

July 20, 2017

ISSUED FOR USE
FILE: 704-ENG.VGEO03022-01
Via Email: mcdonnellr@mmm.caMMM Group Limited
Suite 200 - 48 Quarry Park Blvd. SE
Calgary, AB T2C 5P2**Attention:** Mr. Robert McDonnell, B.E.S., M. L. Arch, AALA
Manager, Landscape Architecture (Calgary)**Subject:** Parks Canada Agency - Icefields Parkway Entry Gates Redevelopment
Niblock and David Thompson Entry Gates Geotechnical Report

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) has been retained by MMM Group Limited (MMM) to undertake geotechnical engineering services pertaining to the redevelopment of the Niblock Entry Gate (Niblock Gate) and the David Thompson Highway Entry Gate (David Thompson Gate) on the Icefield Parkway Highway (Hwy 93) in Banff National Park.

This report provides geotechnical recommendations for site preparation, building foundation design, and the re-use of existing fill material for construction of the proposed entry gates. In addition, this report also provides preliminary concrete pavement design recommendations for the stopping ramps at the Niblock Gate kiosks.

This geotechnical report summarizes our observations of the current site conditions and provides the results of the geotechnical subsurface exploration completed on October 8, 2015. The subsurface exploration program was carried out based on conceptual drawings received from MMM on September 14, 2015 and consisted of testpits and laboratory testing.

Based on information from several discussions with the MMM design team, and the drawings of the proposed entry gates received on January 26, 2017, we understand that the existing sites will be redesigned and laid out similar to the Banff Park Trans-Canada East Gate, with the new gate control structure(s) located more in-line with main roadway with new traffic flow and laneway configurations. We also understand that the design of the buildings are subject to the specifications in Part 9 of 2012 National Building Code of Canada (NBCC, 2012).

This report should be read in conjunction with Tetra Tech's General Conditions, provided in Appendix A.

2.0 SITE DESCRIPTION

The Niblock Gate is located on the south entrance of Hwy 93, approximately four kilometres north of Lake Louise, Alberta. The current entry gates are located in the pull-over laneway, and traffic moves through two lanes to the control structures with a third lane being for flow-through traffic. A Parks Canada maintenance and service yard is located to the northeast with an access road from Hwy 93 located approximately 350 m east of the control gate area. The highway through the site is a two lane road and was recently paved, however the road pavement structure is currently unknown.

The general layout of the Niblock Gate is shown on Figure 1.

The current David Thompson Gate is located approximately 5 km northeast from the Hwy 11 and Hwy 93 junction (Saskatchewan River Crossing). There is currently one gate control structure which is located between the lanes of the highway. The proposed new David Thompson Gate structure (one kiosk) and appropriate laneways, traffic calming measures and signage is to be located closer to intersection of Hwy 11 and Hwy 93 than the existing entry gate location.

The general layout of the David Thompson Gate is shown on Figure 2.

3.0 GEOTECHNICAL EXPLORATION AND SUBSURFACE CONDITIONS

Tetra Tech completed a geotechnical site exploration to determine the composition of the near-surface soil, depth to bedrock (if encountered), and groundwater conditions that underlie the site. The test locations were selected based on the following drawings dated September 14, 2015 provided by MMM:

- Niblock Concept 1 V3-R1-A1; and
- Saskatchewan River Crossing Concept V3-R1-A1.

The site exploration consisted of the completion of five (5) excavator-dug testpits at the Niblock Gate (TP15-NG01 through TP15-NG05) and two (2) excavator-dug testpits at the David Thompson Gate (TP15-DT01 and TP-DT-02). A total of nine (9) samples of the potential bearing stratum material were collected for geotechnical laboratory testing and analysis.

3.1 Testpits

Testpits were excavated using a Komatsu 138US LC excavator equipped with a hydraulic thumb. Tetra Tech's personnel were present during the exploration to identify testpit locations, observe the excavation, log and take photos of the testpits and excavated material, and collect select samples for laboratory testing. Testpits were typically excavated to refusal, or where the equipment limitations were reached (full boom length, etc.). All testpits were backfilled with the excavated materials and were bucket compacted.

Soils were logged in general accordance to with Tetra Tech Work Method 4400 (which is generally consistent with ASTM D2488), by visual inspection of the excavation walls, or, where entry into the excavation was no longer safe, sampling from the excavator bucket.

Estimates of soil consistency were determined from observation of excavation difficulty and visual classification of recovered samples. The distribution of grain size within sample materials is based on an estimate of the percentage of the total volume of soil excavated. These estimates are based on engineering judgement and are subjective. Representative samples were collected from excavations as required. Samples were collected as grab bag samples and were therefore disturbed. Samples were sent to our geotechnical soil testing lab in Calgary for geotechnical index testing.

The testpit locations were surveyed using a handheld GPS device with an accuracy of +/- 5 m and are shown in Figure 1 and Figure 2. The testpit logs, along with photographs and laboratory test results, are provided in the Appendices.

3.2 Niblock Gate Soil Conditions

A sandy gravel layer was encountered within five testpits across the site. The material is generally described as dry, compact, grey to grey brown, fine to coarse-grained gravel, with fine to coarse-grained sand. The thickness of

the sandy gravel layer encountered during the subsurface exploration ranged from 2.0 m to 4.0 m, however the overall thickness of the layer was not determined due to the excavating depth limitations of the excavator.

Fill material was encountered near the surface in TP15-NG04 and TP15-NG05. The fill is generally described as gravel and sand, damp, brown to grey. The fill material is likely surplus road base and road sub-base fill material from the highway construction and on-going maintenance. Bedrock was not encountered in the testpits during excavation. The depth to groundwater was not determined as no water was observed entering testpits during excavation. The locations of the Niblock Gate testpits are presented in Figure 1.

3.3 David Thompson Gate Soil Conditions

A gravel layer underlying a 0.1 m thick topsoil layer was encountered within the two testpits excavated at the site. The material is generally described as moist to wet, loose, blue grey to grey, fine to coarse-grained gravel, with some fine to coarse-grained sand. The thickness of the gravel layer encountered during the subsurface exploration ranged from 2.5 m to 3.0 m, however the overall thickness of the layer was not determined due to the excavating depth limitations of the excavator and the unstable collapsing testpit walls. Bedrock was not encountered in the testpits during excavation. The depth to groundwater was not determined as no water was observed entering testpits during excavation. The locations of the David Thompson Gate testpits are presented in Figure 2.

4.0 DESIGN CRITERIA

4.1 Foundation Design Parameters

Based on discussion with the project structural engineer and 75% Design Drawings (received January 26, 2017), Tetra Tech understands that MMM propose using a raft foundation as the building design is open space concept with no internal columns or load bearing walls, thereby all the loading will be restricted to the perimeter of the structure(s). The following are the provided design loads for the buildings:

- Column Loads = 80 kN (factored);
- Wall loads = 20 kN/m (factored); and
- Wind (Lateral) Loads = 20 kN (factored).

4.2 Design Traffic

The design traffic was calculated based on the information provided by MMM:

- The peak hour traffic volume is understood to be 297 vehicles with 11% heavy (intercity buses and maintenance trucks) traffic;
- Average Annual Daily Traffic (AADT) of 2970 (Based on the assumption that AADT is 10 times the peak traffic);
- Average Daily Truck Traffic (ADTT) of 327 for Niblock Gate;
- Annual traffic growth rate of 3.0%; and
- Design period of 20 years.

Based on the above information, the design Equivalent Single Axle Loading (ESAL) was determined to be 3.2×10^6 . The same design traffic was used for David Thompson Gate for pavement structure design.

4.3 Concrete Pavement Design Parameters

All concrete design parameters are based on information provided by MMM, including proposed site layout drawings (received January 26, 2017) and traffic loading conditions (March 15, 2017). According to MMM Drawings No. T-NGL-02, the proposed Niblock Gate will include stopping ramps and kiosk islands comprised of concrete pavement that will tie-in to the Highway 93 asphalt pavement at both ends. Based on the MMM Drawing No. T-DGL-02 there is no concrete pavement sections proposed for the David Thompson Gate.

Due to work area restrictions at the project site, no testpits were excavated through the existing road prism. Therefore, the top of the granular subgrade is assumed to be 400 mm below the top of the existing asphalt. Following removal of the ACP surface and subcut of the granular base to make room for 230 mm thick concrete pavement section, it is anticipated that the remaining granular base under the existing roadway will have a nominal thickness of approximately 170 mm. In areas of new construction, a minimum of 150 mm of granular base (20 or 25 mm maximum aggregate size) should be placed on the prepared subgrade.

For the Portland Cement Concrete Pavement (PCCP) design, the modulus of subgrade reaction was taken as 125 MPa/m.

4.4 Asphalt Concrete Pavement Parameters

The American Association of State Highway and Transportation Officials (AASHTO) flexible asphalt concrete pavement design methodology, outlined in the Guide for Design of Pavement Structures (1993), was used for the design of asphalt concrete pavement structure.

The design input values required by the AASHTO methodology and used in the design of the pavement structure design are summarized in Table 1.

Table 1: AASHTO Pavement Design Inputs for New Construction

Criteria	Value	Rationale
Reliability	85%	Based on engineering judgement, roadway classification, and considering a rehabilitation design.
Serviceability		In accordance with generally accepted pavement engineering principles, AASHTO Pavement Design Manual.
Initial Serviceability Index (P_i)	4.2	
Terminal Serviceability Index (P_t)	2.5	
Serviceability Loss (ΔPSI)	1.7	
Overall Standard Deviation (S_o)	0.45	
20 Year Design ESALs	3.21 Million	As per Section 4.2.
Subgrade Resilient Modulus (M_r)	40 MPa	The value is selected based on subgrade soil type as observed during test pitting at the project locations.
Structural Layer Coefficients (α)	Asphalt Concrete – 0.40 Granular Base Coarse – 0.14 Granular Sub-Base Coarse – 0.10	In accordance with generally accepted pavement engineering principles, AASHTO Pavement Design Manual.

5.0 GEOTECHNICAL DESIGN RECOMMENDATIONS

Based on the inferred subsurface conditions presented in Section 3.0, and discussions with the MMM Project team and the design criteria presented in Section 4.0, the proposed sites are considered suitable for the proposed raft foundation supported structures.

The following sections provide geotechnical recommendations for site preparation, backfill materials, foundation design, and drainage. The recommendations below are applicable for the Niblock Gate and David Thompson Gate.

5.1 Foundation Design

Based on the expected subsurface conditions, and provided that adequate site preparation is completed, as discussed in Section 5.3, and structural fill is compacted, as discussed in Section 5.4, the proposed entry gate buildings may be supported on raft foundations founded on either native sand and gravel, or imported structural fill.

The footings should be at least 450 mm wide and pad footings should have a minimum dimension of 900 mm. For confinement purposes, the foundations should be located at least 600 mm below finished grade.

5.2 Seismicity

The 2015 National Building Code of Canada spectral values for Site Class C for 5% damping, which was obtained from the interactive website <http://www.earthquakescanada.nrcan.gc.ca/index-eng.php>, are provided in Table 2, below.

Table 2: Spectral Accelerations for Site Class C for 5% Damping

Site	Peak Ground Acceleration (PGA)	Sa(0.05)	Sa(0.1)	Sa(0.2)	Sa(0.3)	Sa(0.5)	Sa(1.0)	Sa(2.0)	Sa(5.0)	Sa(10.0)
Niblock	0.075	0.092	0.139	0.167	0.151	0.111	0.060	0.029	0.011	0.0037
David Thompson	0.076	0.093	0.140	0.168	0.153	0.112	0.060	0.029	0.010	0.0035

The 2015 National Building Code of Canada Table 4.1.8.4.-A provides guidelines for site classification, which can be determined using “average” shear wave velocity, SPT N-value correlations, and/or undrained shear strength in the top 30 m of soils.

Based on the observations and results of the subsurface exploration, the recommended classification for design should be Site Class D for the Niblock and David Thompson sites.

5.3 Site Preparation

The initial site preparation work should include stripping of any vegetation, predominantly clay topsoil, and imported fill from the proposed building and access road areas. Stripping depths will vary locally throughout the site. The excavation of the poor quality materials should extend horizontally beyond the entry gate foundations, underground utilities, or pavement at least twice the depth of the excavation (i.e., 2H:1V slope down from the base of the entry gate foundation or edge of road).

Temporary excavation side slopes should be no steeper than 1H:1V to a maximum depth of 2 m in the sand and gravel material. Tetra Tech should review the excavation side slopes prior to worker entry into the excavation.

Tetra Tech should be present to review the stripping operations to confirm that all unsuitable materials have been fully removed and competent soils are exposed prior to placement of engineered fill. The exposed subgrade should be proof rolled with Tetra Tech present to determine if any additional sub-excavation is required.

5.4 Structural Fill

Structural fill is classified as compacted, granular material required for replacing soils that do not meet the required material design parameters, or for raising grades within the footprint of proposed buildings and roadways.

Any excavated granular material should be stockpiled and reviewed by Tetra Tech for potential re-use as structural fill (refer to Section 5.5). Any poor quality excavated materials (i.e., organic or cohesive soils) should be disposed of and the excavations should be backfilled with adequately compacted structural fill (discussed in Section 5.3).

Structural fill should consist of free-draining, well-graded, non-cohesive with a maximum particle size of 25 mm and less than 8% fines (material finer than 80 μm). The structural fill material should be placed in discrete lifts of a maximum thickness of 300 mm at a suitable water content.

Structural fill should not be placed and compacted during freezing conditions and in no case should frozen fill be used. The structural fill should be compacted to the following:

- Minimum 98% Standard Proctor Maximum Dry Density (SPMDD) in building areas;
- Minimum 95% SPMDD in landscape areas; and
- Compaction as recommended in Sections 6.1 and Section 7.2 for asphalt and concrete pavements.

Tetra Tech should be present to review the placement and test the compaction of the structural fill during construction. Materials not meeting the gradation or compaction specifications will have to be remediated.

5.5 Reuse of Materials

During site preparation, volumes of sand and gravel excavated on-site will be available. Tetra Tech considers that the excavated granular material is likely suitable for use as structural fill provided that the material is well-graded with a maximum particle size no greater than 50 mm and less than 10% fines.

Tetra Tech should review any excavated native granular material for potential re-use as structural fill.

5.6 Bearing Resistances

The Structural Engineer should design the raft foundations based on the Serviceability Limit States (SLS) and Ultimate Limit States (ULS) bearing resistance provided in Table 3.

Table 3: SLS and ULS Bearing Resistances

Foundation Soil	SLS Bearing Resistance* (kPa)	ULS Factored Bearing Resistance** (kPa)
Structural Fill or Compact natural Sand and Gravel	100	150
* SLS Bearing Pressure based on limiting total post-construction settlement to 25 mm and differential settlement to 20 mm over a horizontal distance of 10 m.		
** Geotechnical resistance factor of 0.5 used as per Canadian Foundation Engineering Manual, 2006.		

Tetra Tech should review the exposed subsurface conditions during construction to confirm that the bearing surfaces are suitable to support the bearing resistances provided.

5.7 Frost Penetration Depth

Tetra Tech recommends the placement of non-frost susceptible soil/fill a minimum 600 mm below the footing and extending a minimum of 600 mm laterally from the exterior edge of the raft slab. This requirement may be relaxed depending on a visual inspection of the subgrade described in Section 5.6.

The existing subgrade soil is considered to have a low frost susceptibility and may be suitable for re-use as backfill material which should be verified during construction by a Tetra Tech representative.

5.8 Drainage

As mentioned in Section 3.2 and Section 3.3, groundwater was not encountered during the geotechnical exploration. A water table below the frost depth also limits the potential for frost heave of structure foundations.

However, while no groundwater was encountered during the subsurface exploration program, periods of high precipitation or the spring freshet could result in a temporary elevated groundwater level and seepage. The groundwater seepage can lead to localised erosion, and/or surficial slumping of foundation layers, therefore we recommended that mitigation measures be undertaken.

Perimeter drains could be considered for installation at the foundation elevation around the proposed buildings. The perimeter drains should discharge into a rock soakage pit constructed downslope or another suitable drainage system. The finished exterior design grade should be sloped such that surface water is carried away from the buildings. The purpose of drainage provisions is to prevent the buildup of hydrostatic pressures against floor slabs. Any water-proofing or damp-proofing requirements would be the responsibility of the Architect or Building Envelope consultant, as would any soil gas barrier.

5.9 Buried Services

The natural sand and gravel material should provide adequate support for any proposed service piping. Where sand and gravel is not encountered during trenching for installation of services, the unsuitable materials should be removed to expose a competent layer, and should be backfilled with compacted structural fill (or other suitable bedding material) before installation of the services.

Tetra Tech should be provided with the civil design construction drawings to provide comment on construction sequencing and the potential need for excavation shoring during services installation.

6.0 CONCRETE PAVEMENT RECOMMENDATIONS

Based on the information presented in Section 3.0 and Section 4.0, Tetra Tech has provided the following preliminary recommendations for Portland cement concrete pavement (PCCP) design.

Unless otherwise stated in the following sections, all materials, testing, standard practices, and construction methodologies for the concrete pavement sections covered in this report should be in accordance with the City of Calgary Specifications section “312.00.00 – Portland Cement Pavement”.

Tetra Tech is not responsible for verifying references to other specifications outside of the above named document.

6.1 Structural Design

Based on the provided traffic loading information, a plain doweled concrete pavement comprising the following is recommended:

- 230 mm of concrete over;
- Minimum 150 mm of 25 mm granular base compacted to a minimum of 98% SPMDD over; and
- Prepared granular subgrade.

6.2 Concrete

Detailed concrete specifications are beyond the scope of this work; however, Tetra Tech recommends the use of concrete suitable for a Class C-1 exposure for all exterior flatwork, including pavement and exterior island slabs. The PCCP design is based on a 28-day flexural strength of 4.2 MPa. This typically requires a compressive strength of 35 MPa at 28 days. In the absence of a performance history, trial batching may be required to confirm flexural strength.

The PCCP concrete should contain synthetic macro fibres for improved toughness and resistance to cracking. Design and construction should comply with CSA A23.1 and the General Notes provided on MMM sheet number S-GN-01.

6.3 Joints

The spacing between the proposed kiosk islands indicates that the concrete pavement sections measure 4.0 m in width. Tetra Tech recommends the pavement design should include transverse sawcut contraction joints spaced at about 4.0 m. This spacing will provide for square panels which generally perform favourably compared to longer rectangular panels.

The PCCP will be built with an isolation joint on the window side of the kiosk (south) side and therefore the traffic is anticipated to be running on the free edge of the PCCP to enable vehicle operators to reach the kiosk attendant. Tetra Tech recommends edge thickening near the kiosk. The edge thickening should be concrete with a trapezoidal cross-section comprised 230 mm thick on the north side thickened to 275 mm thick at the kiosk window side. The trapezoidal section avoids the potential for a longitudinal shrinkage crack at the end of the taper.

Depending on anticipated traffic wandering, the edge thickening on the south side of the PCCP may only need to extend for the three panels adjacent to the kiosk or may extend for the full length of the PCCP.

6.4 Load Transfer Devices

Load transfer devices at transverse joints is recommended to reduce faulting. Smooth epoxy coated steel dowels, 32 mm in diameter by 450 mm in length, spaced at 300 mm, placed at mid-depth within the slab are required. Dowels should be placed using a prefabricated dowel baskets to ensure they are oriented perpendicular to the joint and parallel to the pavement surface. Both ends of the PCCP should be thickened by 20% to provide increased strength at the free edges of the pavement.

Painted lane markings should be used to demarcate the standard 3.7 m lane width to minimize heavy vehicle wheel loadings on the edges of the PCCP.

6.5 Surface Finishing and Texturing

After the concrete has been given a preliminary finish by means of floating with wood or magnesium tools, the surface of the fresh concrete shall be checked by the Contractor with a straightedge device not less than 3.0 m in length. High areas indicated by the straightedge device (± 3 mm) shall be removed by the hand-float method. Each successive check with the straightedge device shall lap the previous check path by at least $\frac{1}{2}$ of the length of the straightedge. The standard method of surface finish shall be transverse tining. In advance of curing operations, the pavement shall be given an initial and a final texturing. Initial texturing shall be performed with a burlap drag or broom device that will produce striations perpendicular with the centerline. Final texturing shall be performed with a wire comb tine device that will produce grooves perpendicular with the centerline. The wire comb tine device shall be operated within 150 mm, but not closer than 75 mm, of pavement edges.

Transverse tining shall be done by texturing with a wire comb perpendicular to the centerline of the pavement. The wire comb tines shall be rectangular in cross-section, 3 mm wide, on 12.5 mm ± 3 mm centers, and of sufficient length, thickness, and resilience to form grooves approximately 3 mm deep in the fresh concrete surface. Downward pressure on pavement surface shall be maintained at all times during texturing so as to achieve uniform texturing without measurable variations in pavement profile. Final texture shall be uniform in appearance with substantially all of the grooves having a depth between 2 to 5 mm. Finishing shall take place with the elements of the wire comb as nearly perpendicular to the concrete surface as is practical, to eliminate dragging the mortar.

If the tining equipment has not been previously approved, a test section shall be constructed prior to approval of the equipment.

A monomolecular evaporation retarder may be used to control surface evaporation between floating, finishing and texturing operations. Such materials shall be applied in accordance with manufacturer's directions and shall not be used a finishing aid. A liquid membrane forming curing compound conforming to ASTM C309 shall be applied to the surface in two successive applications within 20 minutes of completion of tining operations.

6.6 Pavement Surface Drainage

The design options are based on a 20 year design life, therefore positive surface drainage of both subgrade and pavement surfacing should be maintained.

Tetra Tech recommends that all joints should be sealed to prevent ponding of water and reduce infiltration. Additionally, special care and attention should be given to surface grading and sealing of joints where stormwater is directed over the roadway. Recommended minimum grades of 1.0% should be used in hard surfaced areas.

6.7 Construction Monitoring

All design and construction recommendations presented in this report are based on the assumption that an adequate level of monitoring will be provided during construction and that all construction will be carried out by a suitably qualified Contractor, experienced in earthworks and roadway construction. An adequate level of monitoring for earthworks construction is considered to be full-time monitoring, compaction testing, and laboratory materials analyses.

All such monitoring should be carried out by suitably qualified persons, independent of the Contractor. One of the purposes of providing an adequate level of monitoring is to check that recommendations, based on data obtained at discrete testpit locations, is relevant to other areas across the site.

7.0 ASPHALT CONCRETE PAVEMENT RECOMMENDATIONS

7.1 Design and Construction Details

Preliminary asphalt pavement design recommendations are provided based on the design criteria and input parameters presented in Section 4.0. The design methodology in 1993 AASHTO *Guide for Design of Pavement Structures* was used to design the asphalt pavement structure. The recommended pavement structure is presented in Table 4.

Table 4: Recommended Pavement Structure

Roadway	Required Structural Number (mm)	Design Thickness (mm)			Total Pavement Structure Thickness (mm)
		Asphalt Concrete Pavement	Crushed Granular Base (25 mm minus)	Crushed Granular Sub-base (80 mm minus)	
Approach Lanes and Exit Lanes at Niblock Gate and David Thompson Gate	112	150	200	300	650

7.2 Subgrade Preparation

The subgrade should be compacted to a minimum of 98% of SPMDD to achieve the subgrade support characteristics assumed in the pavement designs.

Prior to the placement of the granular materials, the prepared subgrade should be proof-rolled to identify any soft areas. Any soft areas identified during proof roll should be reworked or sub-excavated to a minimum depth of 300 mm and backfilled with imported fill material and compacted to the specified compaction as discussed above.

The following are other subgrade considerations for subgrade preparation:

- Topsoil or organic material should not be present within the footprint of the proposed roadways;
- Granular materials should not to be placed on frozen subgrade;
- Any soft or incompetent soils identified during excavation or proof-rolling are to be sub-excavated and removed from the footprint of the proposed roadway; and

- The subgrade conditions should be approved by a Geotechnical engineer prior to the placement of the granular materials.

7.3 Subsurface Drainage

The prepared subgrade areas should be sloped at a minimum of 2% gradient towards ditches or longitudinal subdrains.

7.4 Granular Base and Sub-Base Construction

The granular base/sub-base materials and construction methods should meet the requirements of granular base/sub-base aggregates as per Alberta Transportation's Standard Specifications for Highway Construction. The granular base and sub-base materials should be compacted to a minimum of 98% SPMDD.

7.5 Asphalt Concrete Construction

Use of Alberta Transportation's Asphalt Mix Type H1 with PG 58-34 asphalt cement should be used during the construction of Asphalt pavement.

7.6 Cold Weather Construction and Frost Mitigation

Construction of the subgrade, sub-base, base, and asphalt concrete surfaces should not be undertaken when the temperature is, or is projected to be, below 0° C. Any frost present in granular layers should be addressed by removal of the frost layer, heating to thaw frost, or waiting for the frost to naturally dissipate prior to placing subsequent layers.

8.0 ADDITIONAL WORK

Based on the results of the geotechnical exploration and the results of the analyses completed, we anticipate that the additional geotechnical work required to develop the finalized design may include the following:

- Coordinate with MMM and their project team as the proposed entry gates redevelopment project progresses.
- Provide geotechnical and pavement field reviews during construction to review the site preparation, foundation bearing soils, concrete and asphalt pavement structure, backfill materials, compaction, and pavement construction.

The extent of the additional work outlined in this Section is dependent on an approved scope of work and budget, and the finalized structural designs and the construction schedule provided to Tetra Tech as soon as they become available.

9.0 LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of MMM Group Limited and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than MMM Group Limited, or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Tetra Tech's General Conditions are provided in Appendix A of this report.

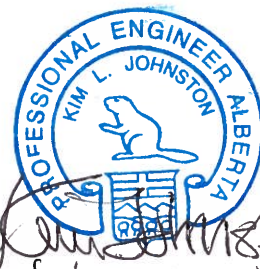
10.0 CLOSURE

We trust this report meets your requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.



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Attachments: Figures (2)
Appendix A – Tetra Tech's General Conditions
Appendix B – Testpit Logs
Appendix C – Laboratory Test Results

FIGURES

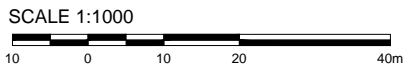
- Figure 1 Niblock Gate Approximate Testpit Location Plan
Figure 2 David Thompson Gate Approximate Testpit Location Plan

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Testpit Locations



NOTES
1. Imagery from Google Earth Pro.

CLIENT
Parks Canada
Agency
Western and
Northern
L'Agence
Parcs Canada
Ouest et Nord
Région



PARKS CANADA - ICEFIELDS PARKWAY ENTRY
GATES REDEVELOPMENT

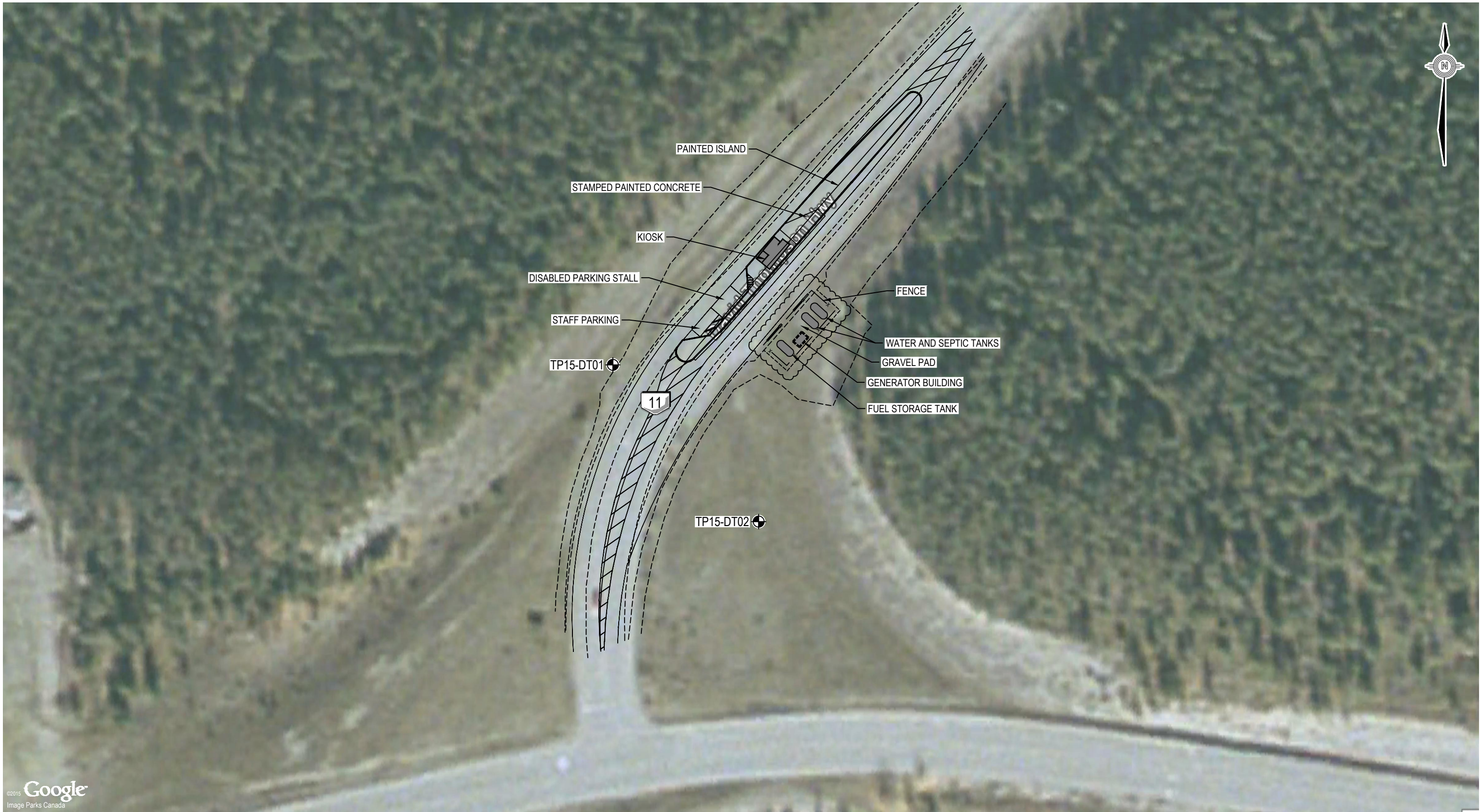
NIBLOCK GATE
APPROXIMATE TESTPIT LOCATIONS

PROJECT NO. ENG.VGEO03022-01	DWN RH	CKD PK	REV 0
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Figure 1

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Q:\Vancouver\Drafting\Engineering\VGEO\03022-01\ENG.VGEO03022-01 Icefield Parkway Testpit locations R1a.dwg [FIGURE 2] July 18, 2017 - 12:47:26 pm (BY: HALL, ROBERT J)



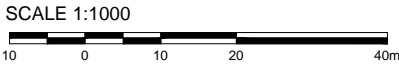
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Testpit Locations

NOTES

- 1. Imagery from Google Earth Pro.
- 2. Site layout based on "T-DGL-T-DGL-02" by WSP/MMM Group Limited, dated January 26, 2017.

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PARKS CANADA - ICEFIELDS PARKWAY ENTRY
GATES REDEVELOPMENT

DAVID THOMPSON GATE
APPROXIMATE TESTPIT LOCATIONS

PROJECT NO. ENG.VGEO03022-01	DWN RH	CKD PK	REV 1
OFFICE VANCOUVER	DATE July 18, 2017		

Figure 2

APPENDIX A

TETRA TECH'S GENERAL CONDITIONS

GENERAL CONDITIONS

GEOTECHNICAL REPORT

This report incorporates and is subject to these "General Conditions".

1.1 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of TETRA TECH's Client. TETRA TECH does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than TETRA TECH's Client unless otherwise authorized in writing by TETRA TECH. Any unauthorized use of the report is at the sole risk of the user.

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1.2 ALTERNATE REPORT FORMAT

Where TETRA TECH submits both electronic file and hard copy versions of reports, drawings and other project-related documents and deliverables (collectively termed TETRA TECH's instruments of professional service); only the signed and/or sealed versions shall be considered final and legally binding. The original signed and/or sealed version archived by TETRA TECH shall be deemed to be the original for the Project.

Both electronic file and hard copy versions of TETRA TECH's instruments of professional service shall not, under any circumstances, no matter who owns or uses them, be altered by any party except TETRA TECH. TETRA TECH's instruments of professional service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.4 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.5 LOGS OF TESTHOLES

The testhole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

1.6 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. TETRA TECH does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

1.7 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

1.8 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

1.9 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

1.10 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well as the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

1.11 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

1.12 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

1.13 SAMPLES

TETRA TECH will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded.

1.14 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of the report, TETRA TECH may rely on information provided by persons other than the Client. While TETRA TECH endeavours to verify the accuracy of such information when instructed to do so by the Client, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information which may affect the report.

APPENDIX B

TESTPIT LOGS

TP15-NG01

Date: 08-Oct-15
Logged By: Paul Kilkenny

Easting: 554931
Northing: 5699583
Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Fines Content (%)	Water Content (%)
From	To					
0	0.2	Gravelly CLAY, with rootlets and organics [Topsoil]				
0.2	3.6	Sandy GRAVEL, some silt, trace clay; dry to moist, compact, brown to grey brown; fine to coarse subrounded to rounded gravel; fine to coarse sand; cobbles up to 150 mm in diameter Material becoming dry with depth	TP15-NG01	1.0	2.2	10.6



Notes:

No groundwater or seepage observed during excavation
 Testpit walls slightly unstable (small amounts of wall collapse during excavation)
 Testpit terminated due to reaching machine and working area limitations
 Excavation backfilled and bucket compacted

TP15-NG02

Date: 08-Oct-15
Logged By: Paul Kilkenny

Easting: 554955
Northing: 5699572
Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Water Content (%)
From	To				
0	0.1	Gravelly CLAY, with rootlets and organics [Topsoil]			
0.1	4.6	Sandy GRAVEL, some silt; dry, compact, grey to grey brown; fine to coarse subangular to rounded gravel; fine to coarse sand; cobbles up to 100 mm in diameter Colouration changing to grey with depth Material becoming more sandy with depth	TP15-NG02	1.5	2.3



Notes:
 No groundwater or seepage observed during excavation
 Testpit walls slightly unstable (small amounts of wall collapse during excavation)
 Testpit terminated due to reaching machine limitations
 Excavation backfilled and bucket compacted

TP15-NG03

Date: 08-Oct-15

Logged By: Paul Kilkenny

Easting: 554999

Northing: 5699565

Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Water Content (%)
From	To				
0	0.2	Gravelly CLAY, with rootlets and organics [Topsoil]			
0.2	4.4	<p>Sandy GRAVEL, trace silt; dry, compact, grey to blue grey; fine to coarse subrounded to rounded gravel; fine to coarse sand; cobbles up to 200 mm in diameter</p> <p>Large boulder (approx. 500 mm in diameter) encountered at 3 m</p> <p>Increasing sand content and less cobbles with depth</p> <p>Material becoming dry to moist with depth</p>	TP15-NG03	1.8 m	2.7



Notes:

No groundwater or seepage observed during excavation
 Testpit walls slightly unstable (small amounts of wall collapse during excavation)
 Testpit terminated due to reaching machine and working area limitations
 Excavation backfilled and bucket compacted

TP15-NG04

Date: 08-Oct-15

Logged By: Paul Kilkenny

Easting: 555034

Northing: 5699556

Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Fines Content (%)	Water Content (%)
From	To					
0	1.1	Gravelly SAND, trace silt [Fill]; brown to grey brown, damp; fine to coarse sand; fine to coarse subangular to angular gravel.	TP15-NG04	0.8		5.9
1.1	1.2	Organics, trace sand; black, fibrous, damp; fine to coarse sand				
1.2	1.3	Sandy GRAVEL; damp, compact, grey to blue grey; fine to coarse subrounded to rounded gravel; fine to coarse sand.				
1.3	4.2	Sandy GRAVEL, trace silt, trace clay; dry, compact, brown to yellow brown; fine to coarse subrounded to rounded gravel; fine to coarse sand; cobbles up to 160 mm in diameter Material increasing sand content and less cobbles with depth	TP15-NG04	2.8	4.1	



Notes:

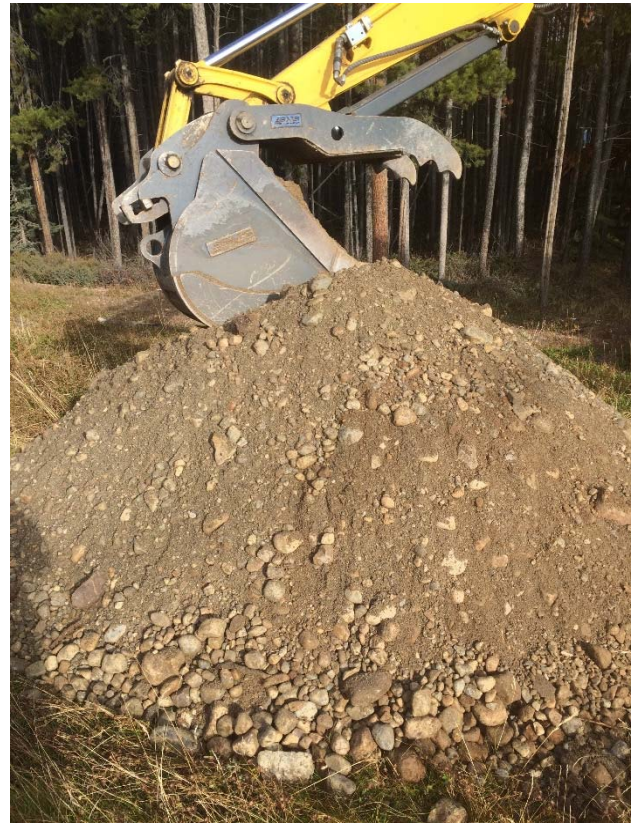
No groundwater or seepage observed during excavation
 Testpit walls slightly unstable (small amounts of wall collapse during excavation)
 Testpit terminated due to reaching machine limitations
 Excavation backfilled and bucket compacted

TP15-NG05

Date: 08-Oct-15
Logged By: Paul Kilkenny

Easting: 555259
Northing: 5699515
Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Water Content (%)
From	To				
0	0.2	Sandy CLAY, with rootlets and organics [Topsoil]			
0.2	0.55	Gravelly SAND, trace clay [Fill]; brown to grey brown, damp; fine to coarse sand; fine to coarse subangular to angular gravel; trace organics			
0.55	0.7	Sandy GRAVEL; damp, compact, grey to blue grey; fine to coarse subrounded to rounded gravel; fine to coarse sand			
0.7	0.8	Organics, trace sand; black to grey black, fibrous, damp; fine to coarse sand			
0.80	2.9	Sandy GRAVEL, some silt, trace clay; dry, compact to dense, grey brown to brown; fine to coarse subrounded to rounded gravel; fine to coarse sand; cobbles up to 140 mm in diameter Increasing sand content and less fines with depth Becoming more dense with depth	TP15-NG05	1.3	2.7



Notes:

No groundwater or seepage observed during excavation
 Testpit walls slightly unstable (small amounts of wall collapse during excavation)
 Testpit terminated due to reaching machine and working area limitations
 Excavation backfilled and bucket compacted

TP15-DT01

Easting: 517668

Date: 08-Oct-15

Northing: 5758200

Logged By: Paul Kilkenny

Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Water Content (%)
From	To				
0.0	0.1	Sandy CLAY, with rootlets and organics [Topsoil]			
0.1	0.3	Sandy GRAVEL, trace silt; damp, loose, grey brown; fine to coarse subrounded to rounded gravel; fine to coarse sand			
0.3	3.6	GRAVEL, some sand, trace silt; damp, loose, grey brown; fine to coarse subrounded to rounded gravel; fine to coarse sand; low plasticity silt; cobbles and boulders up to 300 mm in diameter	TP15-DT01	1.9	



Notes:

No groundwater or seepage observed during excavation
 Testpit walls unstable (wall collapsing during excavation)
 Testpit terminated due to reaching continuous wall collapse
 Excavation backfilled and bucket compacted

TP15-DT02

Date: 08-Oct-15

Logged By: Paul Kilkenny

Easting: 517708

Northing: 5758157

Zone: 11

Depth (m)		Soil Description	Sample No.	Sample Depth (m)	Fines Content (%)	Water Content (%)
From	To					
0.0	0.05	Sandy CLAY, with rootlets and organics [Topsoil]				
0.05	0.7	Sandy GRAVEL, some silt; dry to moist, loose, grey brown; fine to coarse subrounded to rounded gravel; fine to coarse sand; cobbles up to 170 mm in diameter	TP15-DT02	0.6	5.9	
0.7	3.3	GRAVEL, some sand; dry to moist, loose, grey brown; fine to coarse subrounded to rounded gravel; fine to coarse sand; cobbles up to 170 mm in diameter	TP15-DT02	1.3		1.9



Notes:

No groundwater or seepage observed during excavation
 Testpit walls unstable (wall collapsing during excavation)
 Testpit terminated due to reaching continuous wall collapse
 Excavation backfilled and bucket compacted

APPENDIX C

LABORATORY TEST RESULTS

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project: Icefield Parkway Entry Gates Redevelopment

Sample No.: TP-15

Project No.: V13103534-01

Date Tested: November 4, 2015

Client: MMM

Tested By: JB

Address: Banff National Park

Page: 1

[illegible]

Reviewed By: _____ P.Geol.

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PERCENT FINER THAN # 200 SIEVE FORM

ASTM C117 Aggregate, ASTM D1140 Soils

Project: Icefield Parkway Entry Gates Redeveloprr Sample Number: TP-15

Location Banff National Park

Client: MMM

Project Number: V13103534-01

Date Teste November 4, 2015 By: JB

B.H.	NG01	NG04	DT02				
Depth	1.0 m	2.8 m	0.6 m				

Wet Mass & Tare (g)	2349.3	2623.1	2099.2				
Tare Mass (g)	521.2	488	536.8				
Wet Mass (g)	1828.1	2135.1	1562.4				

Initial Mass & Tare (g)	2297.7	2559.1	2050.6				
Tare Mass (g)	521.2	488	536.8				
Initial Mass (g)	1776.5	2071.1	1513.8				

Washed Mass & Tare (g)	2174.4	2473.3	1961.8				
Tare Mass (g)	521.2	488	536.8				
Washed Mass (g)	1653.2	1985.3	1425				

	m%	2.9	3.1	3.2			
Mass Passing #200 (g)	123.3	85.8	88.8				
Percent Passing #200	6.9	4.1	5.9				

B.H.							
Depth							

Wet Mass & Tare (g)							
Tare Mass (g)							
Wet Mass (g)							

Initial Mass & Tare (g)							
Tare Mass (g)							
Initial Mass (g)							

Washed Mass & Tare (g)							
Tare Mass (g)							
Washed Mass (g)							

	m%						
Mass Passing #200 (g)							
Percent Passing #200							

Remarks: _____



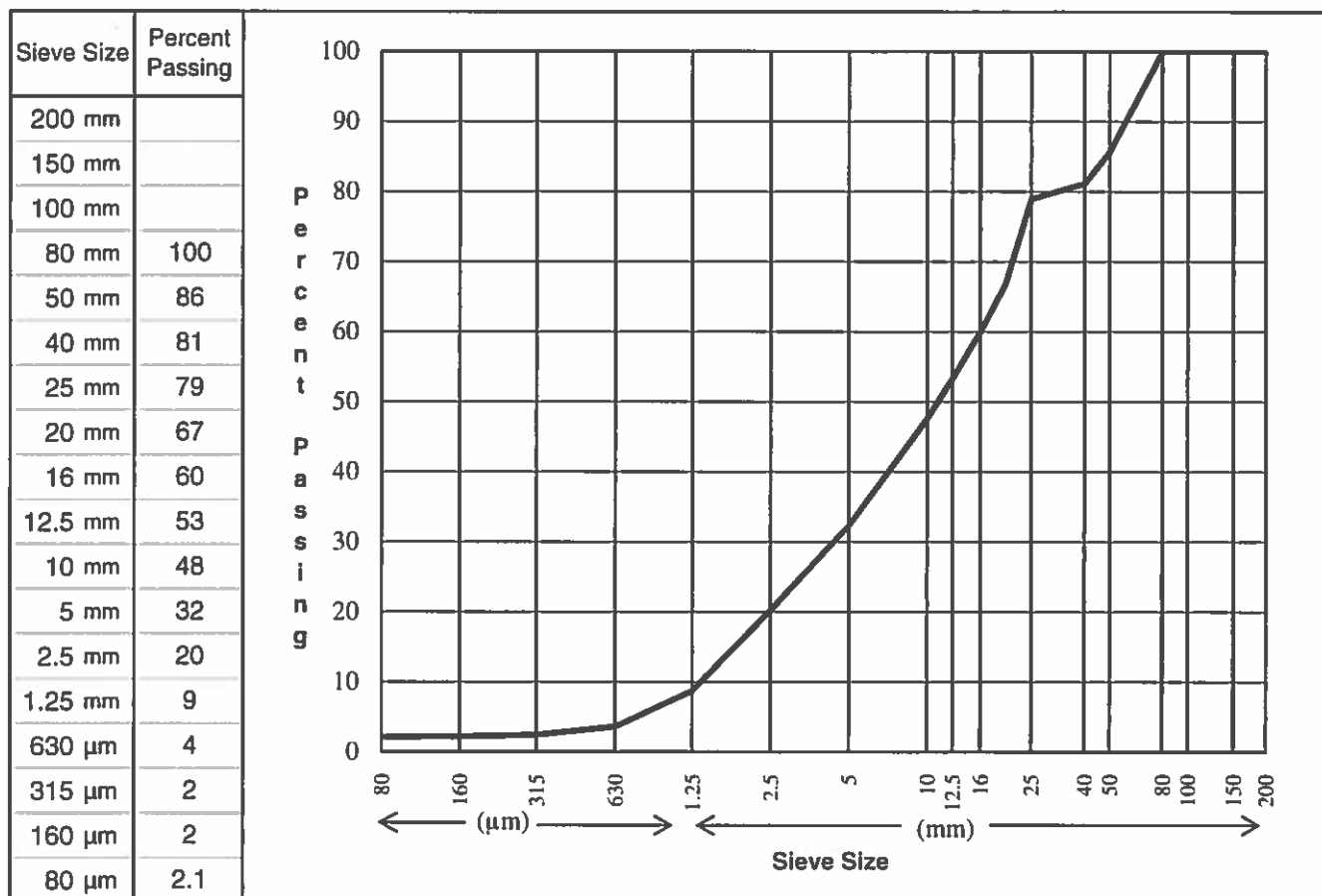
For Internal Use only

SIEVE ANALYSIS REPORT

ASTM C136, C117

Project: Icefield Parkway Entry Gates Redevelopment
 Client: MMM
 Project No.: V13103534-01
 Attention: Robert McDonnell
 Description: GRAVEL, some sand, trace silt
 Source: TP-15
 Location: 1.9 m
 Specification: _____

Sample No.: DT01
 Date Sampled: October 9, 2015
 Sampled By: _____
 Date Tested: November 4, 2015
 Tested By: JB Lab: Calgary
 No. Crushed Faces: _____
 Moisture Content: 1.9%



Remarks: _____

Reviewed By: *[Signature]* P.Geol.

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SIEVE ANALYSIS REPORT

ASTM C136, C117

Project: Icefield Parkway Entry Gates Redevelopment

Sample No.: NG02

Client: MMM

Date Sampled: October 9, 2015

Project No.: V13103534-01

Sampled By:

Attention: Robert McDonnell

Date Tested: November 4, 2015

Description: GRAVEL, some sand, trace silt

Tested By: JB Lab: Calgary

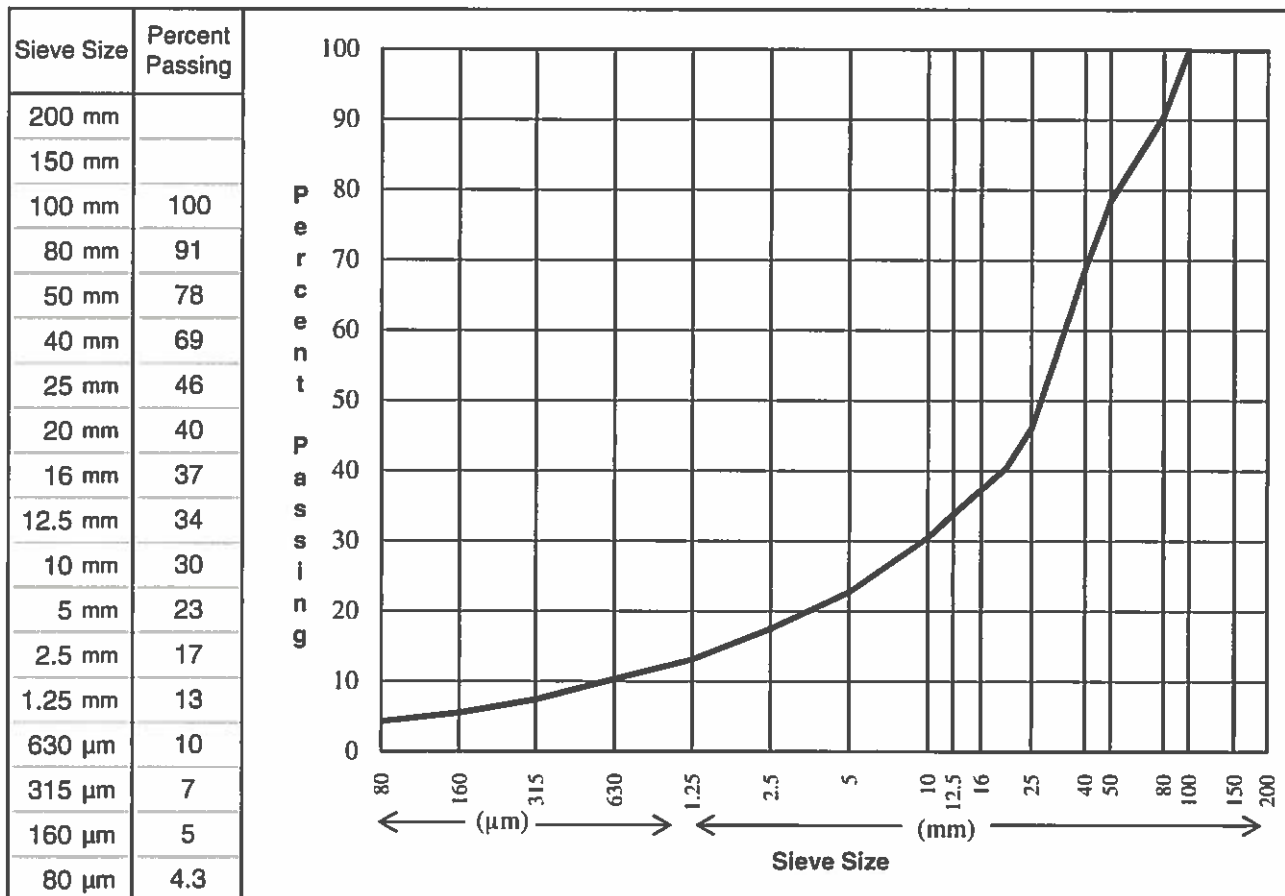
Source: TP-15

No. Crushed Faces:

Location: 1.5 m

Moisture Content: 2.3%

Specification:



Remarks:

Reviewed By:  P.Eng.

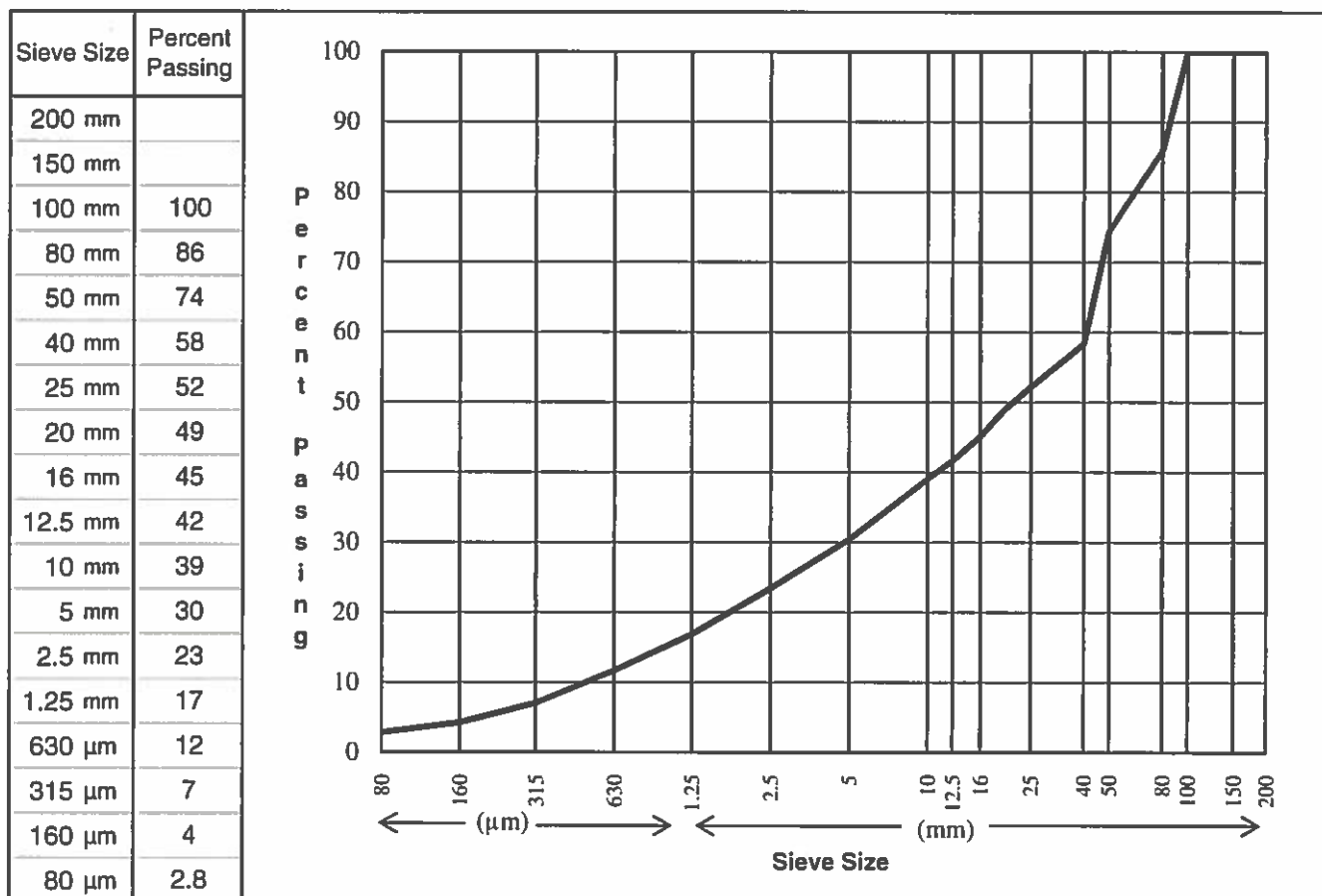
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SIEVE ANALYSIS REPORT

ASTM C136, C117

Project: Icefield Parkway Entry Gates Redevelopment
 Client: MMM
 Project No.: V13103534-01
 Attention: Robert McDonnell
 Description: GRAVEL, sandy, trace silt
 Source: TP-15
 Location: 1.8 m
 Specification: _____

Sample No.: NG03
 Date Sampled: October 9, 2015
 Sampled By: _____
 Date Tested: November 4, 2015
 Tested By: JB Lab: Calgary
 No. Crushed Faces: _____
 Moisture Content: 2.7%



Remarks: _____

Reviewed By: *[Signature]* P.Geol.

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