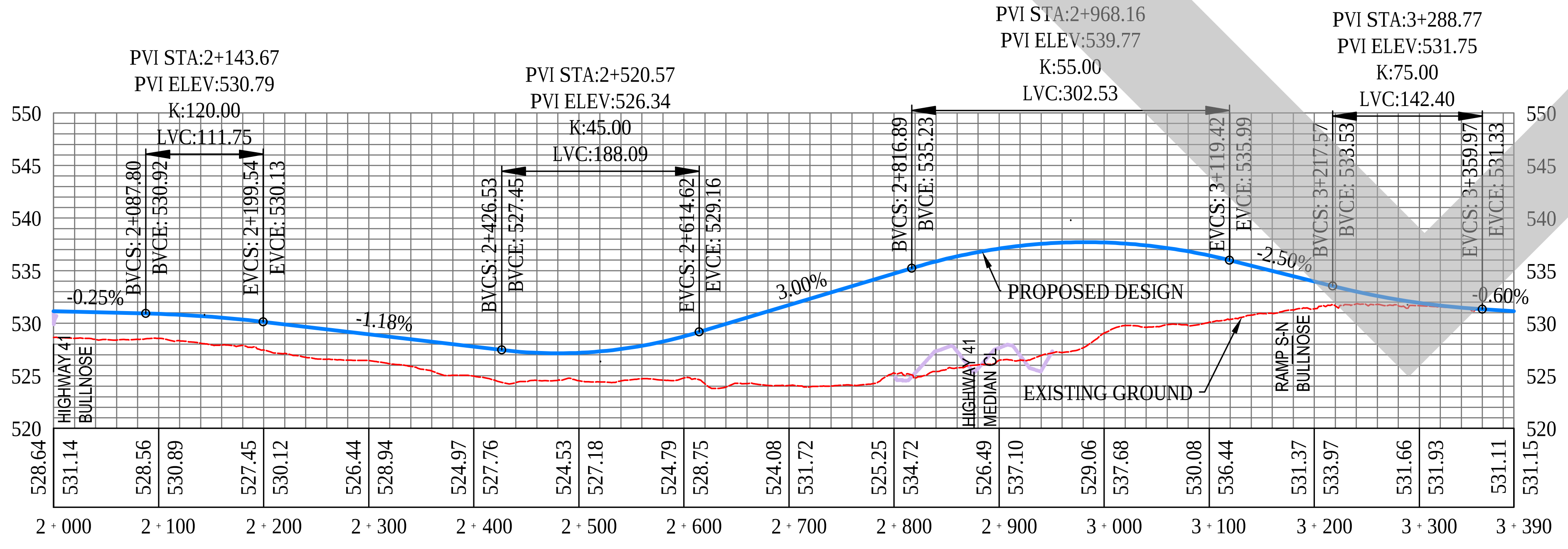

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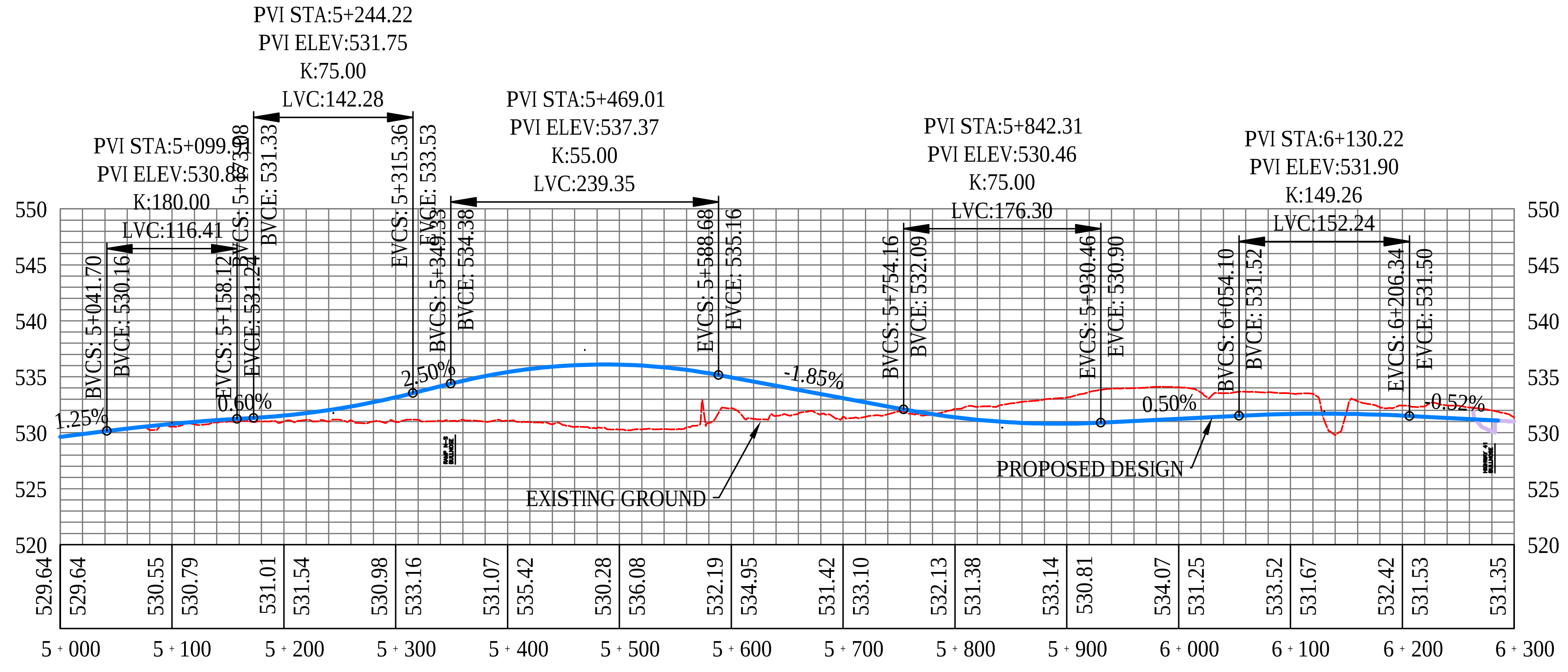


ACAD DWG:X_HWY 41 REALIGNMENT IC_ALIGNMENT AND PROFILE.DWG
LAST REV DATE: January 10, 2022

Saskatoon Freeway

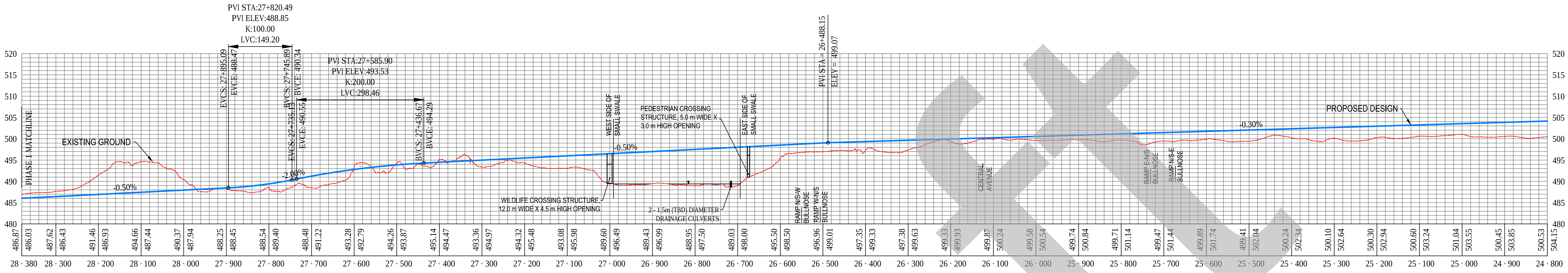
Saskatchewan

REVISIONS						
NO	DATE	SIGNATURE	CS	N/A	TAB NO	Profiles_01
			PHOTO DATE	N/A	SHEET	1 OF 1
			DRAWN BY	J. GREENE	DATE	22/01/10
			DESIGNED BY	AECOM	DATE	22/01/10

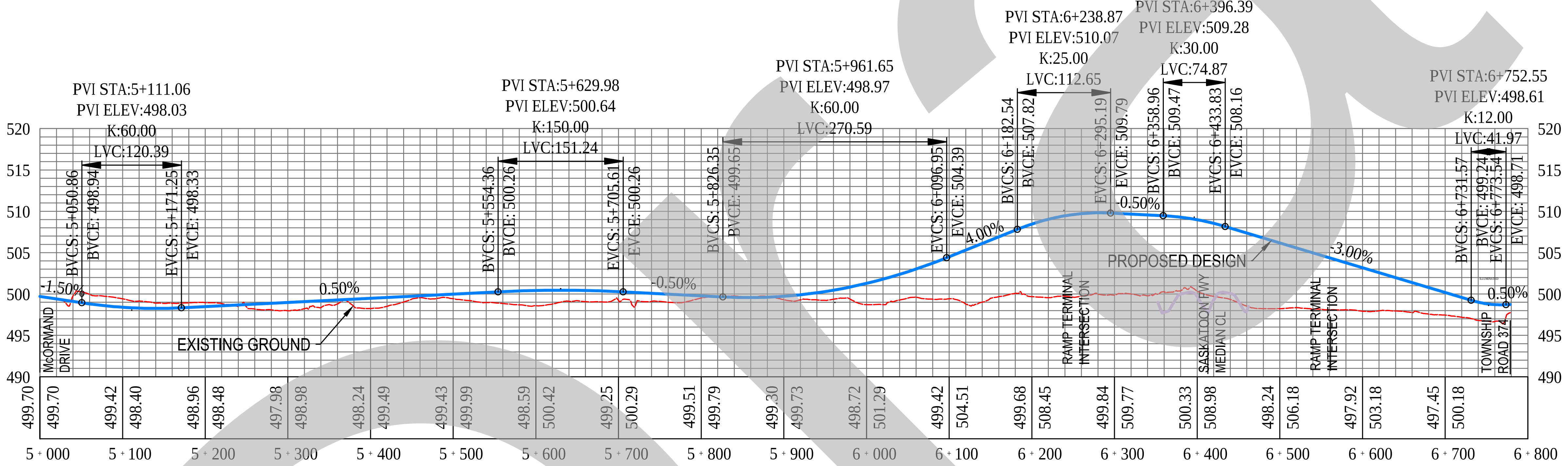
SCALE
1: 5 000 HORIZONTAL
1: 50 000 VERTICAL

CENTRAL AVENUE INTERCHANGE
PROFILES
SASKATOON FREEWAY PROJECT

SASKATOON FREEWAY MAINLINE PROFILE



CENTRAL AVENUE PROFILE



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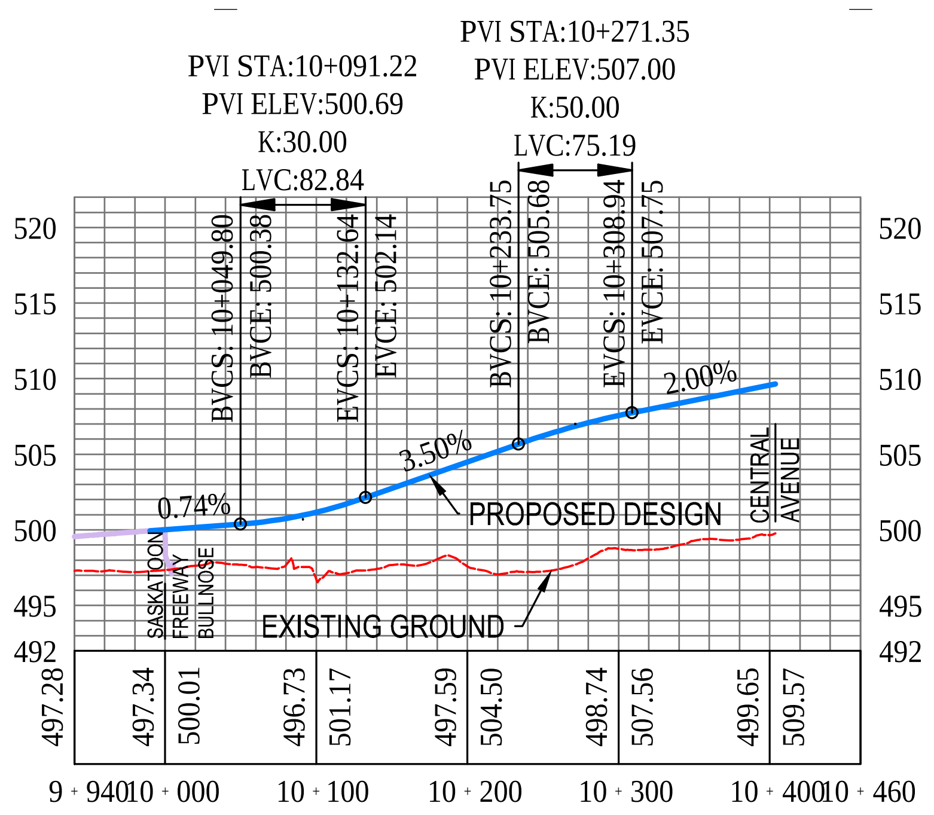

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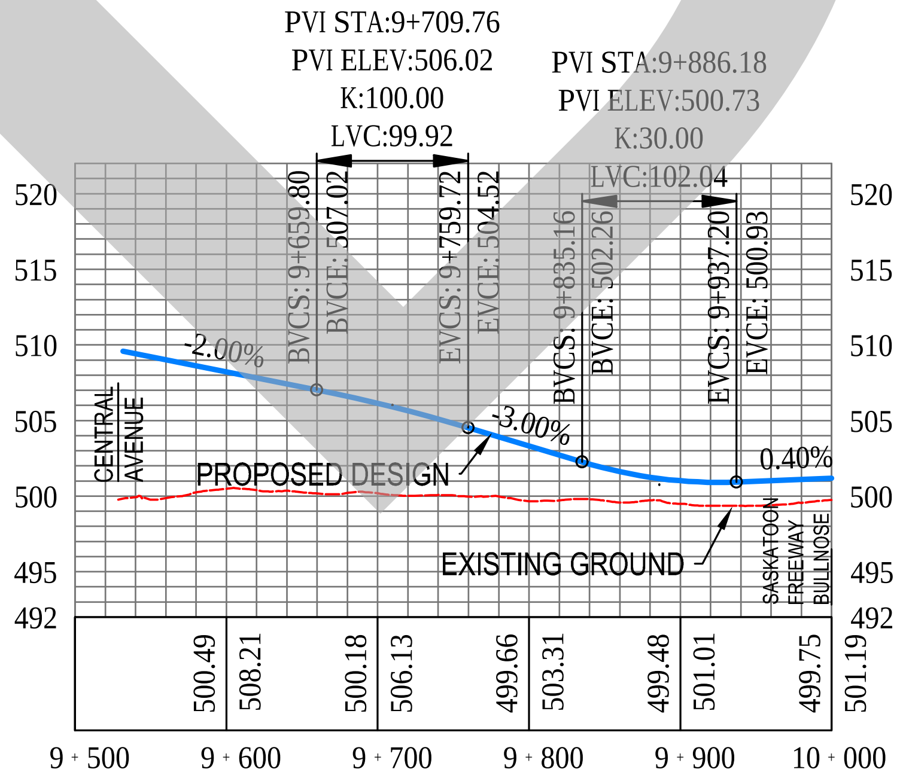

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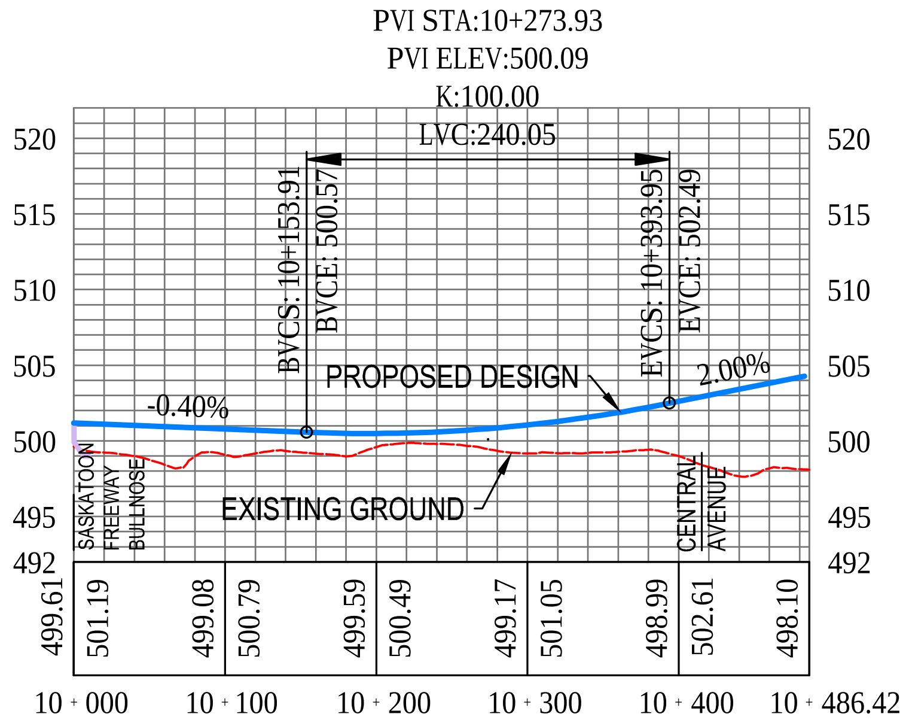
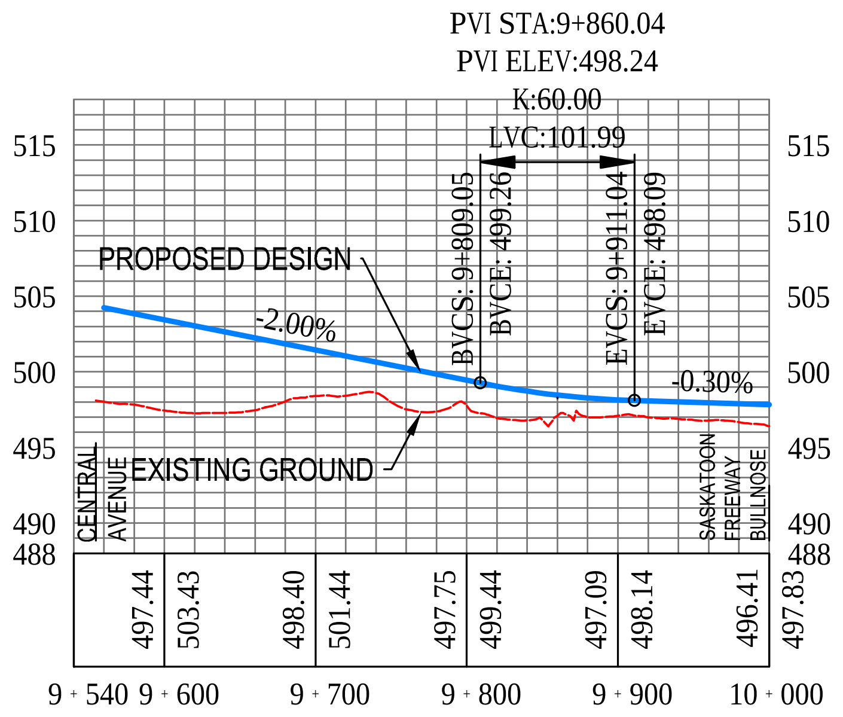


CENTRAL AVE N/S-W RAMP PROFILE

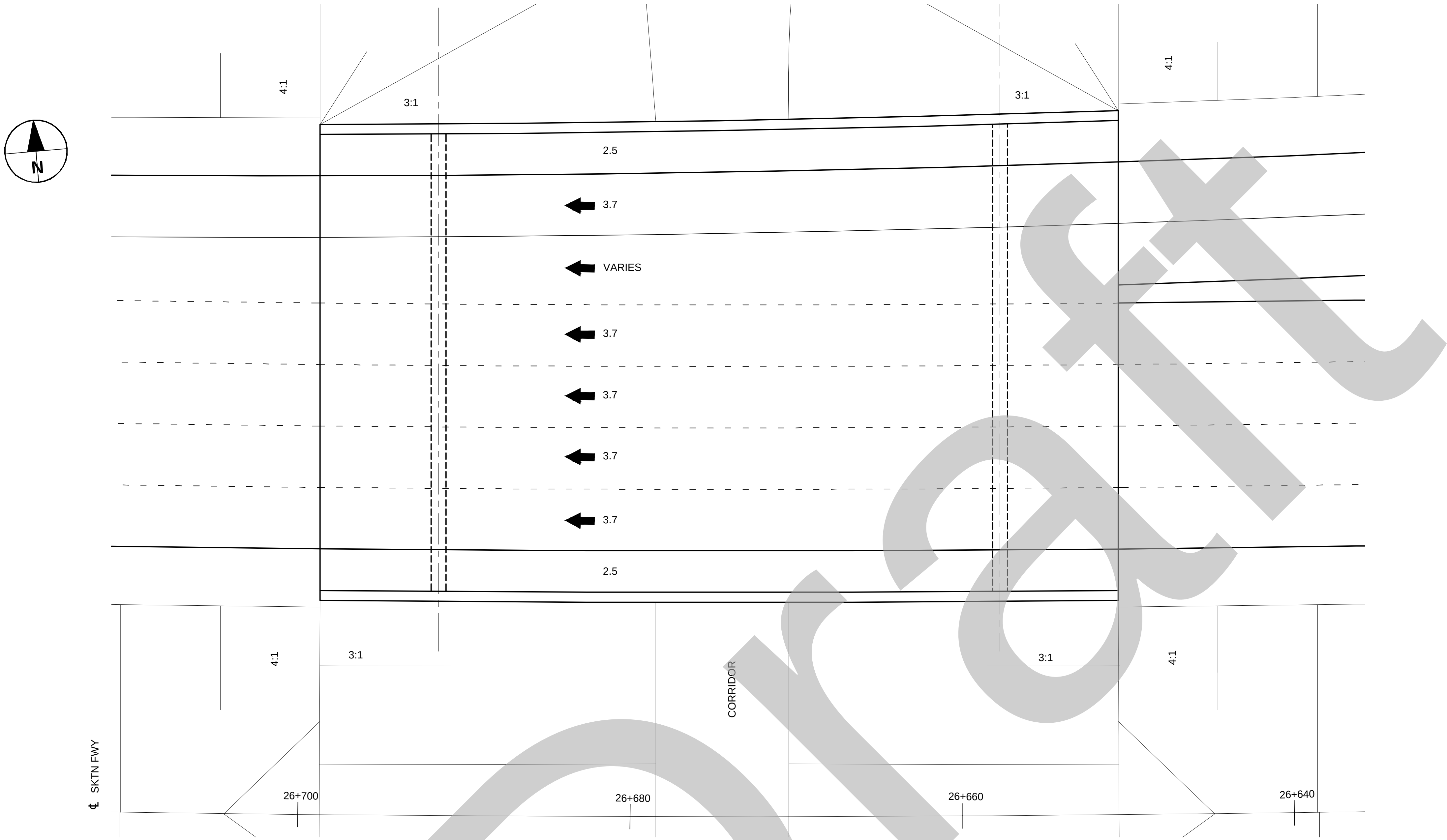


ACAD DWG:X_CENTRAL AVE_IC_ALIGNMENT AND PROFILE.DWG
LAST REV DATE: January 10, 2022

APPENDIX L

Interchange Bridge Plans and Profiles

SMALL SWALE - PEDESTRIAN CORRIDOR UNDERPASS



PLAN

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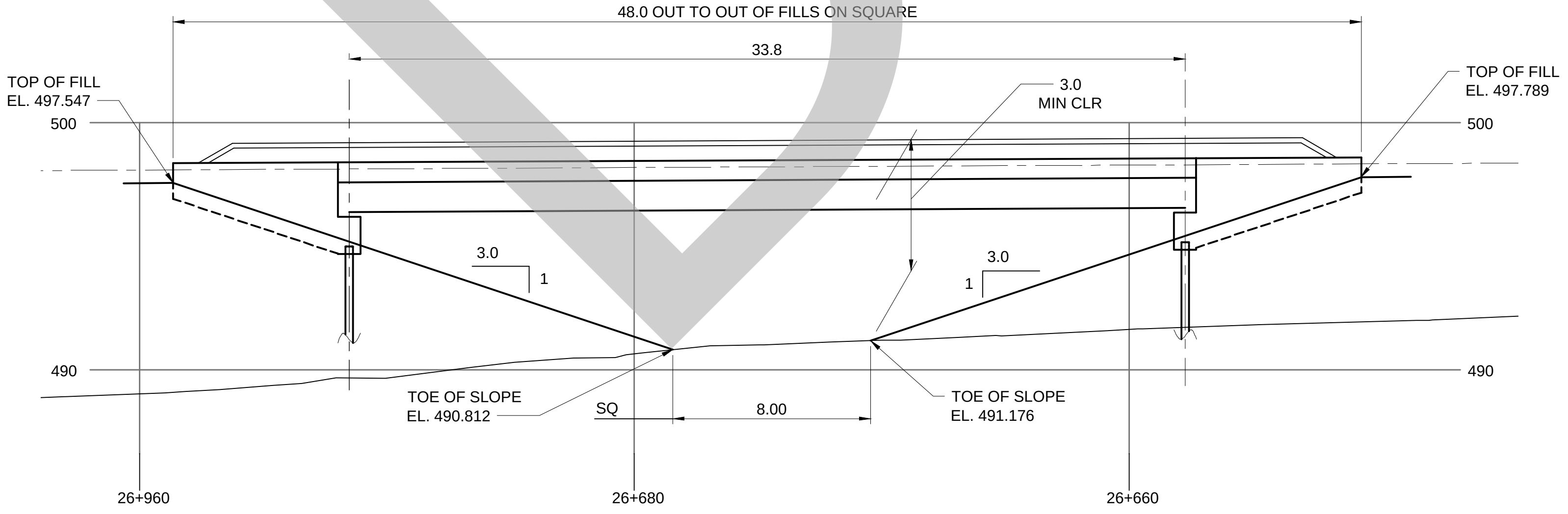
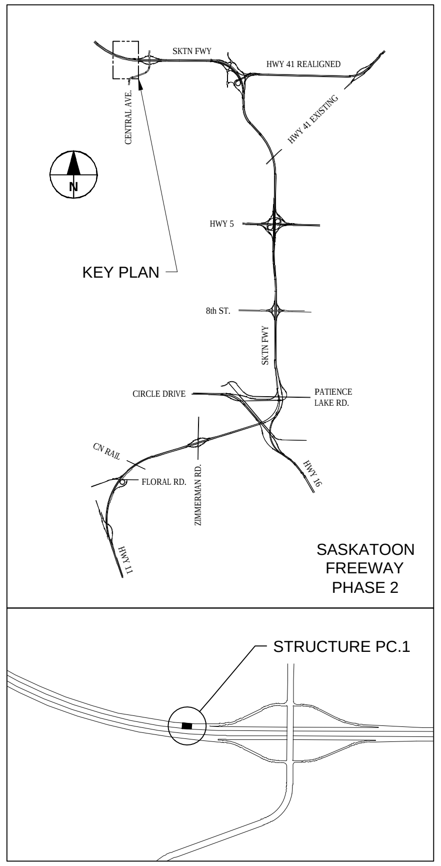


ELEVATION

Scale 1:300



KEY PLAN

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE PC.1

RECOMMENDED BY: ______________________ ________
SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: ______________________ ________
DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

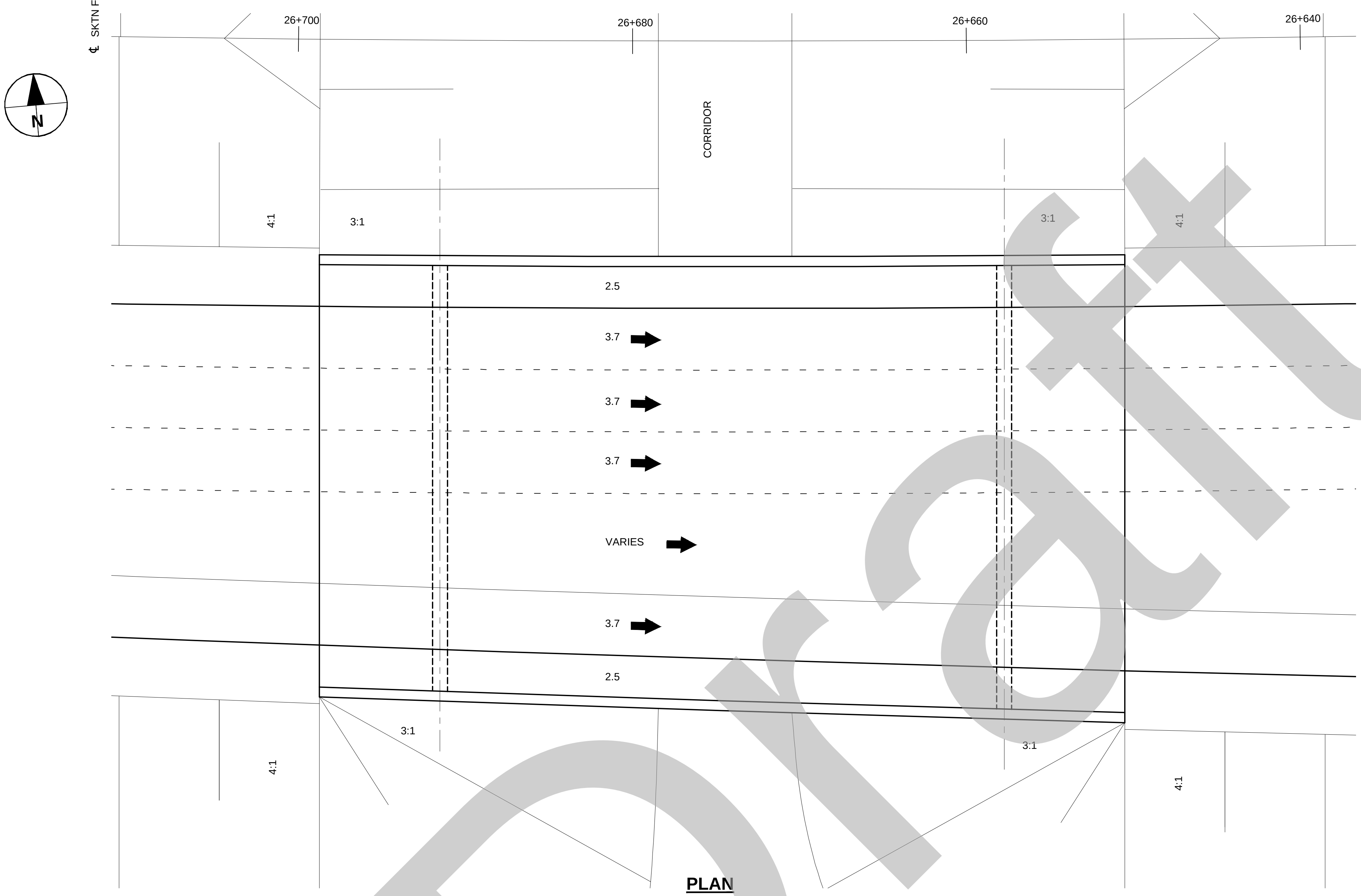
DESIGN	DRAWN	CHECKED	FILE
–	KC	–	–
DATE	DATE	DATE	PLAN
–	–	–	–

Sheet 1 of –

LAST REVISED DATE: 22–JAN–2009 1:40 PM

Filename: C:\USERS\CAMERONKJ\ONEDRIVE - AECOM\DESKTOP\WORK\60594864\PHASE 2\GA-WC-1.DWG

SMALL SWALE - PEDESTRIAN CORRIDOR UNDERPASS



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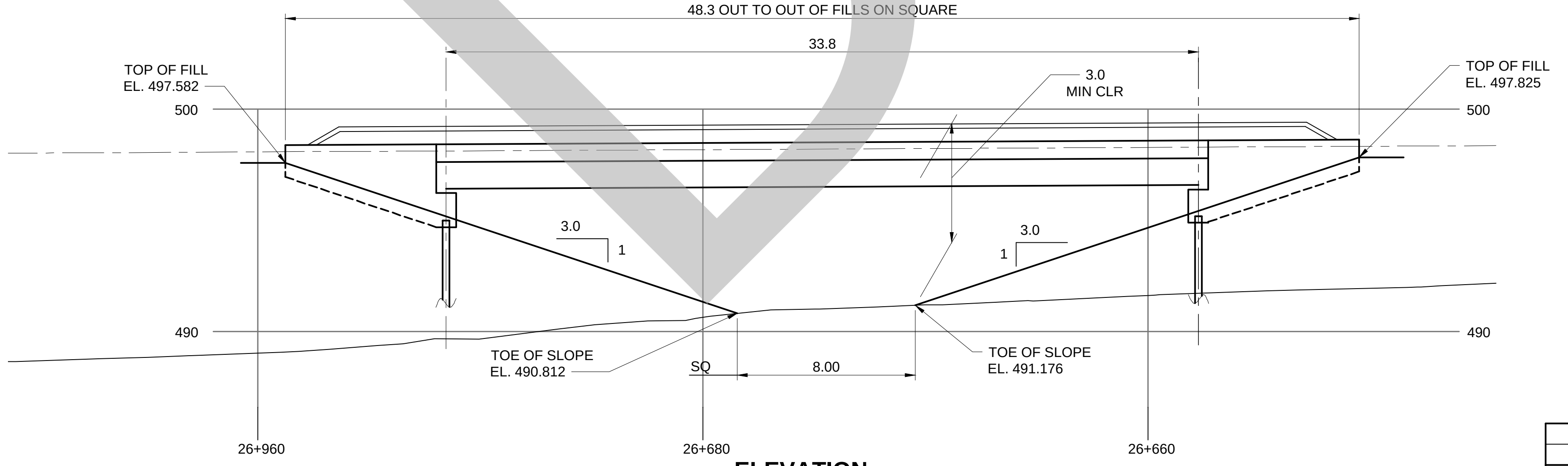

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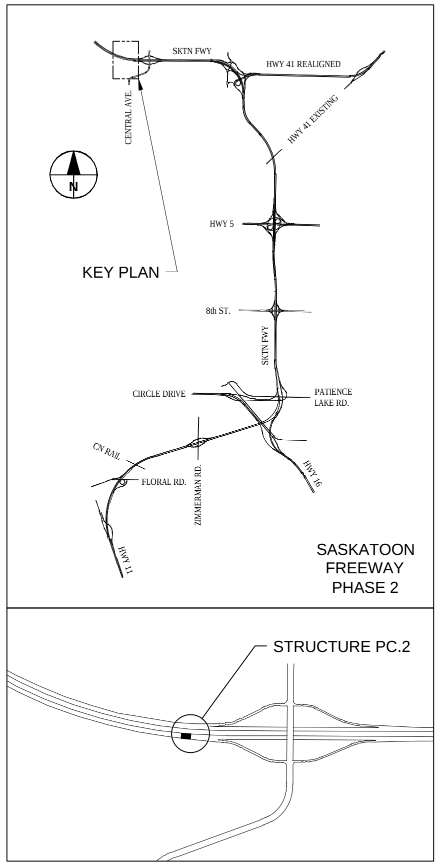

KEY PLAN

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE PC.2

RECOMMENDED BY: SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

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–	KC	–	–
DATE	DATE	DATE	PLAN
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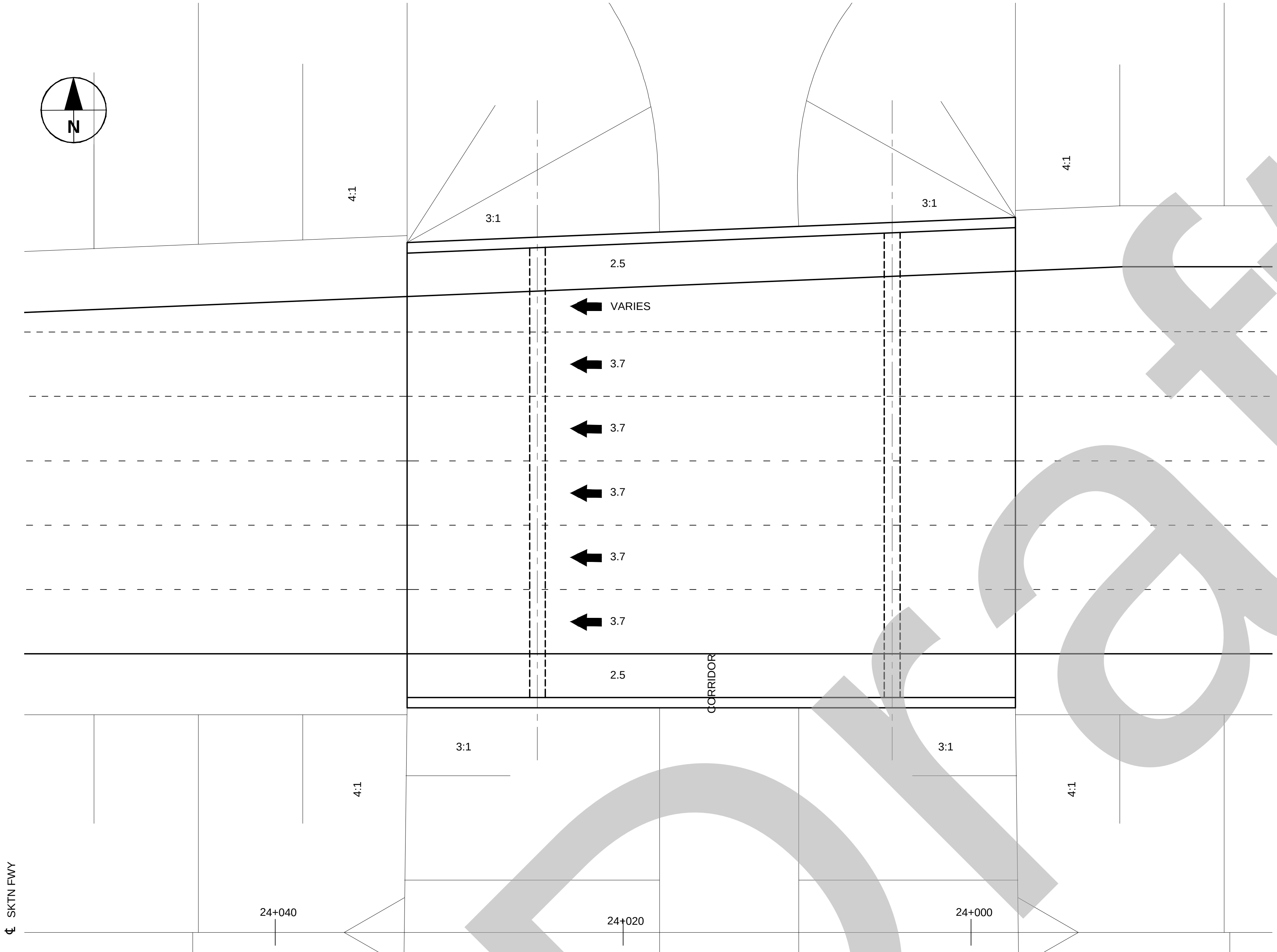
Sheet 1 of –

LAST REVISED DATE: 22-JAN-2009 1:40 PM

Filename: C:\USERS\CAMERONKJ\ONEDRIVE - AECOM\DESKTOP\WORK\60594864\PHASE 2\GA-WC-1.DWG

NORTHEAST SWALE - PEDESTRIAN CORRIDOR UNDERPASS



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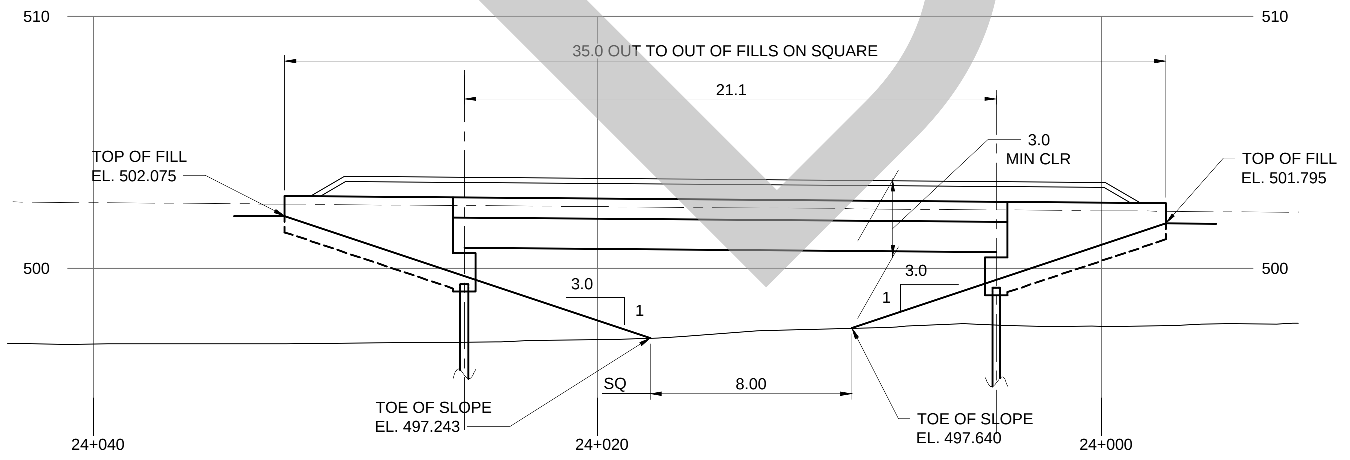

ELEVATION
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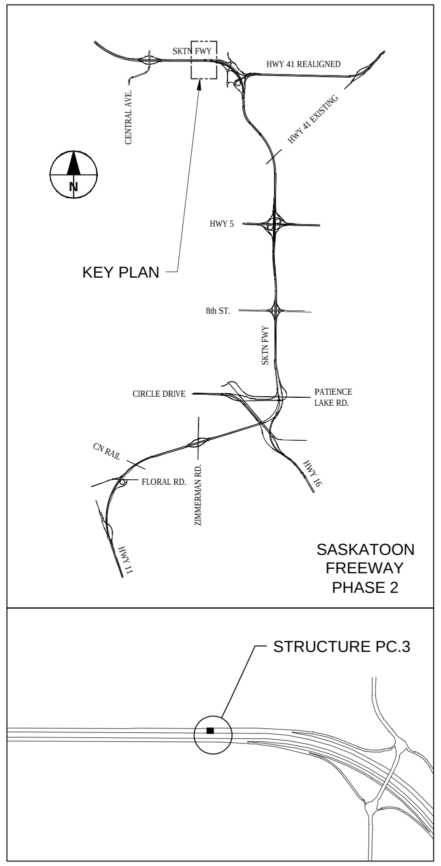

KEY PLAN

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE PC.3

RECOMMENDED BY: ______________________ ________
SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: ______________________ ________
DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

DESIGN	DRAWN	CHECKED	FILE
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DATE	DATE	DATE	PLAN
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Sheet 1 of –

LAST REVISED DATE: 22–JAN–2009 1:40 PM

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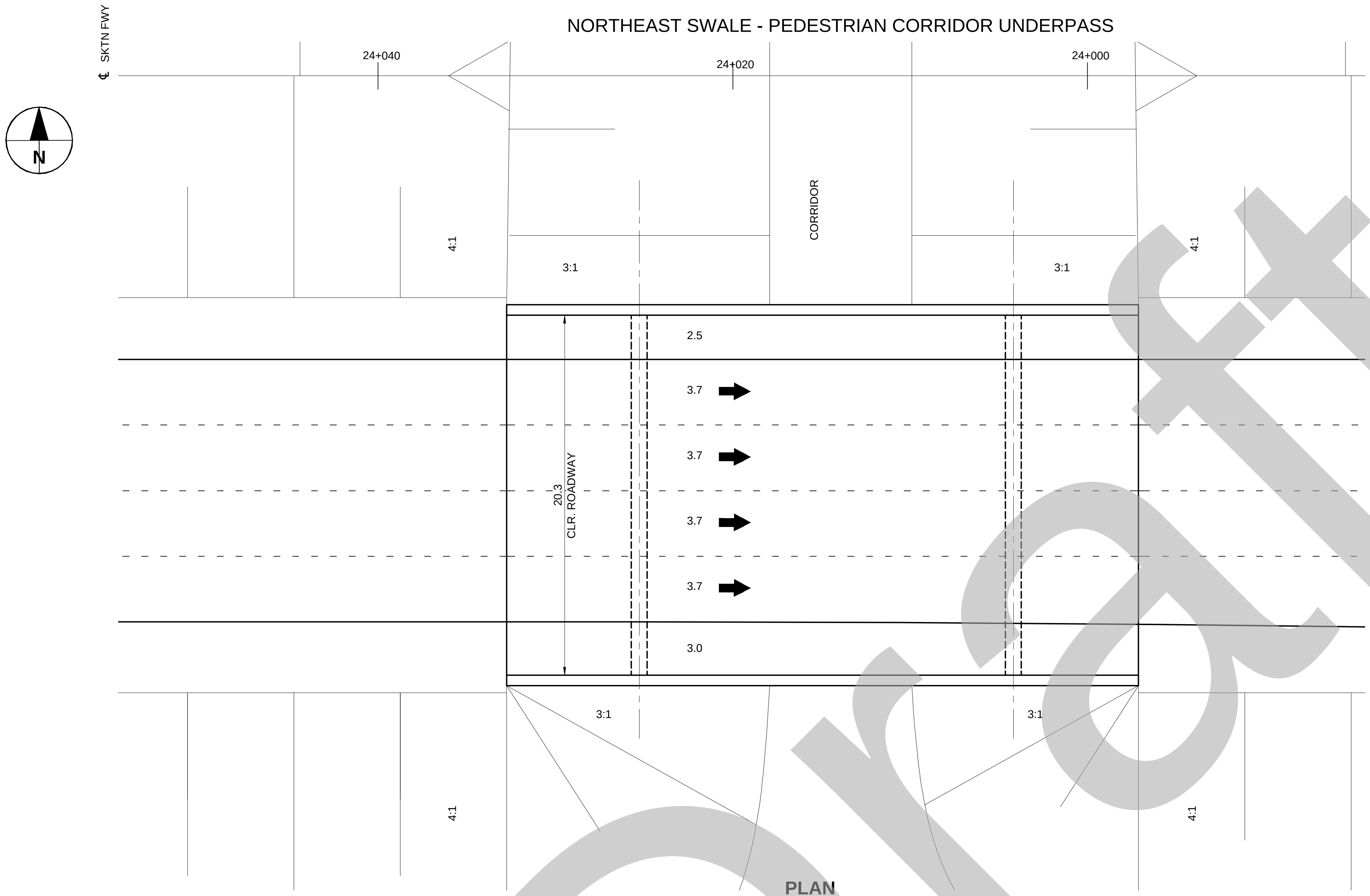
NORTHEAST SWALE - PEDESTRIAN CORRIDOR UNDERPASS



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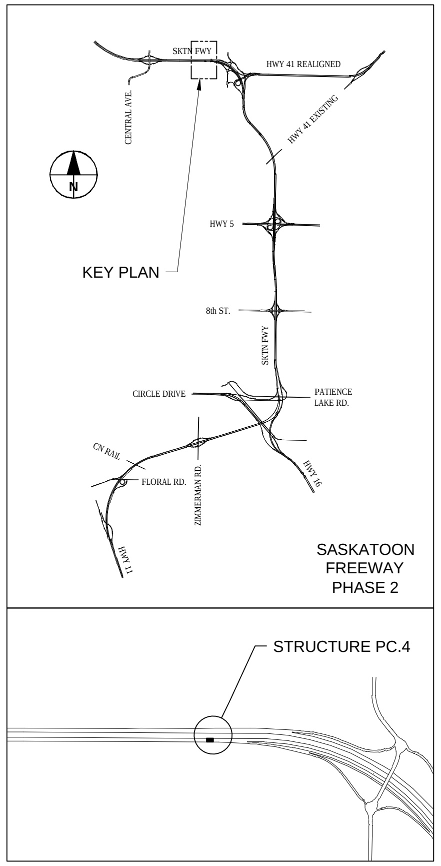

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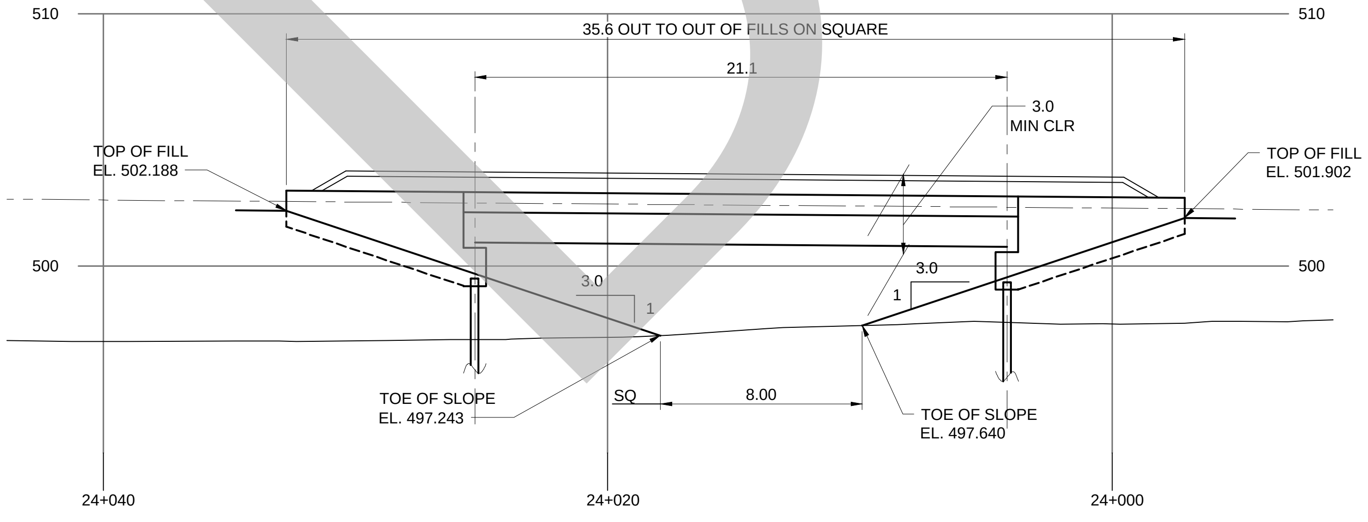

ELEVATION
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PRELIMINARY

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REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE PC.4

RECOMMENDED BY: ________ SENIOR BRIDGE PROJECT MANAGER ________ DATE

APPROVED BY: ________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ________ DATE

DESIGN	DRAWN	CHECKED	FILE
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DATE	**DATE**	**DATE**	**PLAN**
–	–	–	–

Sheet 1 of –

LAST REVISED DATE: 22-JAN-2009 1:40 PM

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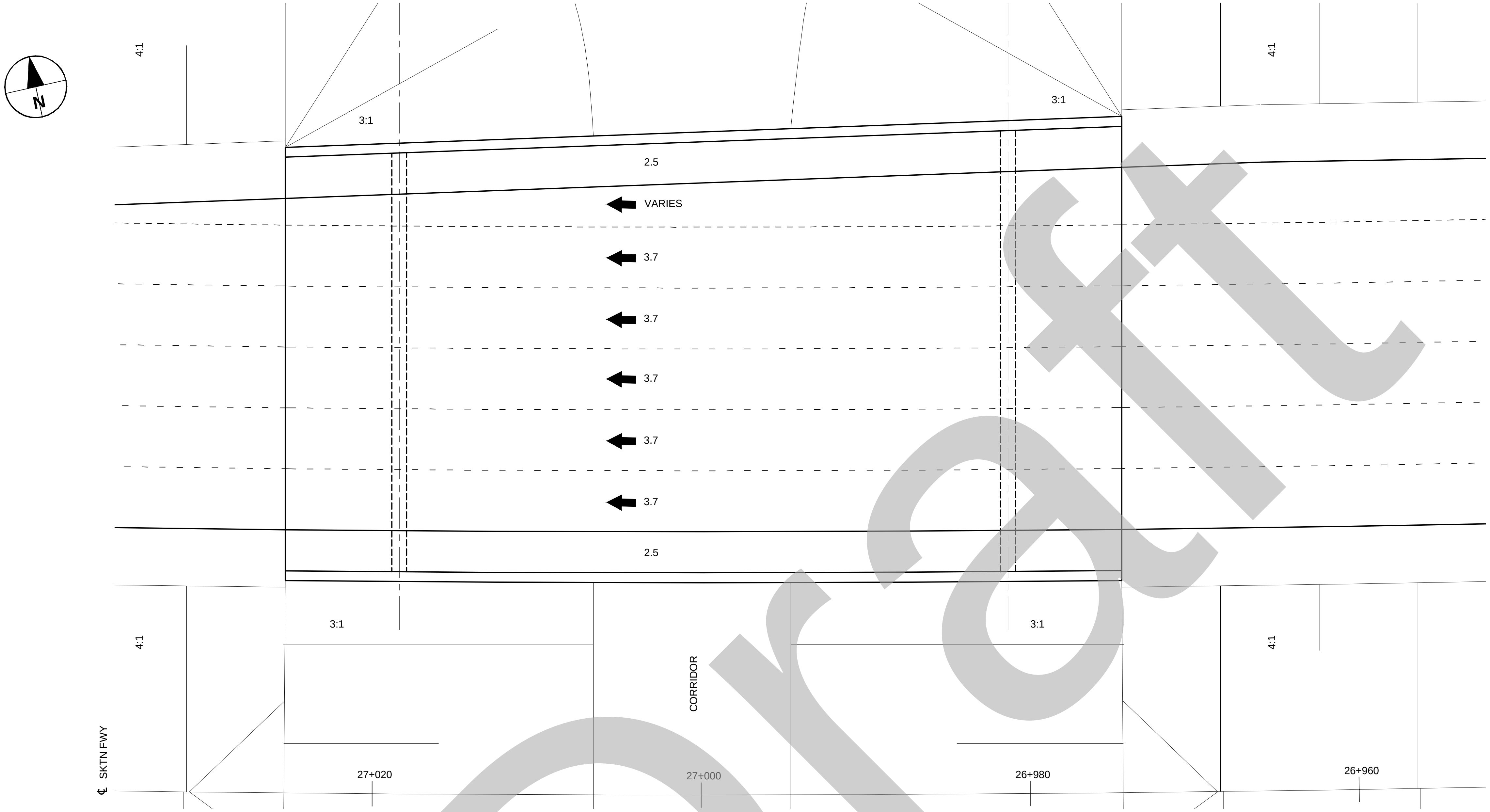
SMALL SWALE - WILDLIFE CORRIDOR UNDERPASS



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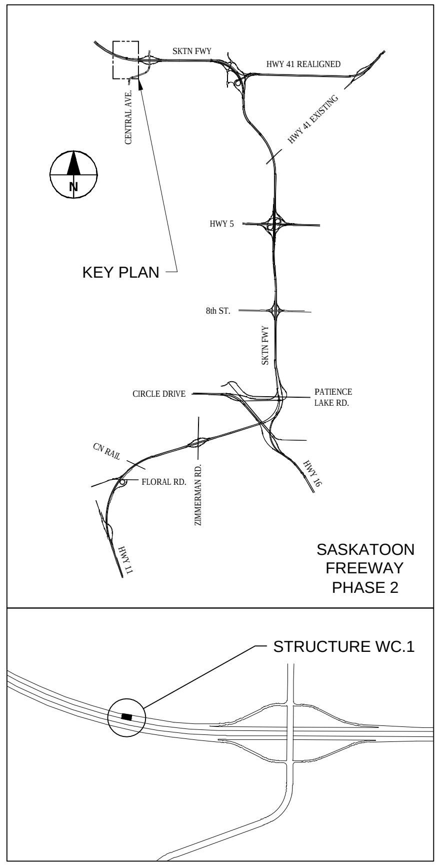

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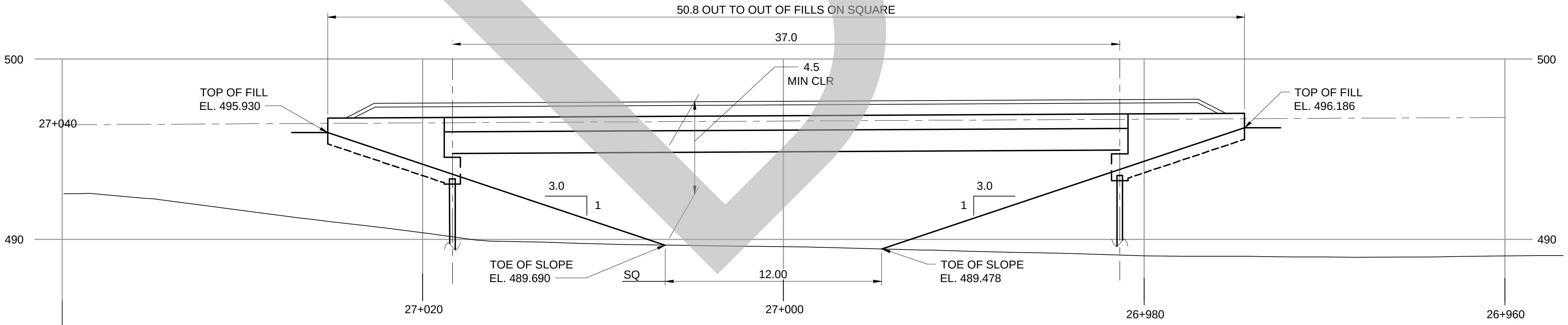

ELEVATION
Scale 1:300

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE WC.1

RECOMMENDED BY: ______ SENIOR BRIDGE PROJECT MANAGER ______ DATE

APPROVED BY: ______ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ______ DATE

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DATE	DATE	DATE	PLAN
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Sheet 1 of –

LAST REVISED DATE: 22–JAN–2009 1:40 PM

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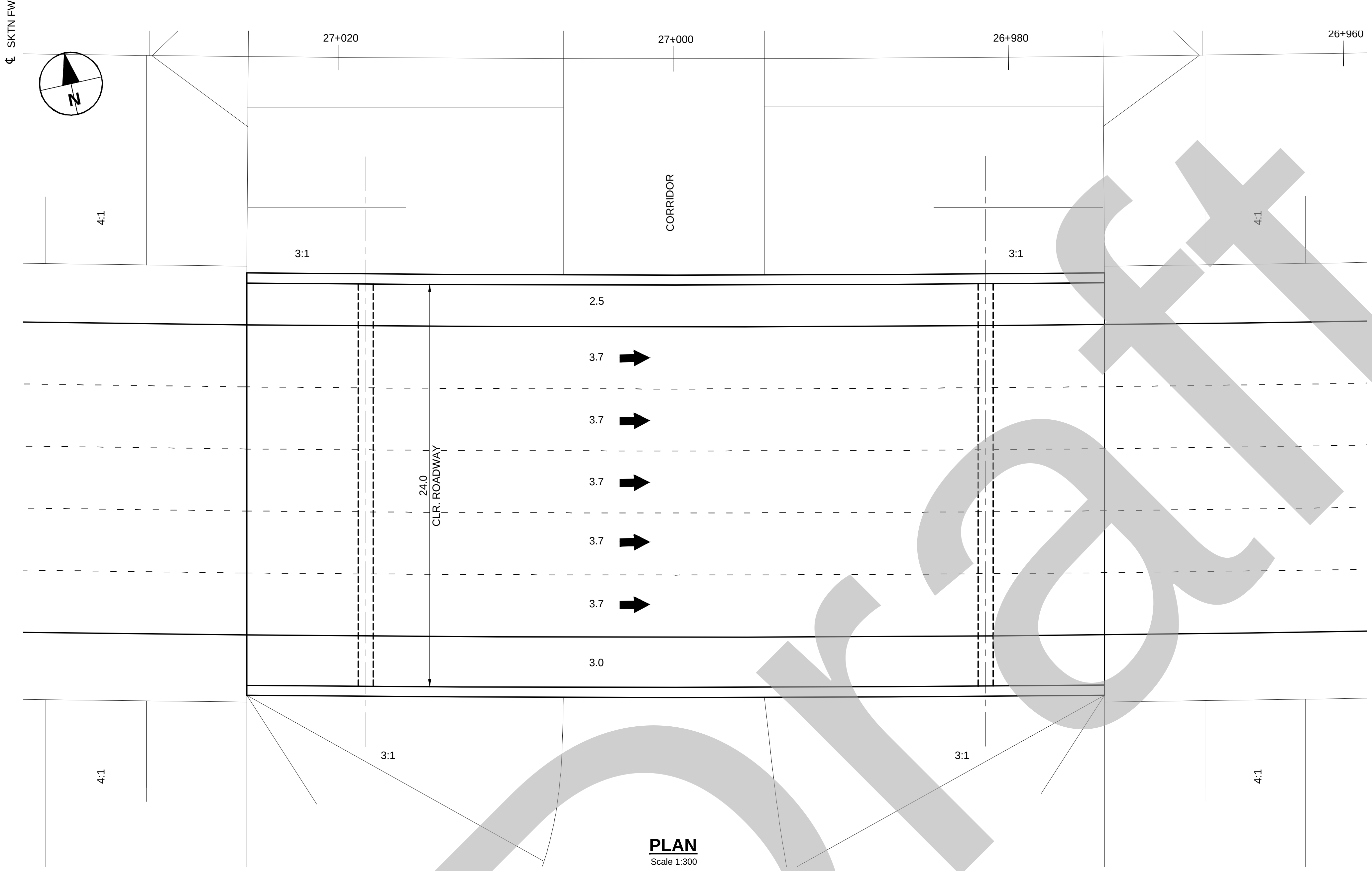
SMALL SWALE - WILDLIFE CORRIDOR UNDERPASS



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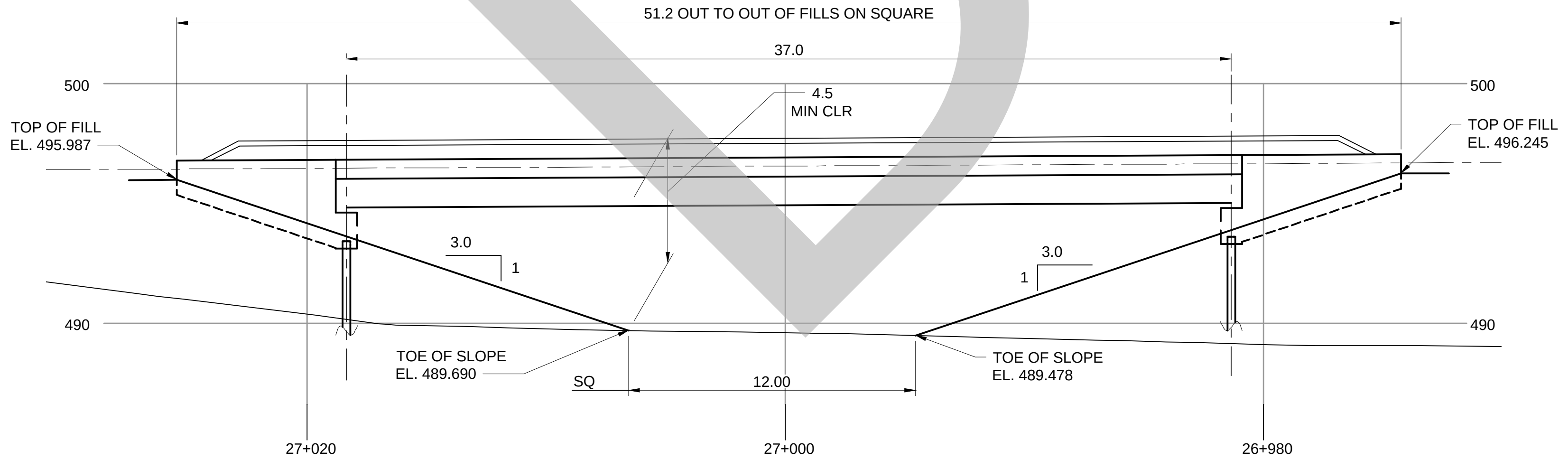

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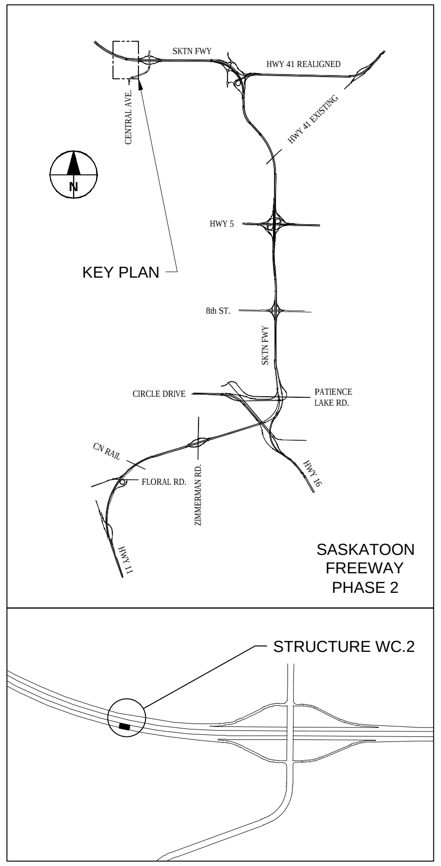

KEY PLAN

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE WC.2

RECOMMENDED BY: ____________________ ________
SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: ____________________ ________
DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

DESIGN	DRAWN	CHECKED	FILE
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DATE	DATE	DATE	PLAN
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Sheet 1 of –

LAST REVISED DATE: 22–JAN–2009 1:40 PM

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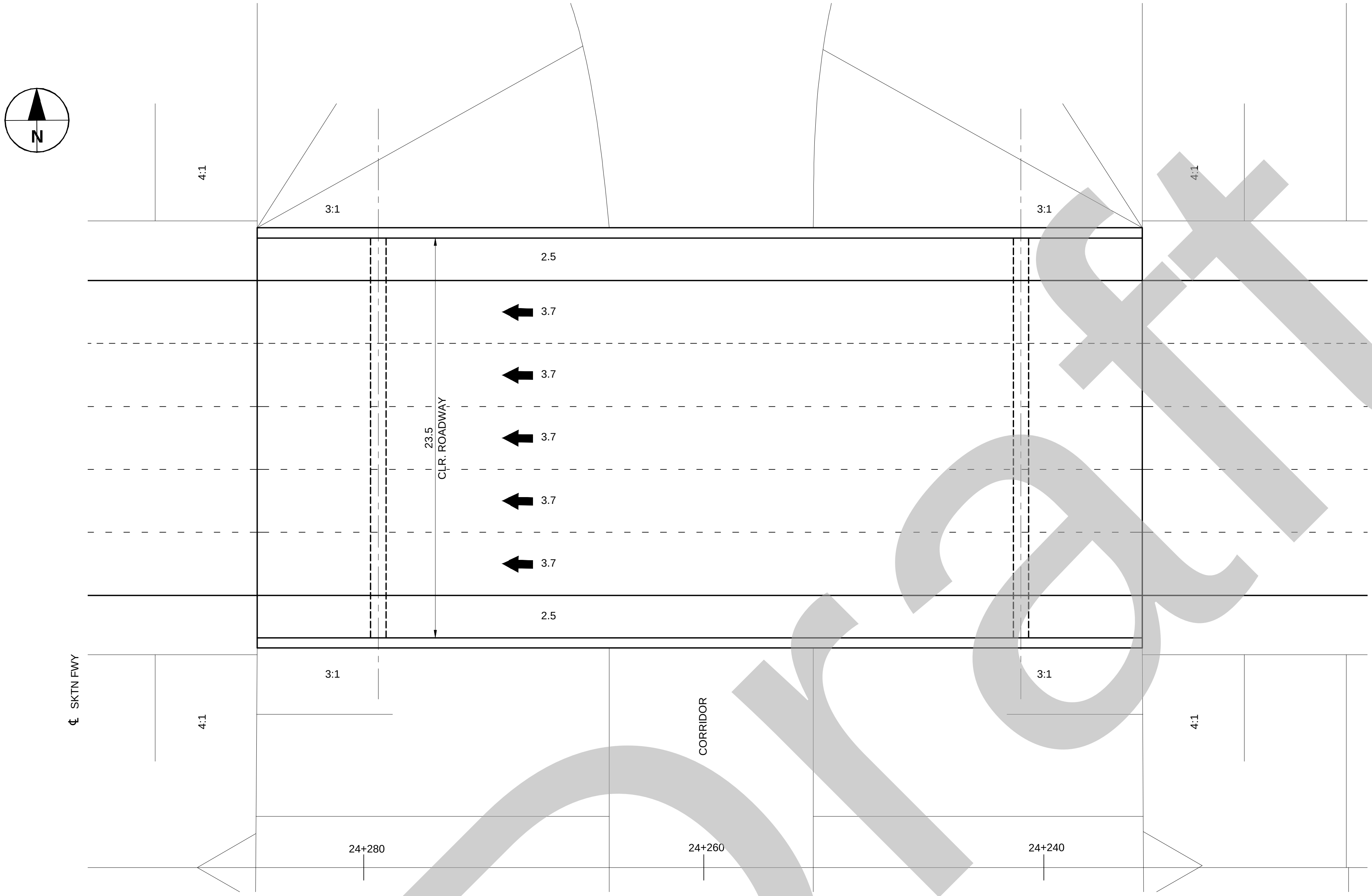
NORTHEAST SWALE - WILDLIFE CORRIDOR UNDERPASS



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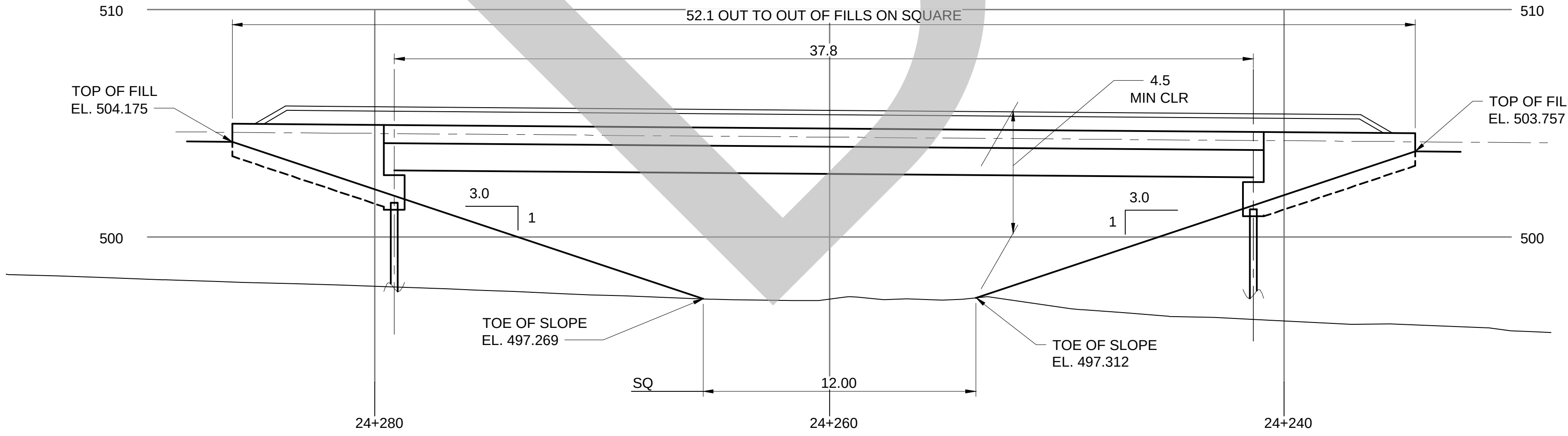

ELEVATION

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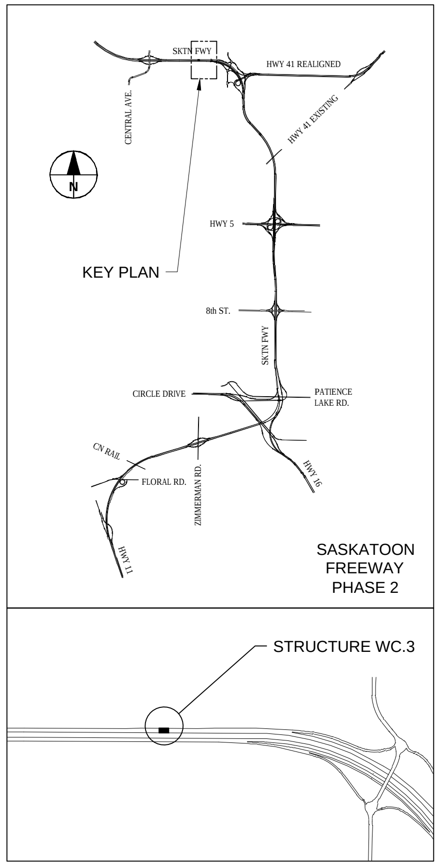

KEY PLAN

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government
of
Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE WC.3

RECOMMENDED BY: ______________________ ________
SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: ______________________ ________
DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

DESIGN –	DRAWN KC	CHECKED –	FILE –
DATE –	DATE –	DATE –	PLAN –

Sheet 1 of –

LAST REVISED DATE: 22–JAN–2009 1:40 PM

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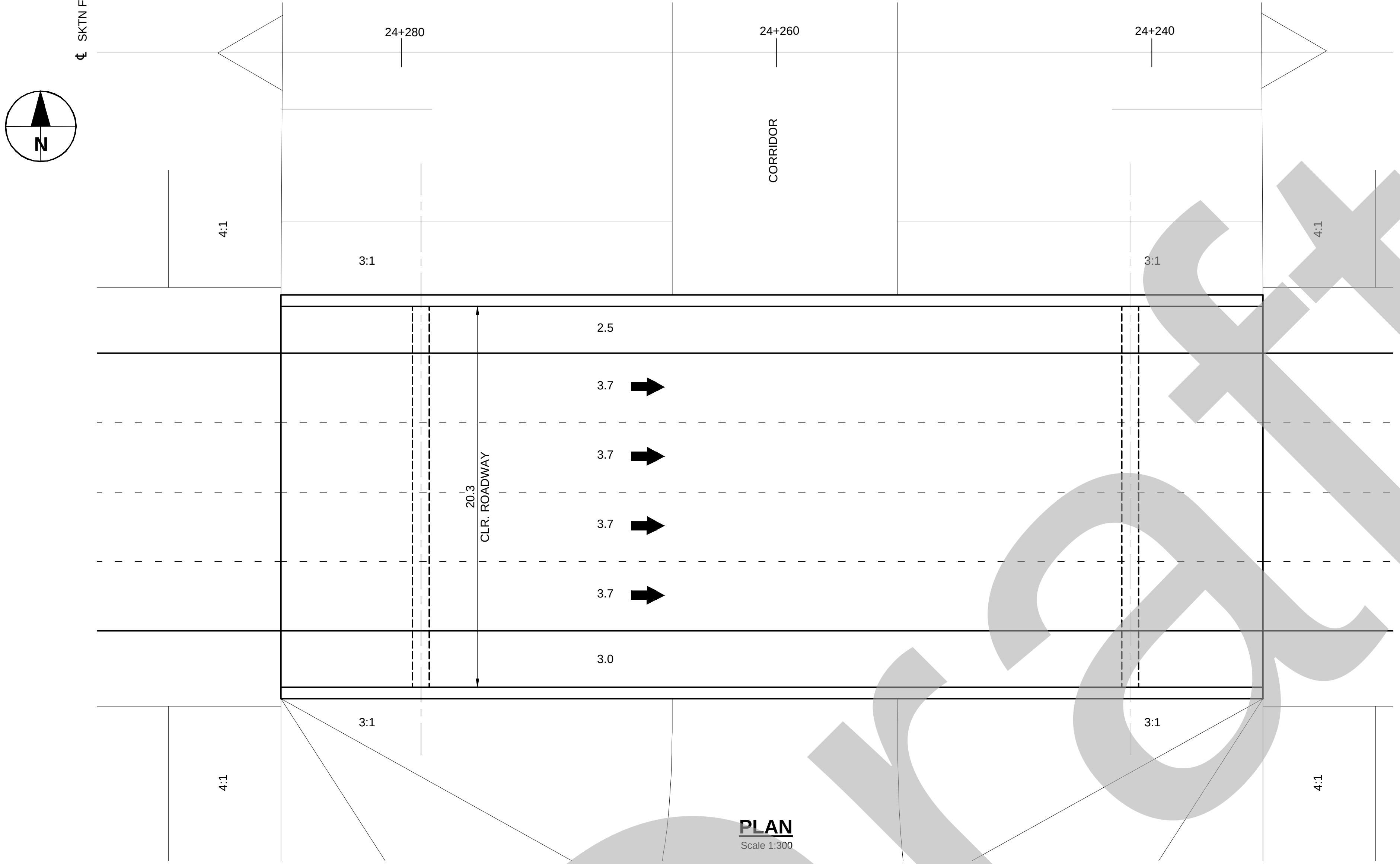
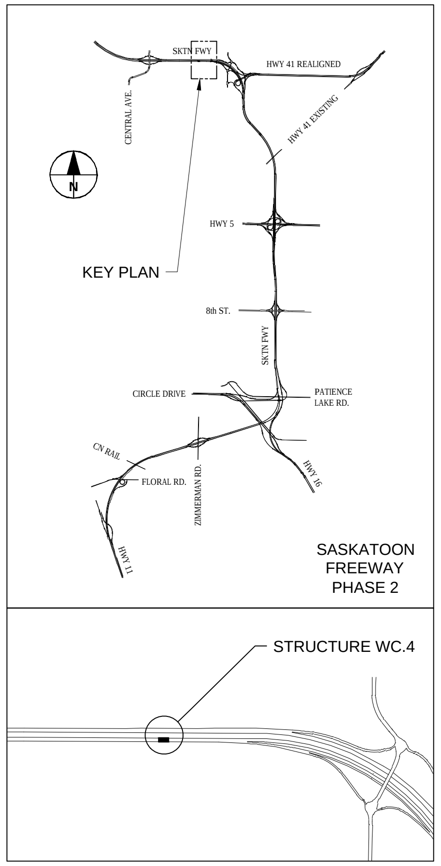
NORTHEAST SWALE - WILDLIFE CORRIDOR UNDERPASS



PLAN
Scale 1:300

ELEVATION
Scale 1:300



KEY PLAN

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE WC.4

RECOMMENDED BY: SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

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Sheet 1 of –

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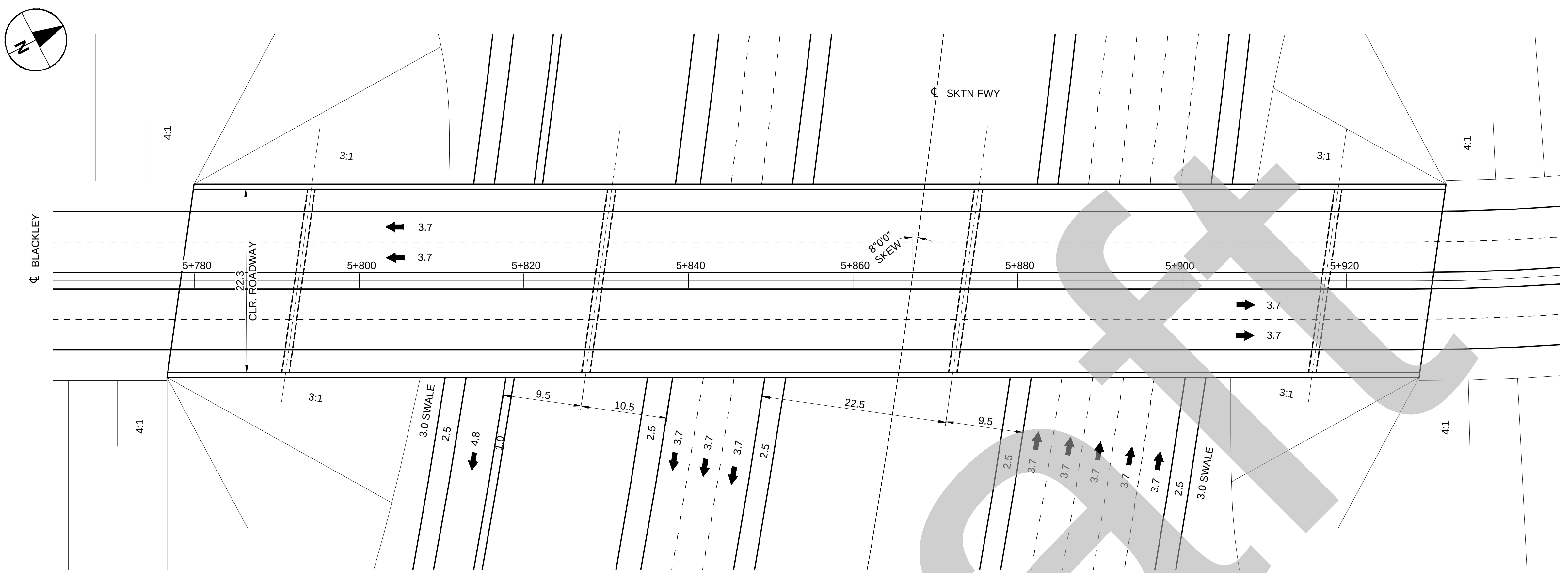

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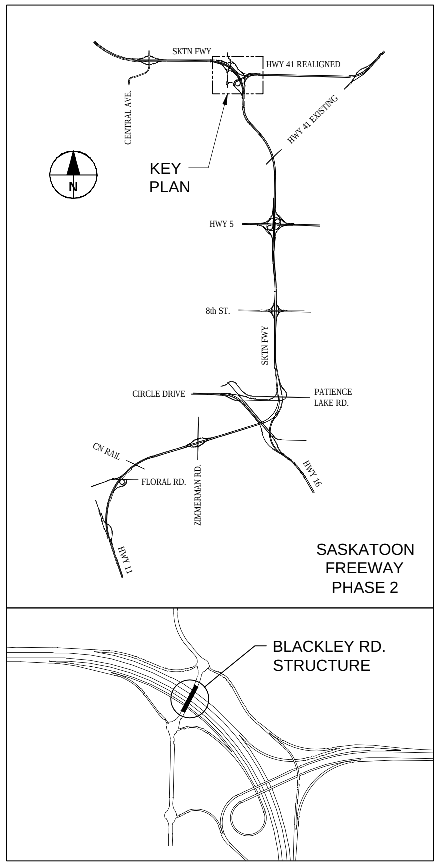

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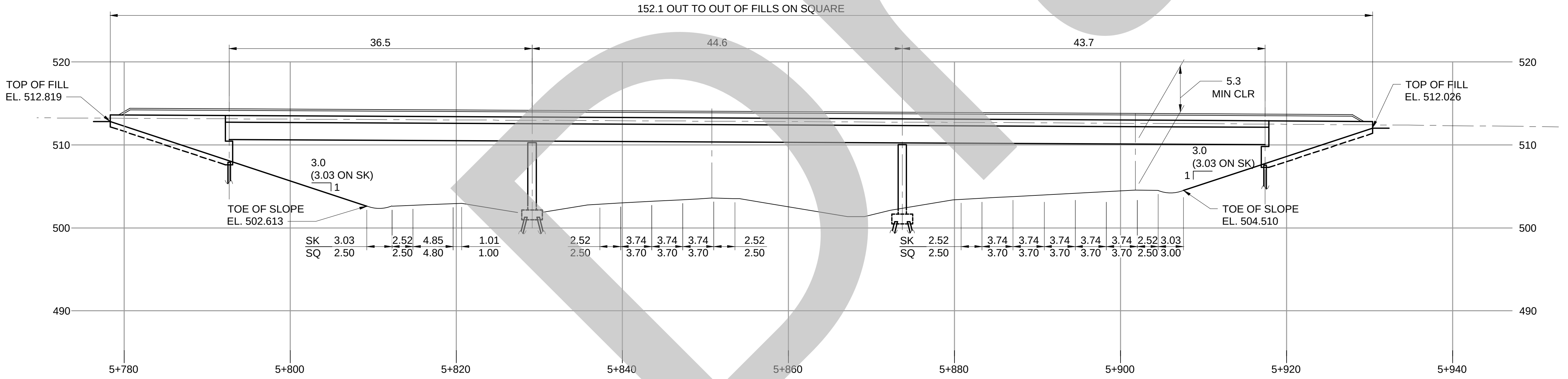

ELEVATION

Scale 1:600

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – BLACKLEY RD. STRUCTURE

RECOMMENDED BY: ____________________ SENIOR BRIDGE PROJECT MANAGER ________ DATE

APPROVED BY: ____________________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ________ DATE

DESIGN	DRAWN	CHECKED	FILE
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DATE	DATE	DATE	PLAN
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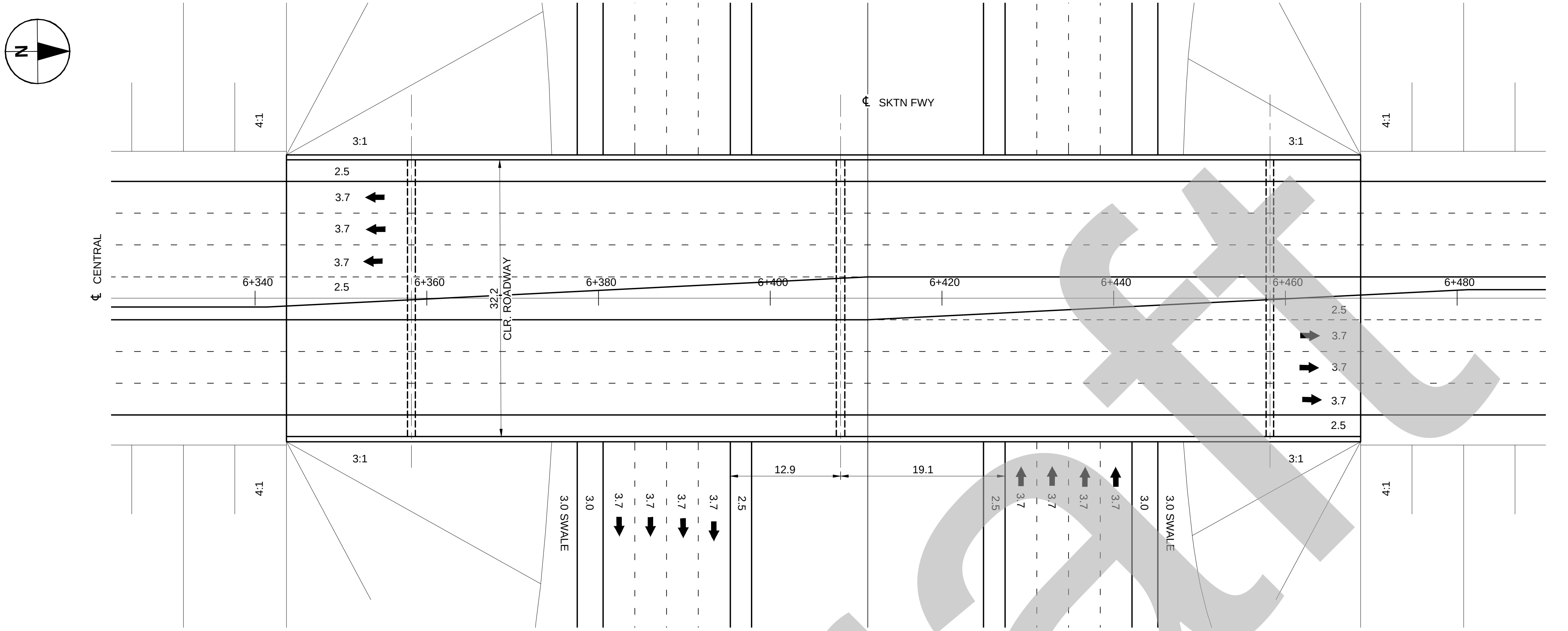

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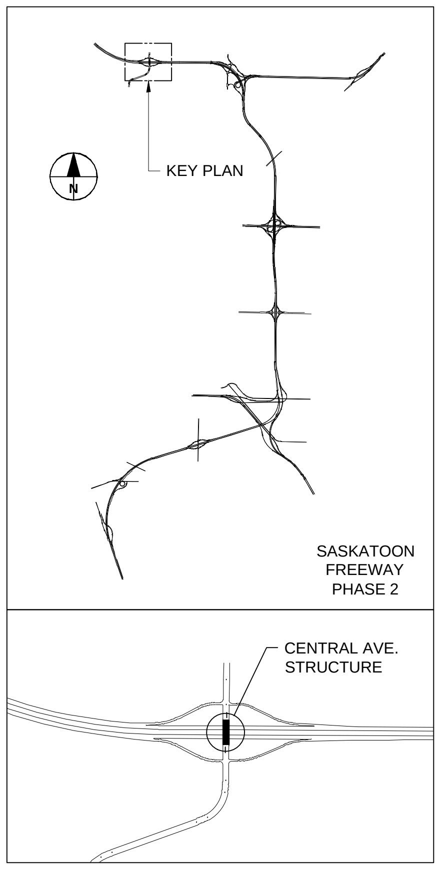

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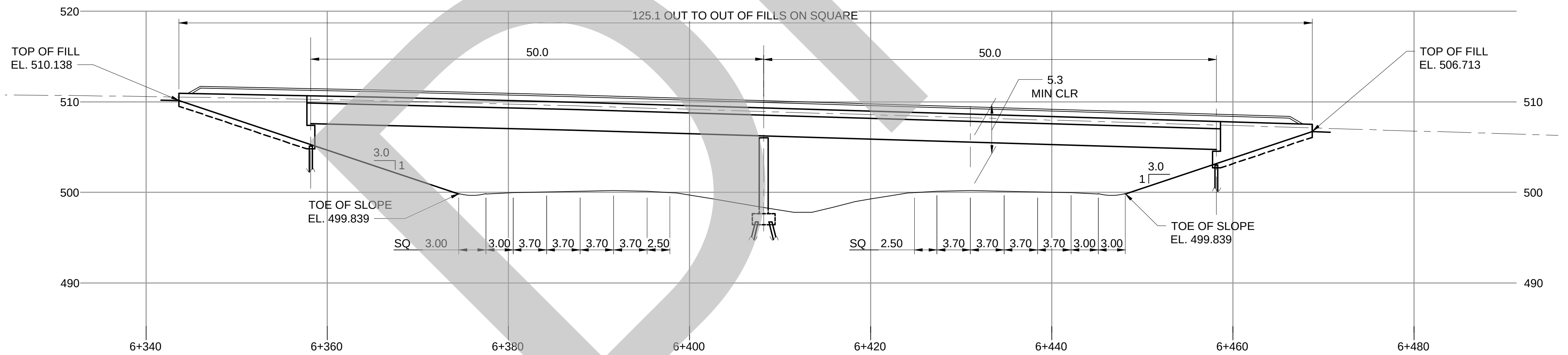

ELEVATION

Scale 1:600

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – CENTRAL AVE. STRUCTURE

RECOMMENDED BY: ________ SENIOR BRIDGE PROJECT MANAGER ________ DATE

APPROVED BY: ________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ________ DATE

DESIGN	DRAWN	CHECKED	FILE
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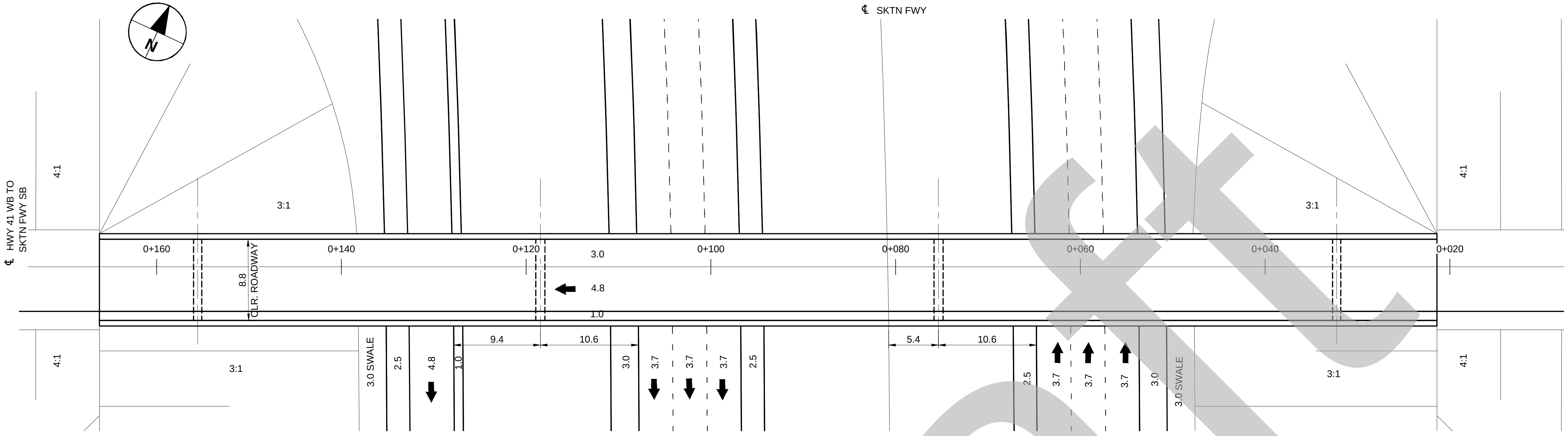

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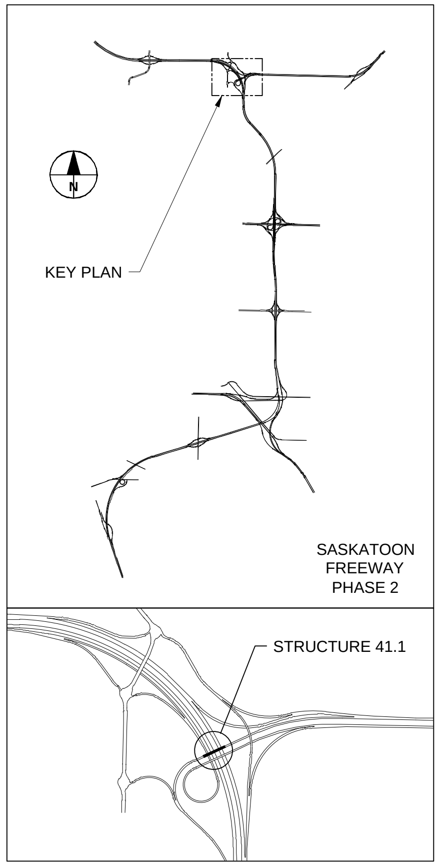

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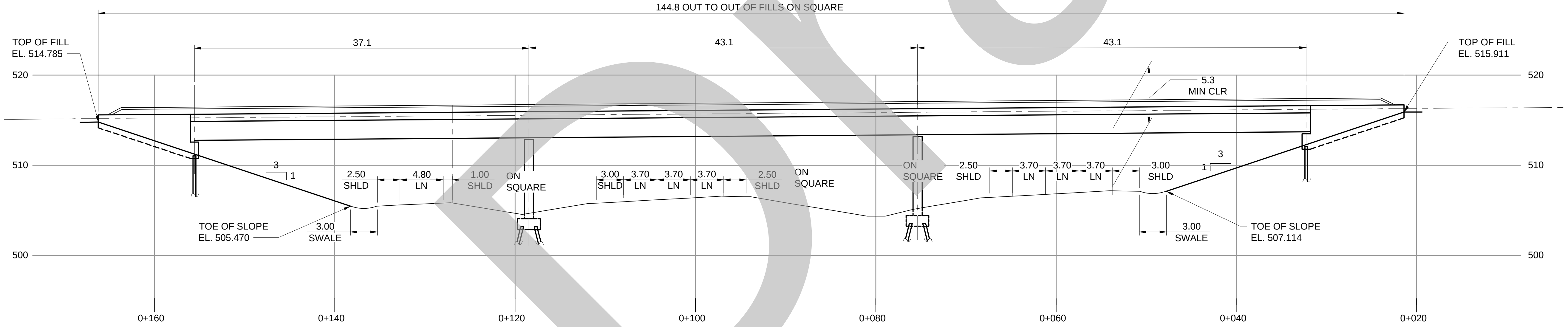

ELEVATION

Scale 1:500

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 41.1

RECOMMENDED BY: ____________ SENIOR BRIDGE PROJECT MANAGER ____ DATE

APPROVED BY: ____________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ____ DATE

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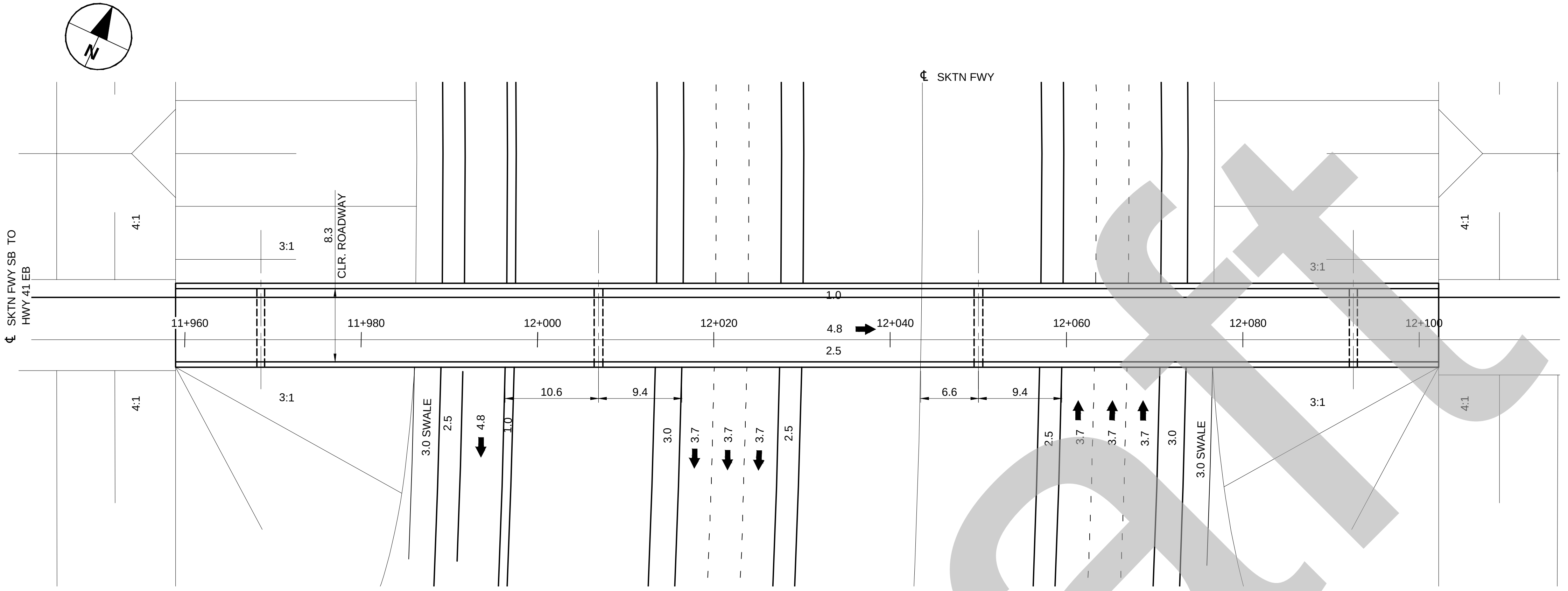

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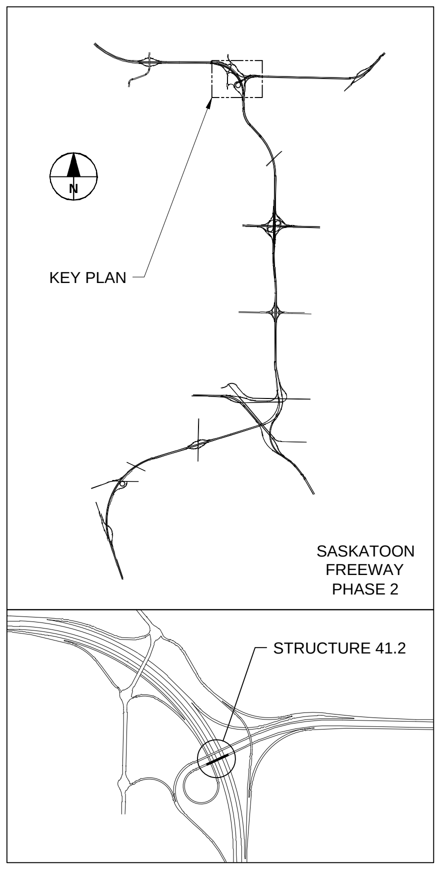

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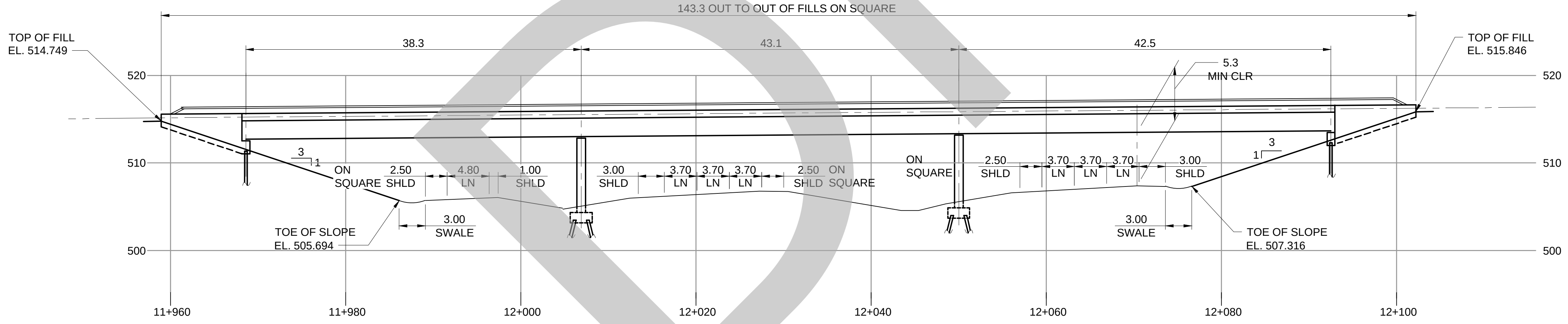

ELEVATION

Scale 1:600

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 41.2

RECOMMENDED BY: ______________________ SENIOR BRIDGE PROJECT MANAGER ________ DATE

APPROVED BY: ______________________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ________ DATE

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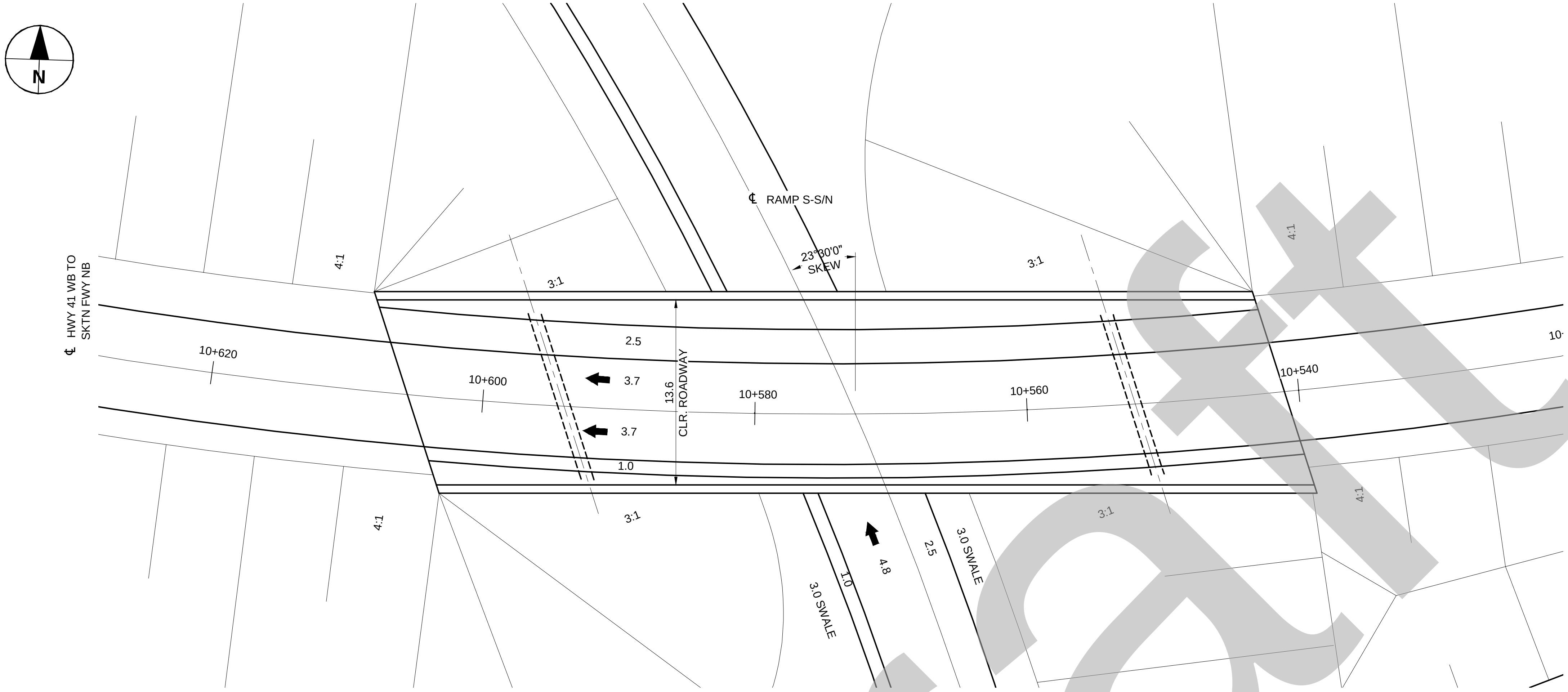

PLAN

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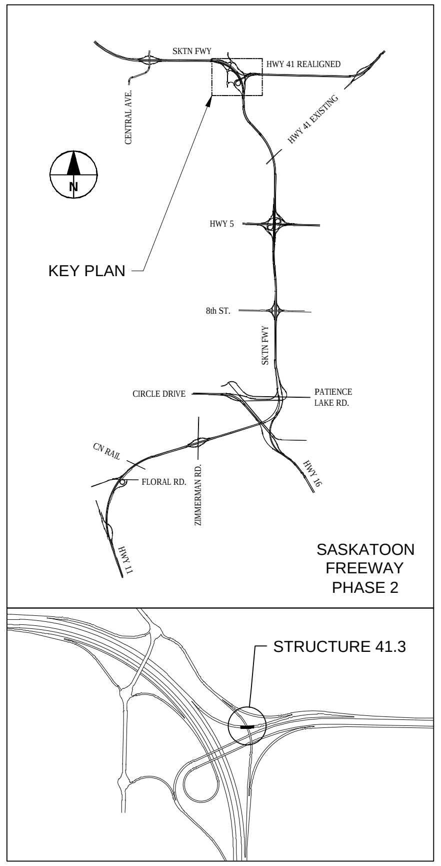

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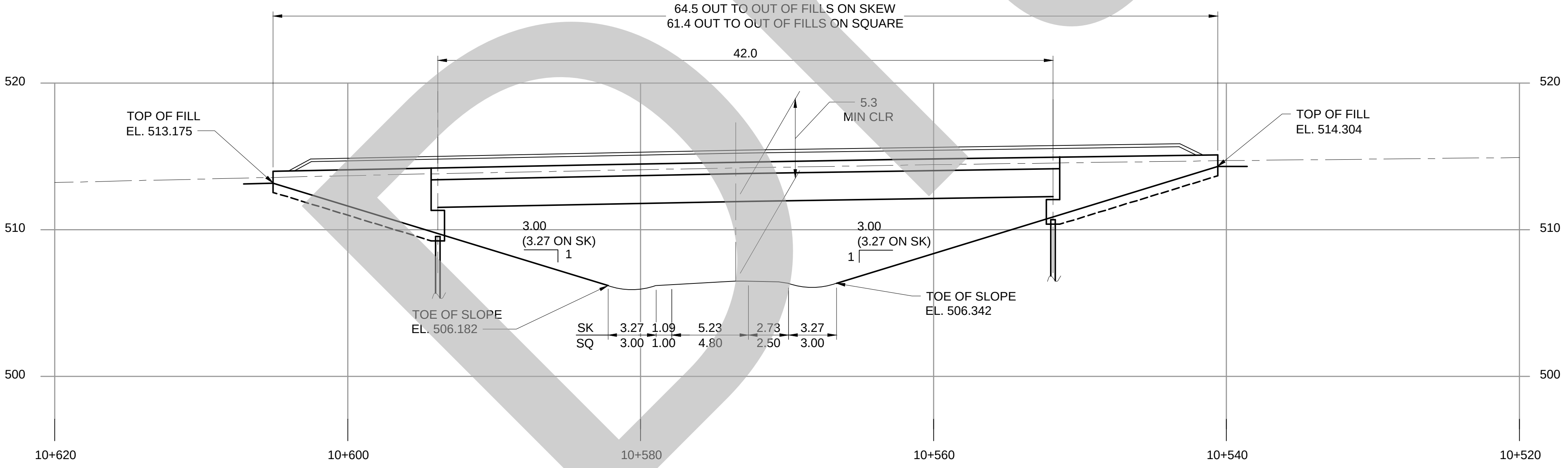

ELEVATION

Scale 1:400

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 41.3

RECOMMENDED BY: ______ SENIOR BRIDGE PROJECT MANAGER ______ DATE

APPROVED BY: ______ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ______ DATE

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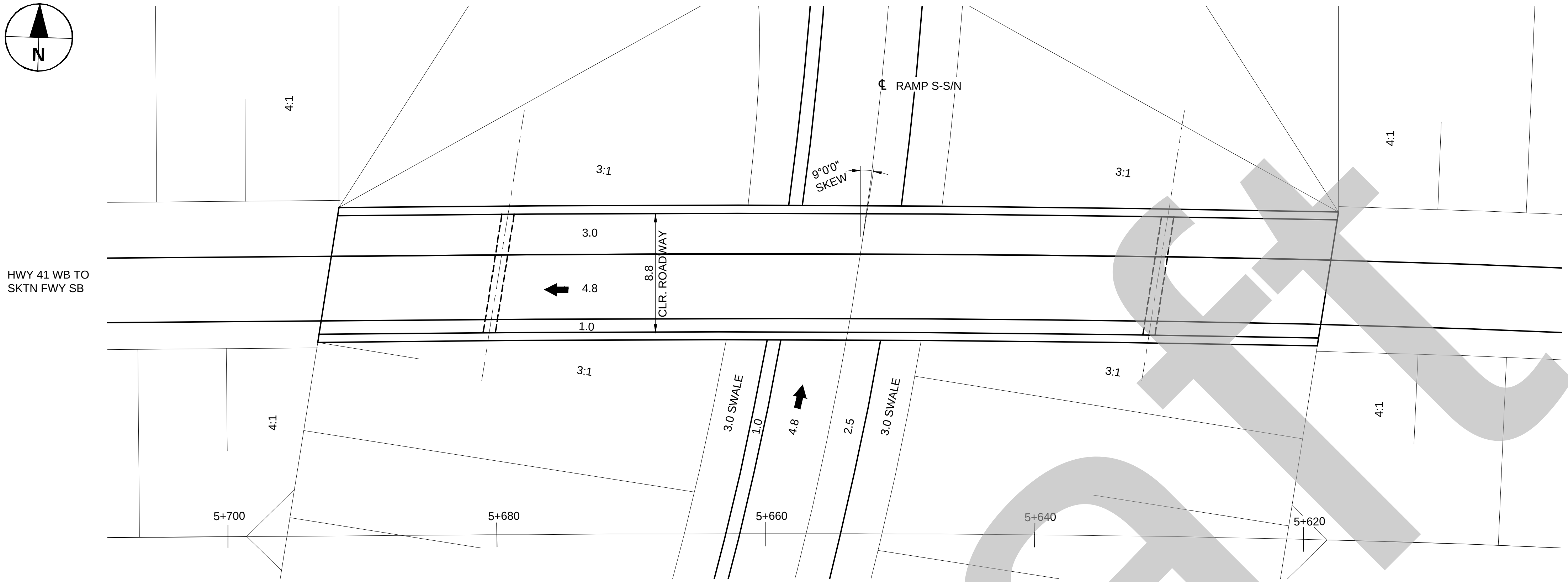

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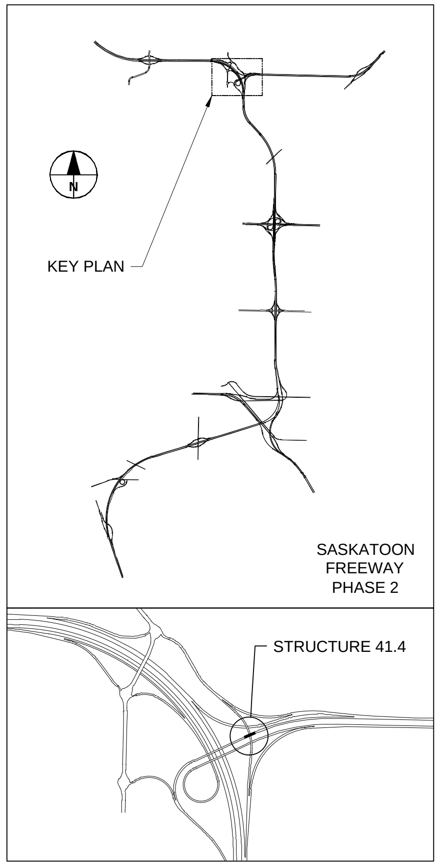

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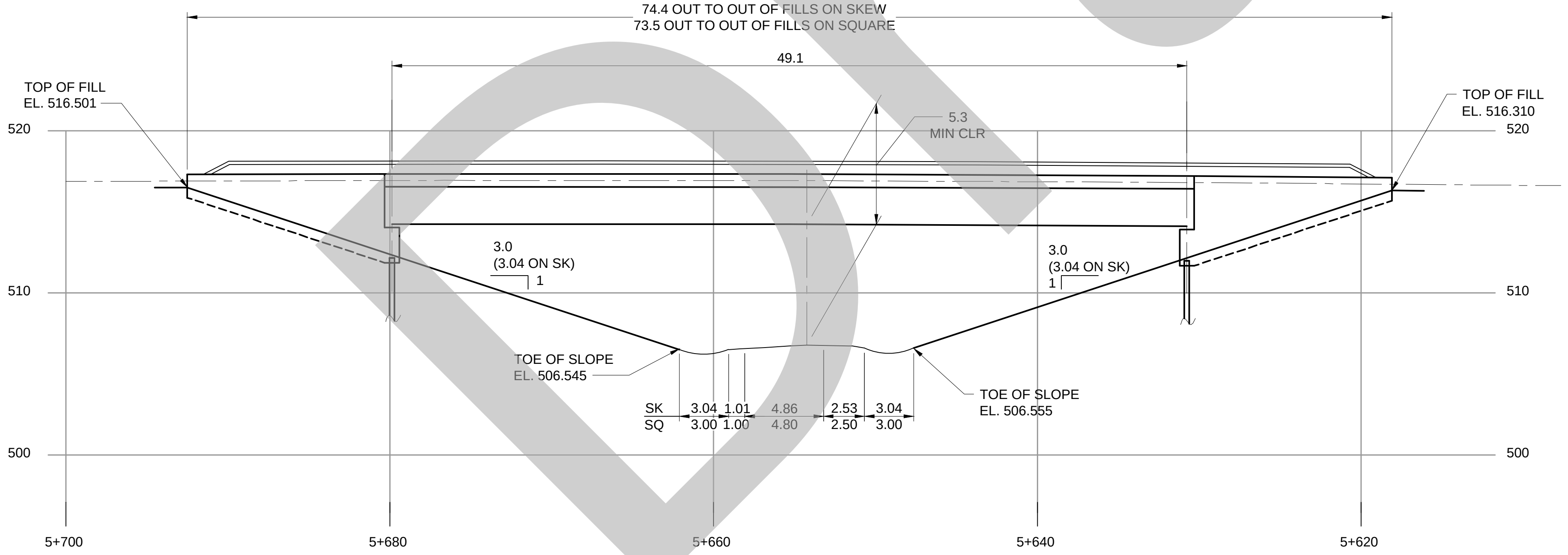

ELEVATION

Scale 1:400

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 41.4

RECOMMENDED BY: ______________________ SENIOR BRIDGE PROJECT MANAGER ________ DATE

APPROVED BY: ______________________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ________ DATE

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DATE	DATE	DATE	PLAN
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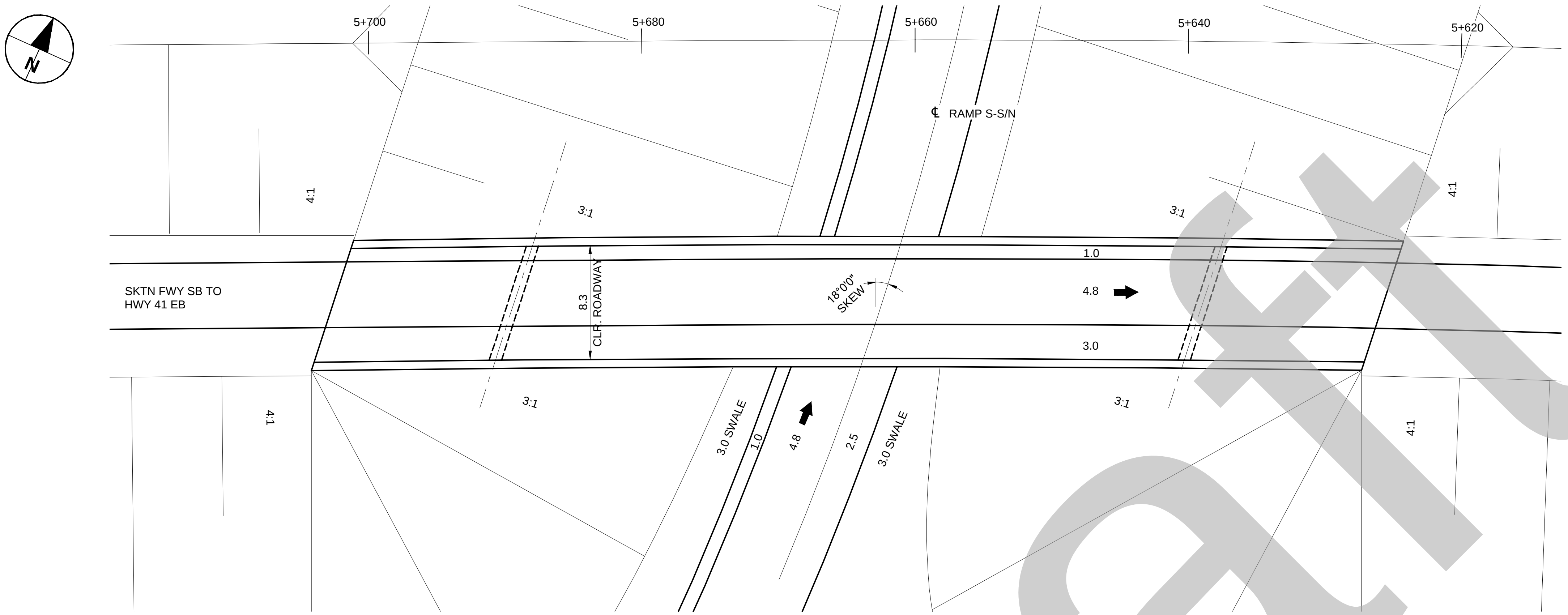

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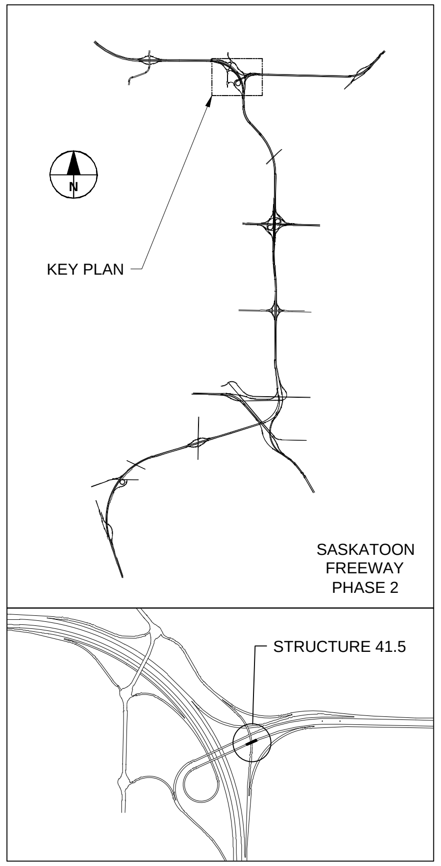

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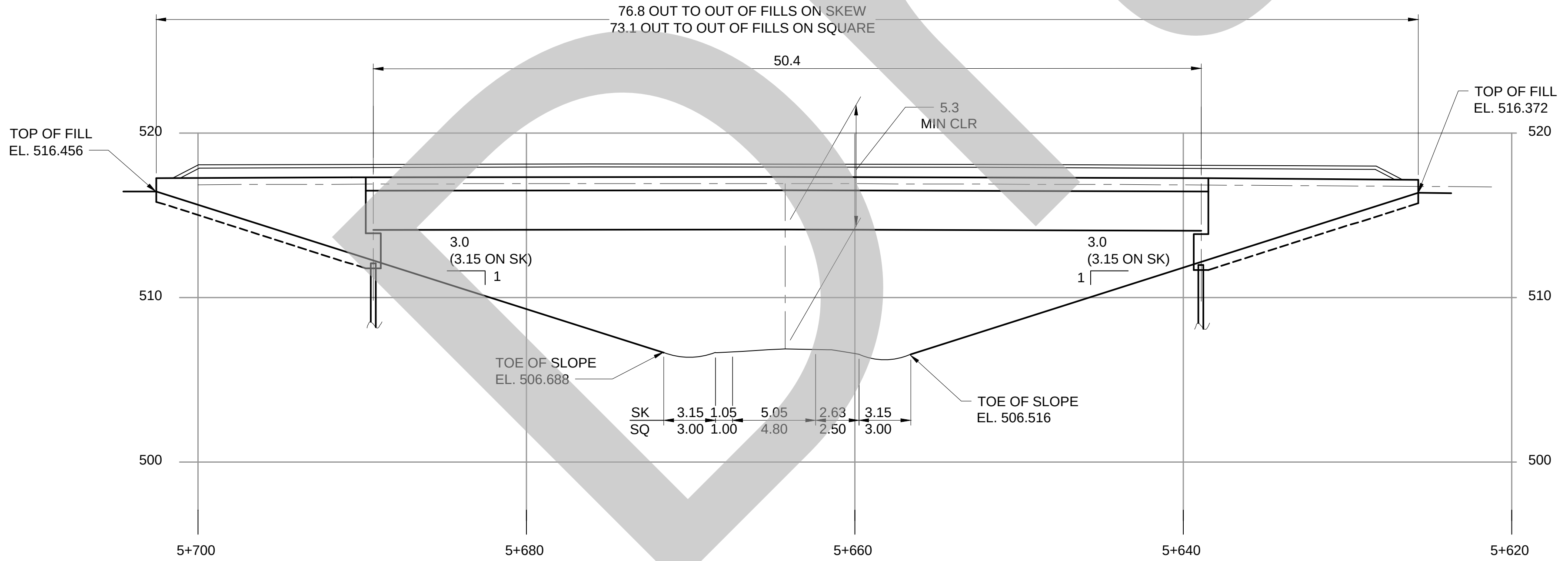

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PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 41.5

RECOMMENDED BY: ____________ SENIOR BRIDGE PROJECT MANAGER ______ DATE

APPROVED BY: ____________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ______ DATE

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DATE	DATE	DATE	PLAN
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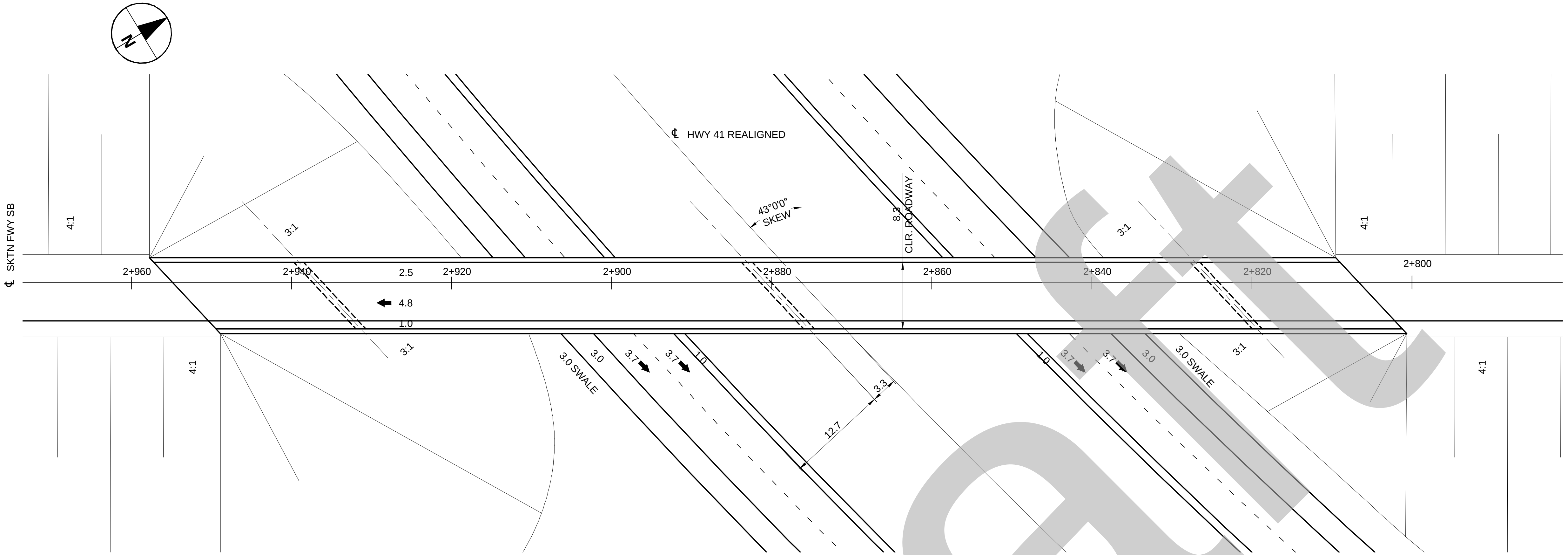

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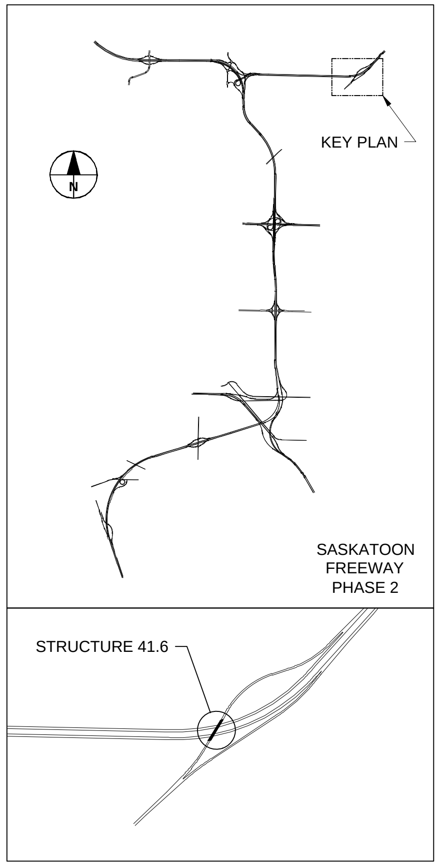

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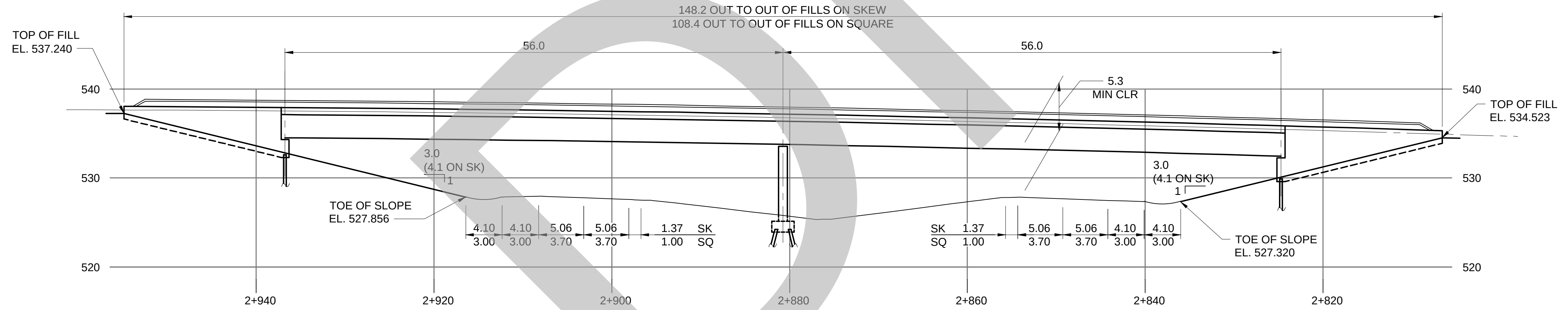

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PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 41.6

RECOMMENDED BY: ____________ SENIOR BRIDGE PROJECT MANAGER ______ DATE

APPROVED BY: ____________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ______ DATE

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DATE	DATE	DATE	PLAN
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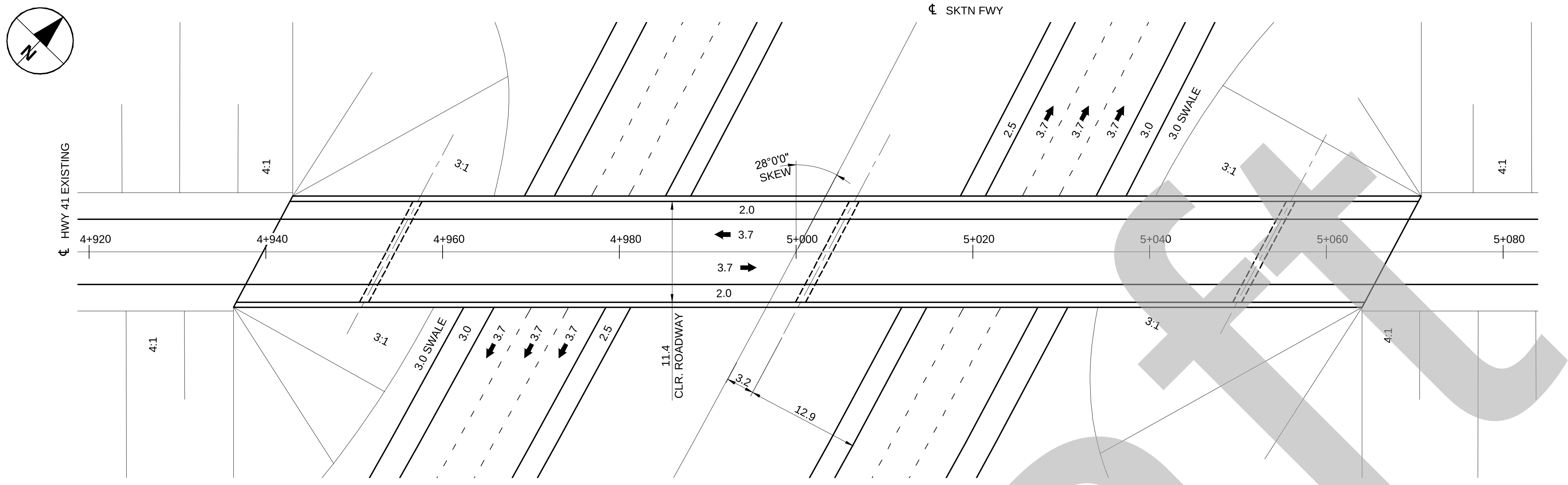

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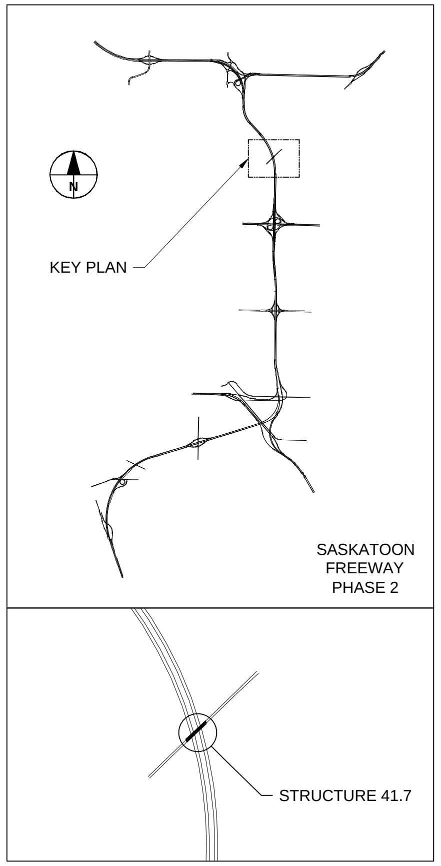

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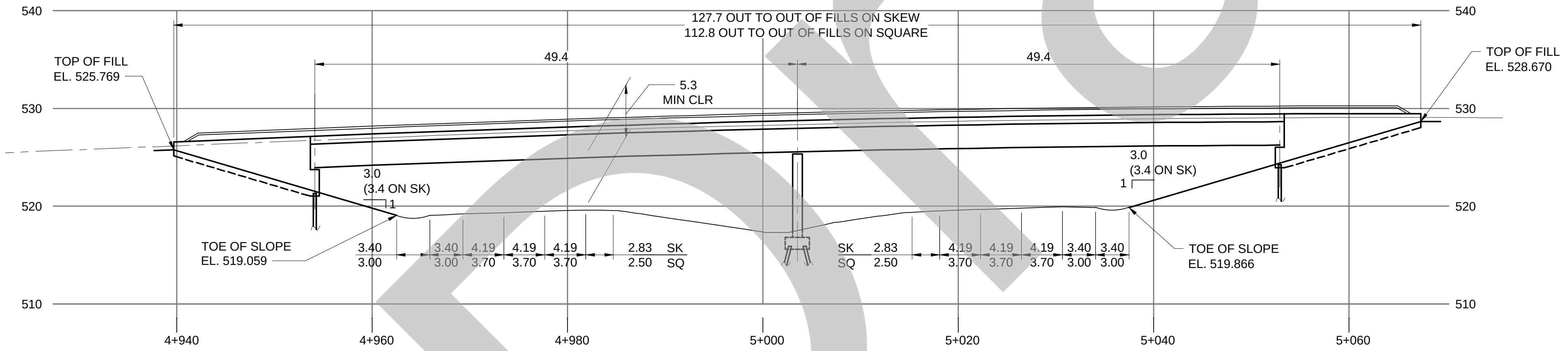

ELEVATION

Scale 1:600

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 41.7

RECOMMENDED BY: ____________ SENIOR BRIDGE PROJECT MANAGER ____ DATE

APPROVED BY: ____________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ____ DATE

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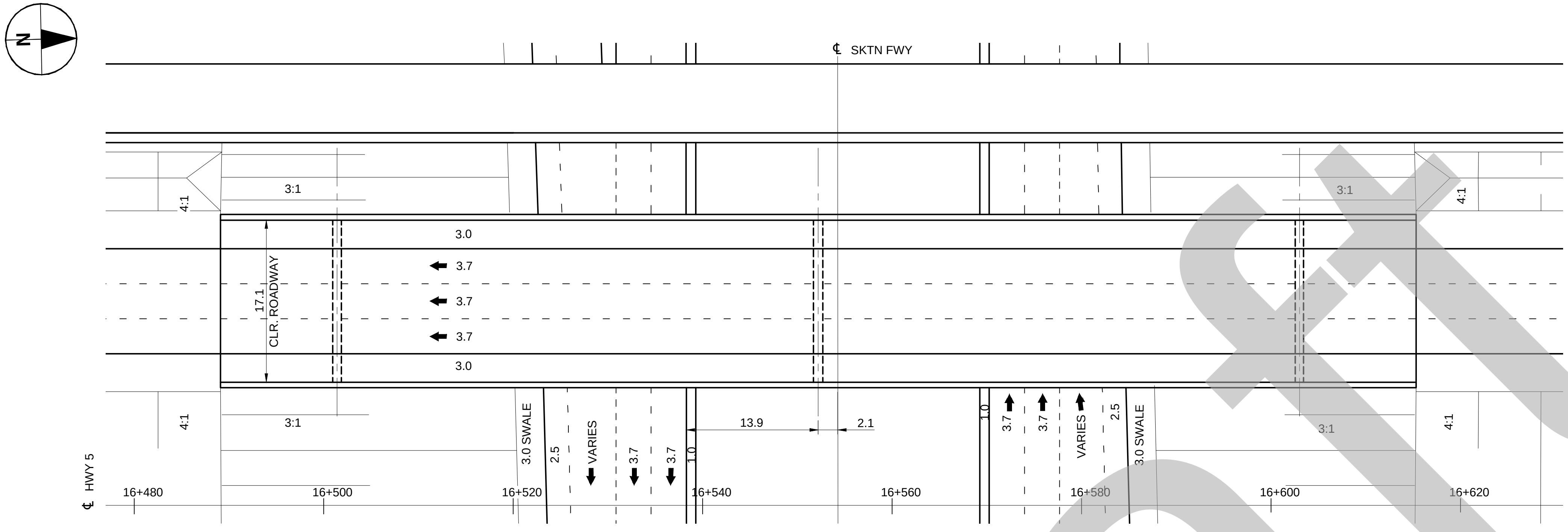

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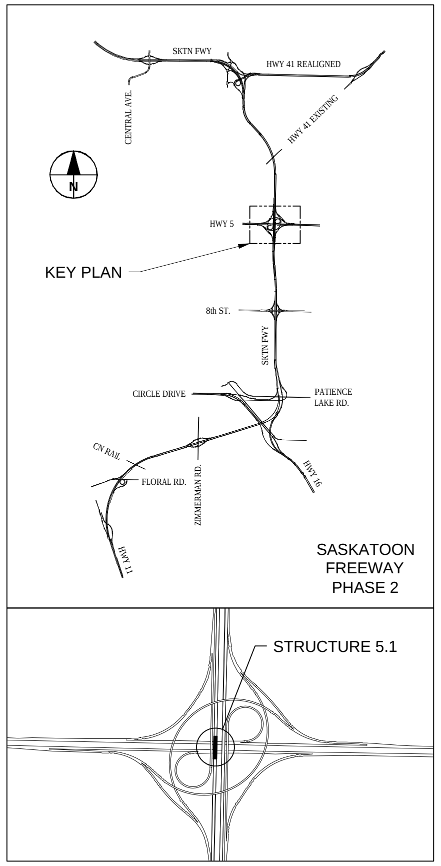

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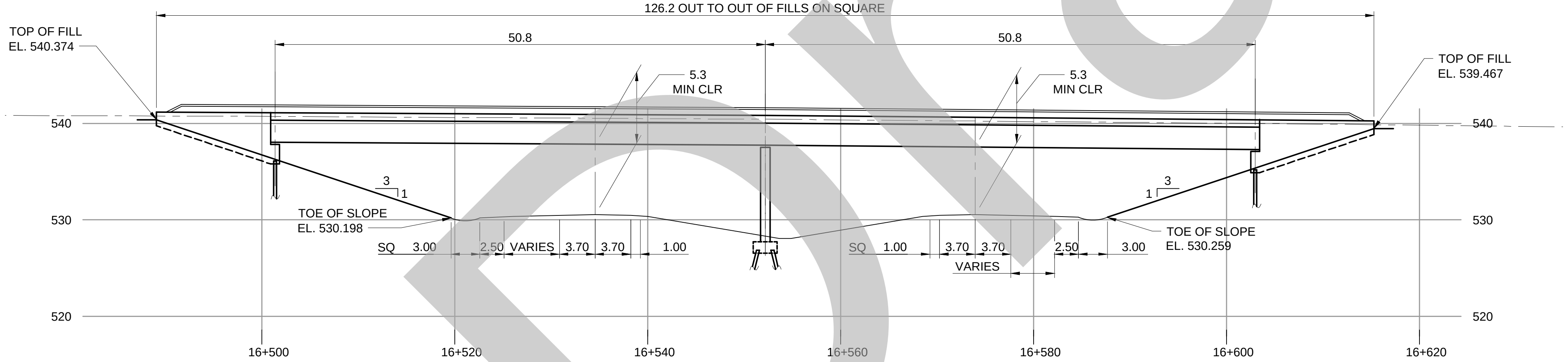

ELEVATION

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PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.1

RECOMMENDED BY: ______ SENIOR BRIDGE PROJECT MANAGER ______ DATE

APPROVED BY: ______ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ______ DATE

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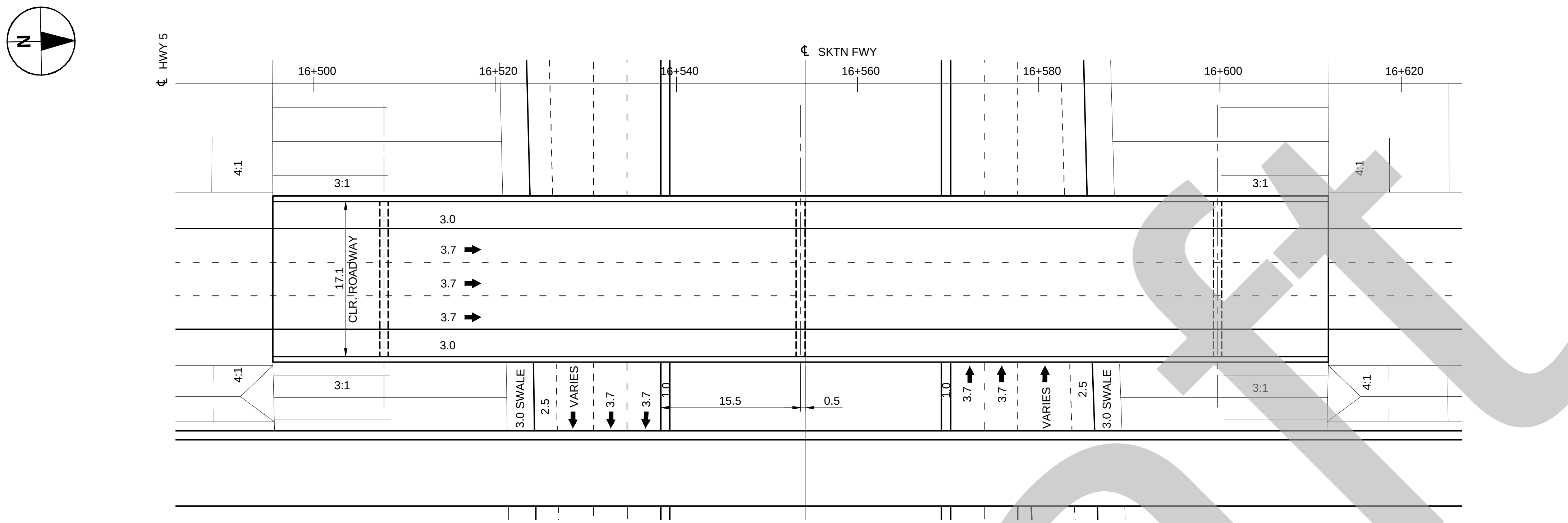

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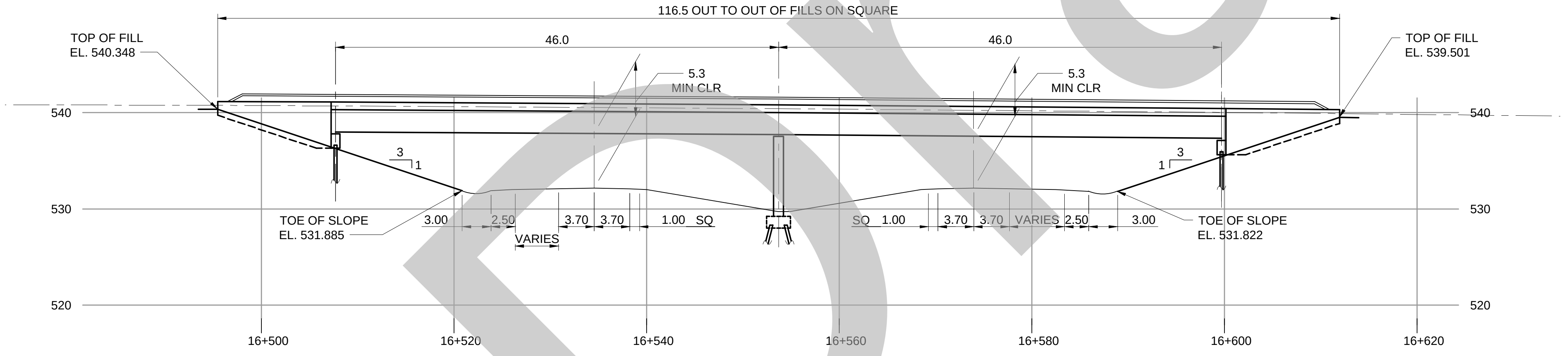

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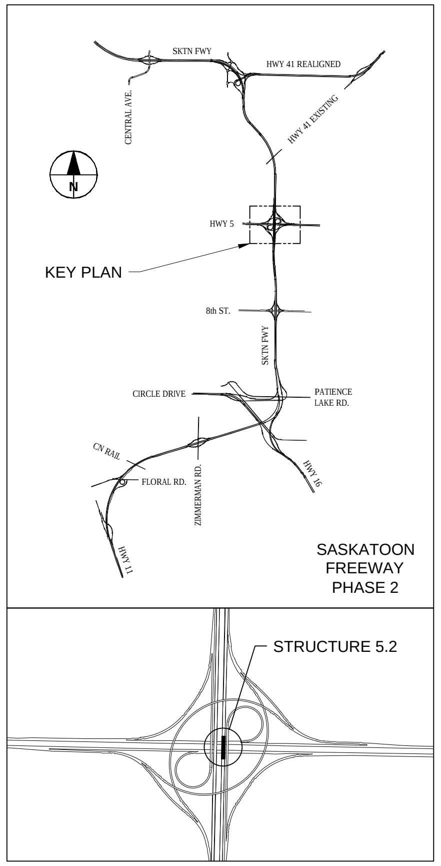

KEY PLAN

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NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.2

RECOMMENDED BY: ____________________ SENIOR BRIDGE PROJECT MANAGER ______ DATE

APPROVED BY: ____________________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ______ DATE

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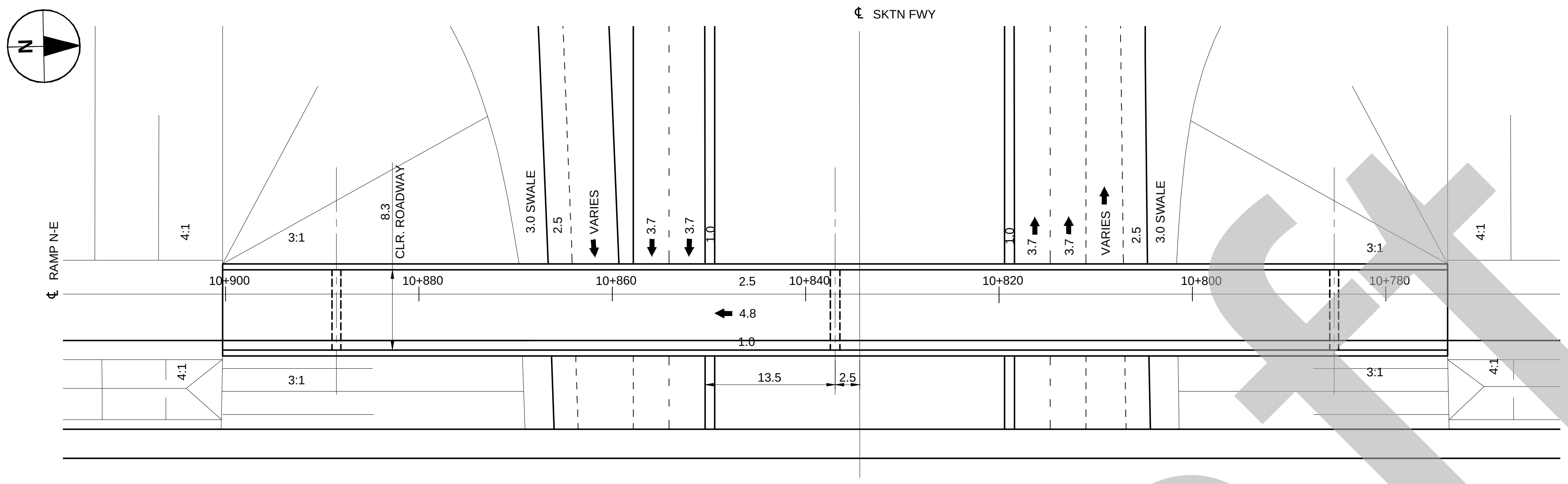

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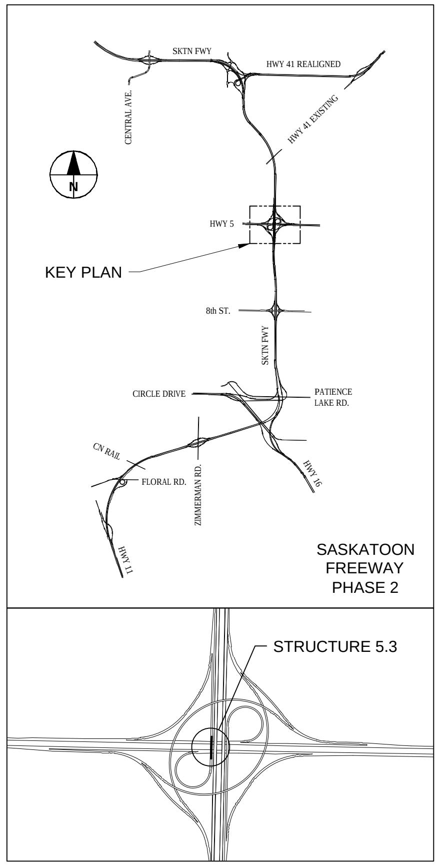

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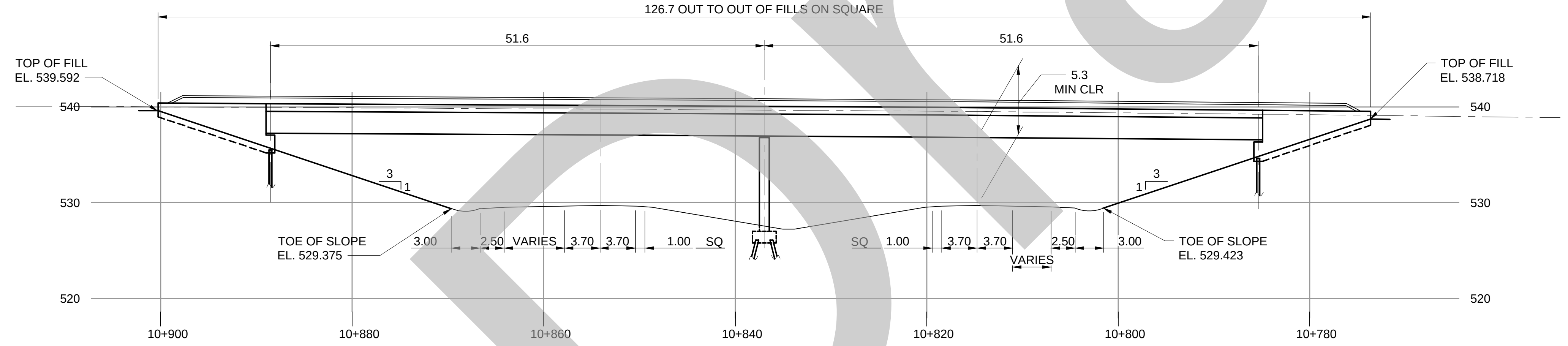

ELEVATION

Scale 1:600

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.3

RECOMMENDED BY: SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

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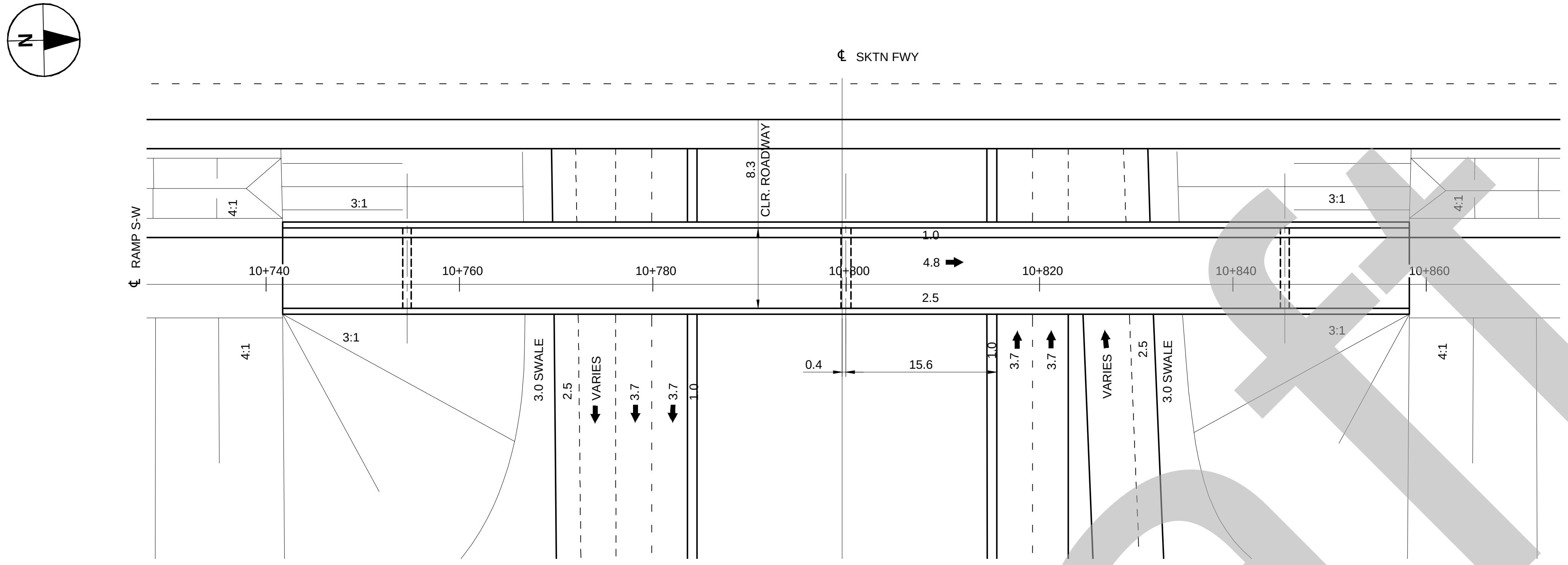

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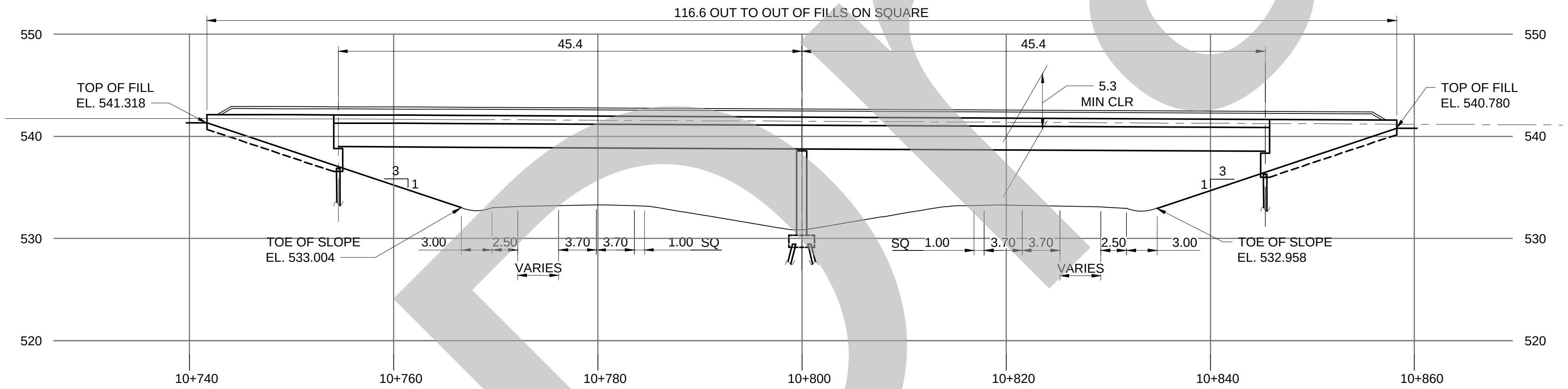

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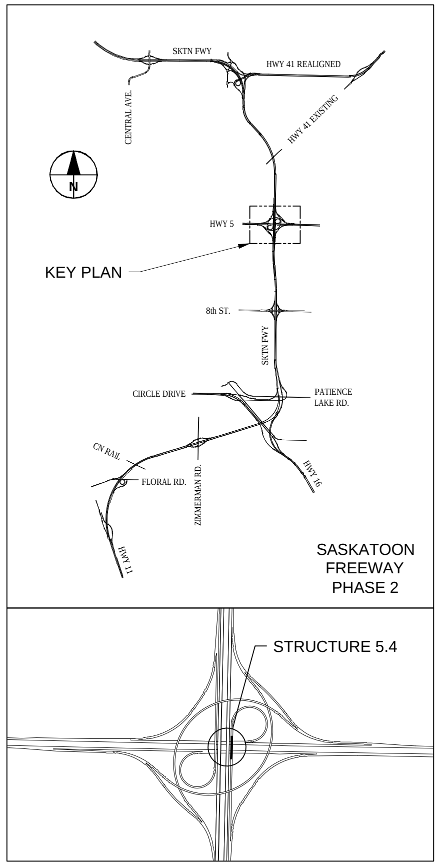

KEY PLAN

PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

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BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.4

RECOMMENDED BY: ____________ SENIOR BRIDGE PROJECT MANAGER ____ DATE

APPROVED BY: ____________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ____ DATE

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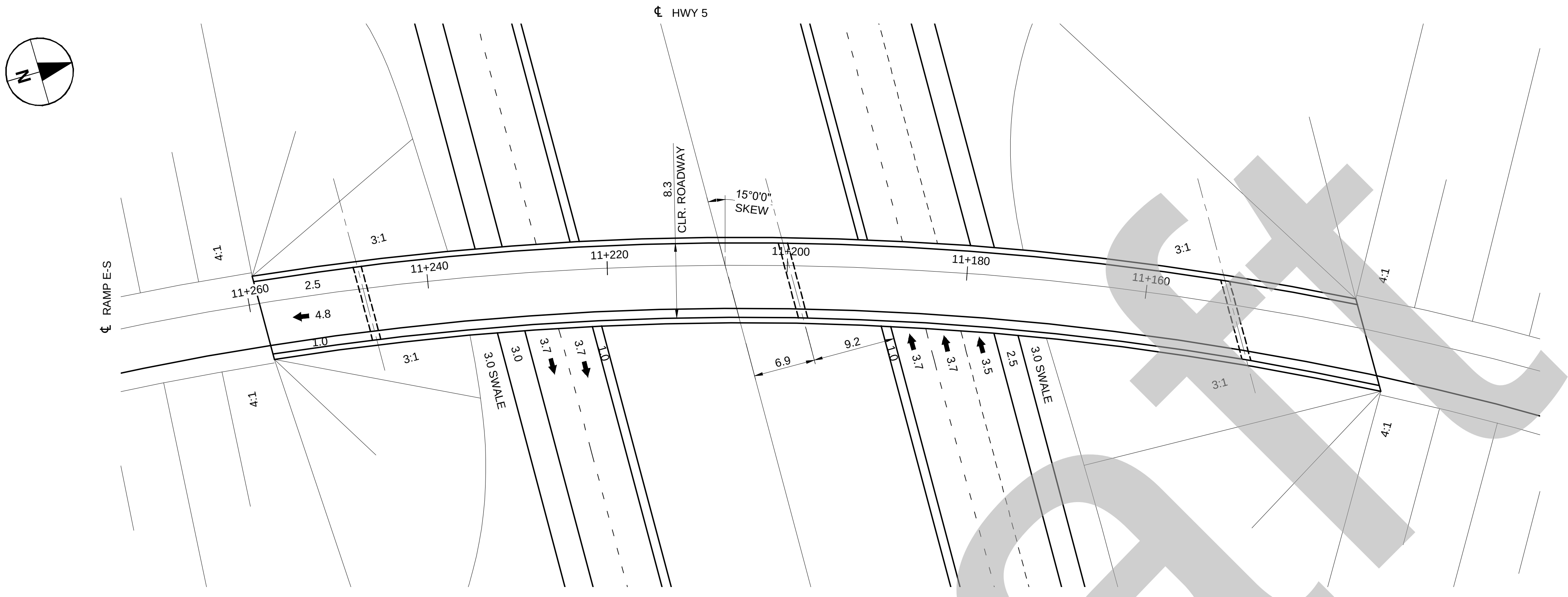

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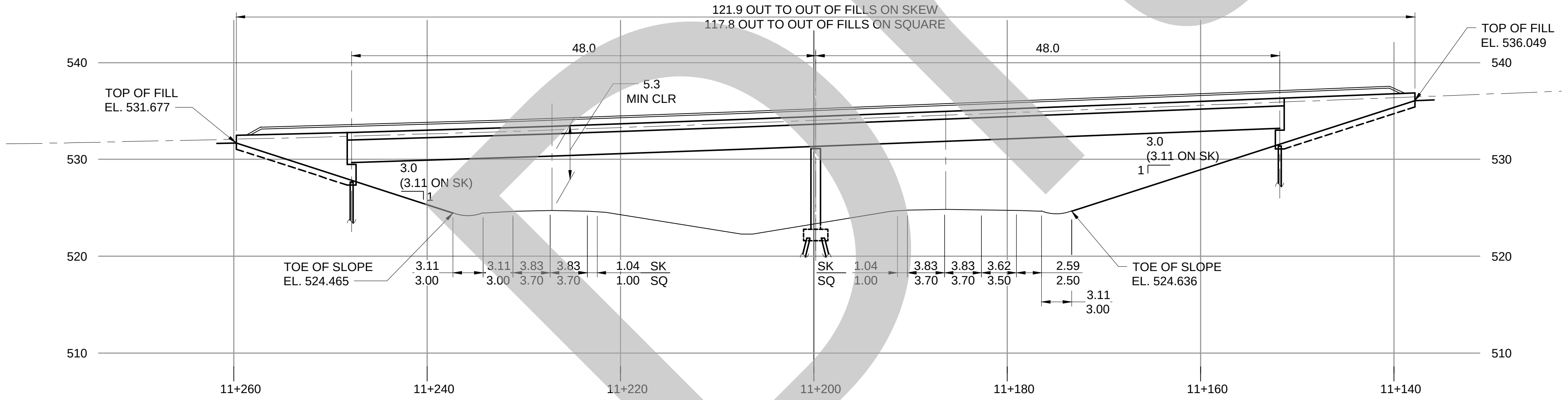

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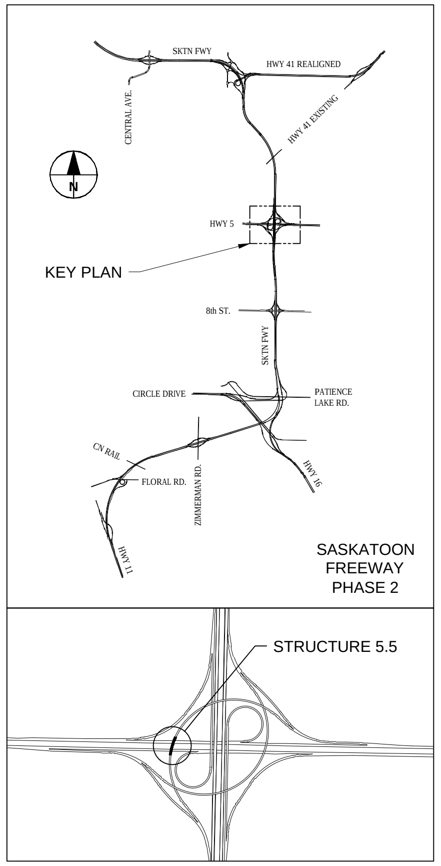

KEY PLAN

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Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.5

RECOMMENDED BY: ______________________ ________
SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: ______________________ ________
DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

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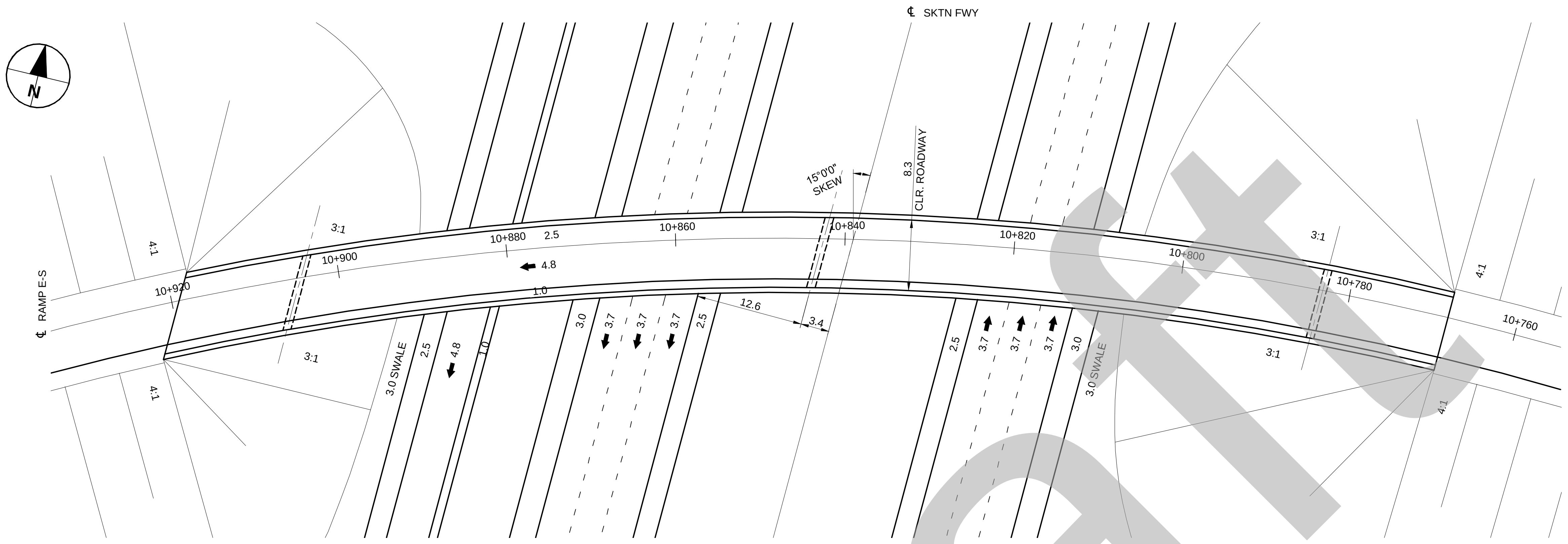

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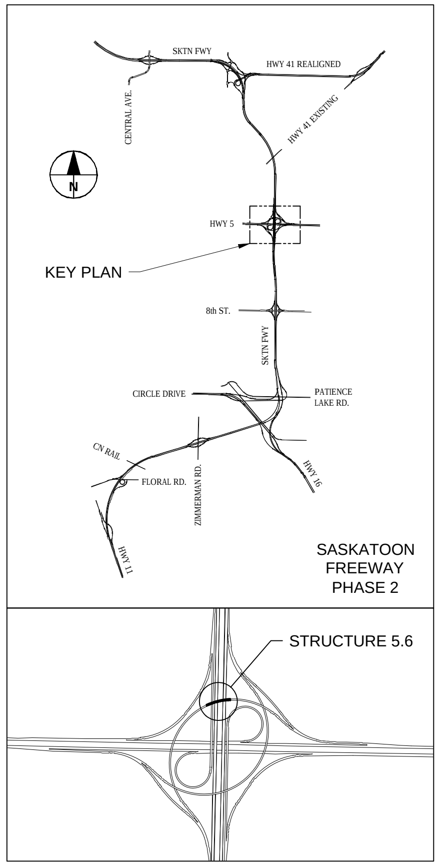

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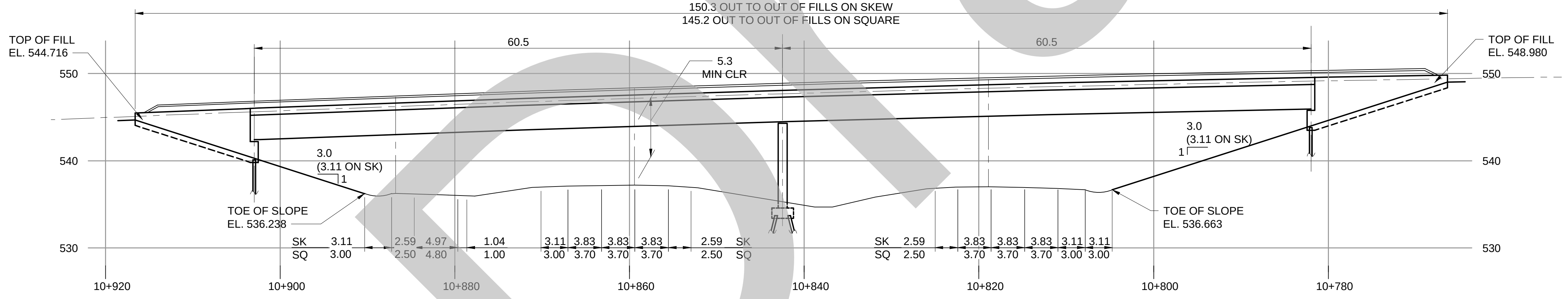

ELEVATION

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PRELIMINARY

NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.6

RECOMMENDED BY: ______ SENIOR BRIDGE PROJECT MANAGER ______ DATE

APPROVED BY: ______ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ______ DATE

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DATE	DATE	DATE	PLAN
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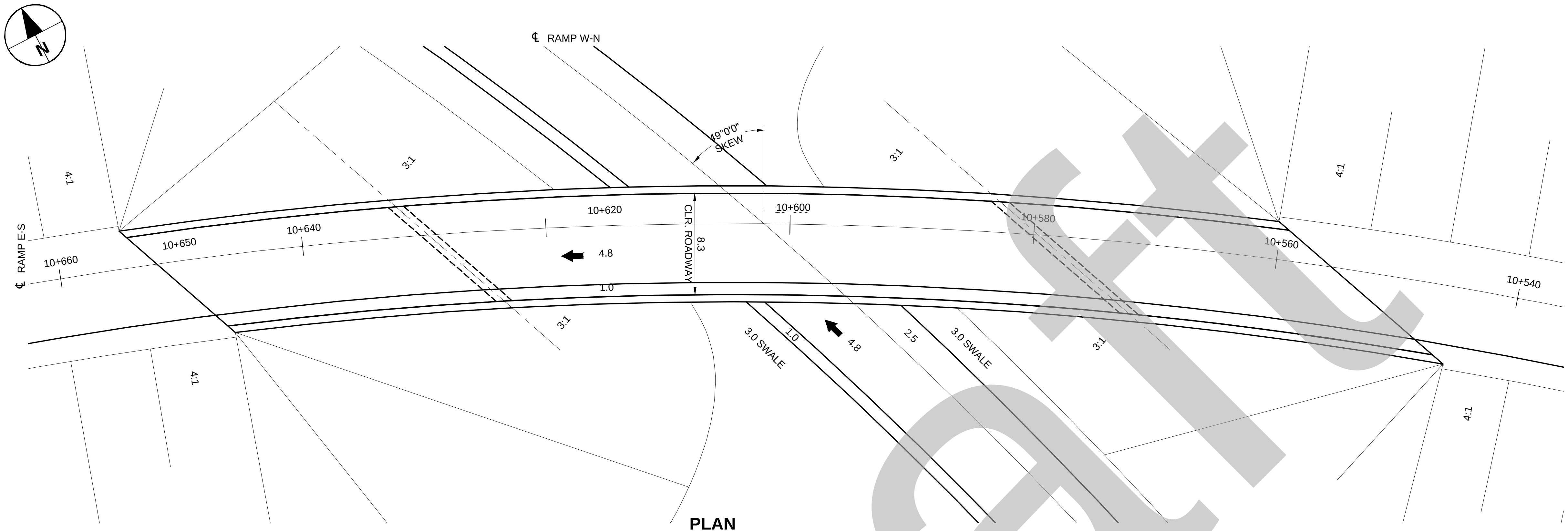

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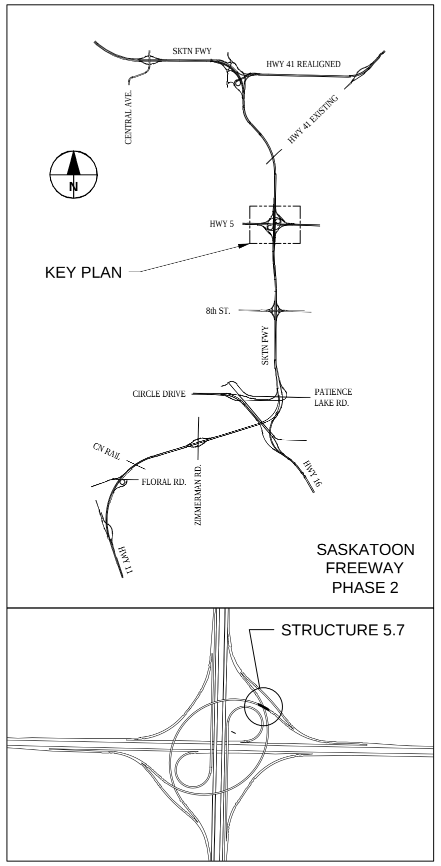

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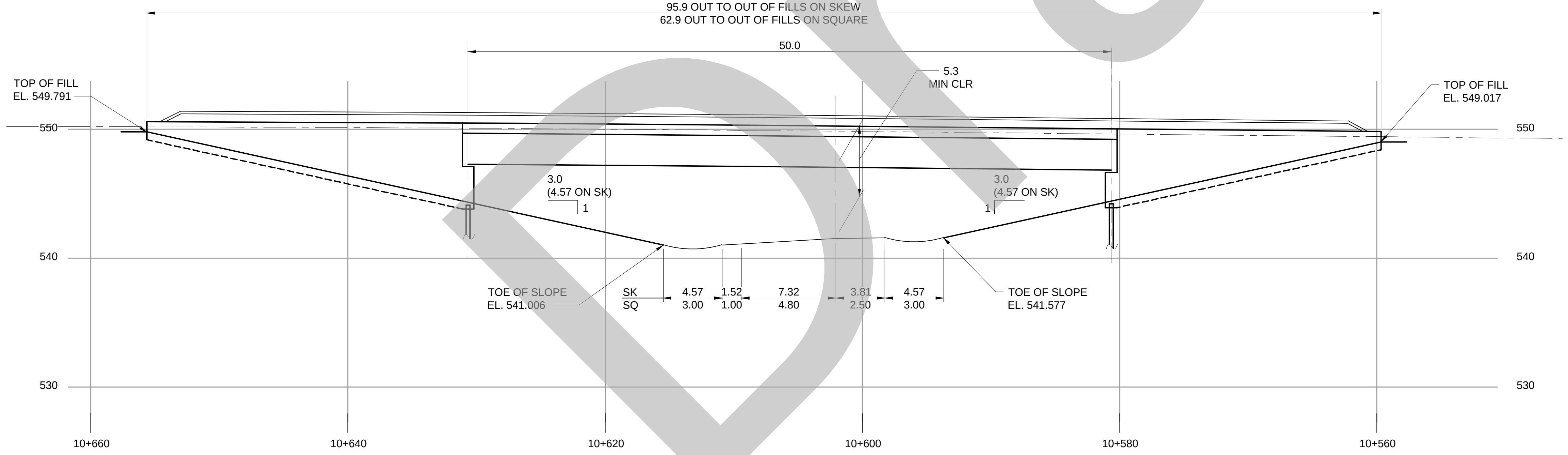

ELEVATION

Scale 1:400

PRELIMINARY

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REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.7

RECOMMENDED BY: ______________________ ________
SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: ______________________ ________
DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

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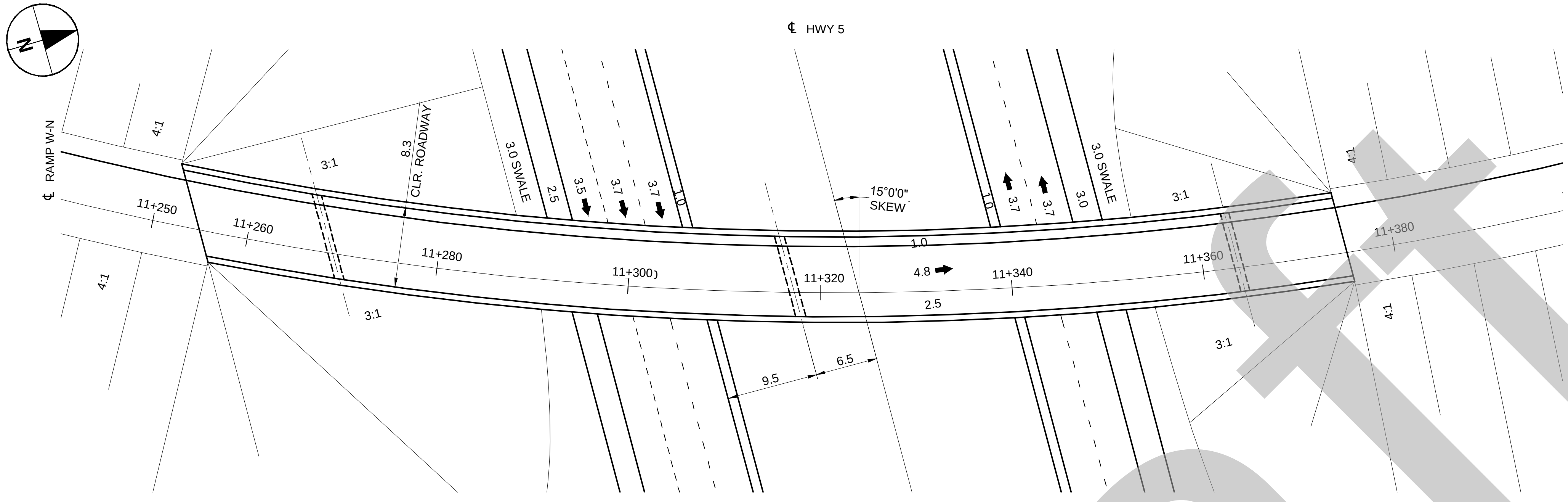

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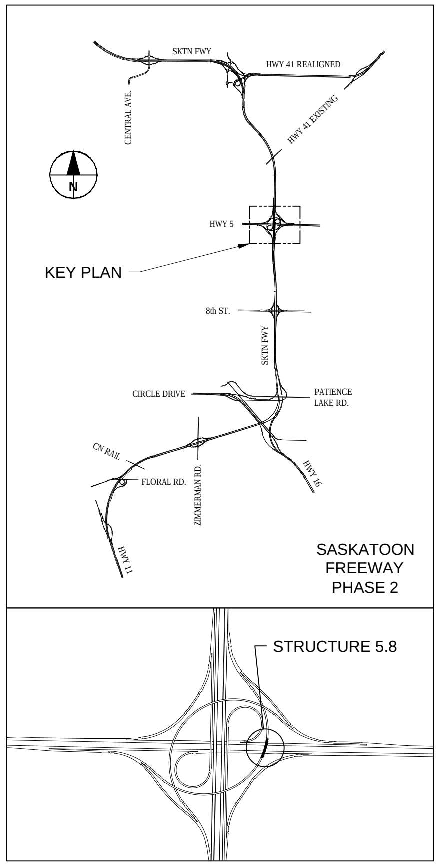

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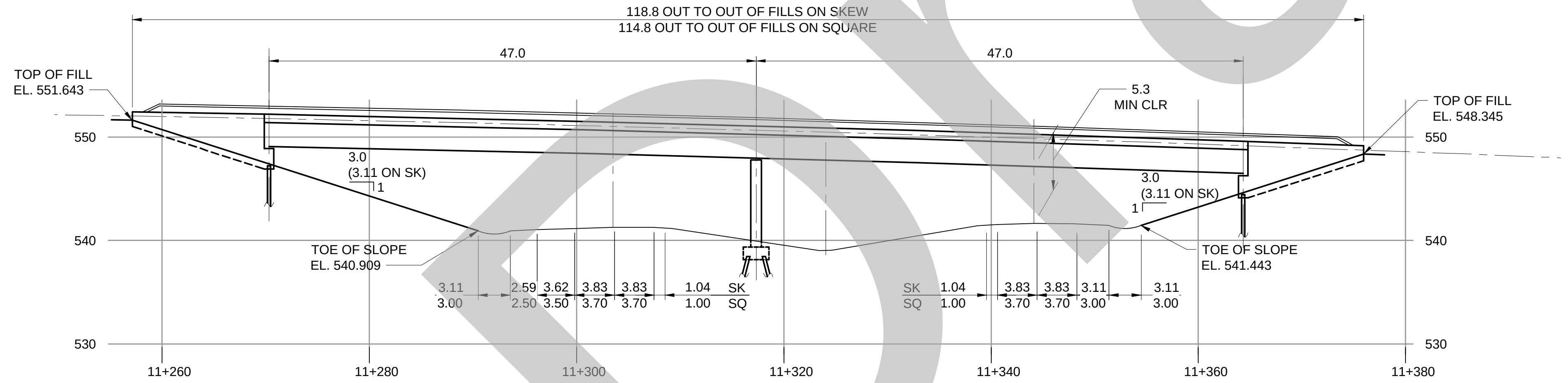

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BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.8

RECOMMENDED BY: ____________ SENIOR BRIDGE PROJECT MANAGER ____ DATE

APPROVED BY: ____________ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ____ DATE

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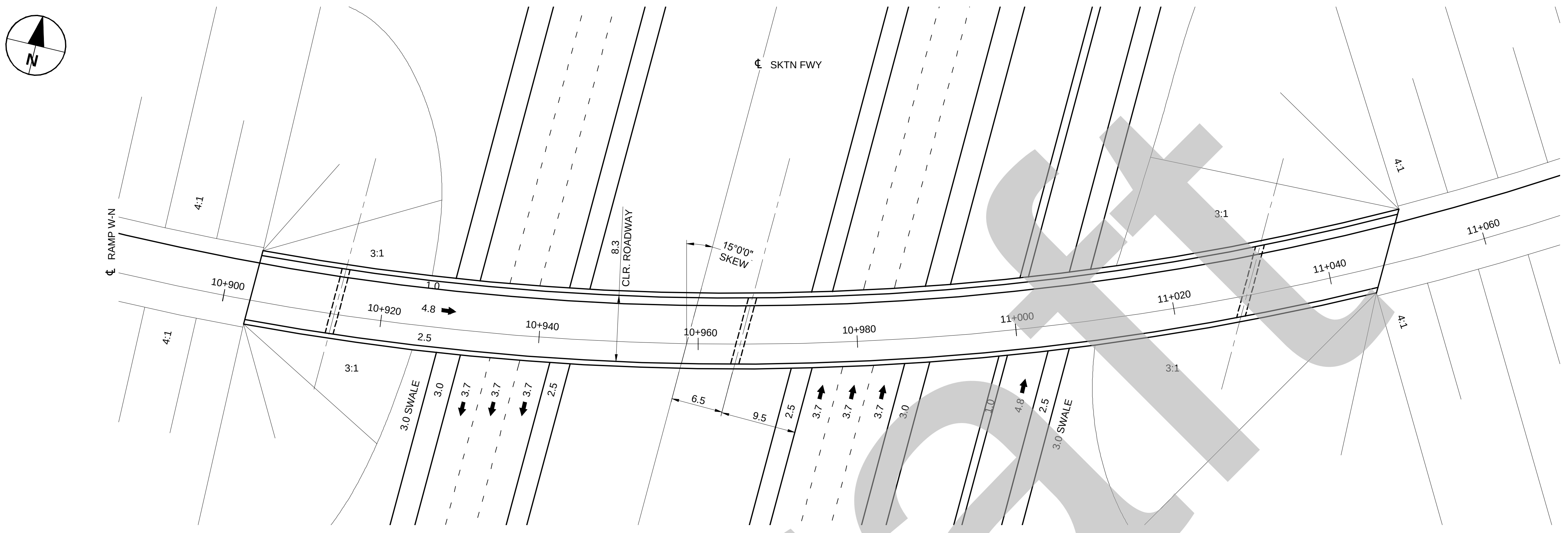

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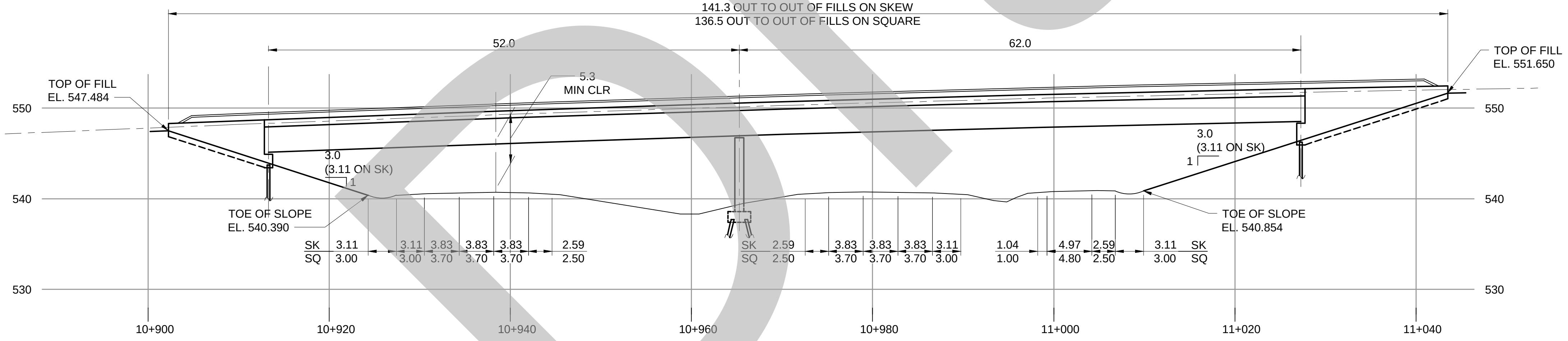

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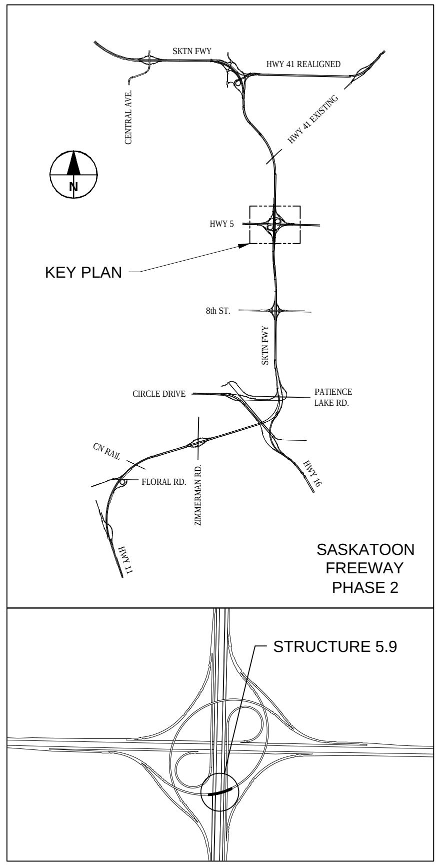

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NO.	DATE	DESCRIPTION

REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.9

RECOMMENDED BY: ______________________ ________
SENIOR BRIDGE PROJECT MANAGER — DATE

APPROVED BY: ______________________ ________
DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION — DATE

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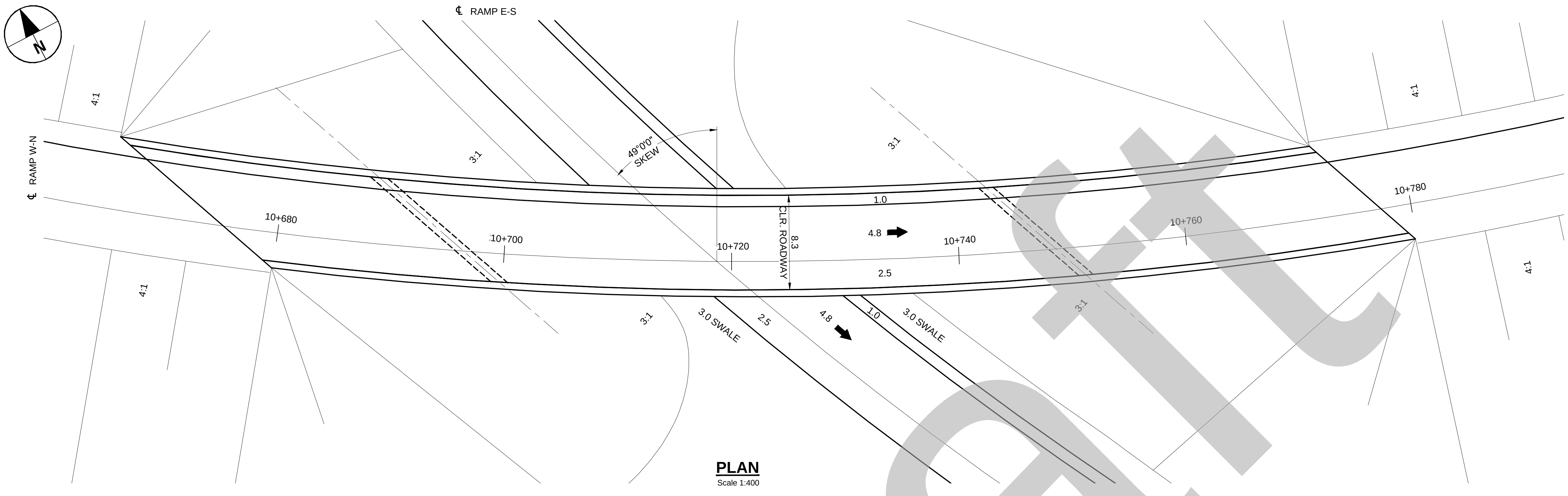

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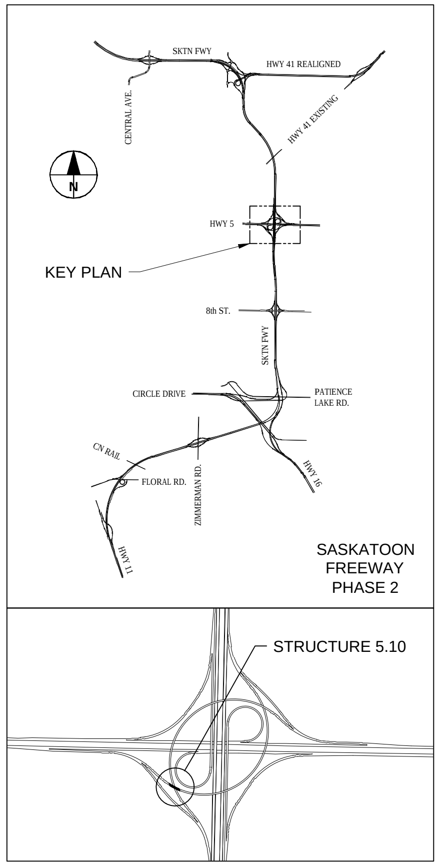

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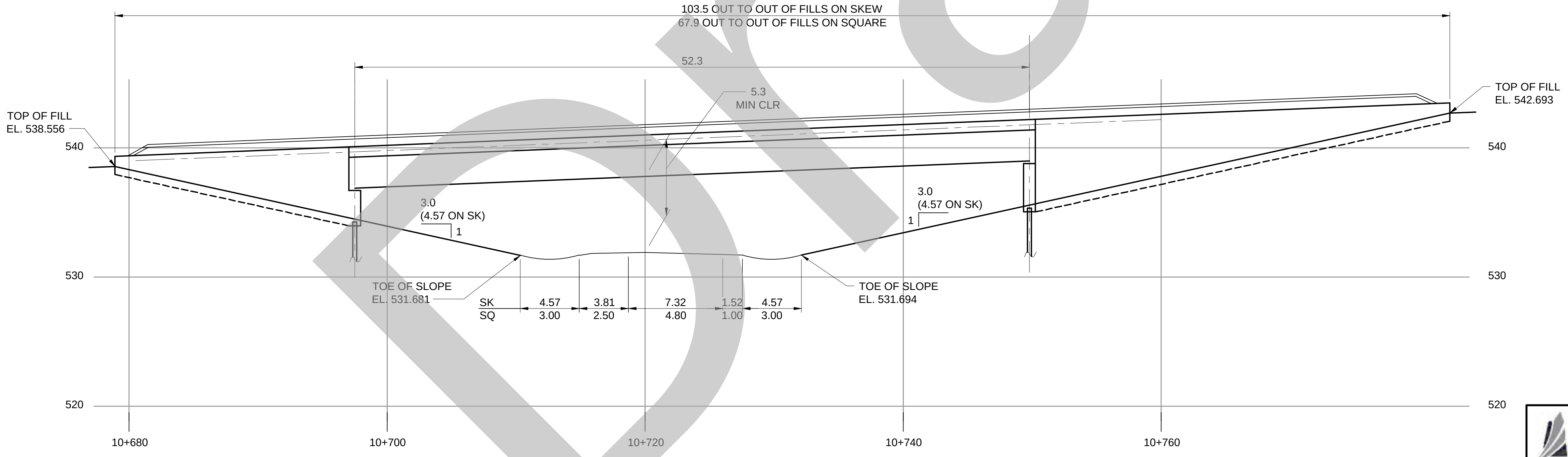

ELEVATION

Scale 1:400

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BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE 5.10

RECOMMENDED BY: ____________________ ________
SENIOR BRIDGE PROJECT MANAGER DATE

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DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

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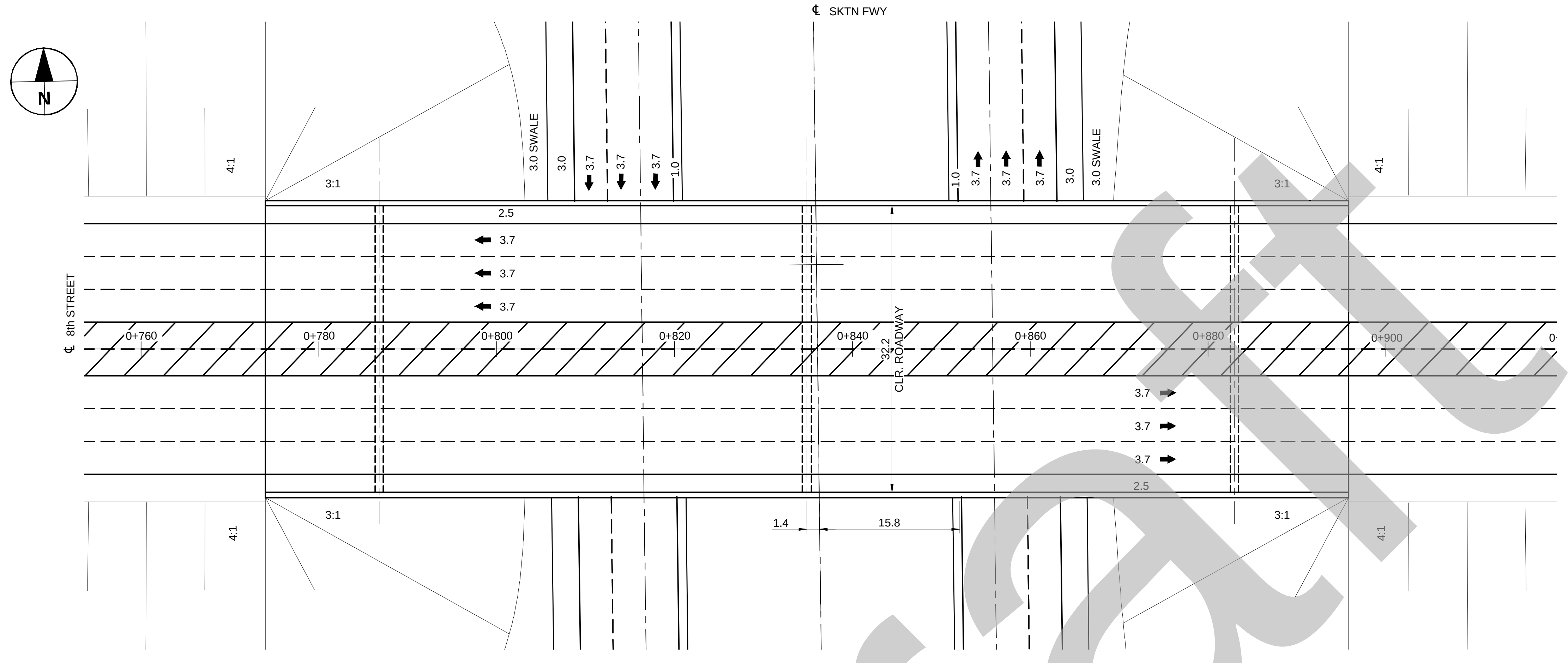

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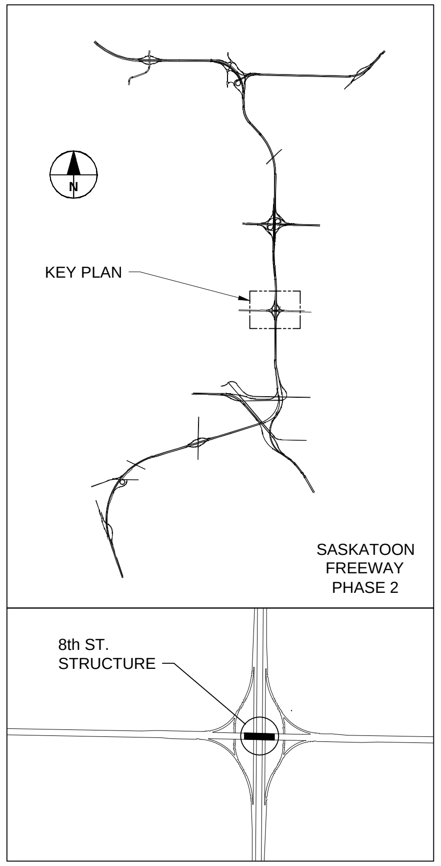

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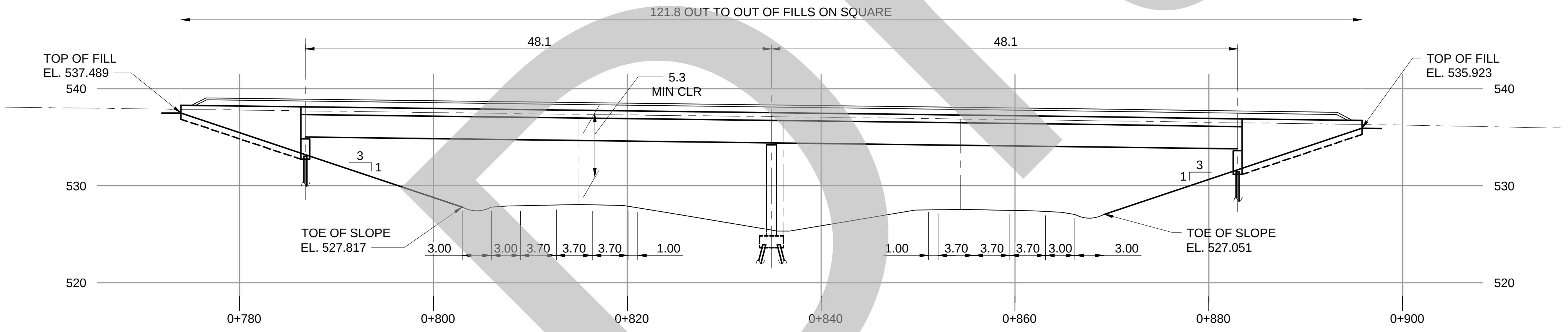

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PRELIMINARY

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REVISIONS

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BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – 8th ST. STRUCTURE

RECOMMENDED BY: ______ SENIOR BRIDGE PROJECT MANAGER ______ DATE

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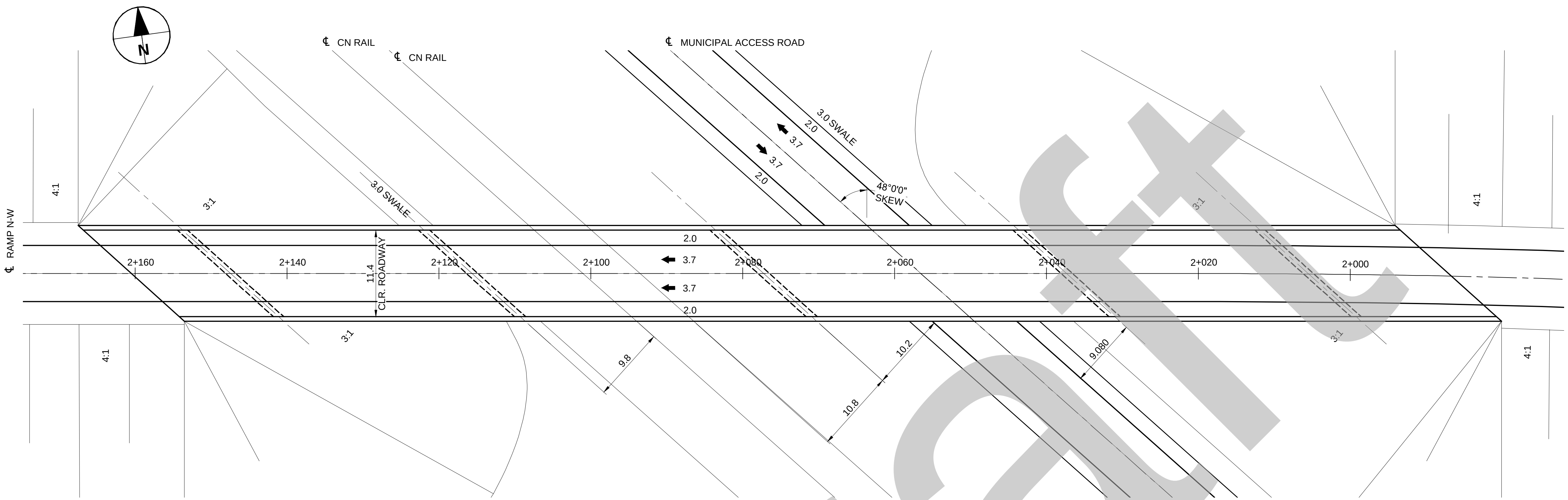

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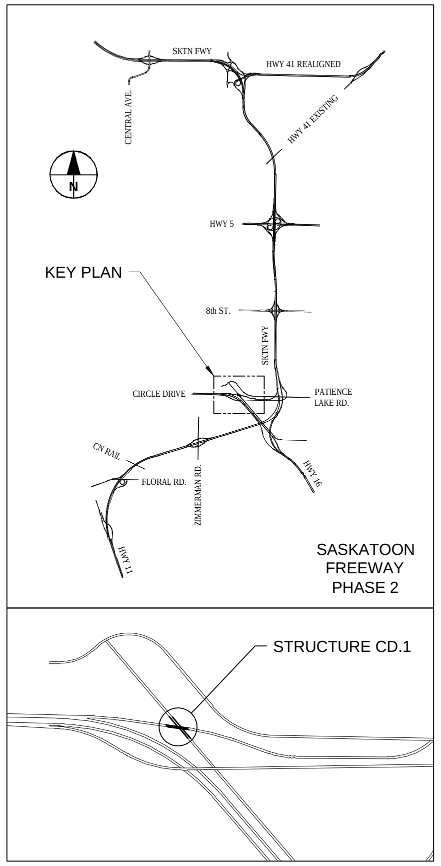

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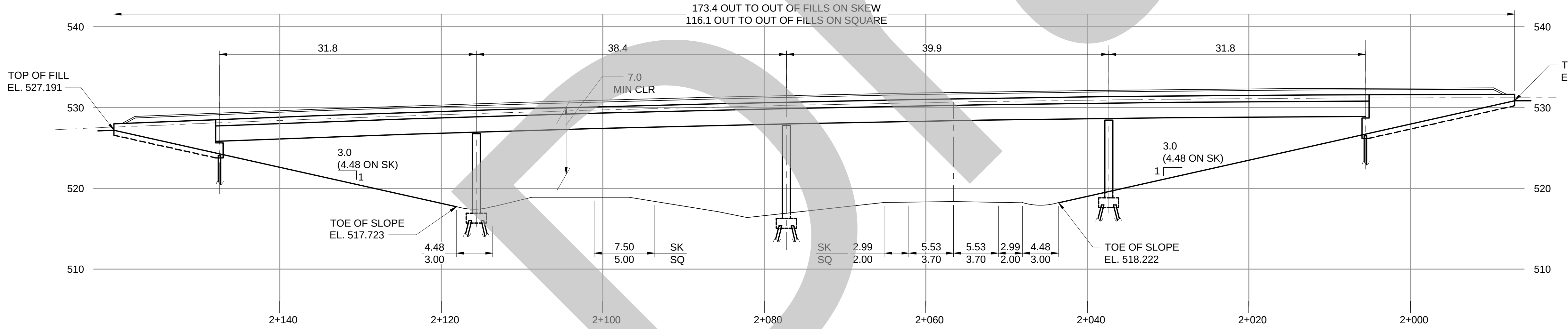

ELEVATION

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PRELIMINARY

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Government of Saskatchewan
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BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE CD.1

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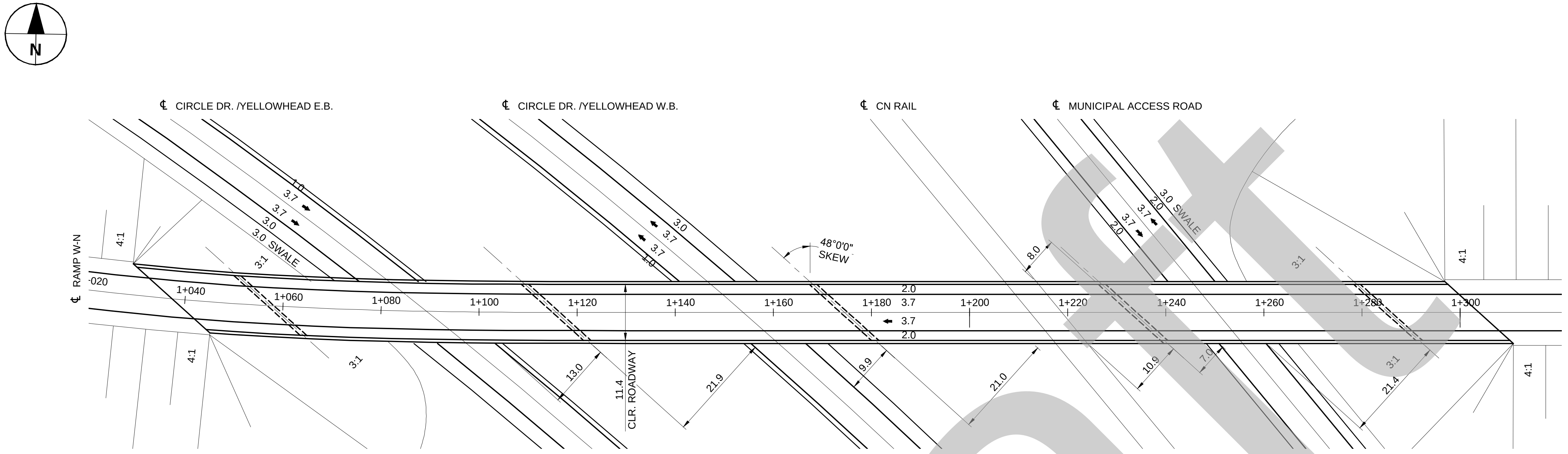

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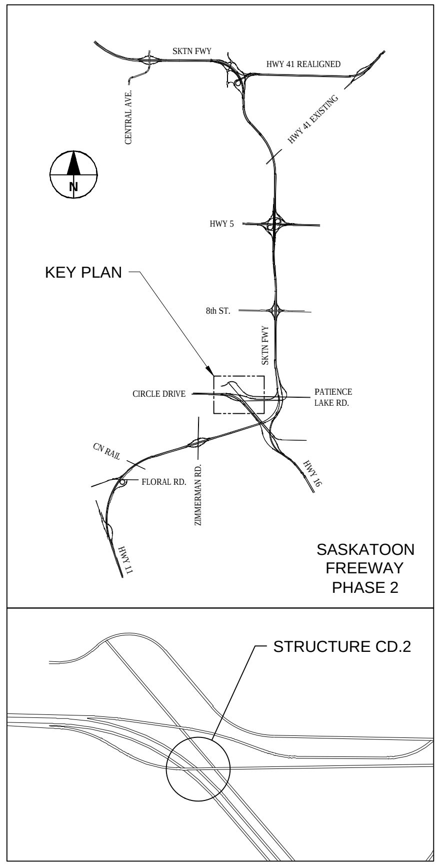

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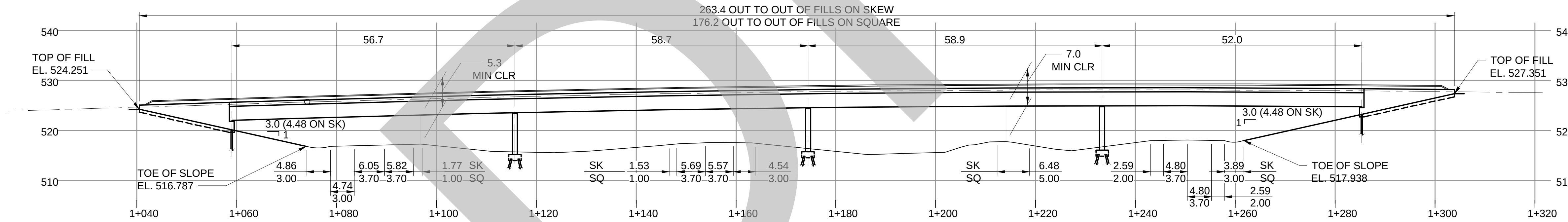

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REVISIONS

Government of Saskatchewan
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BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE CD.2

RECOMMENDED BY: ____ SENIOR BRIDGE PROJECT MANAGER ____ DATE

APPROVED BY: ____ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ____ DATE

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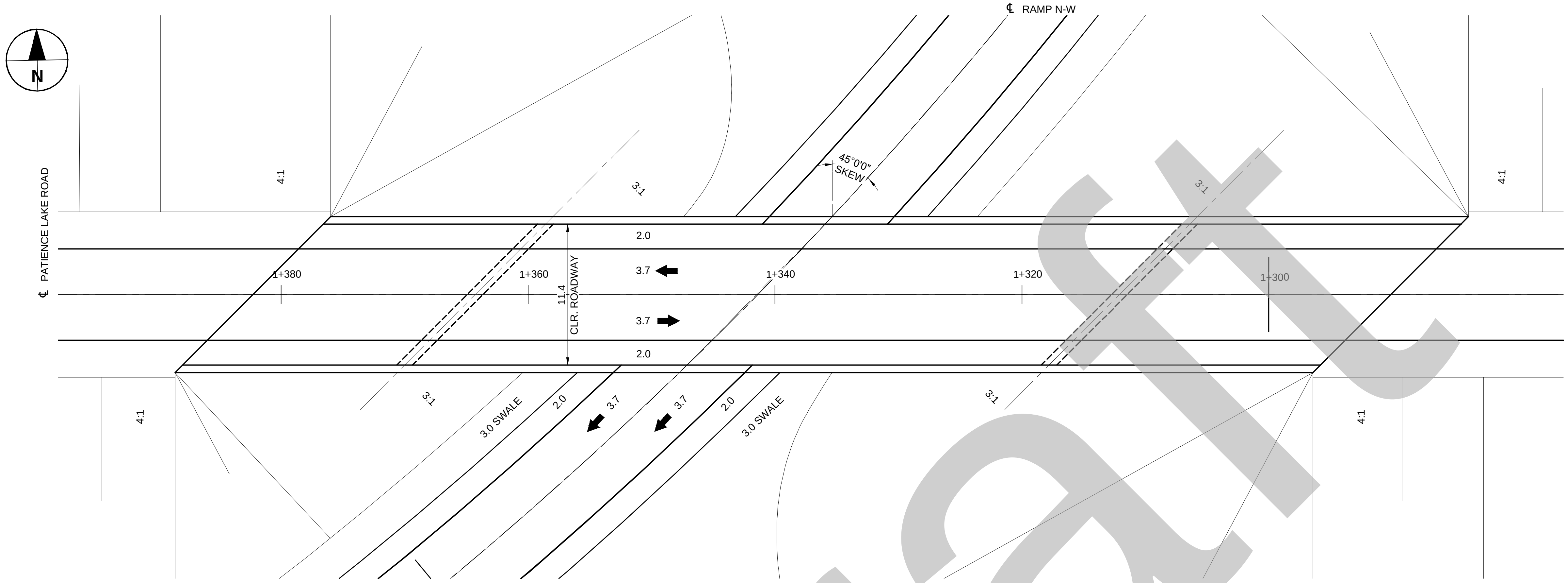

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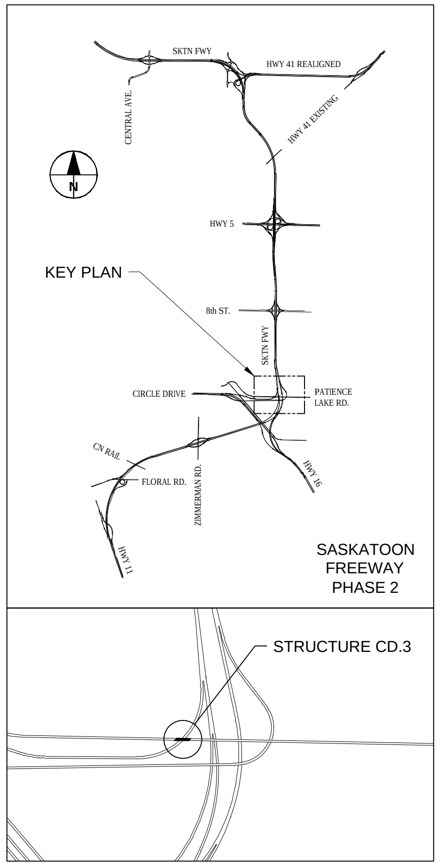

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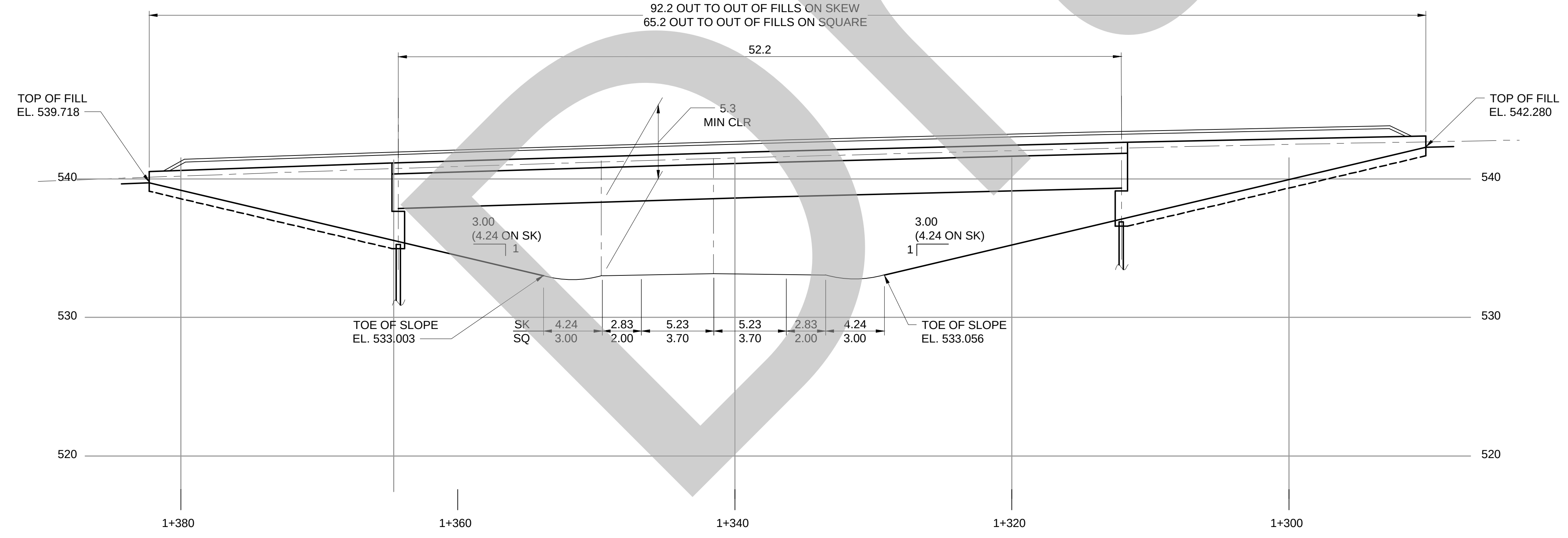

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REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE CD.3

RECOMMENDED BY: ______________________ ________
SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: ______________________ ________
DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

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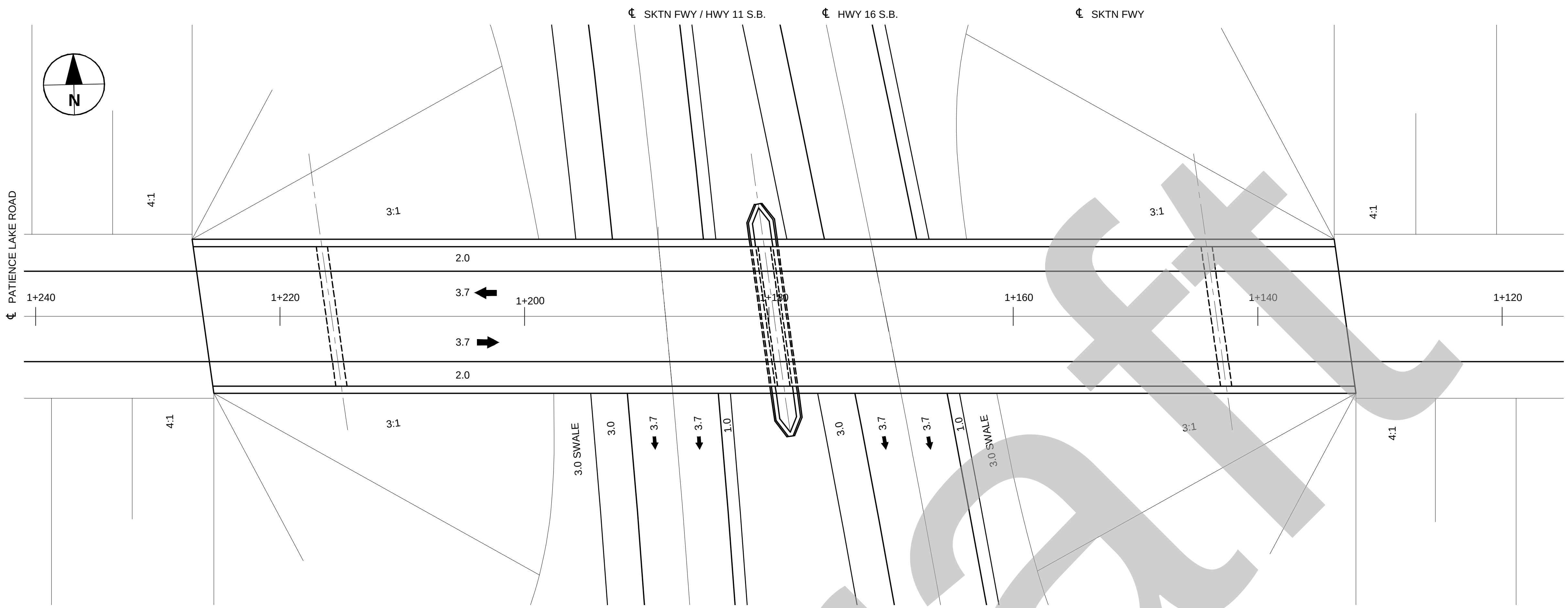

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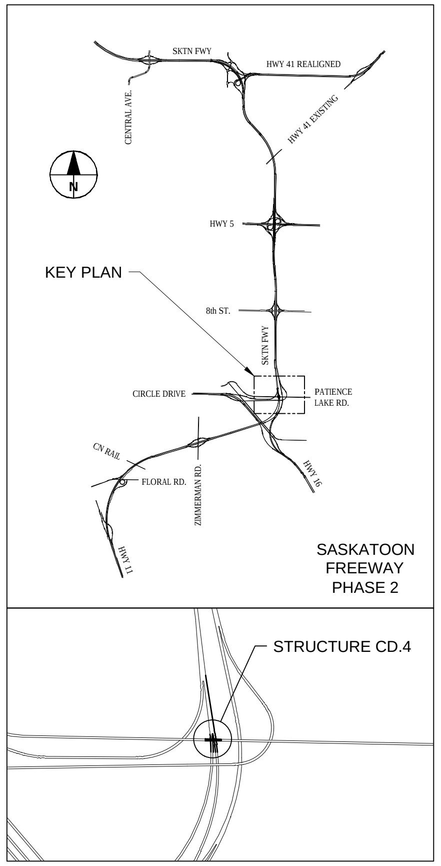

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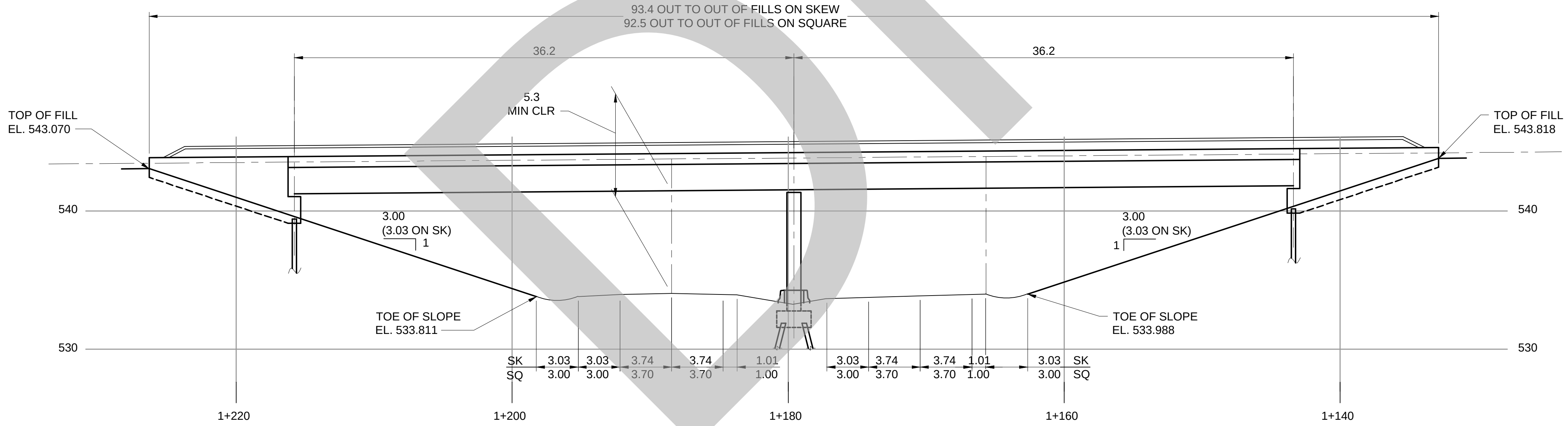

ELEVATION

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PRELIMINARY

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REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE CD.4

RECOMMENDED BY: ______ SENIOR BRIDGE PROJECT MANAGER ______ DATE

APPROVED BY: ______ DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION ______ DATE

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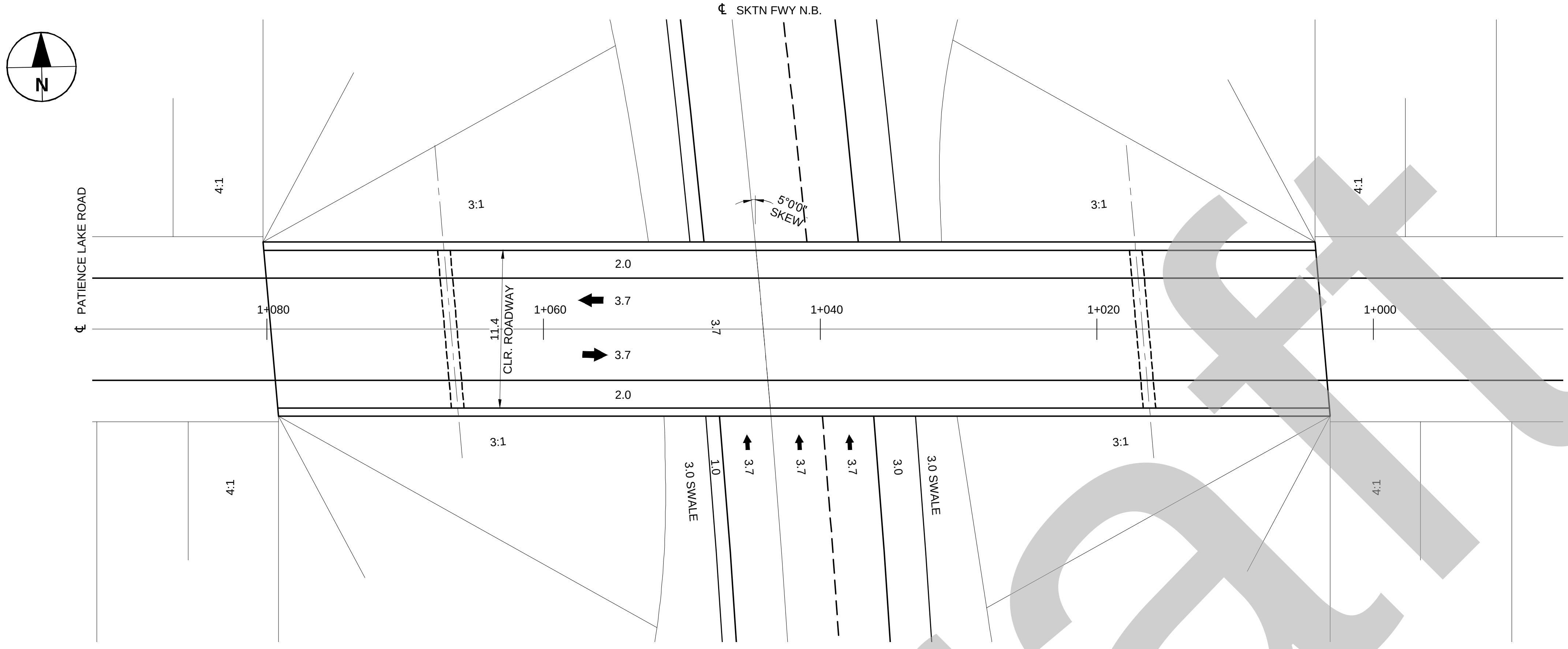

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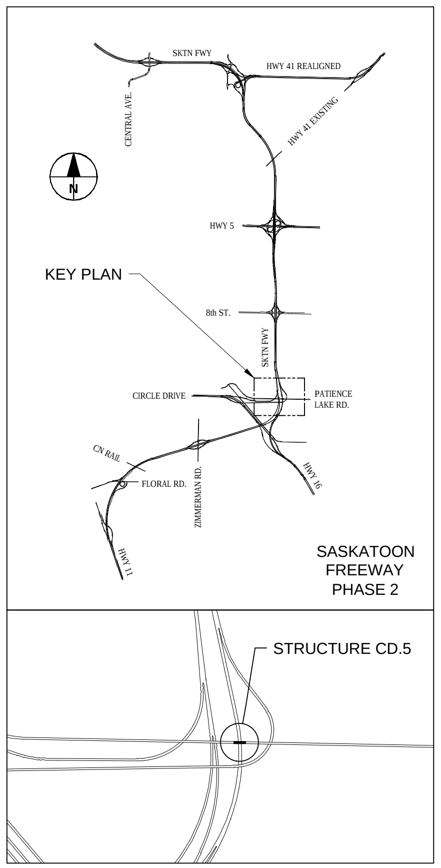

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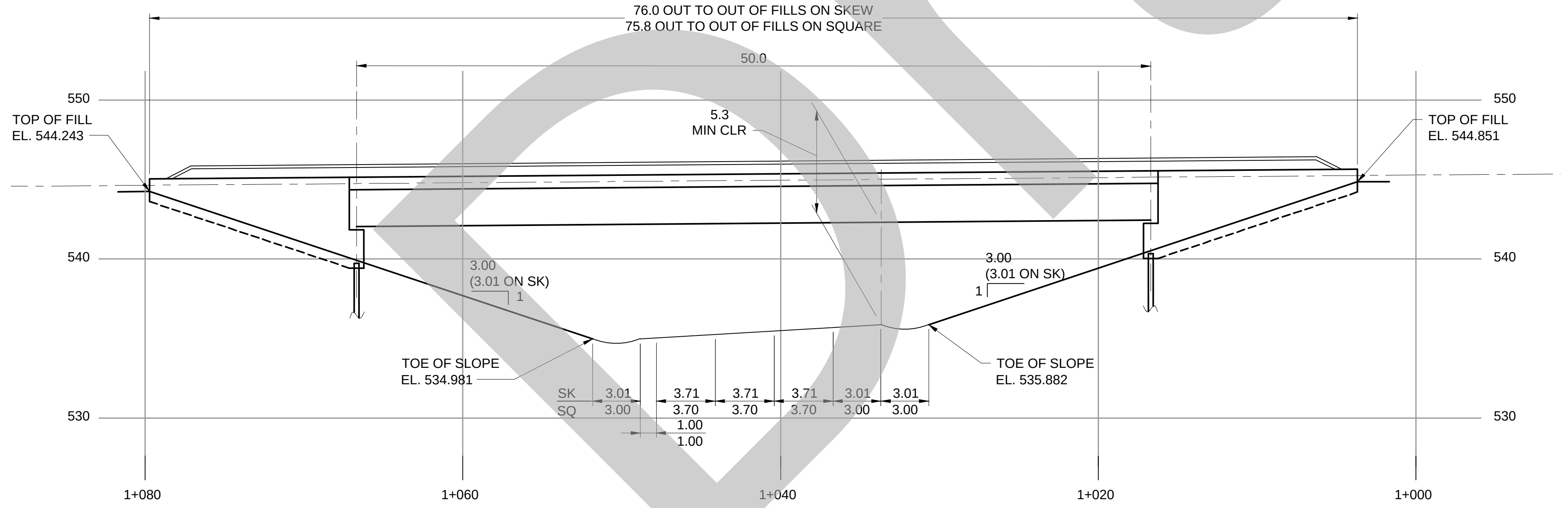

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REVISIONS

Government of Saskatchewan
Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE CD.5

RECOMMENDED BY: SENIOR BRIDGE PROJECT MANAGER DATE

APPROVED BY: DIRECTOR, REGIONAL DESIGN AND CONSTRUCTION DATE

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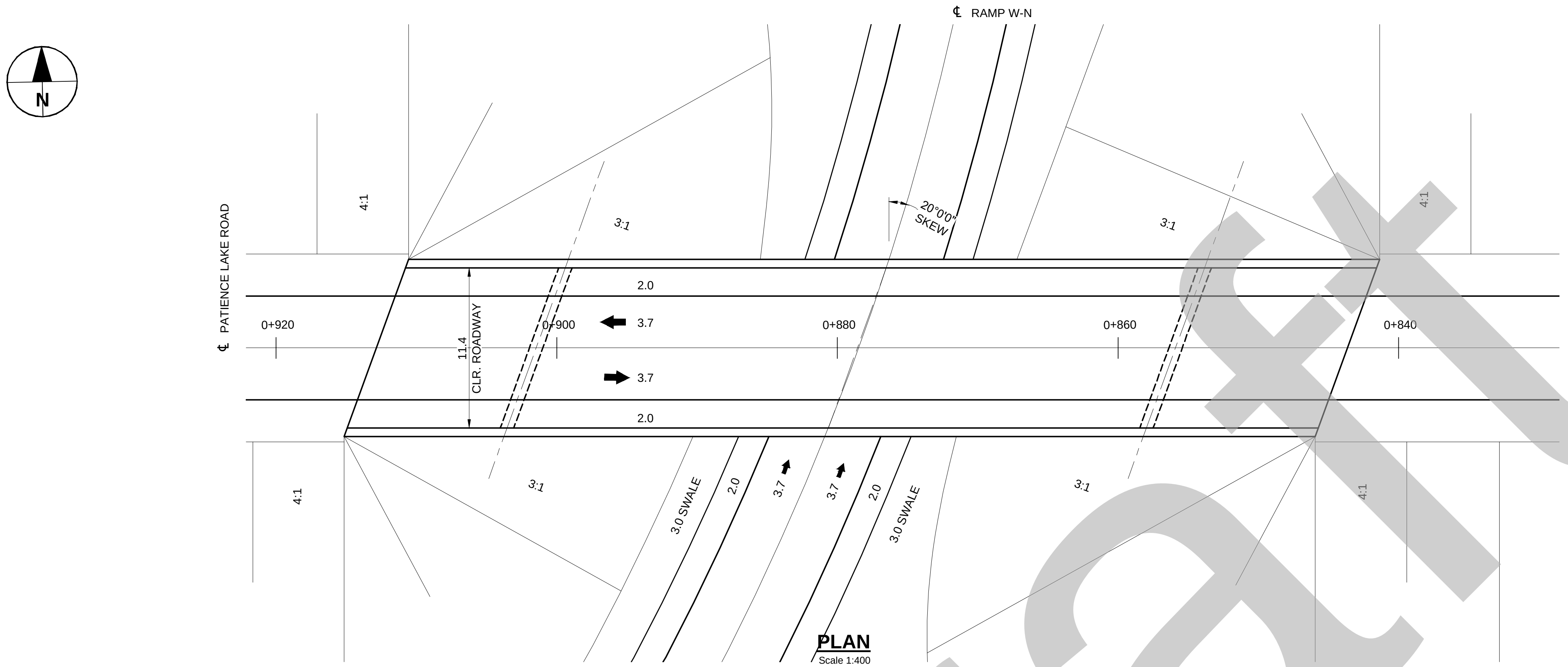

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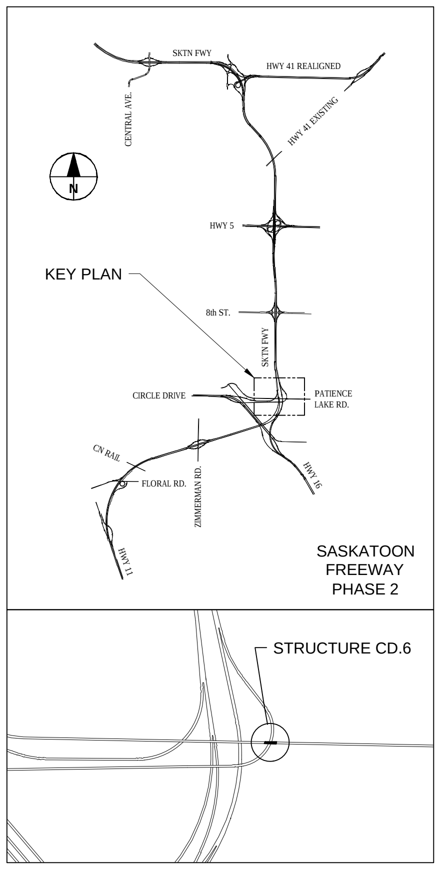

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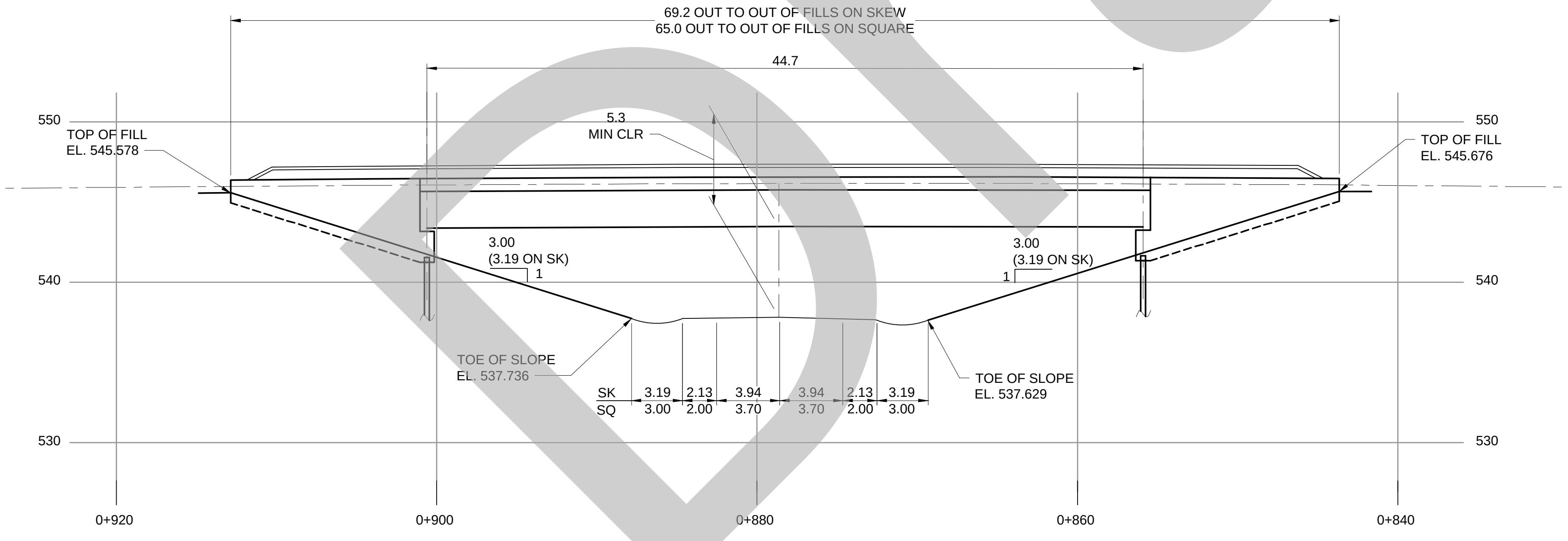

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REVISIONS

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BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE CD.6

RECOMMENDED BY: ____________ SENIOR BRIDGE PROJECT MANAGER ____ DATE

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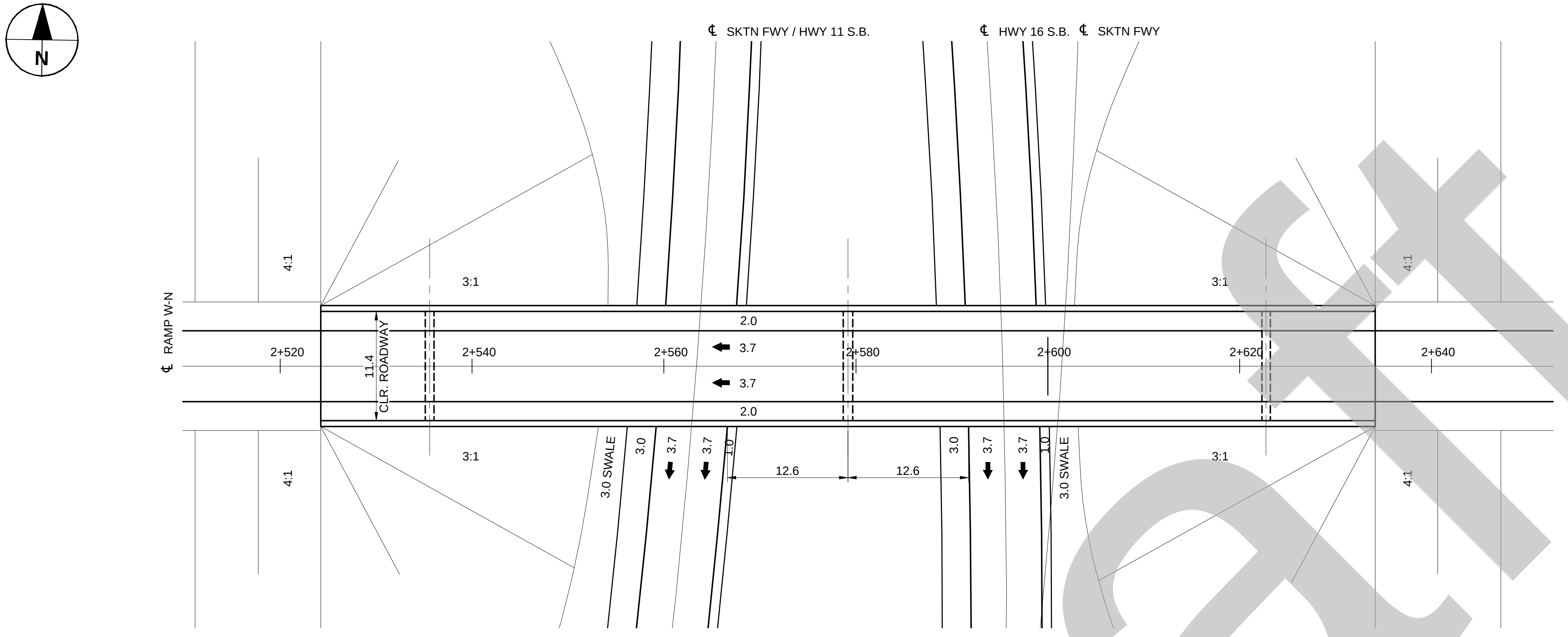

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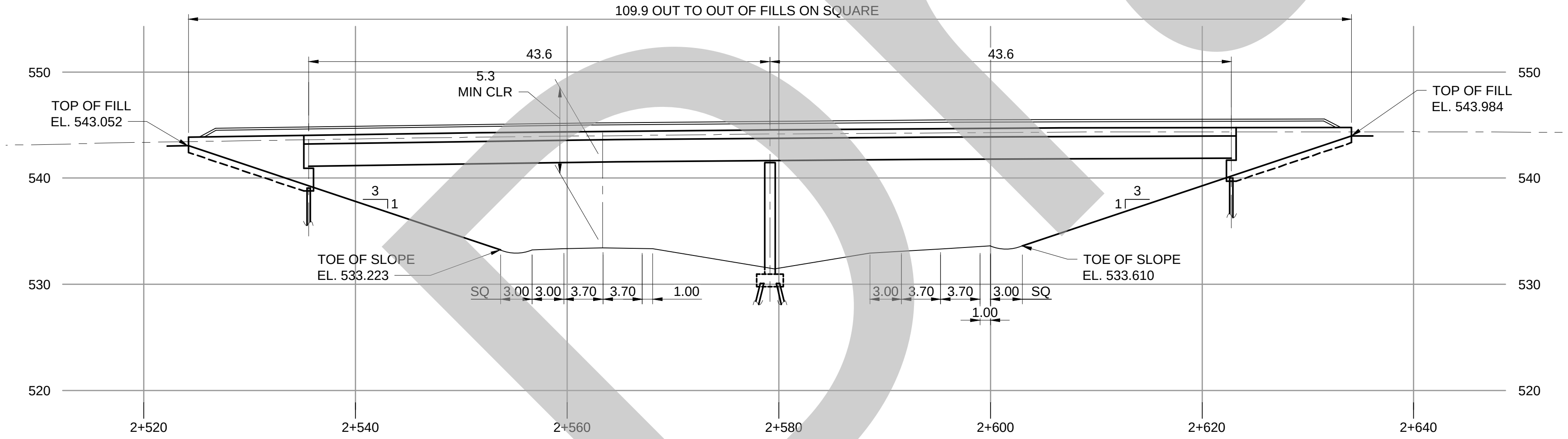

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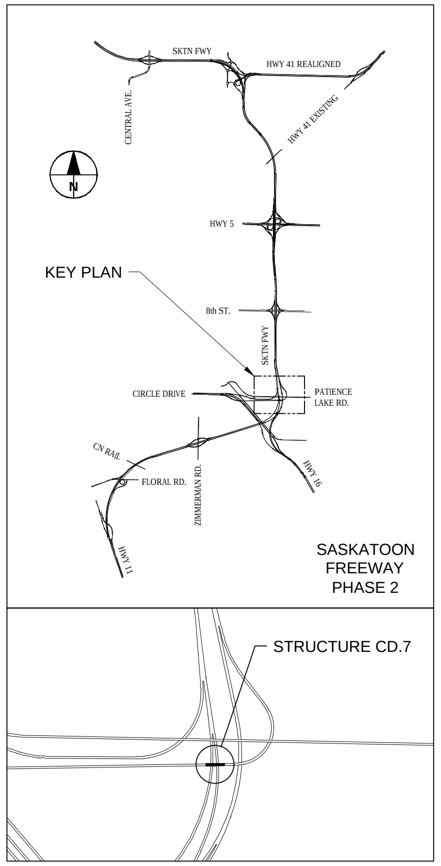

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NO.	DATE	DESCRIPTION

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Ministry of Highways & Infrastructure

BRIDGE SERVICES

FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE CD.7

RECOMMENDED BY: ____________ SENIOR BRIDGE PROJECT MANAGER ______ DATE

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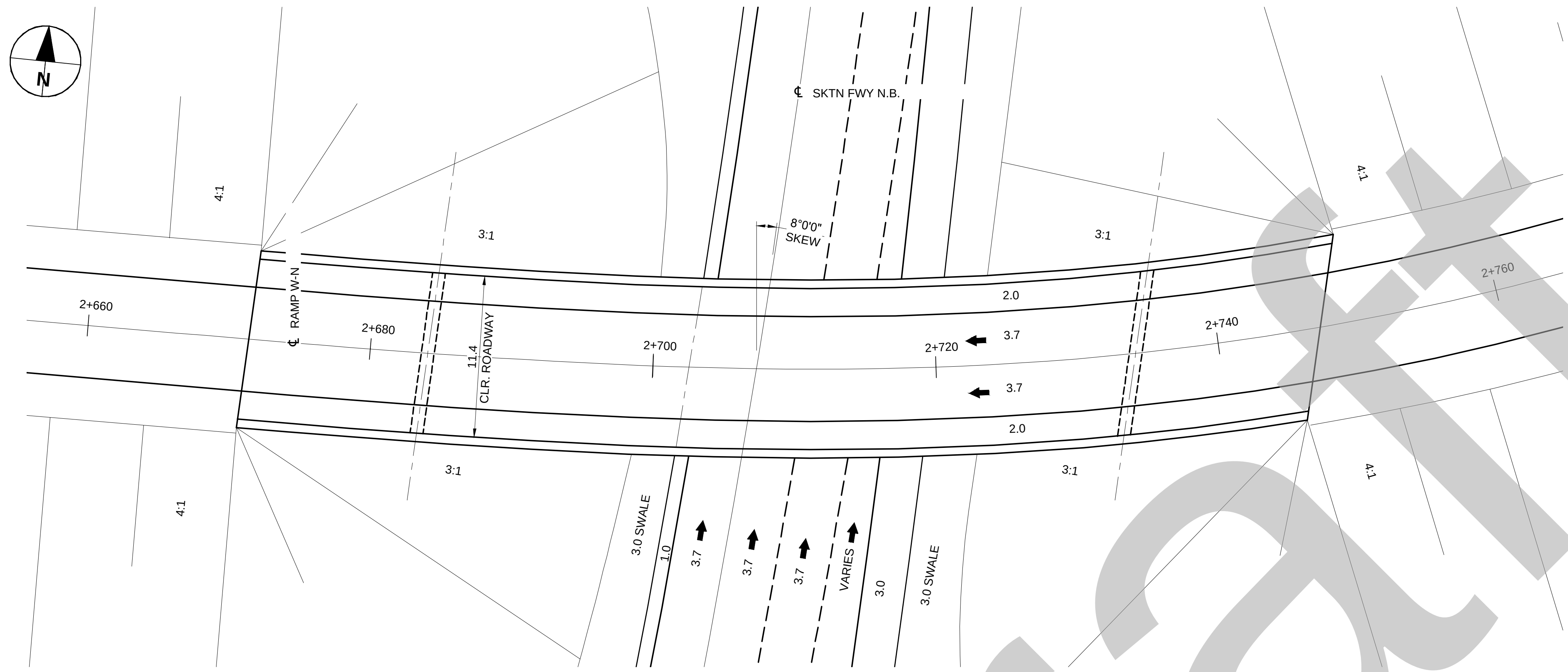

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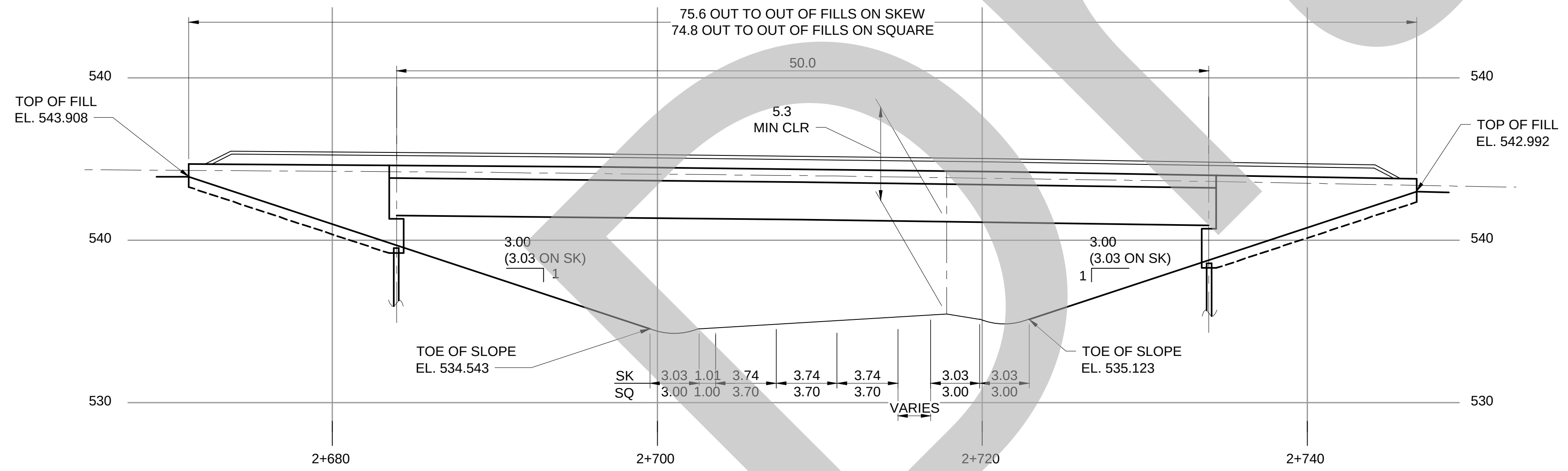

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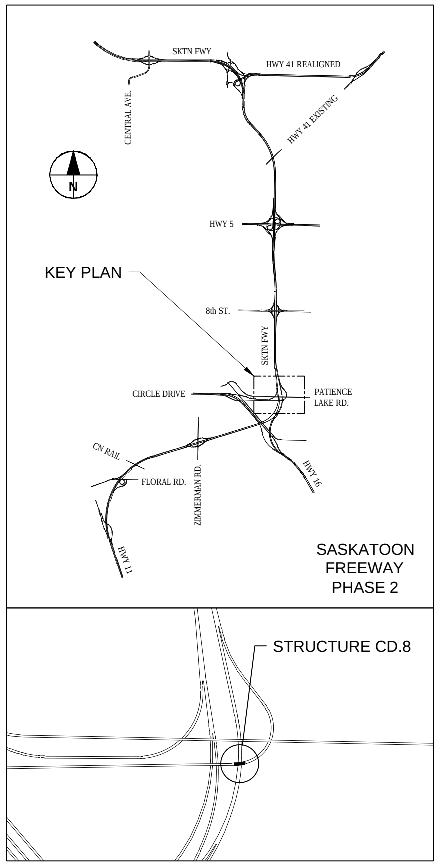

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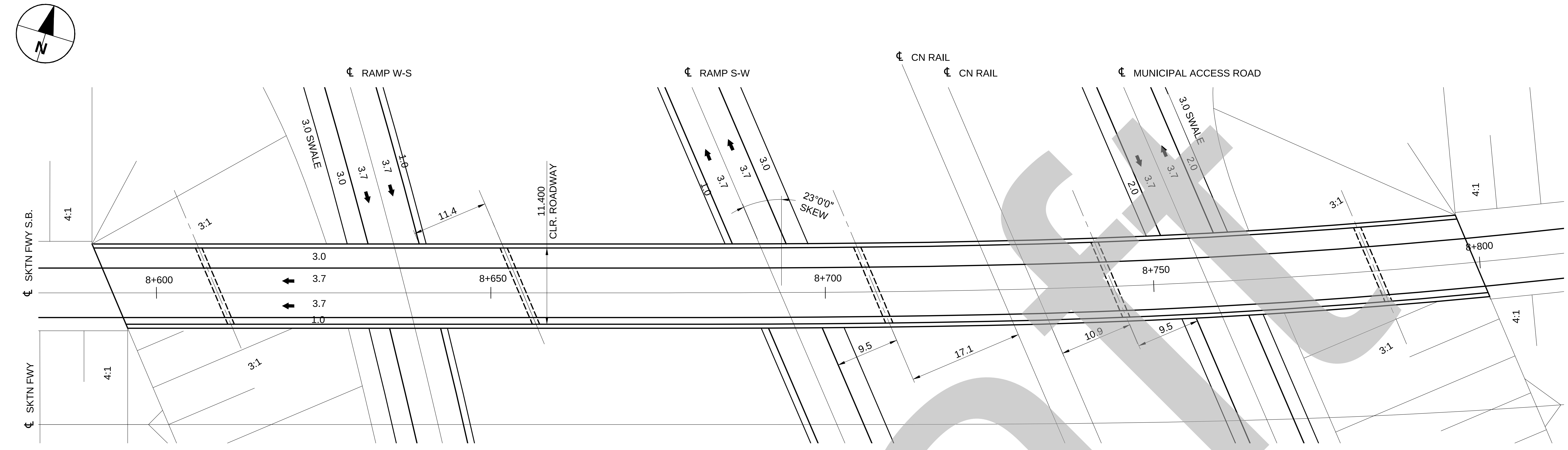

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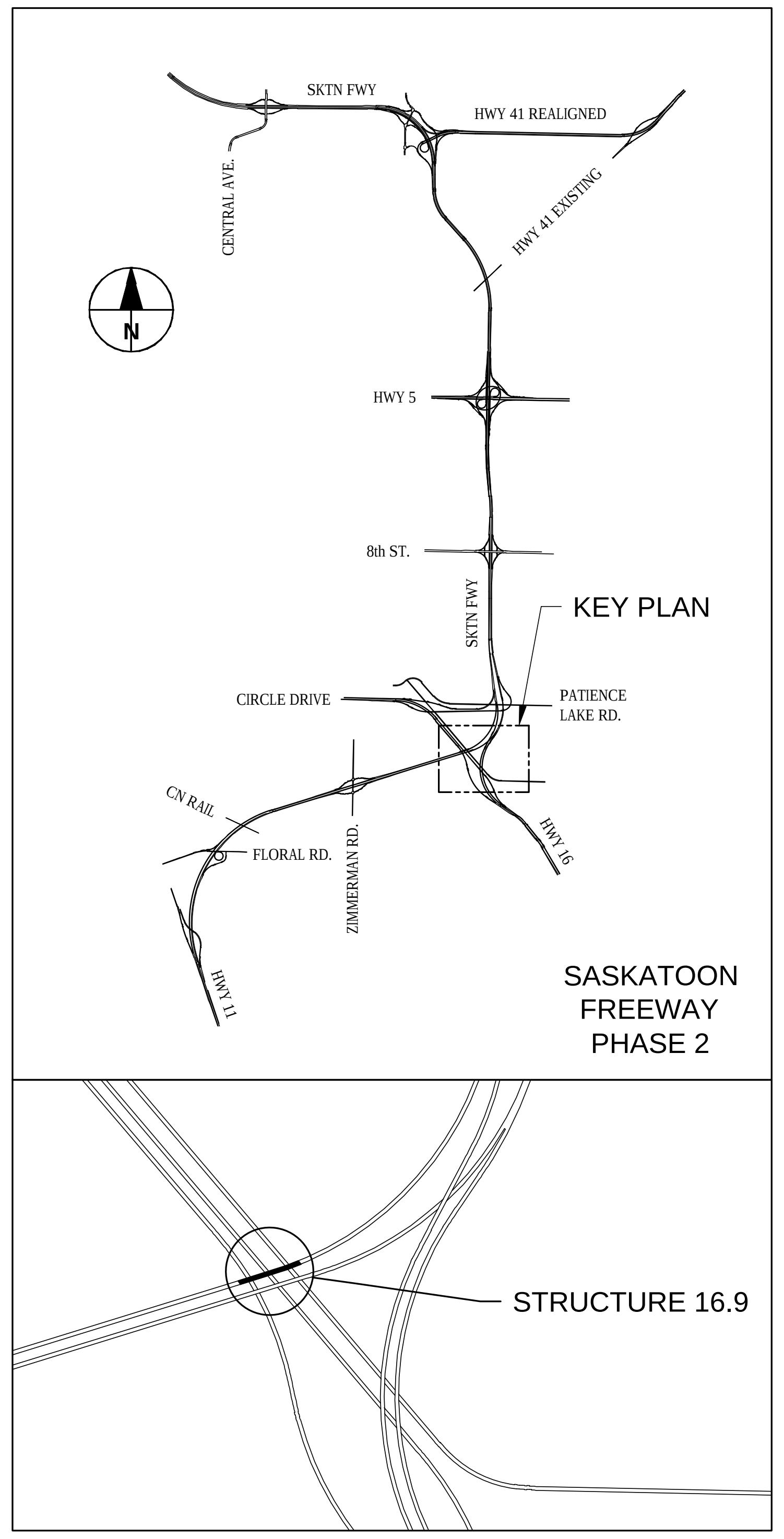

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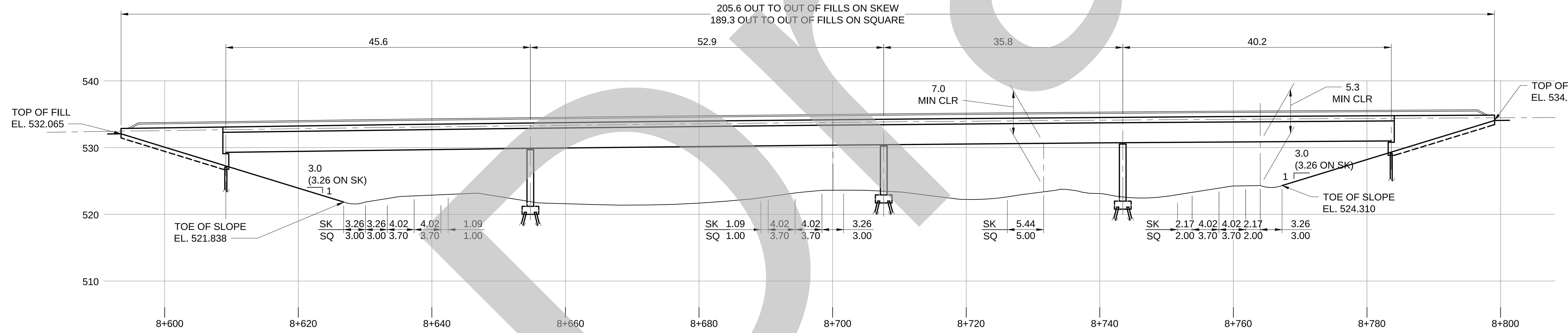

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PLAN AND ELEVATION – STRUCTURE 16.9

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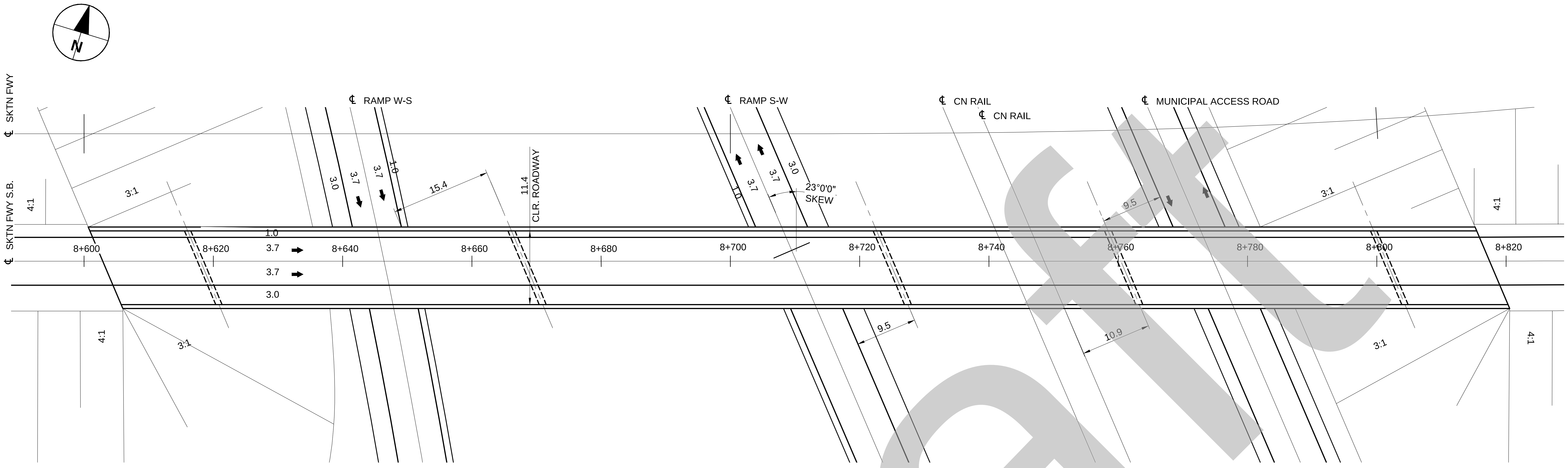

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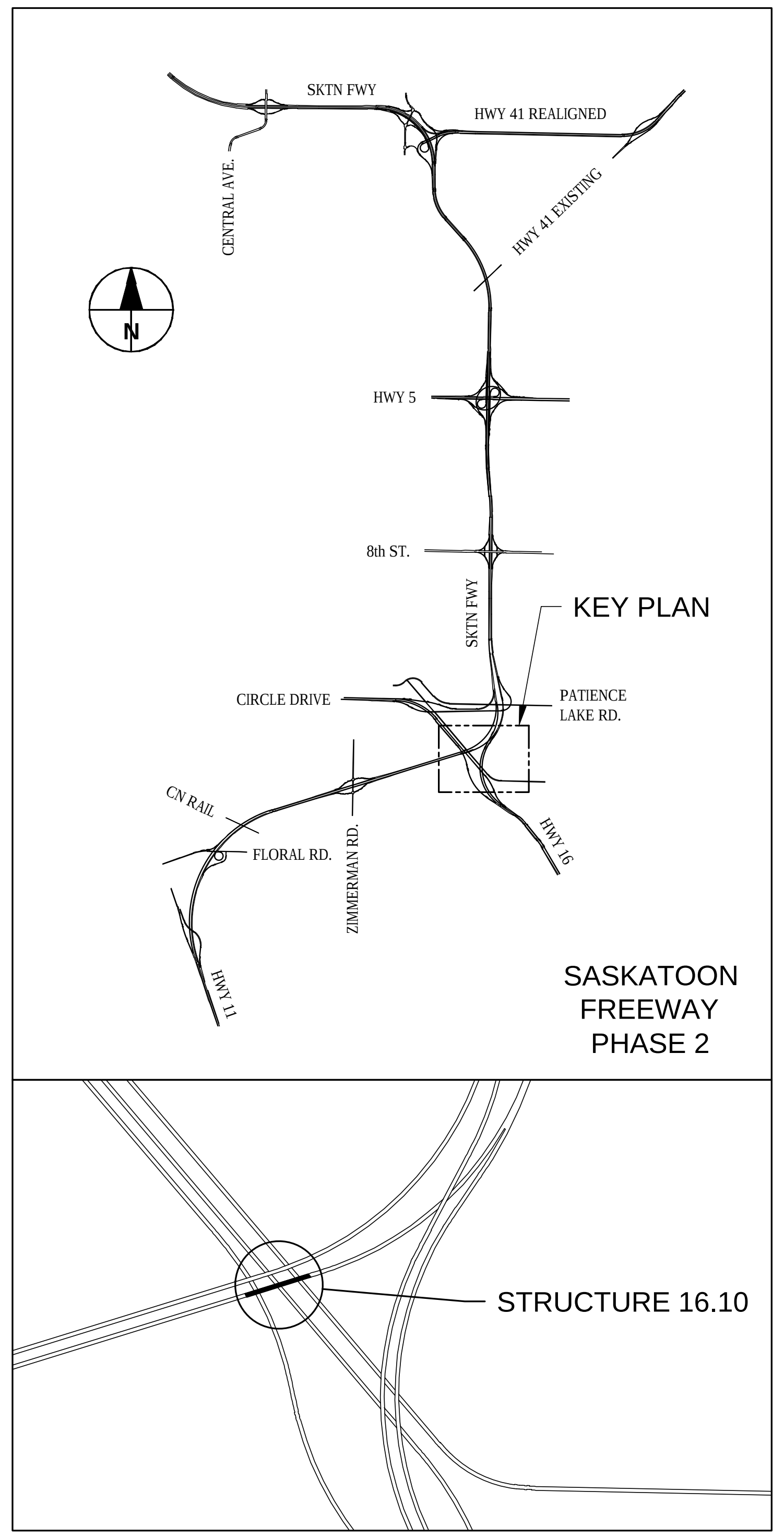

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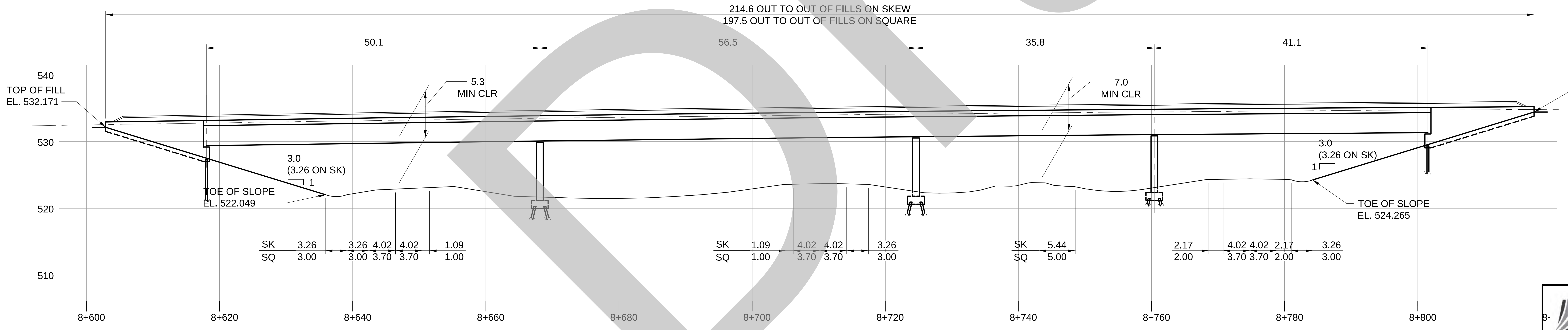

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PLAN AND ELEVATION – STRUCTURE 16.10

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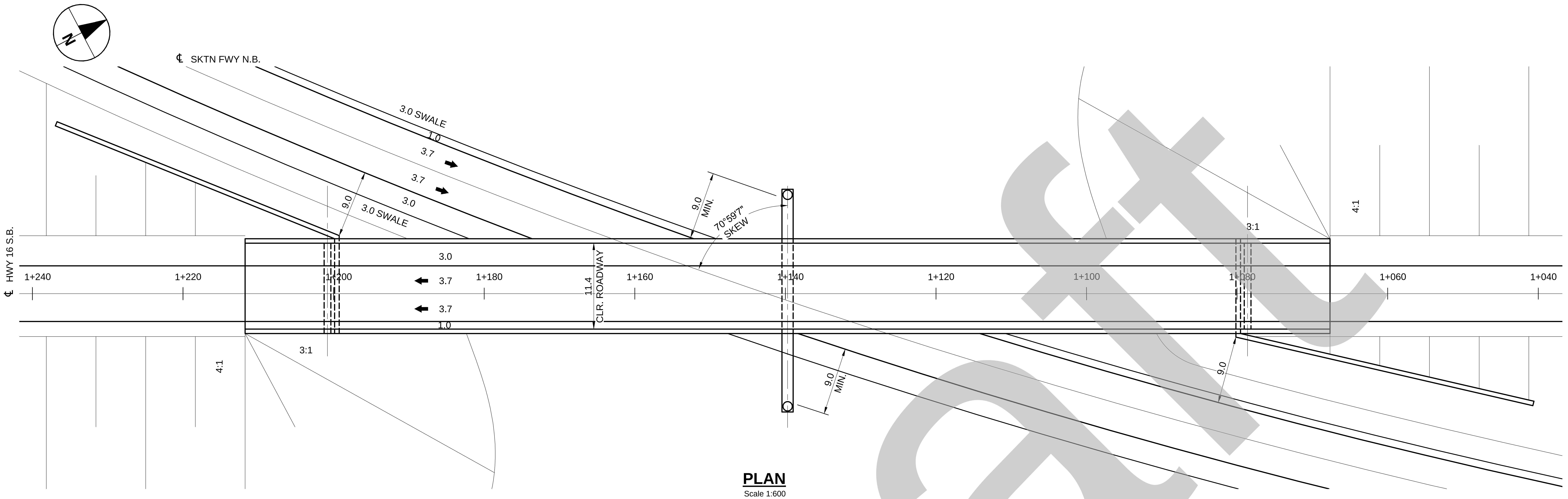

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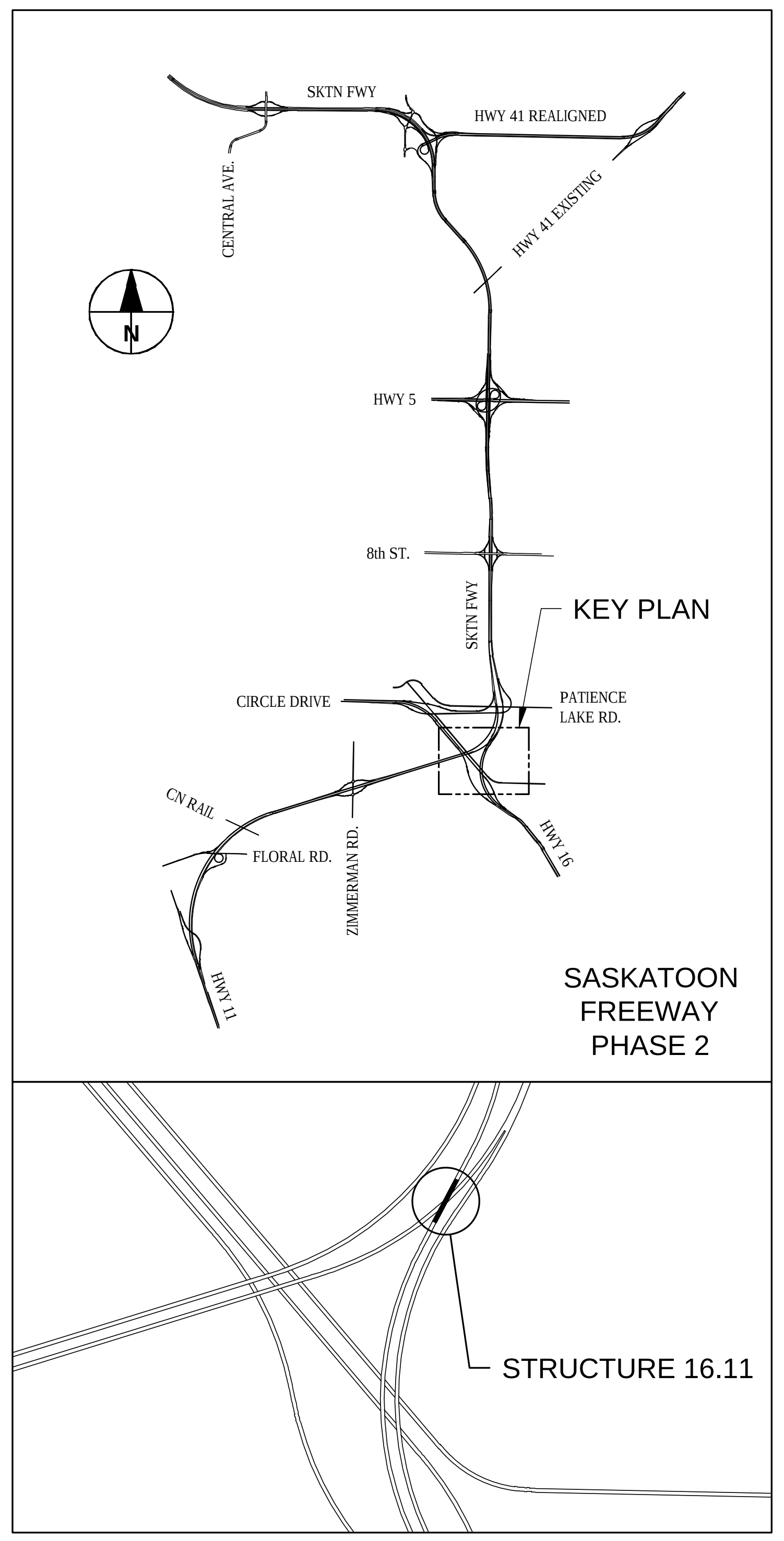

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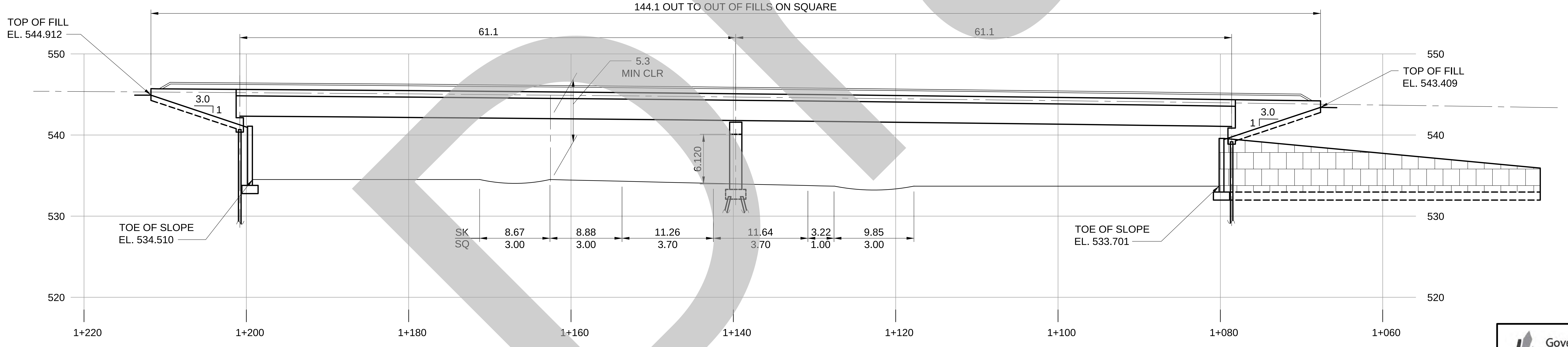

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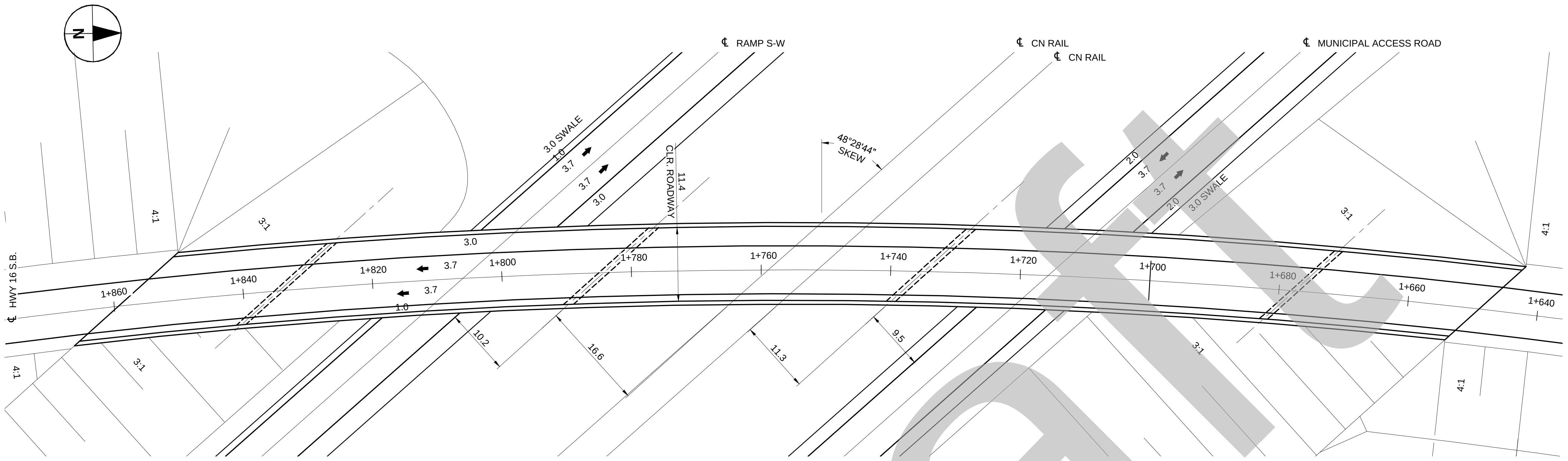

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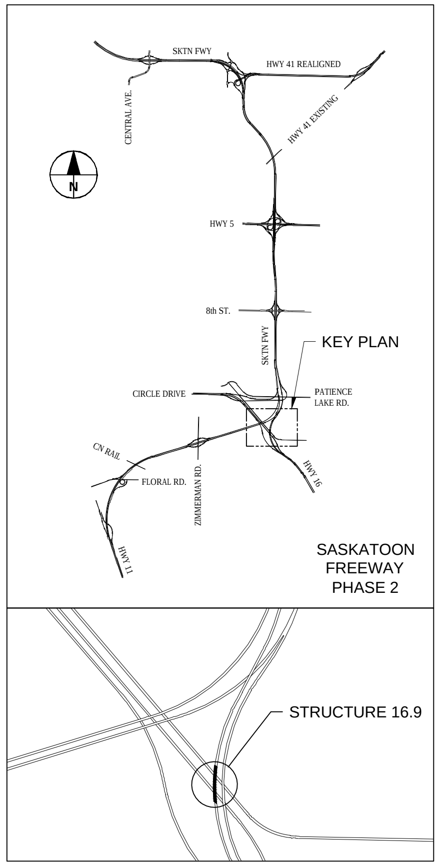

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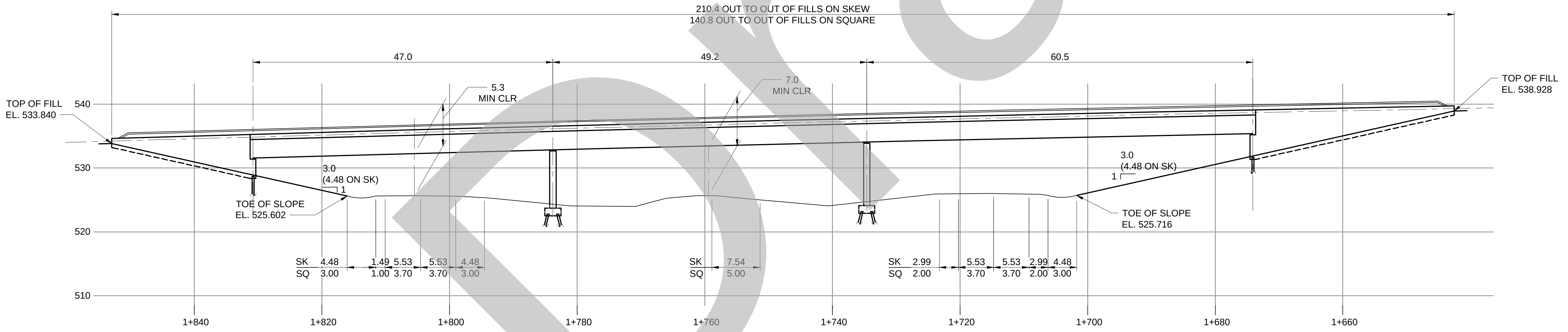

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PLAN AND ELEVATION – STRUCTURE 16.12

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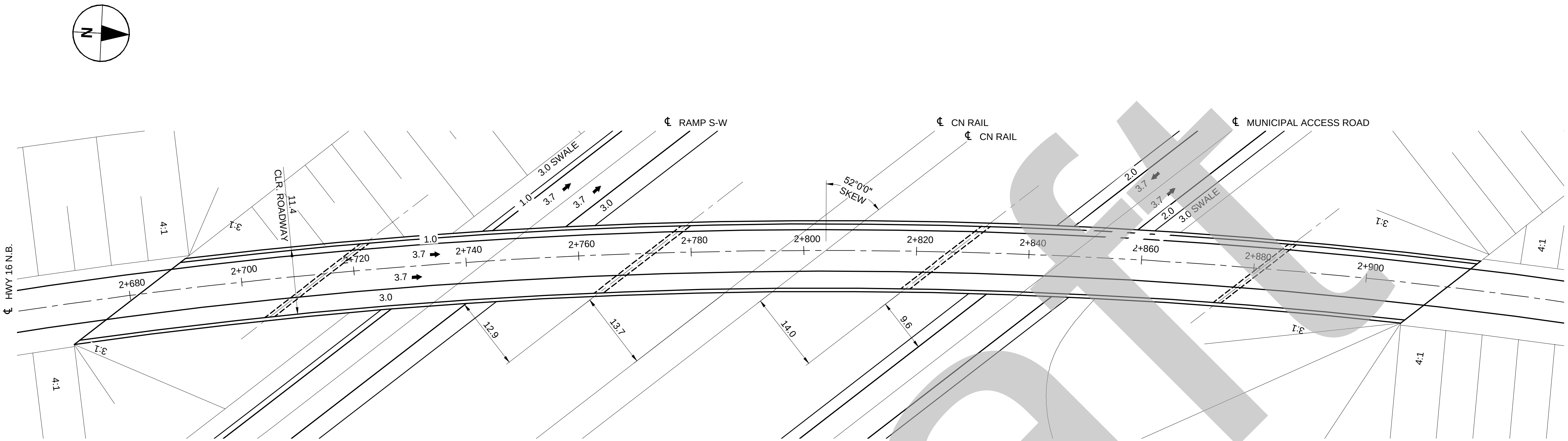

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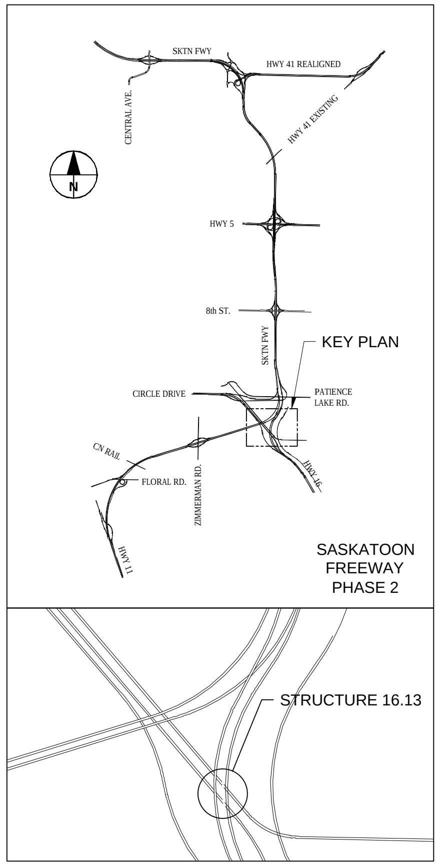

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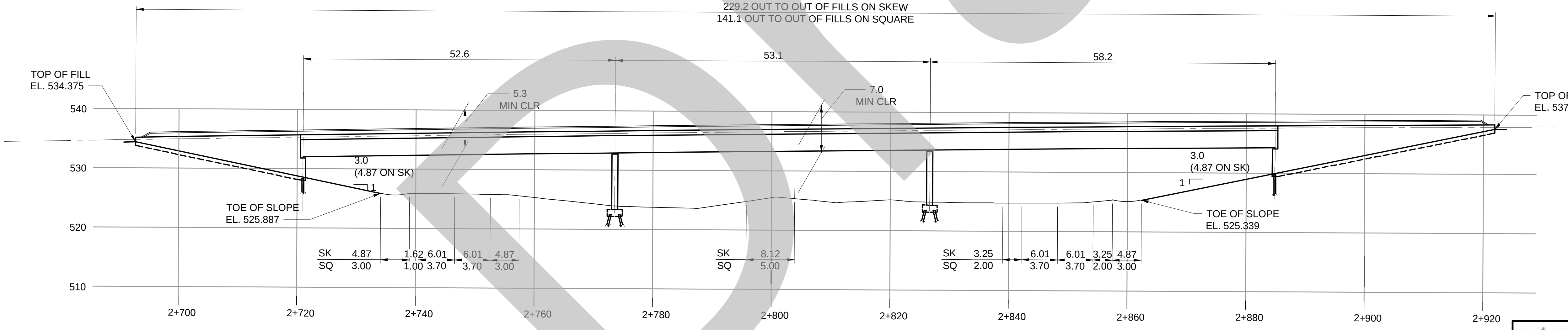

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PLAN AND ELEVATION – STRUCTURE 16.13

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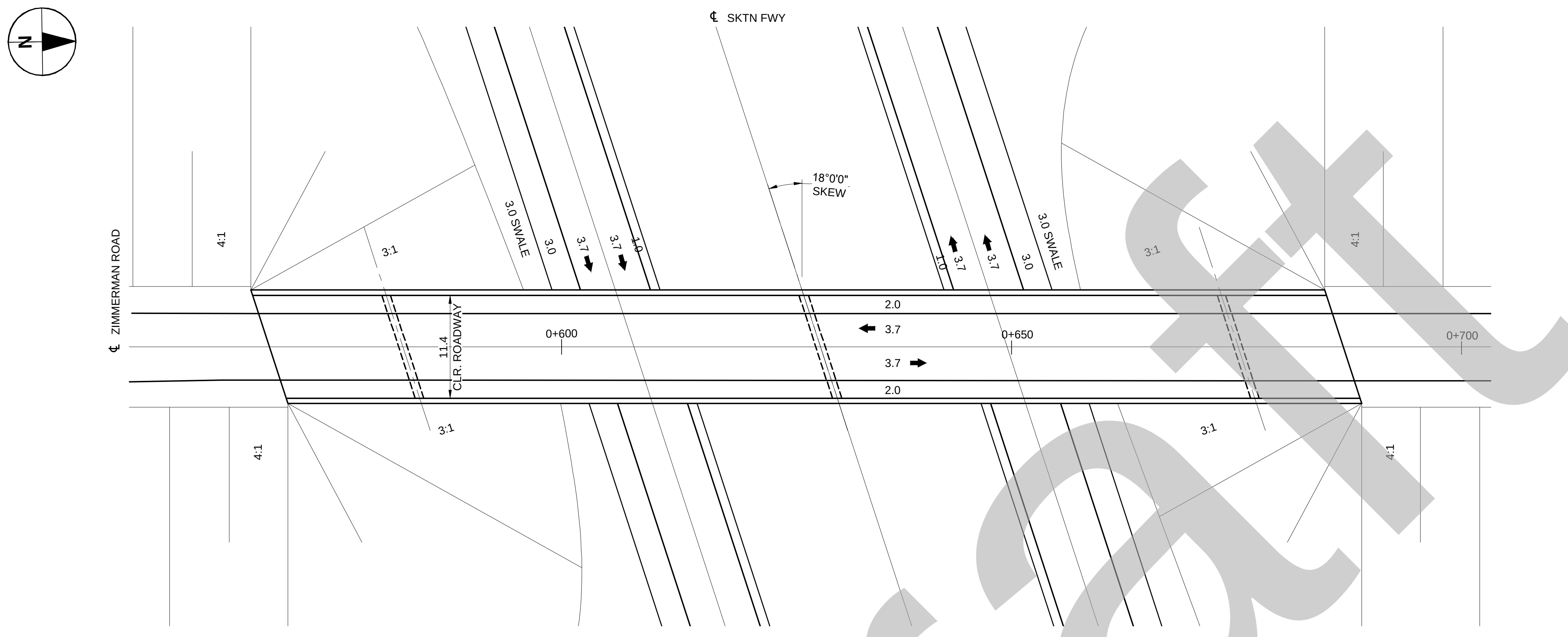

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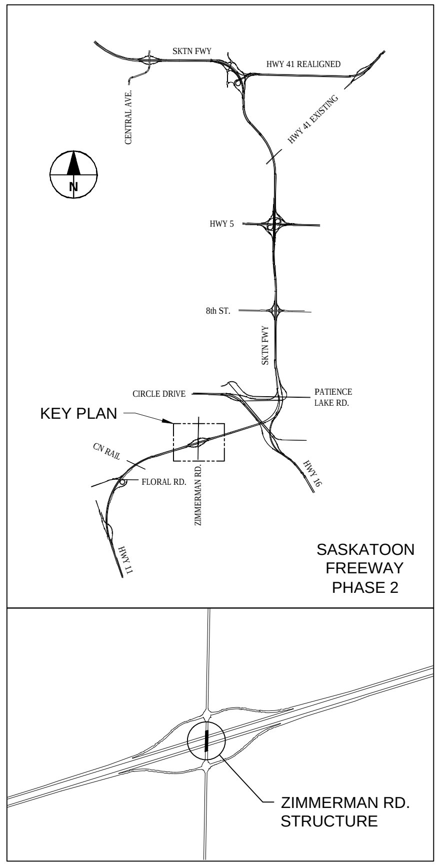

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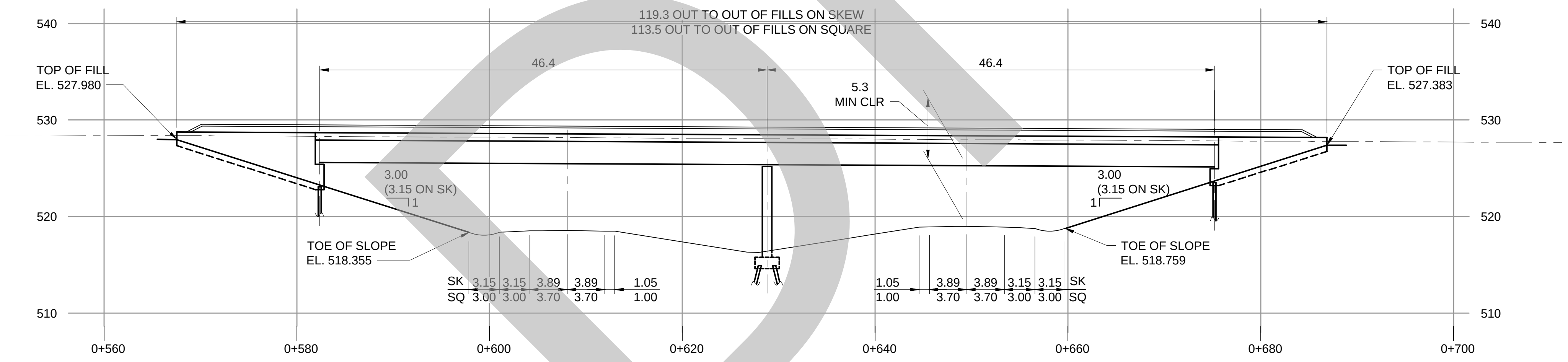

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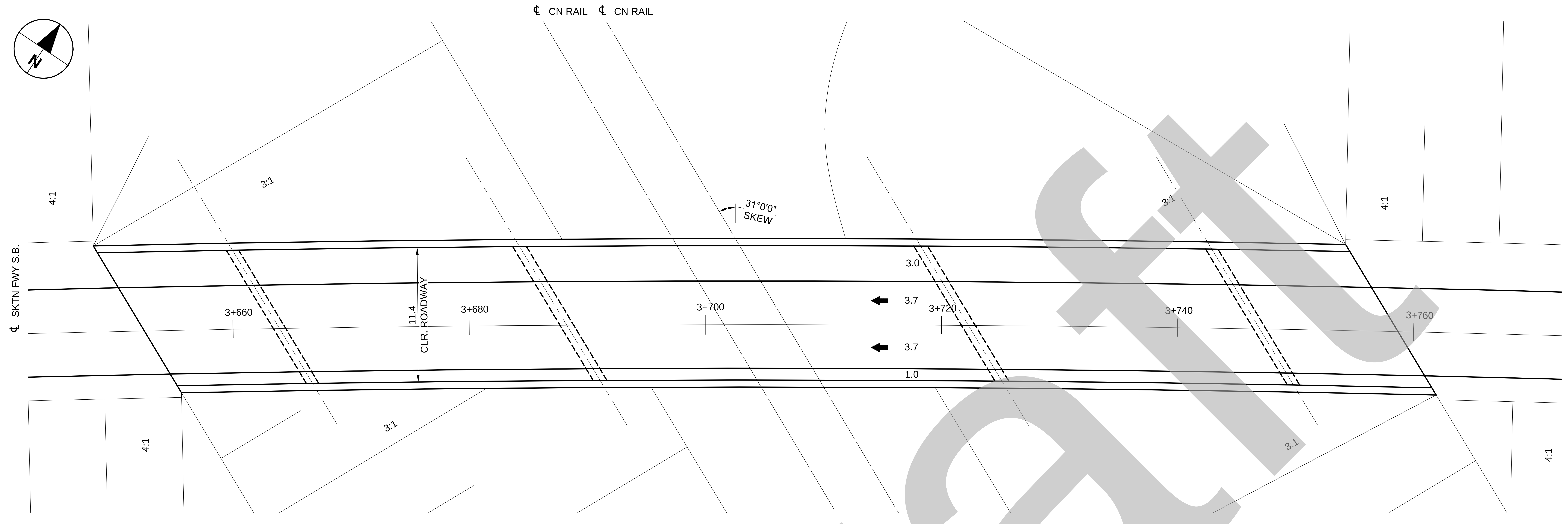

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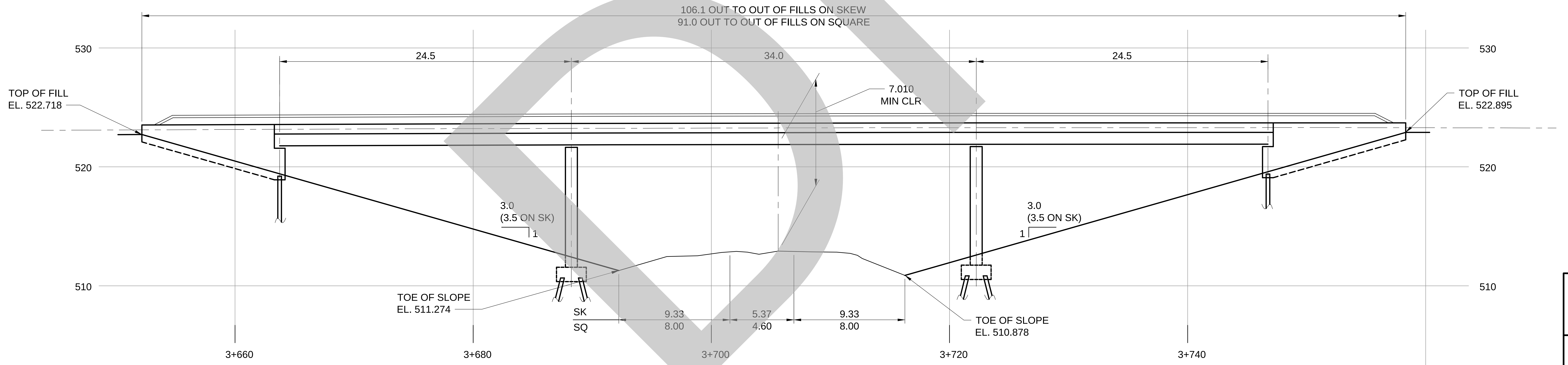

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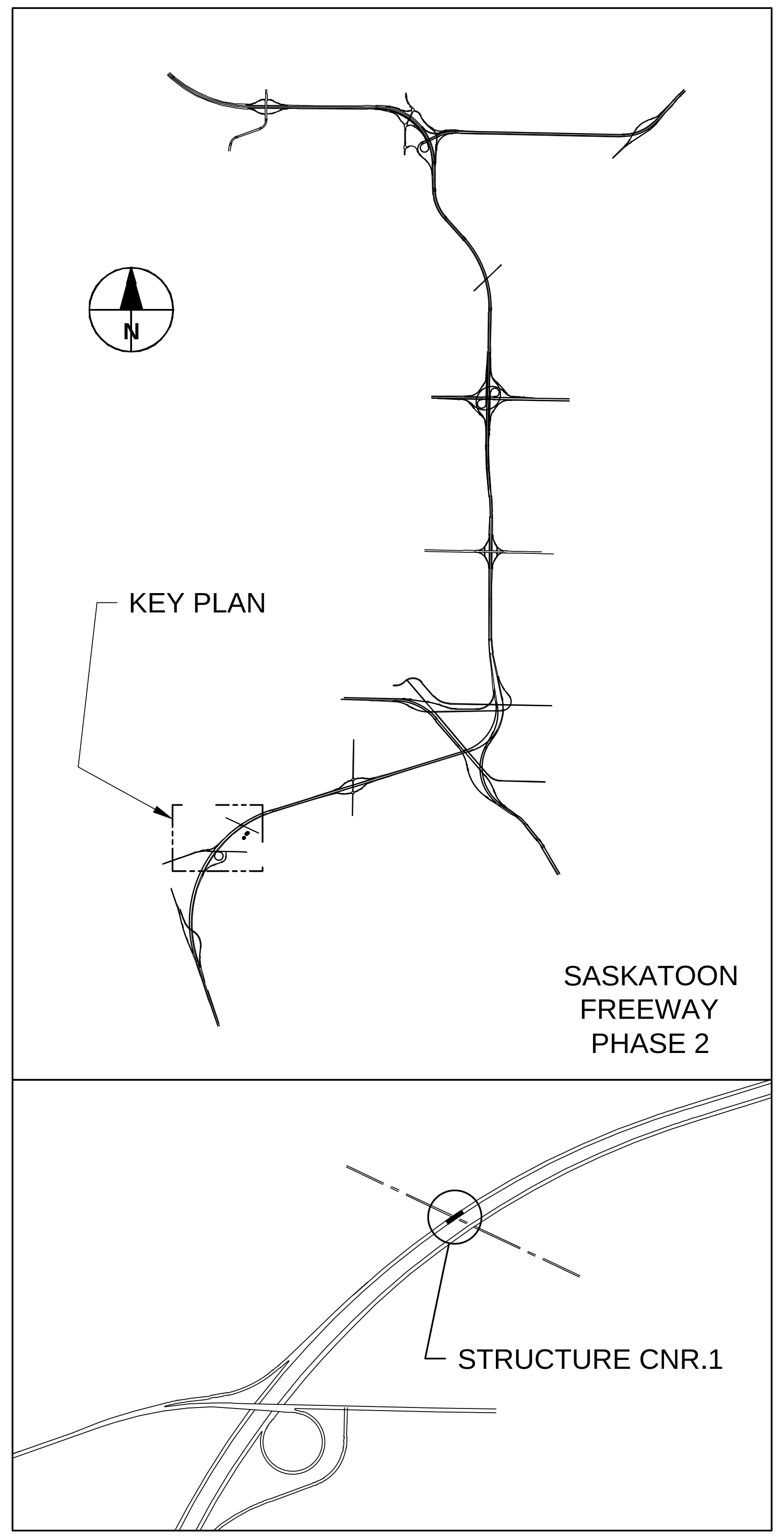

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FUNCTIONAL PLANNING STUDY

PLAN AND ELEVATION – STRUCTURE CNR.1

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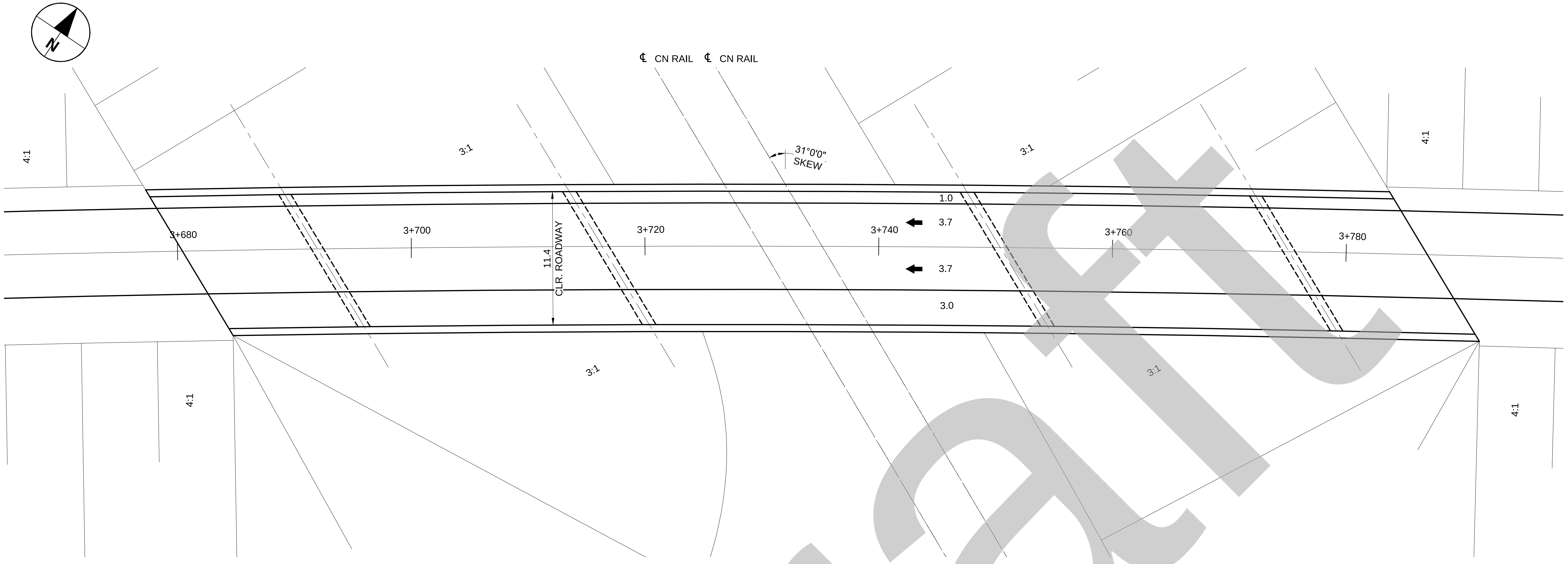

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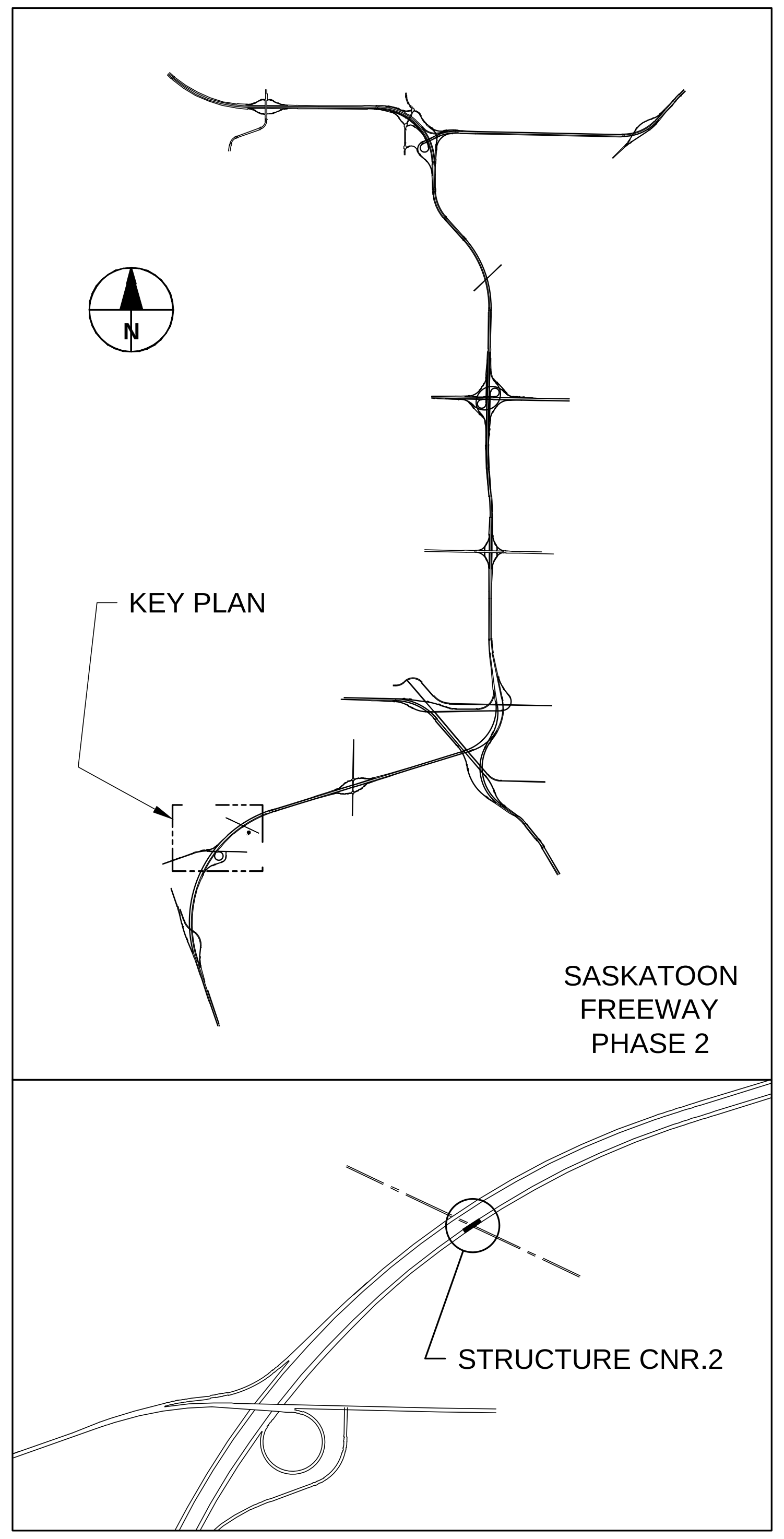

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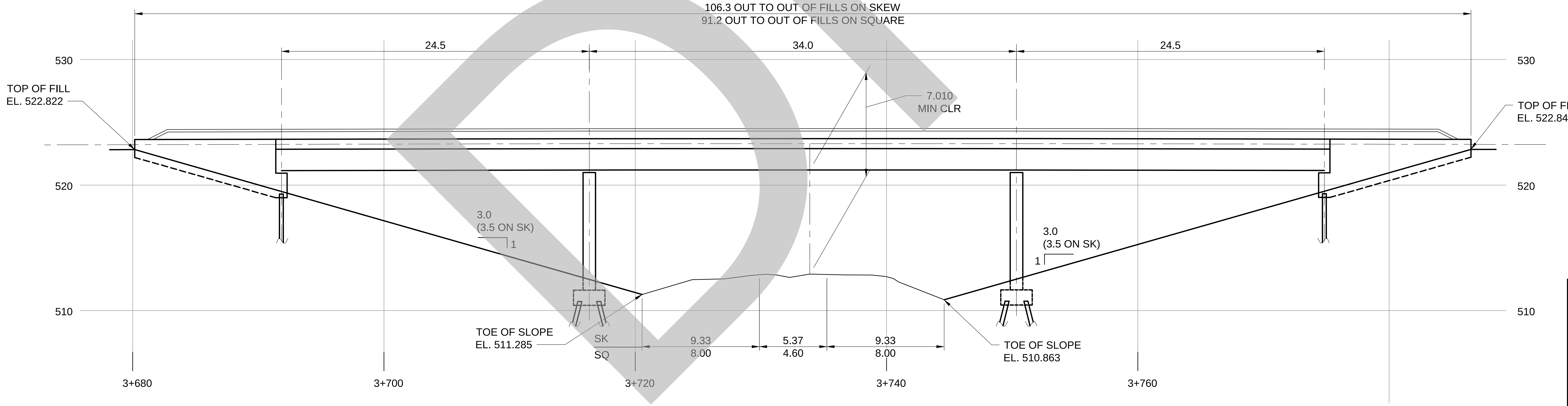

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PLAN AND ELEVATION – STRUCTURE CNR.2

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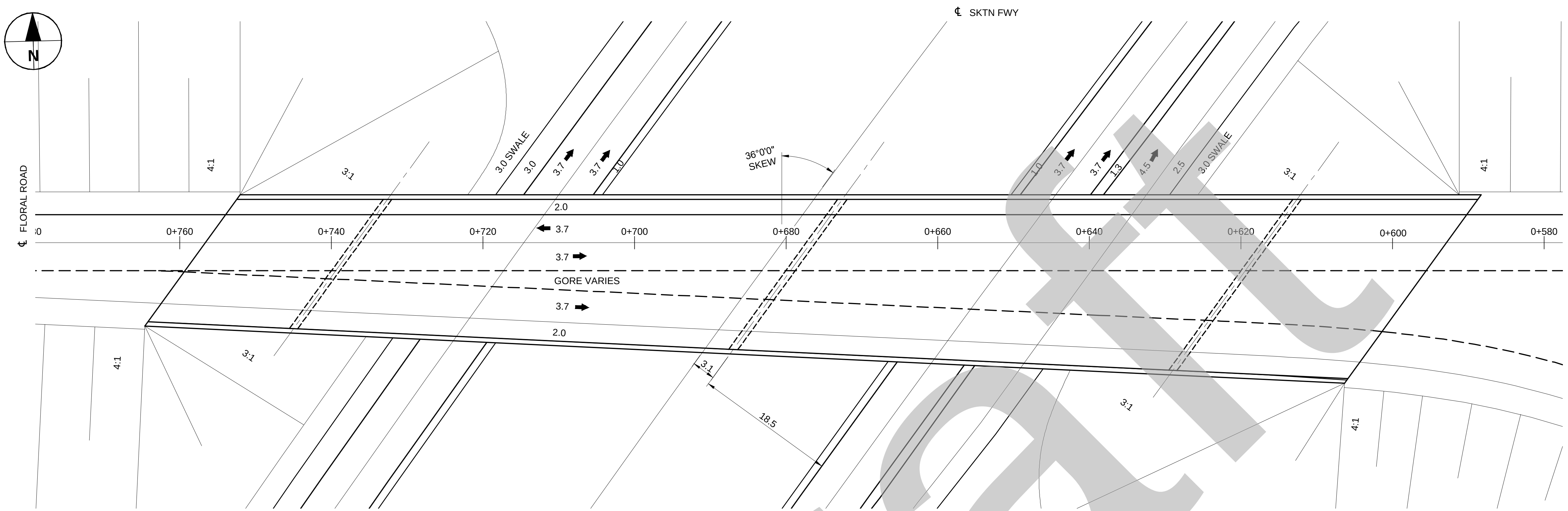

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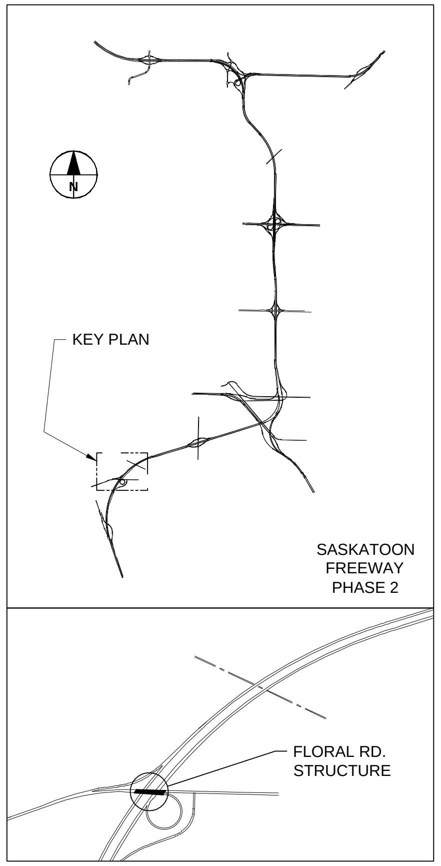

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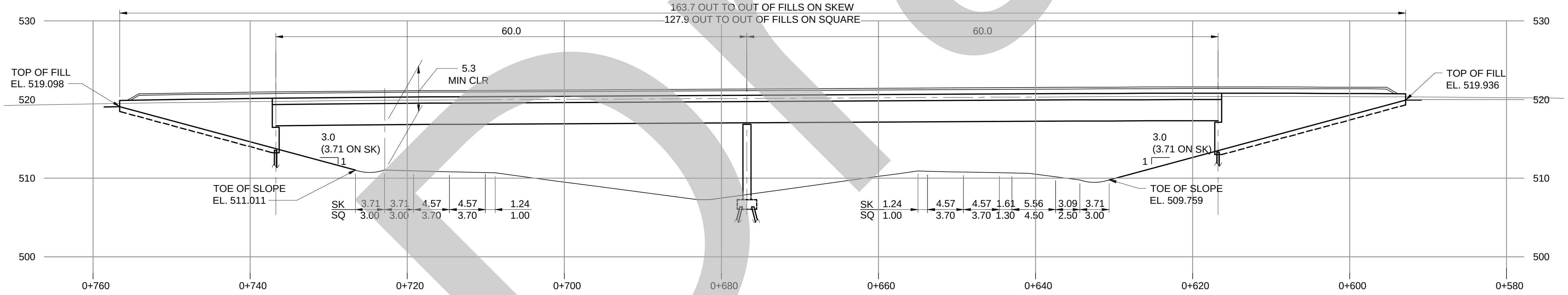

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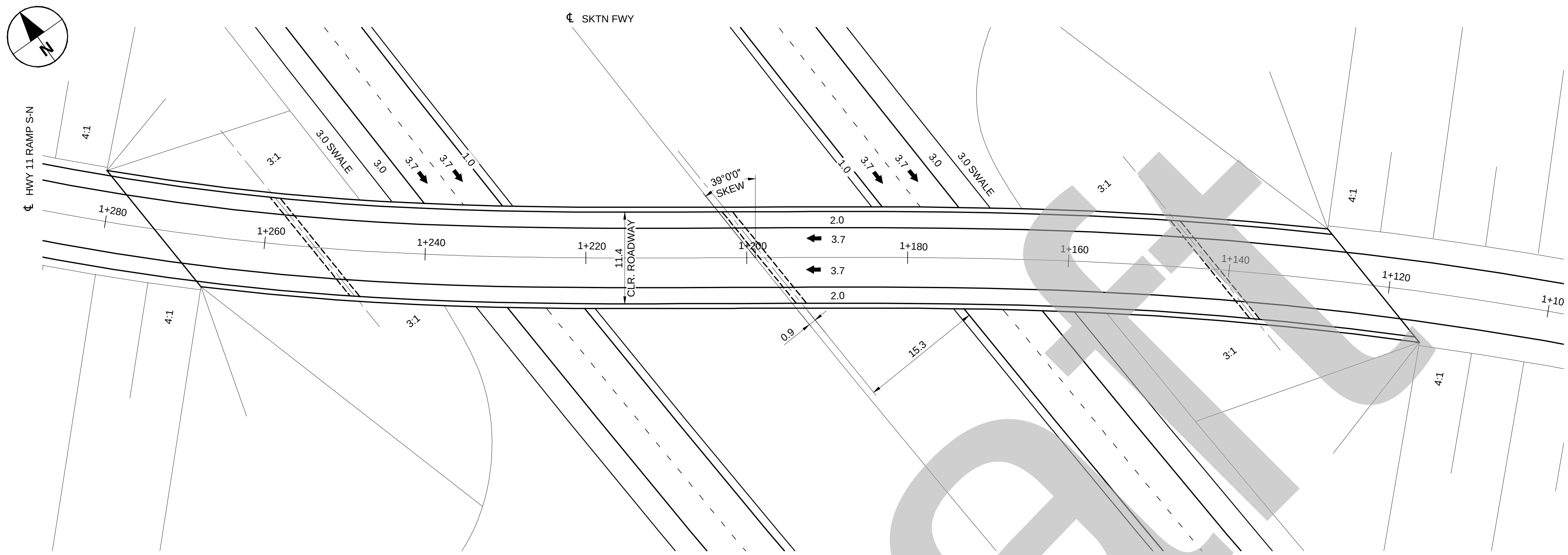

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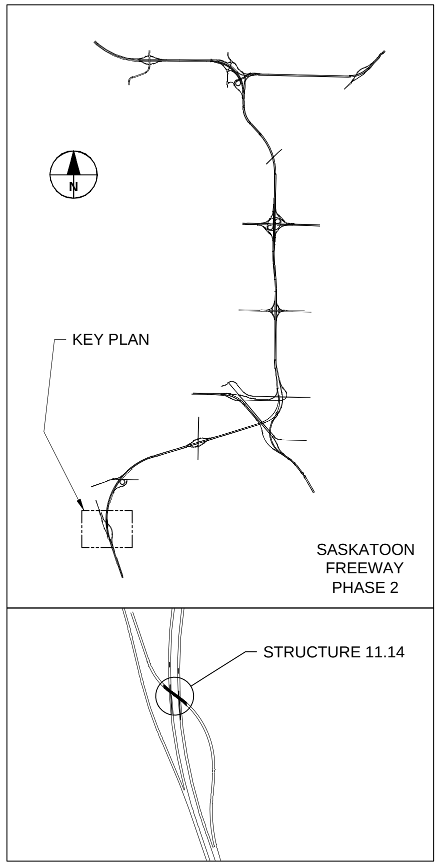

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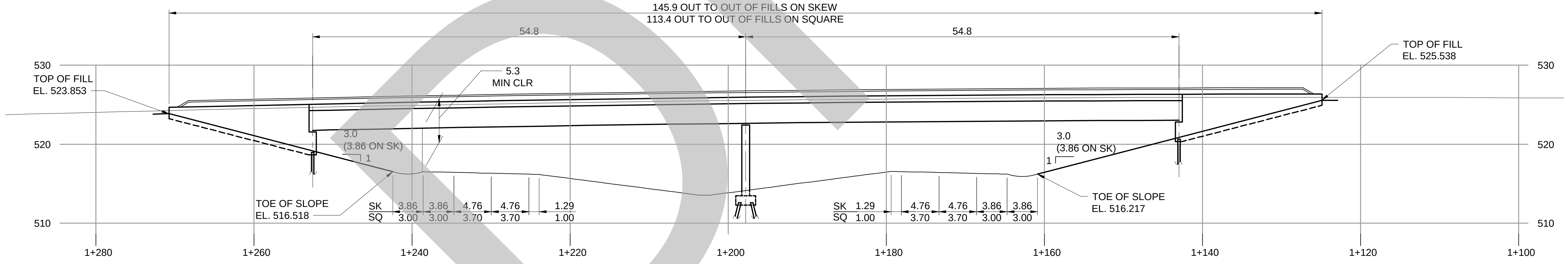

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PLAN AND ELEVATION – STRUCTURE 11.14

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APPENDIX M

Sound Study Criteria and Roll Plan with 65 dBA Ldn Contour

Table M1: Noise Criteria Definitions

Term	Definition
LAeq T	Equivalent continuous A-weighted sound pressure level over a period T; this descriptor accounts for noise fluctuations from moment to moment by averaging on an energy basis.
Ldn	Day - night sound level; this descriptor describes a receiver's cumulative noise exposure from all events over a full 24 hours [LAeq 24h], with a 10 dBA penalty applied to nighttime hours (between 10pm and 7am).
Lden	Day - evening - night sound level; this descriptor describes a receiver's cumulative noise exposure from all events over a full 24 hours [LAeq 24h], with a 5-dB penalty applied to evening hours (between 7pm and 10pm), and a 10-dB penalty applied to nighttime hours (between 10pm and 7am).

Note:
Based on the distribution of hourly traffic volumes for regional commuter rural highways (AADT over 2000), from the document Travel on Saskatchewan Highways 2016, we have the following differences between noise descriptors:
Ldn = LAeq24h + 3 dBA
Lden = LAeq24h + 3 dBA
Lnight = LAeq24h - 5 dBA

DRAFT / CONCEPTUAL

AECOM

SNC·LAVALIN

SASKATOON FREEWAY FUNCTIONAL PLANNING STUDY

PHASE 2 - NOISE STUDY

DATE
JUNE 2023

SCALE
1000m 0m 1km