



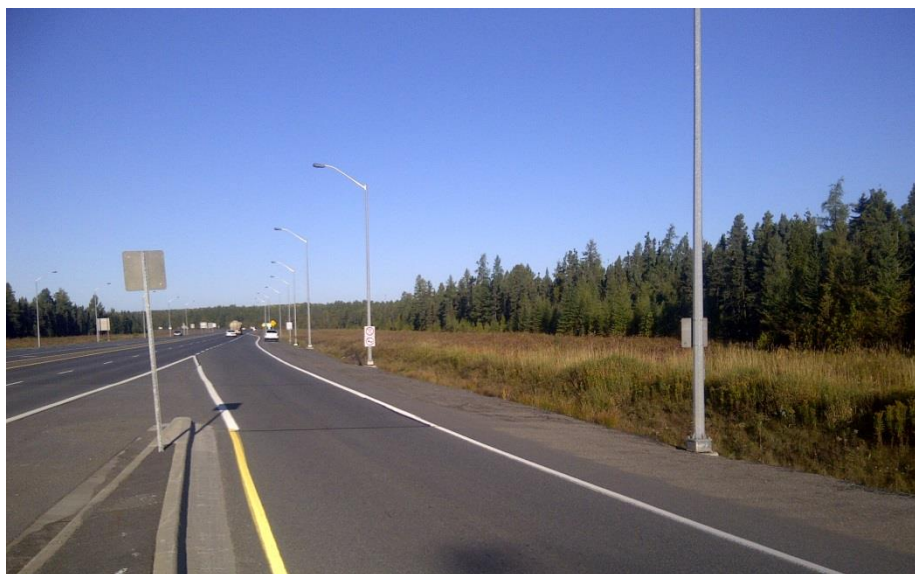
March 31, 2017

PRELIMINARY FOUNDATION REPORT

**HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY
FROM 1 KM SOUTH OF ARTHUR STREET NORTHERLY 13.3 KM TO 1 KM
NORTH OF BALSAM STREET
THUNDER BAY, ONTARIO
GWP 6001-13-00, ASSIGNMENT NO. 6012-E-0050**

Submitted to:

AECOM Canada Ltd.
30 Leek Crescent, 4th Floor
Richmond Hill, ON
L4B 4N4



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REPORT





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1.0 INTRODUCTION

The Ministry of Transportation, Ontario (MTO) has initiated a Planning and Preliminary Design Study under GWP 6001-13-00 for Highways 11/17 and 61, known as the Thunder Bay Expressway (TBE), from 1.0 km south of Arthur Street northerly 13.3 km to 1.0 km north of Balsam Street, within the City of Thunder Bay. The intent of the planning and preliminary design study is to convert the existing four-lane undivided highway with at-grade intersections to a four-lane divided freeway with grade separated access. AECOM Canada Ltd. (AECOM) has been retained by the MTO to complete the Planning and Preliminary Design Study for this project and AECOM in turn has retained Golder Associates Ltd. (Golder) to provide foundation engineering services. A plan view of the overall project limits and Expressway alignment is shown on Figure 001. The Expressway alignment is oriented typically in a north-south direction and is designated as Highway 61 between Arthur Street and Harbour Expressway and as Highway 11/17 between Harbour Expressway and Balsam Street.

The terms of reference for the scope of work are outlined in MTO's Request for Proposal (Purchase Order No. 6012-E-0050) dated April 2013 and subsequent clarifications; and summarized in Golder's proposal P13-1184-0113 dated August 14, 2013, which forms part of AECOM's overall submission in response to the RFP. The work was carried out in accordance with Golder's Quality Control Plan for Foundation Engineering Services dated October 9, 2013. The scope of work includes a visual site reconnaissance and review (desktop study) of available literature to establish existing soil and/or bedrock conditions. A Foundation Investigation is not required for this preliminary level assignment and foundation investigations will be required during detail design at swamp crossings, high fill embankments and bridge/culvert structure locations to obtain information on subsurface conditions to support the assessment and provision of recommendations for foundation design. The work carried out for this study should be considered preliminary in nature and is intended only to highlight general foundation issues for use in comparing the design alternatives.

We understand that the preferred route alternative to accommodate the new divided controlled access freeway consists of shifting the southbound lanes (SBL) westerly paralleling the existing alignment, maintaining the alignment of the existing northbound lanes (NBL) and constructing a 22.5 m wide median. The proposed interchanges will be grade separated, with various configuration alternatives being considered, including with foundation input provided by Golder to AECOM for their selection of the preferred alternative, for each interchange and for preliminary design of the following nineteen structures:

- Five interchanges: Arthur Street, Harbour Expressway, Northwest Arterial (Future), Highway 102 / Red River Road and Balsam Street for a total of 11 structures, which includes two ramp structures at Harbour Expressway.
- Two flyovers: underpasses at Oliver Street and John Street for a total of two structures.
- Three water crossings: Neebing River, McIntyre River and McVicar Creek, for a total of six structures.

Golder is also providing concurrent Pavement Planning and Preliminary Design services for the proposed interchange alignments and realignment. The Pavements Planning and Preliminary Design Report is presented under separate cover.



2.0 SITE DESCRIPTION

The existing highway is a four-lane undivided roadway comprised typically of an approximately 1 m wide median, 3.75 m wide lanes and an approximately 1 m wide paved shoulder along each side of the roadway. Existing interchanges consist of at-grade traffic light controlled intersections with associated left and right turning lanes.

The present day topography within the project limits is variable, however it generally consists of rolling to rugged terrain topography with maturely treed areas, occasional bedrock outcrops (typically low in height and present at the north end of the alignment) separated by occasional low-lying swamp areas, water bodies, small streams and rivers. Much of the area around the TBE alignment is built-up with residential and commercial development. Development is especially dense through the northern portion of the project, beyond the Northwest Arterial (Future) road interchange to Balsam Street. The extent/alignment of the project is shown on the location plan on Figure 001, and segmented, larger scale, more detailed sections are shown on Figures 002 to 012.

The highway surface elevation increases from the south to the north limits, with the following approximate grades at the proposed interchanges/flyovers.

- Arthur Street: Elevation 192 m
- Harbour Expressway: Elevation 197 m
- Oliver Street: Elevation 216 m
- Northwest Arterial (Future): Elevation 229 m
- John Street: Elevation 238 m
- Highway 102/Red River Road: Elevation 245 m
- Balsam Street: Elevation 250 m

2.1 Drainage

The overall regional drainage pattern of the Thunder Bay area is south and east towards Lake Superior. A number of rivers and creeks, which make up the local drainage system, cross the TBE alignment within the project boundaries, including the Neebing River, the McIntyre River, and McVicar Creek. Locally, drainage within the project limits ranges from good in glaciolacturine plain and ground moraine landforms to poor in areas of organic deposits. Drainage of the existing highway pavement and subgrade is provided by the raised highway platform in fill areas, and by roadside ditches within cut sections. Approximate location of low lying swamp areas observed along the alignment during the field reconnaissance are shown in green shading on Figures 002 to 012. Cross-drainage of the existing highway is provided by a number of centreline culverts and the following major water crossings:

- Neebing River approximately 300 m north of Arthur Street
- McIntyre River approximately 600 m south John Street
- McVicar Creek approximately 1.3 km north of the Highway 102/Red River Road



3.0 INVESTIGATION PROCEDURE

3.1 Desktop Study

A desktop study was completed for the TBE alignment, which consisted of the collection, compilation and cursory review of available existing geological subsurface information, including MTO's GEOCRES library, geological maps and well drilling records, as well as existing information such as previous route planning reports for this site and aerial imagery. This facilitated the development of a general understanding of the anticipated foundation conditions at each proposed interchange location and potential bridge structure foundation locations, and allowed for the identification of areas of potential foundation concern, both within the overall interchange location (cut/fill; presence of swampy ground) and at/within the footprint of structure foundations (i.e., presence of soft ground, depth to bedrock).

3.1.1 Review of Existing Studies and Reports

The following geotechnical related information was provided by MTO at the proposal stage and a cursory review was completed by Golder as part of the desktop study:

- GWP 1-94-00 – Preliminary Design Report, Northwest Arterial Interchange (DS-Lea 1996)
- GWP 374-90-00 – Planning Study Report, Harbour Expressway to Broadway Avenue (MRC 1995)
- GWP 619-89-00 – Detail Design, John Street to Red River Road (Parker 1995)
- GWP 15-89-00 – Planning Study Report, Arthur Street to Balsam Avenue (MRC 1992)
- WP 15-89-00 – Preliminary Design Report, John Street to Red River Road (MRC 1992)

The following foundation reports were obtained by Golder from MTO GEOCRES library:

- GEOCRES 52A-17: W.P. 59-69-00 – Foundation Investigation Report for Proposed Approach Embankment at the Crossing of Thunder Bay Expressway and Highway # 11 and # 17 – Scheme 'B', City of Thunder Bay, District No. 19 (Department of Highways, Ontario, 1970)
- GEOCRES 52A-43: W.P. 62-F-230C – Soil Conditions and Foundation Study, Proposed Lakehead Ring Road, Fort William-Port Arthur, Ontario (H.Q. Golder & Associates Ltd., 1962)
- GEOCRES 52A-46: W.J. 63-F-121, W.P. 922-64 – Proposed Neebing River Structure, Lakehead Expressway, Line 1, District 19, Fort William, Ontario (Ministry of Transportation, Ontario, 1964)
- GEOCRES 52A-60: W.P. 905-74-01 – Twinning McVicar Creek Culvert, Thunder Bay Expressway – Ontario, (Ministry of Transportation and Communications, Ontario, 1974)
- GEOCRES 52A-73: W.P. 906-76-02 – Foundation Investigation Report for Neebing River Structure, 0.2 km East of Highway 61 and Arthur Street, District 19, Thunder Bay (Ministry of Transportation, Ontario, 1978)
- GEOCRES 52A-93: W.P. 399-87-01 – Foundation Investigation Report for High Mast Lighting, Thunder Bay Expressway, Hwy. 11/17, District 19, Thunder Bay (Ministry of Transportation, Ontario, 1990)



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- GEOCRE 52A-103: W.P. 115-91-01 – Foundation Investigation Report for High Mast Lighting Foundation, Hwy 11 & 17 Harbour Expressway Interchange, District 19, Thunder Bay (Ministry of Transportation, Ontario, 1991)
- GEOCRE 52A-105: W.P. 33-90-02 – Foundation Investigation and Design Report for Proposed Highway 11/17 Underpass Structure at John Street, District 19, Thunder Bay (Ministry of Transportation, Ontario, 1991)
- GEOCRE 52A-109: W.P. 619-89-02 – Foundation Investigation Report for Proposed Highway 11/17 Underpass Structure at Red River Road/Hwy. 102, District 19, Thunder Bay (Ministry of Transportation, Ontario, 1992)
- GEOCRE 52A-110: W.P. 619-89-00 – Foundation Investigation and Design Report for Proposed Highway 11/17 Bridge Structure Crossing the McIntyre River, District 19, Thunder Bay (Ministry of Transportation, Ontario, 1991)
- GEOCRE 52A-113: W.P. 619-89-02(A) – Foundation Investigation and Design Report for Proposed Retaining Wall Along Highway 11/17 at Red River Road and Hwy.102, District 19, Thunder Bay (Ministry of Transportation, Ontario, 1992)

In September 2014, Golder visited the City of Thunder Bay to obtain applicable geotechnical reports along the existing highway alignment and the following report was considered relevant:

- Soils Investigation, Watermain Crossing Expressway near McVickers (MTO's McVickers Creek) Creek, Thunder Bay, Ontario, Ref No. 74-2-T4, April 1974, by Dominion Soil Investigation Limited

3.1.2 Review of Well Records

The Ontario Ministry of the Environment (MOE) well records within approximately 200 m of the existing TBE alignment were obtained in August 2015. A cursory review of the well records indicate that wells are present within the vicinity of Oliver Road, McIntyre River and John Street.

3.1.3 Physiography and Geology

A cursory review of the following geological mapping information was completed for the summary of the physiography and geology summarized below:

- Geological Survey of Canada. Physiographic Regions of Canada. "A" Series Map 1254A, 1:5,000,000 (Bostock H.S., 1970)
- Ontario Geological Survey. Northern Ontario Engineering Geology Terrain Study 71, Thunder Bay Area (NTS 52A/SW) District of Thunder Bay. 41 p. Accompanied by Maps 5047 and 5048. Scale 1:1,000,000 (Mollard, D.G., & Mollard, J.D. 1983)

The City of Thunder Bay and the portion of the TBE within the project limits is located in the Physiographic Region of Canada known as the Port Arthur Hills. The Port Arthur Hills Region encompasses the City of Thunder Bay and



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extends from the shore of Lake Superior inland about 25 km and stretches from the Canadian and American Border north to Nipigon, Ontario, where it tapers as it meets the shores of Lake Superior (Bostock, 1970).

According to Mollard and Mollard (1983):

- A large and relatively flat area of Pleistocene lacustrine deposits extends west from the City of Thunder Bay to Kakabeka Falls, Ontario, along the Kmanisitikwia River and southwest towards Whitefish Lake, following the Whitefish River.
- The surficial geology along the subject portion of the TBE varies. The south portion of the project, from Arthur Street to approximate location of the Northwest Arterial (Future) Road, generally consist of a glacio-lacustrine plain deposit of sand and minor silt, with level to gently sloping topography. In a number of areas along the southern portion of TBE alignment, including around the Harbour Expressway, the Northwest Arterial (Future) Road and north of Oliver Road, surficial organic deposits of peat and muck overlay the glaciolacustrine material. Further north along the TBE alignment, around the Northwest Arterial (Future) Road and beyond, the surficial geology generally consists of ground moraine of silty glacial till with plain to rolling or undulating topography. Further north, near John Street, the ground moraine deposit becomes thinner; a surficial veneer overlying bedrock. At the north end of the project, near Balsam Street, the surficial geology consists primarily of bedrock knobs with some minor areas consisting of a surficial veneer of gravelly sand till ground moraine over bedrock.
- The Port Arthur Hills are generally comprised of Proterzoic volcanic tabular sheet intrusions (mafic sills) within ancient sediments. The sills tilt to the south, forming mesas, cuestras, and narrow steep sided ridges. Some of these landforms extend as headlands or promontories in Lake Superior.

3.2 Field Reconnaissance

A site reconnaissance (i.e., field study) was completed in September 2014, in conjunction with the pavement engineering representative, to document visual observations of natural features and inference of subsurface conditions, pertinent to the assessment of the foundation design and construction issues associated with the applicable structures and to create a photographic record of the surface conditions at each of the structures. The photographs of structure locations, Sheets 1 to 10, are included in Appendix A. Approximate boundaries of swamps, excess material berms and exposed bedrock outcrops identified during the site reconnaissance are shown on Figures 002 to 012 where applicable.

Since alignment staking was not included as part of this assignment, the site reconnaissance work relied heavily on the use of existing features (i.e. roadways, buildings and waterways) as landmarks, as well as on a handheld Global Positioning System (GPS) unit, for orientation and location.

3.3 Interchange Assessment

For each of the five interchanges proposed for the project (i.e., Arthur Street, Harbour Expressway, Northwest Arterial (Future), Highway 102/Red River Road and Balsam Street), between three and six interchange/ramp configuration alternatives were identified by AECOM in 2015. For Harbour Expressway, two interchange



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alternatives each with various ramp alternatives were presented for a Partial Freeway to Freeway and Full Freeway to Freeway configuration. The available existing information from the desktop study and field reconnaissance was reviewed by Golder to compare each interchange alternative using a qualitative and quantitative analysis for a comparison of the various alternatives from a foundations/pavements perspective. We understand that the preferred alternative for each interchange was selected by AECOM considering preliminary input from each of the various engineering disciplines including preliminary foundation ranking for the various alternatives developed by Golder. We further understand that AECOM presented the preferred alignment for each interchange at their Public Information Centre in Thunder Bay on June 23, 2015.

Foundation considerations for the interchange alternatives include a quantitative assessment of the extent of swamp/soft ground areas and topographic variability/terrain ruggedness along the route and within the footprint of the interchange ramps, the potential for embankment stability/settlement issues and general drainage characteristics of the alignments and within the interchange footprints, as well as a qualitative assessment of the conditions / type of foundations anticipated to be required at the structure locations.

It should be noted that the same set of assessment factors and methodology was used for both the foundations and pavements evaluations in this study. A summary of the assessment factors, the indicators and the measures, as utilized for the evaluation, is presented below.

Foundation Factor	Indicator	Measure: Criterion
General Topography	Extent of Topographic/Terrain Variation	Quantitative Assessment / Estimate of Conditions: (Difficult/Very Rugged, Neutral, Open); (% of Total Route Length or Ramp Footprint/Service Road Alignment)
Overall Drainage Pattern	Drainage Ability/Extent of Ponded Water	Quantitative Assessment: (Rapid, Fair, Poor/Ponded Water Present); (% of Total Route Length or Ramp Footprint/Service Road Alignment)
Swamp and Soft Ground	Extent of Swamp and Soft Ground	Quantitative Assessment: (Major Deep Swamps/Difficult Conditions, Minor/Shallow Swamps, No Swamps Expected); (% of Total Route Length or Ramp Footprint/Service Road Alignment)
Potential for embankment stability/settlement issues	Extent and severity of soft ground conditions	Quantitative Assessment: [Difficult embankment conditions (Very soft/Deep Clay Deposits) or Favourable embankment conditions (Thin or No Clay Deposits)]; (% of Total Route Length or Ramp Footprint/Service Road Alignment)
Foundation Types at Structure Locations	Anticipated depth to Bedrock (Shallow or Deep)	Qualitative Assessment: (Exposed Bedrock/Shallow Foundations, Unknown/Possible Deep Foundations); (Estimated number of each)



Using the criteria listed above, each indicator was assessed by assigning a numerical estimate (% of total length, number of each type of foundation unit, etc.) to each associated measure. A difficulty rating (1=Difficult, 2=Neutral, 3=Favourable) for each measure was then assigned. The combination of the numerical estimate of the measure and the difficulty rating then provide a sub-total for each Foundation Factor, which are then summed to provide an overall score (or total weighted ranking) for each potential route or interchange alternative. The highest total weighted ranking (overall score) represents the preferred alternative. It is noted that an equal weighting has been assigned to each of the Foundation Factors for this assignment.

Details of the procedures used for the evaluation of the interchange alternatives, including sample calculations, are presented in Appendix B. The results of the comparison, including the numerical estimates of each measure for the various indicators that comprise the foundation evaluation, were compiled and tabulated. The completed foundation/geotechnical portions of the evaluation for the interchange alternatives are presented in Tables 1 to 6 following the text of this report. We understand from AECOM that at Harbour Expressway the Partial Freeway to Freeway alternative is preferred over the Full Freeway to Freeway configuration. The overall score from a foundations perspective for each alternative is shown at the bottom of each table. In several cases, similar output results were obtained, suggesting that those interchange alternatives were not preferred over another.

4.0 SUBSURFACE CONDITIONS

4.1 Arthur Street

The following presents a summary of the reported subsurface conditions in the vicinity of Arthur Street:

- OGS electronic mapping accessed June 2014: Glaciolacustrine plain deposits consisting of sands and silts.
- MTO GEOCRE5 52A-17: A total of five boreholes were advanced at the site with one borehole advanced to 23.3 m depth and the remaining four boreholes advanced to between 13.3 m and 15.7 m depth. All the boreholes encountered very loose to compact silts and sands with clayey silt layers of irregular thicknesses to the full depth of the borehole except in the deep borehole in which a stiff silty clay deposit was encountered below a depth of 16.8 m to the bottom of the borehole. Bedrock was not encountered in the boreholes. Groundwater was observed in the open boreholes at depths ranging from 1.2 to 2.4 m.

4.2 Neebing River

The following presents a summary of the reported subsurface conditions in the vicinity of Neebing River:

- OGS electronic mapping accessed June 2014: Glaciolacustrine plain deposits consisting of sands and silts.
- MTO GEOCRE5 52A-43: Golder advanced one borehole in April 1962 at the existing crossing for the original highway construction and the borehole encountered a 38 m thick deposit of firm to stiff silty clay/clayey silt with silt layers, underlain by an approximately 3 m thick deposit of stiff to hard silty clay and further underlain by shale bedrock at 41 m depth, which was cored for a length of 3 m.



- MTO GEOCRE5 52A-46: Two boreholes and five dynamic cone penetrations tests were advanced by MTO. The boreholes advanced indicate stratified silts, sand and clays underlain by shale bedrock at approximately 41 m to 45 m depths.
- MTO GEOCRE5 52A-73: Three power auger hand holes were advanced to 4.9 m to 5.5 m depths as part of an MTO foundation investigation report for the widening of the existing Neebing River Structure in July 1966.

4.3 Harbour Expressway

The following presents a summary of the reported subsurface conditions in the vicinity of Harbour Expressway:

- OGS electronic mapping accessed June 2014 indicates peat/organic deposits are present at least 700 m around the intersection; and beyond the boundary of the peat/organics, glaciolacustrine plain deposits are present consisting of sands and silt soils.
- MTO GEOCRE5 52A-103: A total of four boreholes were advanced to depths between 9.1 m and 15.2 m for high mast lights pole foundations. Two boreholes encountered peat to 1.5 m and 2.0 m depth and the other two boreholes encountered sand and gravel fill to 3.9 m depth. Underlying the peat/fill, a 1 m to 2 m thick deposit of loose to compact fine sand was encountered, underlain by a 5 m to 7 m thick deposit of firm to stiff clayey silt to the shale bedrock surface encountered between 8.6 m and 13.8 m depth. Groundwater observed in the open boreholes was recorded at depths between 1.2 m and 3.5 m.
- GWP 15-89-00 – Planning Study Report Arthur Street to Balsam Avenue (MRC 1992) references the Williams Bog Wetland (referred to as Arthur Bog in Appendix F in the GWP 15-89-00 report) with an extensive peat deposit in the area of Harbour Expressway.

4.4 Oliver Road

The following presents a summary of the reported subsurface conditions in the vicinity of Oliver Road:

- OGS electronic mapping accessed June 2014: Glaciolacustrine plain deposits consisting of sands and silts.
- MTO GEOCRE5 52A-93: A total of two boreholes were advanced to depths of 3.4 m and 4.8 m for high mast lights pole foundations and encountered deposits of dense to very dense silty sand or sandy silt and firm to very stiff clayey silt underlain by shale, greywacke or conglomerate bedrock at 1.8 m and 3.0 m depth (Elevations 215.4 m and 210.1 m, respectively). Groundwater observed in the open boreholes was recorded at a depth of about 1.6 m.
- Based on the available MOE digital well records, there are two registered wells east of TBE and 1 registered well west of TBE. The recorded water levels range from ground surface to 11 m below ground surface, and the recorded depth to bedrock ranges between ground surface and 6.1 m below ground surface.



4.5 Northwest Arterial (Future) Interchange

The following presents a summary of the reported subsurface conditions in the vicinity of Northwest Arterial (Future):

- OGS electronic mapping accessed June 2014: Ground moraine deposits consisting of silt till are present to the west of TBE and peat/organic deposits are present to the east of TBE.
- GWP 1-94-00 – Preliminary Design Report – Northwest Arterial Interchange (DS-Lea 1996) Appendix B presents the Ministry's preliminary foundation investigation report and Appendix J presents the Ministry's preliminary pavement design report. In March 1995, a total of 24 probes advanced with an air track machine encountered refusal at depths between about 3 m and 7 m depth below ground surface, between Elevation 220 m and 224 m, generally dipping down from the west to the east. The water level, where measured, was at or near ground surface or estimated to as deep as about 1 m below ground surface, shallower on the west and deeper on the east ends of the site.
- GWP 15-89-00 – Planning Study Report, Arthur Street to Balsam Avenue (MRC 1992) Appendix F referenced previous probes at the site, which encountered a 1 m to 1.5 m thick deposit of peat, underlain by a deposit of sandy silt to silty sand, and with a shallow water table at shallow depth.
- During our field reconnaissance in September 2014, Golder observed organics and sands/silts in the recently excavated ditches for the reconstruction of Golf Links Road (see Sheet 5, Photograph 2 for Northwest Arterial in Appendix A).

4.6 McIntyre River

The following presents a summary of the reported subsurface conditions in the vicinity of McIntyre River:

- OGS electronic mapping accessed June 2014: Ground moraine deposits consisting of silt till.
- MTO GEOCRE 52A-110: A total of two boreholes were advanced in 1991 to supplement boreholes that were drilled at the site in July 1964 and September 1979. In general, overburden ranging in thickness from 1.4 m to 2.5 m was encountered overlying Cherty Iron Formation bedrock.
- GWP 15-89-00 – Planning Study Report, Arthur Street to Balsam Avenue (MRC 1992) Appendix F referenced that the existing bridge footings are founded on bedrock, and that the upper 0.5 m of bedrock being heavily weathered.

4.7 John Street

The following presents a summary of the reported subsurface conditions in the vicinity of John Street:

- OGS electronic mapping accessed June 2014: Ground moraine deposits consisting of silt till.
- MTO GEOCRE 52A-93: A total of two boreholes were advanced to depths of 5.2 m and 8.8 m for high mast lights pole foundations and encountered 2.1 m of fill or organic material underlain by 1.2 m to 1.6 m thick deposits of loose to compact sands/silts, underlain by bedrock in the shallower borehole. In the deeper



borehole, the sands/silts are underlain by deposits of very stiff to hard clayey silt, which was further underlain by very dense sand and gravel. The bedrock consisted of taconite or brecca and was encountered at depths of 3.3 m and 7.2 m (Elevations 228.8 m and 234.7 m, respectively). Groundwater observed in the open boreholes was measured at a depth of about 2.1 m and 2.5 m.

- MTO GEOCRE5 52A-105: A total of seven boreholes were advanced within the vicinity of the John Street site for the original underpass design. An up to 3.6 m thick layer of sand fill was encountered underlying the roadway. Underlying the fill, relatively thin deposits of silt sand to sandy silt were encountered, further underlain by a till deposit. The overburden materials are underlain by a cherty iron formation bedrock. The bedrock surface was encountered between Elevations 230.3 m and 233.4 m (between 5.0 m and 6.7 m below existing ground surface).
- Based on the available MOE digital well records, there is one registered well west of TBE with a reported static water level at 6.1 m below ground surface, and the depth to bedrock of 1.2 m below ground surface.

4.8 Highway 102/Red River Road

The following presents a summary of the reported subsurface conditions in the vicinity of Highway 102 and Red River Road:

- OGS electronic mapping accessed June 2014: Ground moraine deposits consisting of silt till.
- MTO GEOCRE5 52A-109: A total of six boreholes were advanced in May 1991 to depths ranging between 2.9 m and 7.7 m and encountered fill to depths ranging from 1.2 m to 2.8 m (with 0.7 m of peat below the fill in one borehole), a firm to hard clayey silt deposit 0.3 m to 1.6 m thick was encountered below the fill in several boreholes, a compact to very dense till deposit comprised of silt, sand, and gravel ranging in thickness from 0.4 m to 2.0 m was encountered in all boreholes, underlain by cherty iron formation bedrock was encountered in three boreholes at depths ranging from 2.9 to 4.7 m, between Elevations 239.9 m and 241.2 m. The groundwater level observed in the open boreholes and measured in one piezometer ranged from 1.5 m to 2.1 m depth below ground surface.
- MTO GEOCRE5 52A-113: In August of 1991, a total of three boreholes were advanced at the southwest quadrant of River Road/Highway 11/17 for a proposed N-W ramp retaining wall. The boreholes were advanced to depths ranging between 2.4 m and 3.4 m and encountered a surficial clayey silt deposit up to 1.1 m thick, underlain by a silt, sand and gravel till deposit. The boreholes were terminated on probable bedrock. Two of the boreholes were dry upon completion of drilling and a standpipe was installed in a third borehole in which the water level was recorded at a depth of 1.5 m below ground surface.

4.9 McVicar Creek

The following presents a summary of the reported subsurface conditions in the vicinity of McVicar Creek:

- OGS electronic mapping accessed June 2014: Ground moraine deposits consisting of silt till bordered to the east with bedrock knobs.



- MTO GEOCRE5 52A-43: Golder advanced Borehole 23 in April 1962 and the borehole encountered a 2.6 m thick deposit of silty sand and gravel till, underlain by shale and quartzite bedrock at Elevation 234.5 m, which was cored to a depth of 5.6 m. The groundwater level in the standpipe piezometer was measured at Elevation 236.8 m (approximately 0.2 m below ground surface).
- MTO GEOCRE5 52A-60: A total of four boreholes were advanced within the vicinity of the culvert location in September 1974. Two of the boreholes encountered up to 7.6 m of fill suggesting that they were drilled through the existing embankment. Underlying the fill deposit, relatively thin deposits of organic silt and gravelly sand were encountered. Probable bedrock was encountered between 2.0 m and 10.1 m below ground surface.
- A soils investigation for the City of Thunder Bay for a watermain crossing was completed southwest of McVicars Creek in March 1974. A total of three boreholes were advanced to between 6.1 m and 7.9 m depths. Cobbles and boulders were noted to be present within the silty till deposit encountered from ground surface to the bottom of the boreholes.

4.10 Balsam Street

The following presents a summary of the reported subsurface conditions in the vicinity of Balsam Street:

- OGS electronic mapping accessed June 2014 and confirmed during our September 2014 field reconnaissance: Bedrock knobs across the site.
- MTO GEOCRE5 52A-43: Golder advanced Borehole 24 in April 1962 and encountered a 1.3 m thick till deposit of silty clay with sand and gravel. Granite diorite metamorphosed bedrock was encountered at a depth of 1.3 m and cored to a depth of 3.7 m. The borehole was dry upon completion of drilling.

5.0 DISCUSSION ON PRELIMINARY FOUNDATION DESIGN RECOMMENDATIONS FOR STRUCTURES

This section of the report provides preliminary foundation design recommendations for the proposed Highways 11/17 and 61 TBE structures from Arthur Street to Balsam Street in Thunder Bay, Ontario. The preliminary foundation design recommendations are based on interpretation of the limited factual data obtained from existing information available as noted in Sections 3 and 4. The interpretation and recommendations are intended to provide the designers with information to assess preliminary feasible foundation alternatives for the structure foundations and identifies whether potential stability/settlement issues may occur and provides an indication of whether mitigation measures may be required. Further, the recommendations presented should be confirmed during the detail design phase of this project. Where comments are made on construction they are provided to highlight those aspects which could affect the design of the project, and for which special provisions or operational constraints may be required in the contract documents. Those requiring information on aspects of construction should make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods, scheduling and the like.

The alignment of the TBE and location of the various interchanges, road and water crossings are shown on Figures 001 to 012. Preliminary highway profiles were provided in March 2016 by AECOM and Preliminary General Arrangement (GA) drawings were also provided by AECOM between March and May 2016, and as updated in



December 2016. We understand from AECOM that at this preliminary stage, it is likely that the approach embankments to the structures will be constructed of granular fill at slopes inclined at 2 Horizontal to 1 Vertical (2H:1V). If rock fill is available for construction of the embankments, such embankments side slopes should be inclined no steeper than 1.25H:1V. Mid-height berms (2 m wide) should be constructed for granular fill embankments greater than 8 m high and for rock fill embankments greater than 10 m high, as shown in OPSD 202.010 (Slope Flattening).

At several structural sites, Retained Soil System (RSS) walls are proposed for the abutment wing walls and approach embankments due to property limit constraints. Further, at several sites there are retaining walls required for the construction of ramps due to property constraints. While a preliminary discussion on global embankment stability is provided for each structure site, the internal stability of the RSS walls and ramp retaining walls will need to be confirmed by the designer of the proprietary wall.

The estimated depth of frost penetration for the Thunder Bay area is 2.2 m, as per OPSD 3090.100 (Ontario Provincial Standard Drawing for Foundation, Frost Penetration Depths for Northern Ontario). Spread footings founded on soil and pile caps for deep foundations should be provided with a minimum of 2.2 m of conventional soil cover for frost protection. Footings founded on bedrock do not require frost protection.

Sections 5.1 to 5.10 discuss the preliminary foundation issues related to each site and Section 5.11 presents a tabular overview of the expected foundation type and whether stability and/or settlement concerns are anticipated and mitigation measures are considered required.

5.1 Arthur Street Interchange

The preliminary GA indicates that a grade raise up to about 6 m is being proposed for the single span TBE Northbound lane (NBL) and Southbound lane (SBL) structures crossing over Arthur Street (refer to Figure 002), which will be maintained at the existing grade. RSS walls are proposed for the structure wing walls and for the approach embankments to the structure. Deep foundations are anticipated to be required for support of the two structures based on the subsurface conditions identified in Section 4.1. We understand that consideration is being given to supporting the abutments on steel H-piles with the pile caps perched within the embankments on granular pads.

Given the presence of the very loose to compact silty and sandy foundation soils, the proposed approach embankments may likely be stable relative to achieving a Factor of Safety equal to or greater than 1.3. However, the presence of clayey layers of irregular thickness within the sand/silts deposits must be considered at detail design, with the advancement of foundation boreholes and stability analysis.

The non-cohesive foundation soils (sands/silts) below the embankment will settle during construction. The presence and thickness of the clayey layers within the sands/silts will need to be considered during detail design as consolidation of these layers will occur over time (i.e., post construction). The design of the RSS walls must also consider the magnitude of settlement of the foundation soils and need for preloading of the foundation soils and/or need for two-stage wall construction sequence depending on the tolerance that the front facing panels can take to accommodate differential settlement.



Additionally, we understand that retaining walls are being proposed at the following Arthur Street Interchange ramps as follows:

- East side of S-E/W Ramp for 140 m with maximum height of 3.0 m.
- East side of E/W-N Ramp for 100 m with maximum height of 4.9 m.
- West side of N-E/W Ramp for 170 m with maximum height of 7.2 m.

5.2 Neebing River

We understand from AECOM that a single span structure is currently being considered for the TBE NBL and SBL structures crossing Neebing River (refer to Figure 003). A 6 m grade raise is being proposed to accommodate the approach embankments extending to/from the Arthur Street crossing to the south. Deep foundations are anticipated to be required for support of the two structures based on the subsurface conditions identified in Section 4.2.

Given the extensive thickness of cohesive deposits expected to be present at this site, stability and settlement mitigation measures will be required for the proposed approach embankment to the structures, such as the incorporation of toe berms and/or lightweight fill into the embankment mass, installation of wick drains into the subsurface cohesive deposits, or the application of ground improvement in the form of soil mixing of the soft compressible foundation soils, etc., into the design, or staged construction. We understand from previous MTO GEOCRETS reports that widening of the existing Neebing River Bridge approach embankments considered lightweight fill to mitigate stability and settlement, as well as reduce downdrag loads on the bridge pile foundations.

Additionally, given that the existing structure is founded on piles within the cohesive deposit, the proposed grade raise and the proximity of the proposed structures to the existing structure, careful consideration will need to be given to the construction sequencing and methods. Depending on staging and grade raise, the application of downdrag loads on the existing piles will need to be considered if the grade is raised while the bridge is in operation in assessing the performance of the existing structure while it remains in operation.

5.3 Harbour Expressway Interchange

The preliminary GA indicates that a grade raise up to about 7 m is being proposed for the two span Harbour Expressway structure crossing over the TBE NBL and SBL, which will be maintained at existing grade (refer to Figure 005). In addition, three ramp structures are required with each having two spans with grade raises of about 8 m and 9 m. Deep foundations founded on bedrock are anticipated for support of the all structures at this site based on the subsurface conditions identified in Section 4.3.

Embankment construction will need to consider the presence of the low lying swampy conditions encompassing the entire interchange area and the presence of organic and clayey soils under the embankment alignment. Sub-excavation of the peat deposit will be required at this site, and embankment stability and settlement mitigation measures will be required due to the presence of clayey foundations soils and given the height of the proposed embankments (about up to 9 m high). Based on preliminary stability analysis, a toe berm likely not less than 5 m wide will be required for the 9 m high embankment/grade raise, which will need to be confirmed during detail



design. In addition, preloading of the embankments to mitigate settlement will also likely be required, which should also be addressed during detail design.

However, due to property constraints in the area of the Highway 11/17 North to Highway 61 South ramp, we understand that toe berms cannot be accommodated in this area. Alternative mitigation measures, such as full sub-excavation of the clay foundation soils, incorporation of lightweight fills into the ramps embankment mass and/or application of ground improvement in the form of soil mixing of the soft compressible foundation may be required to eliminate the need for toe berms which should be addressed during detail design.

5.4 Oliver Road Interchange

The preliminary GA indicates that a grade raise up to about 2 m is being proposed for the two span Oliver Road underpass structure crossing the TBE NBL and SBL (refer to Figure 006), which are to be constructed within an approximately 4 m deep cut. RSS walls are proposed for the structure wing walls. Shallow foundations for the structure could be founded on the bedrock based on the subsurface conditions identified in Section 4.4, or perched within the approach embankments provided all unsuitable soil (organic and fill materials and firm cohesive soils) are removed prior to embankment construction. During detail design, the shallow depth to the groundwater level, the depth of sub-excavation of the fill material and the depth to the surface of the bedrock, and hence depth of bedrock excavation to accommodate the cut, will need to be considered.

Provided unsuitable soil is sub-excavated as discussed above, stability and settlement mitigation measures are not anticipated to be required at this site.

5.5 Northwest Arterial (Future) Interchange

The preliminary GA indicates that a grade raise up to about 2 m is being proposed for the TBE NBL and SBL structures crossing over the Northwest Arterial (Future) (refer to Figure 007), which will be constructed within an approximately 5 m deep cut. RSS walls are proposed for the structures wing walls. Limited subsurface information is available at this site, as identified in Section 4.5, hence it is unknown at this time if shallow or deep foundations will be required to support the structure; however, shallow foundations are likely suitable at this site, similar to those anticipated for Oliver Road to the south and the McIntyre River crossing to the north. During detail design, the shallow depth to the groundwater level, the depth of sub-excavation of the organic material and the possible need to excavate bedrock (to accommodate the cut) will have to be considered.

Due to the limited subsurface information at this site, it is unknown if embankment stability and settlement will be a concern. However, detail design will need to consider the low lying swampy conditions at the site and the presence of a creek at the south end of the site.

Additionally, we understand that a retaining wall is being proposed at the following Northwest Arterial (Future) Interchange ramp:

- Between TBE and N-E/W Ramp for 100 m with maximum height of 4.3 m.



5.6 McIntyre River

The preliminary GA indicates that the grade of the proposed TBE NBL and SBL structures crossing McIntyre River (refer to Figure 008) will be consistent with the existing structure. Based on the presence of bedrock at shallow depth below ground surface at this site as identified in Section 4.6, shallow foundations founded on bedrock are feasible at this site.

Provided unsuitable soil is sub-excavated, stability and settlement mitigation measures are not anticipated to be required at this site.

5.7 John Street

The preliminary GA indicates that a grade raise of up to about 4 m is being proposed for the John Street structure crossing over the NBL and SBL of the TBE (refer to Figure 009), which is within an approximately 4 m deep cut. Based on the subsurface conditions outlined in Section 4.7, which indicate non-cohesive soil deposits over bedrock at depths between about 5.0 m and 6.7 m below ground surface, it is considered that shallow foundations perched within the approach embankments are appropriate for support of the structure, provided all unsuitable soil (organic and fill materials) are removed prior to embankment construction. The shallow depth groundwater level, the depth of sub-excavation of the fill material and the possible excavation of bedrock (to accommodate the cut) will need to be considered at the detail design stage, including assessing whether deep foundations would be more suitable for support of the structure (i.e., for integral abutment design).

Provided unsuitable soil is sub-excavated, stability and settlement mitigation measures are not anticipated at this site.

5.8 Highway 102/Red River Road Interchange

The preliminary GA indicates that a grade raise of up to about 3 m is being proposed for the Highway 102/Red River Road structure crossing over the TBE NBL and SBL (refer to Figure 010), which will be constructed within an approximately 4 m cut. RSS walls are proposed for the structure wing walls. Given the presence of a compact to dense fill deposit underlain by bedrock at shallow depth (at about 2.9 m and 4.7 m) below ground surface, shallow foundations founded on bedrock, or alternatively perched within the approach embankments, would be suitable for support of the overpass Structure. Based on the subsurface conditions identified in Section 4.8, all unsuitable soil (organic and fill materials) should be removed from the foundations and approach embankments footprints prior to footing/embankment construction. The depth to the groundwater level, the depth of sub-excavation of the fill material required and the depth to bedrock, including the thickness of bedrock excavation required to accommodate the cut will need to be considered at detail design.

Provided unsuitable soil is sub-excavated as discussed above, stability and settlement mitigation measures are not anticipated at this site.

Additionally, we understand that a retaining wall is being proposed at the following Highway 102/Red River Road Interchange ramp:

- West side of N-E/W Ramp for 90 m with maximum height of 2.9 m.



5.9 McVicar Creek

The preliminary GA indicates that the grade of the proposed TBE NBL and SBL structures crossing McVicar Creek (refer to Figure 011) will be consistent with the existing embankment grade and the new structures will replace the existing 5.5 m wide and 2.3 m high box culvert carrying the creek flow and the adjacent 4.3 m diameter corrugated steel pipe, used for pedestrian traffic. Based on the subsurface information identified in Section 4.9, shallow foundations founded on the silty sand and gravel till deposit, or on bedrock at shallow depth below founding elevation, are considered feasible at this site.

Provided unsuitable soil is sub-excavated, stability and settlement mitigation measures are not anticipated at this site.

5.10 Balsam Street Interchange

The preliminary GA indicates that a grade raise of up to about 7 m is being proposed for the TBE NBL and SBL structures crossing over Balsam Street (refer to Figure 012), which is located within an approximately 1 m deep cut. RSS walls are proposed for the structures wing walls. Based on the subsurface conditions identified in Section 4.10, shallow foundations founded on the bedrock would be appropriate for the support of the structures. Alternatively, the footings could be perched within the approach embankments. All unsuitable soil (organic and fill materials) should be removed from the foundations and approach embankments footprints prior to footing/embankment construction. The depth of sub-excavation of the fill material and the depth to bedrock and depth of bedrock excavation required to accommodate the cut will need to be considered at the detail design stage.

Provided unsuitable soil is sub-excavated, stability and settlement mitigation measures are not anticipated at this site.

Additionally, we understand that retaining walls are being proposed at the following locations of the Balsam Street Interchange ramps:

- Between S-E/W and W-N Ramps for 65 m with a maximum height of 2.5 m.
- Between TBE and W-S Ramp for 200 m with a maximum height of 3.5 m.
- Between TBE and E-N Ramp for 310 m with a maximum height of 2.7 m.
- East side of E-N Ramp for 200 m with a maximum height of 3.7 m.

5.11 Foundation Summary of Types and Stability/Settlement Issues/Mitigation

The following summary provides an overview of each site with regards to the anticipated foundation type most suitable for support of the structures at the site(s). The summary also provides an overview of the potential for stability and/or settlement concerns and the anticipated requirement for mitigation measures.



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Above Foundation Report Section / Site	Anticipated Foundation Type (Shallow/Deep)	Potential Stability Concerns, Mitigation Possibly Required (Yes/No)	Potential Settlement Concerns, Mitigation Possibly Required (Yes/No)
5.1 / Arthur Street Interchange	Deep	Yes	Yes (Staged Construction)
5.2 / Neebing River	Deep	Yes	Yes
5.3 / Harbour Expressway Interchange	Deep	Yes	Yes
5.4 / Oliver Road Interchange	Shallow	No	No
5.5 / Northwest Arterial (Future) Interchange	Shallow (To be confirmed during detail design)	To be confirmed during detail design – very limited subsurface information available at this site	
5.6 / McIntyre River	Shallow	No	No
5.7 / John Street	Shallow	No	No
5.8 / Highway 102/Red River Road Interchange	Shallow	No	No
5.9 / McVicar Creek	Shallow	No	No
5.10 / Balsam Street Interchange	Shallow	No	No

6.0 RECOMMENDED FOUNDATION INVESTIGATION FOR DETAIL DESIGN

Detail foundation investigations will be required at all swamp crossings, high fill embankment areas, retaining wall locations and bridge/culvert structure foundation sites to obtain information on subsurface conditions and for the assessment of foundation conditions to provide recommendations for foundation design. The following sections present the recommended drilling programs for these areas.

Table 7 following the text of this report summarizes the locations of structures and retaining walls at which a foundation investigation should be carried out at the detail design stage. For high fill embankments and the areas of low lying ground/swamps, we recommend that a staged investigation approach be utilised in which the geotechnical investigation for pavements is carried out initially, followed by a foundations investigation if deep deposits of organic soils or soft/firm cohesive deposits are encountered. In any case, a foundation investigation program should be developed and implemented for areas of embankments greater than 4.5 m high, suitable for the assessment of stability/settlement of the embankments and to allow for the development of foundations mitigation measures as may be required.

6.1 Structures

At bridge structure locations, one borehole should be advanced to investigate the subsurface conditions at each of the approach embankments. At the foundation elements for the bridge structures:



- Deep foundation elements: a minimum of two boreholes should be advanced with one borehole advanced to refusal conditions and one borehole advanced to 3 m into the refusal stratum.
- Shallow foundation elements: a minimum of two boreholes should be advanced to 3 m into refusal stratum. If bedrock is encountered within the shallow foundation zone a minimum of five boreholes should be advanced within the foundation footprint including bedrock coring in at least three of the boreholes.

At structural culvert sites, four boreholes should be advanced, one borehole at the inlet and one borehole at the outlet ends plus two boreholes along the proposed culvert alignment, one of the boreholes which should be advanced through the existing roadway embankment constituting the future NBL. At structural culvert extensions one borehole should be advanced at the embankment crest location and one borehole should be advanced at the proposed culvert outlet.

6.2 Retaining Walls

At the proposed retaining wall locations, one borehole should be advanced at each end of the proposed wall and along the wall footprint with a maximum spacing of 50 m between boreholes. The boreholes should be advanced to depths of 3 m into a competent stratum to resist settlement/instability issues or 10 m below the base of the wall, whichever is less.

6.3 Swamp Crossings/High Fill Areas

In areas of high fill embankments and low lying ground/swamp conditions where deep deposits of organic material and cohesive soil are encountered during the pavement investigation at detail design, the foundation investigation boreholes should consist of primary boreholes located along the centreline of the proposed alignment at a longitudinal spacing of 25 m to 50 m (depending on the length of the swamp/high fill crossing) and along the toes of the embankment at intermediate locations defined as the midpoint between the primary boreholes. At the intermediate locations, one borehole should be advanced at the toe of the embankment and one DCPT should be advanced at the opposite toe of the embankment at the same midpoint station in an alternating pattern along the toes. Consideration should be given to limiting the investigation areas to along the centreline of each of the NBL and SBL embankments, along the NBL embankment outside (east) toe, along the median closer to the inside (east) toe of the SBL embankment and along the SBL embankment outside (west) toe.

The borehole investigation should extend to the extreme ends of the swamp/soft ground areas in order to accurately define the limits of the swamp/soft ground along the alignment.

7.0 CLOSURE

This Foundation Design Report was prepared by Mr. Adam Core, P.Eng., and reviewed by Mr. Andre Bom, P.Eng., a senior geotechnical engineer and Associate of Golder. Mr. Jorge Costa, P.Eng., a Designated MTO Foundations Contact and Senior Consultant with Golder, conducted an independent quality control review of this report.

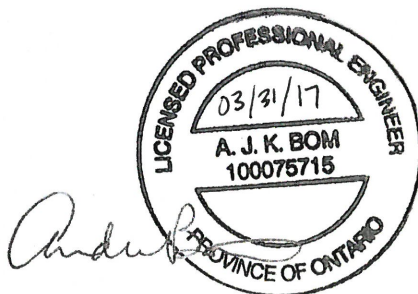


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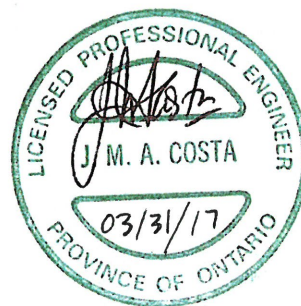
Report Signature Page

GOLDER ASSOCIATES LTD.

Adam Core, P.Eng.
Geotechnical Engineer



Andre Bom, P.Eng.
Associate/Geotechnical Engineer



Jorge M.A. Costa, P.Eng.
Designated MTO Foundation Contact, Senior Consultant

AC/AB/JMAC/kp

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Table 1 - Evaluation of Interchange Alternatives – Arthur Street

FACTOR	INDICATOR	MEASURE	ALTERNATIVE INTERCHANGE CONFIGURATIONS					
			Alternative 1 Previous PSR, Diamond	Alternative 2 Roundabout Intersection ⁴	Alternative 3 Diverging Diamond Interchange	Alternative 4 Single Point Urban Interchange	Alternative 5 Dogbone Interchange	Alternative 6 Parclo B/Diamond
Geotechnical / Foundations	A. Extent of topographic/terrain variation	(Difficult/Very Rugged, Neutral, Open) as a % of Total Length	Difficult: 12.5% Neutral: 75% Open: 12.5%	Difficult: 10% Neutral: 10% Open: 80%	Difficult: 25% Neutral: 75% Open: 0%	Difficult: 25% Neutral: 75% Open: 0%	Difficult: 25% Neutral: 75% Open: 0%	Difficult: 0% Neutral: 80% Open: 20%
			Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)
			2.00	2.70	1.75	1.75	1.75	2.20
	B. Drainage Ability / Extent of Ponded Water	(Rapid, Fair, Poor/Ponded Water Present) as a % of Total Area	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%
			Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)
			2.20	2.20	2.20	2.20	2.20	2.20
	C. Extent of swamps and soft ground	(Major Deep Swamps, Difficult Conditions, Minor and Shallow Swamps) as a % of Total Length	Major: (0%) Minor: (5%) Favourable: (95%)	Major: (0%) Minor: (5%) Favourable: (95%)	Major: (0%) Minor: (10%) Favourable: (90%)	Major: (0%) Minor: (10%) Favourable: (90%)	Major: (0%) Minor: (10%) Favourable: (90%)	Major: (0%) Minor: (5%) Favourable: (95%)
			Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)
			2.95	2.95	2.90	2.90	2.90	2.95
	D. Potential soft clay foundation, embankment stability and settlement issues	(Difficult embankment foundation conditions, favourable embankment foundation conditions) as a % of total length	Difficult: 50% Favourable: 50%	Difficult: 0% Favourable: 100%	Difficult: 50% Favourable: 50%	Difficult: 50% Favourable: 50%	Difficult: 50% Favourable: 50%	Difficult: 50% Favourable: 50%
			Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)
			1.75	2.5	1.75	1.75	1.75	1.75
	E. Anticipated depth to Bedrock (Shallow or Deep) ¹	(Exposed Bedrock/Shallow Foundations, Unknown/Possible Deep Foundations)/(Estimated number of each)	Structures 0 shallow foundation structures 2 deep foundation structures	Structures 0 shallow foundation units 0 deep foundation structures	Structures 0 shallow foundation structures 2 deep foundation structures	Structures 0 shallow foundation structures 2 deep foundation structures	Structures 0 shallow foundation structures 2 deep foundation structures	Structures 0 shallow foundation structures 2 deep foundation structures
			Weight = [(0.75 x S) + (0.25 x D)]/2	No Structures	Weight = [(0.75 x S) + (0.25 x D)]/2	Weight = [(0.75 x S) + (0.25 x D)]/2	Weight = [(0.75 x S) + (0.25 x D)]/2	Weight = [(0.75 x S) + (0.25 x D)]/2
			0.25	1	0.25	0.25	0.25	0.25
	F Potential frost problems	(Cut/Fill material) (presence of silt)	Neutral: 80% Favourable: 20%	Neutral: 10% Favourable: 90%	Neutral: 80% Favourable: 20%	Neutral: 80% Favourable: 20%	Neutral: 80% Favourable: 20%	Neutral: 75% Favourable: 25%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.20	2.90	2.20	2.20	2.20	2.25
	G. Suitability of excavated material for use as fill	(Difficult, Neutral, Favorable) as a % of Total Area	Neutral: 90% Favourable: 10%	Neutral: 70% Favourable: 30%	Neutral: 90% Favourable: 10%	Neutral: 90% Favourable: 10%	Neutral: 90% Favourable: 10%	Neutral: 90% Favourable: 10%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.10	2.30	2.10	2.10	2.10	2.10
	H. Potential erosion control issues	(Difficult, Neutral, Favorable) as a % of Total Area	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.80	2.80	2.80	2.80	2.80	2.80
	I. Drill rig and construction accessibility	(Difficult, Neutral, Favorable) as a % of Total Area	Difficult: 10% Favourable: 90%	Difficult: 0% Favourable: 100%	Difficult: 5% Favourable: 95%	Difficult: 5% Favourable: 95%	Difficult: 5% Favourable: 95%	Difficult: 5% Favourable: 95%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.80	2.90	2.90	2.90	2.90	2.90
	J. Construction feasibility	(Difficult, Neutral, Favorable) as a % of Total Area	Difficult: 50% Favourable: 50%	Difficult: 25% Favourable: 75%	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%	Difficult: 40% Favourable: 60%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.00	2.50	1.20	1.20	1.20	1.20
Foundations Summary ^{2,3}			9.15	11.35 ⁴	8.85	8.85	8.85	9.35
Pavements Summary ^{2,3}			19.05	21.25 ⁴	18.05	18.05	18.05	18.60

*Notes:
1. Excludes retaining wall foundation elements.
2. Foundations summary includes Indicators “A” to “E”. Pavements summary includes Indicators “A” to “C” and “F” to “J”.
3. Higher evaluation value indicates preferred alternative.
4. We understand that Alternative 2 is no longer being considered as an option based on the traffic assessment.

Prepared by: AC
Checked by: JBH/AB
Approved by: JMAC



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Table 2 - Evaluation of Interchange Alternatives – Harbour Expressway (Partial Freeway to Freeway)

FACTOR	INDICATOR	MEASURE	ALTERNATIVE INTERCHANGE CONFIGURATIONS		
			Alternative P1 Previous PSR, Diamond	Alternative P2 Previous PSR, With Diamond and Roundabout	Alternative P3 Modified Parclo With Grade Seperated W-N Ramp
Geotechnical / Foundations	A. Extent of topographic/terrain variation	(Difficult/Very Rugged, Neutral, Open) as a % of Total Length	Difficult: 60% Neutral: 15% Open: 25%	Difficult: 55% Neutral: 20% Open: 25%	Difficult: 25% Neutral: 25% Open: 50%
			Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)
			1.65	1.70	2.25
	B. Drainage Ability / Extent of Ponded Water	(Rapid, Fair, Poor/Ponded Water Present) as a % of Total Area	Poor: 80% Rapid-Fair: 20%	Poor: 80% Rapid-Fair: 20%	Poor: 50% Rapid-Fair: 50%
			Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)
			1.30	1.30	1.75
	C. Extent of swamps and soft ground	(Major Deep Swamps, Difficult Conditions, Minor and Shallow Swamps) as a % of Total Length	Major: (80%) Minor: (20%) Favourable: (0%)	Major: (80%) Minor: (20%) Favourable: (0%)	Major: (50%) Minor: (50%) Favourable: (0%)
			Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)
			1.20	1.20	1.50
	D. Potential soft clay foundation, embankment stability and settlement issues	(Difficult embankment foundation conditions, favourable embankment foundation conditions) as a % of total length	Difficult: 100% Favourable: 0%	Difficult: 100% Favourable: 0%	Difficult: 75% Favourable: 25%
			Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)
			1.0	1.0	1.38
	E. Anticipated depth to Bedrock (Shallow or Deep) ¹	(Exposed Bedrock/Shallow Foundations, Unknown/Possible Deep Foundations)/ (Estimated number of each)	Structures 0 shallow foundation structures 3 deep foundation structures	Structures 0 shallow foundation structures 3 deep foundation structures	Structures 0 shallow foundation structures 3 deep foundation structures
			Weight = (0.75 x S) + (0.25 x D)] / 3	Weight = (0.75 x S) + (0.25 x D)] / 3	Weight = (0.75 x S) + (0.25 x D)] / 3
			0.25	0.25	0.25
	F Potential frost problems	(Cut/Fill material) (presence of silt)	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%	Neutral: 25% Favourable: 75%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.50	2.50	2.75
	G. Suitability of excavated material for use as fill	(Dfficult, Neutral, Favorable) as a % of Total Area	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.5	2.5	2.5
	H. Potential erosion control issues	(Dfficult, Neutral, Favorable) as a % of Total Area	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.80	2.80	2.80
	I. Drill rig and construction accessibility	(Dfficult, Neutral, Favorable) as a % of Total Area	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%	Difficult: 70% Favourable: 30%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			1.20	1.20	1.60
	J. Construction feasibility	(Dfficult, Neutral, Favorable) as a % of Total Area	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%	Difficult: 70% Favourable: 30%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			1.20	1.20	1.60
Foundations Summary ^{2,3}			5.40	5.45	7.13
Pavements Summary ^{2,3}			14.35	14.40	16.75

*Notes:

1. Excludes retaining wall foundation elements.
2. Foundations summary includes Indicators “A” to “E”. Pavements summary includes Indicators “A” to “C” and “F” to “J”.
3. Higher evaluation value indicates preferred alternative.

Prepared by: AC
Checked by: JBH/AB
Approved by: JMAC



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Table 3 - Evaluation of Interchange Alternatives – Harbour Expressway (Full Freeway to Freeway as an alternative to Partial Freeway)

FACTOR	INDICATOR	MEASURE	ALTERNATIVE INTERCHANGE CONFIGURATIONS			
			Alternative F1	Alternative F2	Alternative F3	Alternative F4
Geotechnical / Foundations	A. Extent of topographic/terrain variation	(Difficult/Very Rugged, Neutral, Open) as a % of Total Length	Difficult: 80% Neutral: 10% Open: 10%	Difficult: 90% Neutral: 5% Open: 5%	Difficult: 90% Neutral: 5% Open: 5%	Difficult: 70% Neutral: 20% Open: 10%
			Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)
			1.30	1.15	1.15	1.40
	B. Drainage Ability / Extent of Poned Water	(Rapid, Fair, Poor/Ponded Water Present) as a % of Total Area	Poor: 75% Rapid-Fair: 25%	Poor: 75% Rapid-Fair: 25%	Poor: 75% Rapid-Fair: 25%	Poor: 75% Rapid-Fair: 25%
			Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)
			1.38	1.38	1.38	1.38
	C. Extent of swamps and soft ground	(Major Deep Swamps, Difficult Conditions, Minor and Shallow Swamps) as a % of Total Length	Major: (90%) Minor: (10%) Favourable: (0%)	Major: (90%) Minor: (10%) Favourable: (0%)	Major: (90%) Minor: (10%) Favourable: (0%)	Major: (90%) Minor: (10%) Favourable: (0%)
			Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)
			1.10	1.10	1.10	1.10
	D. Potential soft clay foundation, embankment stability and settlement issues	(Difficult embankment foundation conditions, favourable embankment foundation conditions) as a % of total length	Difficult: 100% Favourable: 0%	Difficult: 100% Favourable: 0%	Difficult: 100% Favourable: 0%	Difficult: 100% Favourable: 0%
			Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)
			1.00	1.00	1.00	1.00
	E. Anticipated depth to Bedrock (Shallow or Deep) ¹	(Exposed Bedrock/Shallow Foundations, Unknown/Possible Deep Foundations)/ (Estimated number of each)	Structures 0 shallow foundation structures 3 deep foundation structures	Structures 0 shallow foundation structures 8 deep foundation structures	Structures 0 shallow foundation structures 6 deep foundation structures	Structures 0 shallow foundation structures 6 deep foundation structures
			Weight = (0.75 x S) + (0.25 x D) / 3	Weight = (0.75 x S) + (0.25 x D) / 8	Weight = (0.75 x S) + (0.25 x D) / 8	Weight = (0.75 x S) + (0.25 x D) / 6
			0.25	0.25	0.25	0.25
	F Potential frost problems	(Cut/Fill material) (presence of silt)	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.50	2.50	2.50	2.50
	G. Suitability of excavated material for use as fill	(Difficult, Neutral, Favorable) as a % of Total Area	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.50	2.50	2.50	2.50
	H. Potential erosion control issues	(Difficult, Neutral, Favorable) as a % of Total Area	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%	Neutral: 20% Favourable: 80%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.80	2.80	2.80	2.80
	I. Drill rig and construction accessibility	(Difficult, Neutral, Favorable) as a % of Total Area	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			1.20	1.20	1.20	1.20
	J. Construction feasibility	(Difficult, Neutral, Favorable) as a % of Total Area	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			1.20	1.20	1.20	1.20
Foundations Summary ^{2,3}			5.03	4.88	4.88	5.13
Pavements Summary ^{2,3}			13.98	13.83	13.83	14.08

*Notes:
1. Excludes retaining wall foundation elements.
2. Foundations summary includes Indicators “A” to “E”. Pavements summary includes Indicators “A” to “C” and “F” to “J”.
3. Higher evaluation value indicates preferred alternative

Prepared by: AC
Checked by: JBH/AB
Approved by: JMAC



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Table 4 - Evaluation of Interchange Alternatives – Northwest Arterial (Future)

FACTOR	INDICATOR	MEASURE	ALTERNATIVE INTERCHANGE CONFIGURATIONS		
			Alternative 1 Previous Study Parclo/Diamond	Alternative 2 Previous Study Alternative Modified Roundabouts	Alternative 3 Parclo A4
Geotechnical / Foundations	A. Extent of topographic/terrain variation	(Difficult/Very Rugged, Neutral, Open) as a % of Total Length	Difficult: 80% Neutral: 10% Open: 10%	Difficult: 80% Neutral: 10% Open: 10%	Difficult: 80% Neutral: 10% Open: 10%
			Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)
			1.30	1.30	1.30
	B. Drainage Ability / Extent of Ponded Water	(Rapid, Fair, Poor/Ponded Water Present) as a % of Total Area	Poor: 30% Rapid-Fair: 70%	Poor: 30% Rapid-Fair: 70%	Poor: 30% Rapid-Fair: 70%
			Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)
			2.05	2.05	2.05
	C. Extent of swamps and soft ground	(Major Deep Swamps, Difficult Conditions, Minor and Shallow Swamps) as a % of Total Length	Major: (0%) Minor: (10%) Favourable: (90%)	Major: (0%) Minor: (10%) Favourable: (90%)	Major: (0%) Minor: (10%) Favourable: (90%)
			Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)
			1.90	1.90	1.90
	D. Potential soft clay foundation, embankment stability and settlement issues	(Difficult embankment foundation conditions, favourable embankment foundation conditions) as a % of total length	Difficult: 50% Favourable: 50%	Difficult: 50% Favourable: 50%	Difficult: 50% Favourable: 50%
			Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)
			1.75	1.75	1.75
	E. Anticipated depth to Bedrock (Shallow or Deep) ¹	(Exposed Bedrock/Shallow Foundations, Unknown/Possible Deep Foundations)/ (Estimated number of each)	Structures 0 shallow foundation structures 2 deep foundation structures	Structures 0 shallow foundation structures 2 deep foundation structures	Structures 0 shallow foundation structures 2 deep foundation structures
			Weight = (0.75 x S) + (0.25 x D) / 2	Weight = (0.75 x S) + (0.25 x D) / 2	Weight = (0.75 x S) + (0.25 x D) / 2
			0.25	0.25	0.25
	F Potential frost problems	(Cut/Fill material) (presence of silt)	Neutral: 70% Favourable: 30%	Neutral: 70% Favourable: 30%	Neutral: 70% Favourable: 30%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.30	2.30	2.30
	G. Suitability of excavated material for use as fill	(Dfficult, Neutral, Favorable) as a % of Total Area	Neutral: 80% Favourable: 20%	Neutral: 80% Favourable: 20%	Neutral: 80% Favourable: 20%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.20	2.20	2.20
	H. Potential erosion control issues	(Dfficult, Neutral, Favorable) as a % of Total Area	Neutral: 90% Favourable: 10%	Neutral: 90% Favourable: 10%	Neutral: 90% Favourable: 10%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.10	2.10	2.10
	I. Drill rig and construction accessibility	(Dfficult, Neutral, Favorable) as a % of Total Area	Difficult: 75% Favourable: 25%	Difficult: 75% Favourable: 25%	Difficult: 75% Favourable: 25%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			1.50	1.50	1.50
	J. Construction feasibility	(Dfficult, Neutral, Favorable) as a % of Total Area	Difficult: 25% Favourable: 75%	Difficult: 25% Favourable: 75%	Difficult: 25% Favourable: 75%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.50	2.50	2.50
Foundations Summary ^{2,3}			7.25	7.25	7.25
Pavements Summary ^{2,3}			15.85	15.85	15.85

*Notes:
1. Excludes retaining wall foundation elements.
2. Foundations summary includes Indicators “A” to “E”. Pavements summary includes Indicators “A” to “C” and “F” to “J”.
3. Higher evaluation value indicates preferred alternative

Prepared by: AC
Checked by: JBH/AB
Approved by: JMAC



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Table 5 - Evaluation of Interchange Alternatives – Highway 102 / Red River Road

FACTOR	INDICATOR	MEASURE	ALTERNATIVE INTERCHANGE CONFIGURATIONS				
			Alternative 1 Previous Study, Parclo A4	Alternative 2 Diamond	Alternative 3 Diverging Diamond	Alternative 4 Single Point Urban Interchange	Alternative 5 Dogbone Interchange
Geotechnical / Foundations	A. Extent of topographic/terrain variation	(Difficult/Very Rugged, Neutral, Open) as a % of Total Length	Difficult: 5% Neutral: 90% Open: 5%	Difficult: 5% Neutral: 90% Open: 5%	Difficult: 5% Neutral: 90% Open: 5%	Difficult: 5% Neutral: 90% Open: 5%	Difficult: 5% Neutral: 90% Open: 5%
			Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)
			2.00	2.00	2.00	2.00	2.00
	B. Drainage Ability / Extent of Ponded Water	(Rapid, Fair, Poor/Ponded Water Present) as a % of Total Area	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%
			Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)
			2.20	2.20	2.20	2.20	2.20
	C. Extent of swamps and soft ground	(Major Deep Swamps, Difficult Conditions, Minor and Shallow Swamps) as a % of Total Length	Major: (0%) Minor: (5%) Favourable: (95%)	Major: (0%) Minor: (5%) Favourable: (95%)	Major: (0%) Minor: (10%) Favourable: (95%)	Major: (0%) Minor: (10%) Favourable: (95%)	Major: (0%) Minor: (10%) Favourable: (95%)
			Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)
			2.95	2.95	2.90	2.90	2.90
	D. Potential soft clay foundation, embankment stability and settlement issues	(Difficult embankment foundation conditions, favourable embankment foundation conditions) as a % of total length	Difficult: 0% Favourable: 100%	Difficult: 0% Favourable: 100%	Difficult: 0% Favourable: 100%	Difficult: 0% Favourable: 100%	Difficult: 0% Favourable: 100%
			Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)
			2.50	2.50	2.50	2.50	2.50
	E. Anticipated depth to Bedrock (Shallow or Deep)	(Exposed Bedrock/Shallow Foundations, Unknown/Possible Deep Foundations)/ (Estimated number of each)	Structures 2 shallow foundation structures 0 deep foundation structures	Structures 2 shallow foundation structures 0 deep foundation structures	Structures 2 shallow foundation structures 0 deep foundation structures	Structures 2 shallow foundation structures 0 deep foundation structures	Structures 2 shallow foundation structures 0 deep foundation structures
			Weight = (0.75 x S) + (0.25 x D) / 2	Weight = (0.75 x S) + (0.25 x D) / 2	Weight = (0.75 x S) + (0.25 x D) / 2	Weight = (0.75 x S) + (0.25 x D) / 2	Weight = (0.75 x S) + (0.25 x D) / 2
			0.75	0.75	0.75	0.75	0.75
	F. Potential frost problems	(Cut/Fill material) (presence of silt)	Neutral: 30% Favourable: 70%	Neutral: 30% Favourable: 70%	Neutral: 30% Favourable: 70%	Neutral: 30% Favourable: 70%	Neutral: 30% Favourable: 70%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.70	2.70	2.70	2.70	2.70
	G. Suitability of excavated material for use as fill	(Difficult, Neutral, Favorable) as a % of Total Area	Neutral: 60% Favourable: 40%	Neutral: 60% Favourable: 40%	Neutral: 60% Favourable: 40%	Neutral: 60% Favourable: 40%	Neutral: 60% Favourable: 40%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.40	2.40	2.40	2.40	2.40
	H. Potential erosion control issues	(Difficult, Neutral, Favorable) as a % of Total Area	Neutral: 40% Favourable: 60%	Neutral: 40% Favourable: 60%	Neutral: 40% Favourable: 60%	Neutral: 40% Favourable: 60%	Neutral: 40% Favourable: 60%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.60	2.60	2.60	2.60	2.60
	I. Drill rig and construction accessibility	(Difficult, Neutral, Favorable) as a % of Total Area	Difficult: 25% Favourable: 75%	Difficult: 25% Favourable: 75%	Difficult: 25% Favourable: 75%	Difficult: 25% Favourable: 75%	Difficult: 25% Favourable: 75%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.50	2.50	2.50	2.50	2.50
	J. Construction feasibility	(Difficult, Neutral, Favorable) as a % of Total Area	Difficult: 50% Favourable: 50%	Difficult: 50% Favourable: 50%	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%	Difficult: 90% Favourable: 10%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.00	2.00	1.20	1.20	1.20
Foundations Summary ^{2,3}			10.40	10.40	10.35	10.35	10.35
Pavements Summary ^{2,3}			19.35	19.35	18.50	18.50	18.50

*Notes:
1. Excludes retaining wall foundation elements.
2. Foundations summary includes Indicators “A” to “E”. Pavements summary includes Indicators “A” to “C” and “F” to “J”.
3. Higher evaluation value indicates preferred alternative.

Prepared by: AC
Checked by: JBH/AB
Approved by: JMAC





PRELIMINARY FOUNDATION REPORT
HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY
GWP 6001-13-00

Table 6 - Evaluation of Interchange Alternatives – Balsam Street

FACTOR	INDICATOR	MEASURE	ALTERNATIVE INTERCHANGE CONFIGURATIONS		
			Alternative 1 Previous Planning Study Parclo A4 with Realignment	Alternative 2 Previous Planning Study, Parclo A2/A4	Alternative 3 Parclo A2 with Roundabouts
Geotechnical / Foundations	A. Extent of topographic/terrain variation	(Difficult/Very Rugged, Neutral, Open) as a % of Total Length	Difficult: 80% Neutral: 15% Open: 5%	Difficult: 40% Neutral: 30% Open: 30%	Difficult: 50% Neutral: 30% Open: 20%
			Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)	Weight = (1 x D)+(2 x N)+(3 x O)
			1.25	1.90	1.70
	B. Drainage Ability / Extent of Ponded Water	(Rapid, Fair, Poor/Ponded Water Present) as a % of Total Area	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%	Poor: 20% Rapid-Fair: 80%
			Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)	Weight = (1 x P)+(2.5 x R-F)
			2.20	2.20	2.20
	C. Extent of swamps and soft ground	(Major Deep Swamps, Difficult Conditions, Minor and Shallow Swamps) as a % of Total Length	Major: (0%) Minor: (5%) Favourable: (95%)	Major: (0%) Minor: (5%) Favourable: (95%)	Major: (0%) Minor: (5%) Favourable: (95%)
			Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)	Weight = (1 x Mj) + (2 x Mn) + (3 x F)
			2.95	2.95	2.95
	D. Potential soft clay foundation, embankment stability and settlement issues	(Difficult embankment foundation conditions, favourable embankment foundation conditions) as a % of total length	Difficult: 0% Favourable: 100%	Difficult: 0% Favourable: 100%	Difficult: 0% Favourable: 100%
			Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)	Weight = (1 x D) + (2.5 x F)
			2.50	2.50	2.50
	E. Anticipated depth to Bedrock (Shallow or Deep) ¹	(Exposed Bedrock/Shallow Foundations, Unknown/Possible Deep Foundations)/ (Estimated number of each)	Structures 2 shallow foundation structures 0 deep foundation structures	Structures 2 shallow foundation structures 0 deep foundation structures	Structures 2 shallow foundation structures 0 deep foundation structures
			Weight = (0.75x S) + (0.25 x D) / 2	Weight = (0.75x S) + (0.25 x D) / 2	Weight = (0.75x S) + (0.25 x D) / 2
			0.50	0.50	0.50
	F Potential frost problems	(Cut/Fill material) (presence of silt)	Neutral: 70% Favourable: 30%	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.30	2.50	2.50
	G. Suitability of excavated material for use as fill	(Dfficult, Neutral, Favorable) as a % of Total Area	Neutral: 60% Favourable: 40%	Neutral: 30% Favourable: 70%	Neutral: 30% Favourable: 70%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.40	2.70	2.70
	H. Potential erosion control issues	(Dfficult, Neutral, Favorable) as a % of Total Area	Neutral: 80% Favourable: 20%	Neutral: 50% Favourable: 50%	Neutral: 50% Favourable: 50%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.20	2.50	2.50
	I. Drill rig and construction accessibility	(Dfficult, Neutral, Favorable) as a % of Total Area	Neutral: 70% Favourable: 30%	Neutral: 40% Favourable: 60%	Neutral: 40% Favourable: 60%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			2.30	2.60	2.60
	J. Construction feasibility	(Dfficult, Neutral, Favorable) as a % of Total Area	Difficult: 60% Favourable: 40%	Difficult: 50% Favourable: 50%	Difficult: 50% Favourable: 50%
			Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)	Weight = (1 x D)+(2 x N)+(3 x F)
			1.80	2.00	2.00
Foundations Summary ^{2,3}			9.65	10.30	10.10
Pavements Summary ^{2,3}			17.40	19.35	19.15

*Notes:
1. Excludes retaining wall foundation elements.
2. Foundations summary includes Indicators “A” to “E”. Pavements summary includes Indicators “A” to “C” and “F” to “J”.
3. Higher evaluation value indicates preferred alternative.

Prepared by: AC
Checked by: JBH/AB
Approved by: JMAC



PRELIMINARY FOUNDATION REPORT
HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY
GWP 6001-13-00

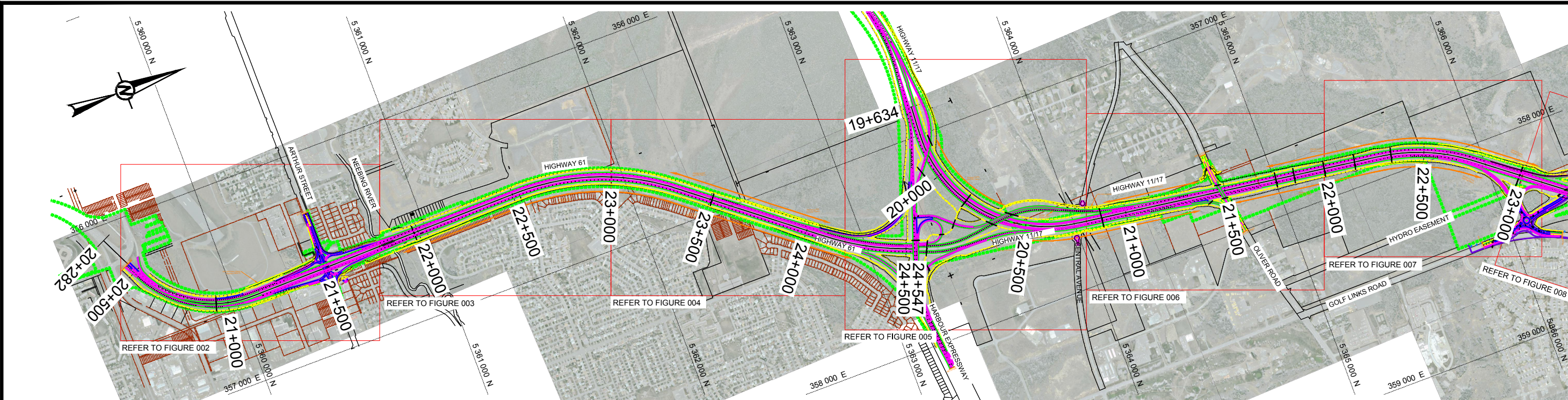
Table 7 - Recommendations for Future Foundation Investigation for Preferred Alternatives

Location ¹	Proposed Structure	Minimum Number of Boreholes per Foundation Element ²
Arthur Street Interchange	NBL Overpass	2 plus 1 at each approach
	SBL Overpass	2 plus 1 at each approach
	Retaining Wall – East Side of S-E/W Ramp (~140 m long)	1 at each end of wall and maximum spacing of 50 m along wall
	Retaining Wall – East Side of E/W-N Ramp (~100 m long)	1 at each end of wall and maximum spacing of 50 m along wall
	Retaining Wall – West Side of N-E/W Ramp (~170 m long)	1 at each end of wall and maximum spacing of 50 m along wall
Neebing River	NBL	2 plus 1 at each approach
	SBL	2 plus 1 at each approach
Harbour Expressway Interchange	NBL/SBL Underpass	2 plus 1 at each approach
	N-S Ramp	2 plus 1 at each approach for each ramp
	N-E/W Ramp	2 plus 1 at each approach for each ramp
Oliver Road Interchange	Underpass	2 plus 1 at each approach
Northwest Arterial (Future) Interchange	NBL Overpass	2 plus 1 at each approach
	SBL Overpass	2 plus 1 at each approach
	Retaining Wall – Between TBE and N-E/W Ramp (~100 m long)	1 at each end of wall and maximum spacing of 50 m along wall
McIntyre River	NBL	5 plus 1 at each approach
	SBL	5 plus 1 at each approach
John Street	Underpass	5 plus 1 at each approach
Highway 102/Red River Road Interchange	Underpass	5 plus 1 at each approach
	Retaining Wall – West Side of N-E/W Ramp (~90 m long)	1 at each end of wall and maximum spacing of 50 m along wall
McVicar Creek	NBL	5 plus 1 at each approach
	SBL	5 plus 1 at each approach
Balsam Street Interchange	NBL Overpass	5 plus 1 at each approach
	SBL Overpass	5 plus 1 at each approach
	Retaining Wall – Between S-E/W and W-N Ramp (~65 m long)	1 at each end of wall and maximum spacing of 50 m along wall
	Retaining Wall – Between TBE and W-S Ramp (~200 m long)	1 at each end of wall and maximum spacing of 50 m along wall
	Retaining Wall – Between TBE and E-N Ramp (~310 m long)	1 at each end of wall and maximum spacing of 50 m along wall
	Retaining Wall – East side of E-N Ramp (~200 m long)	1 at each end of wall and maximum spacing of 50 m along wall

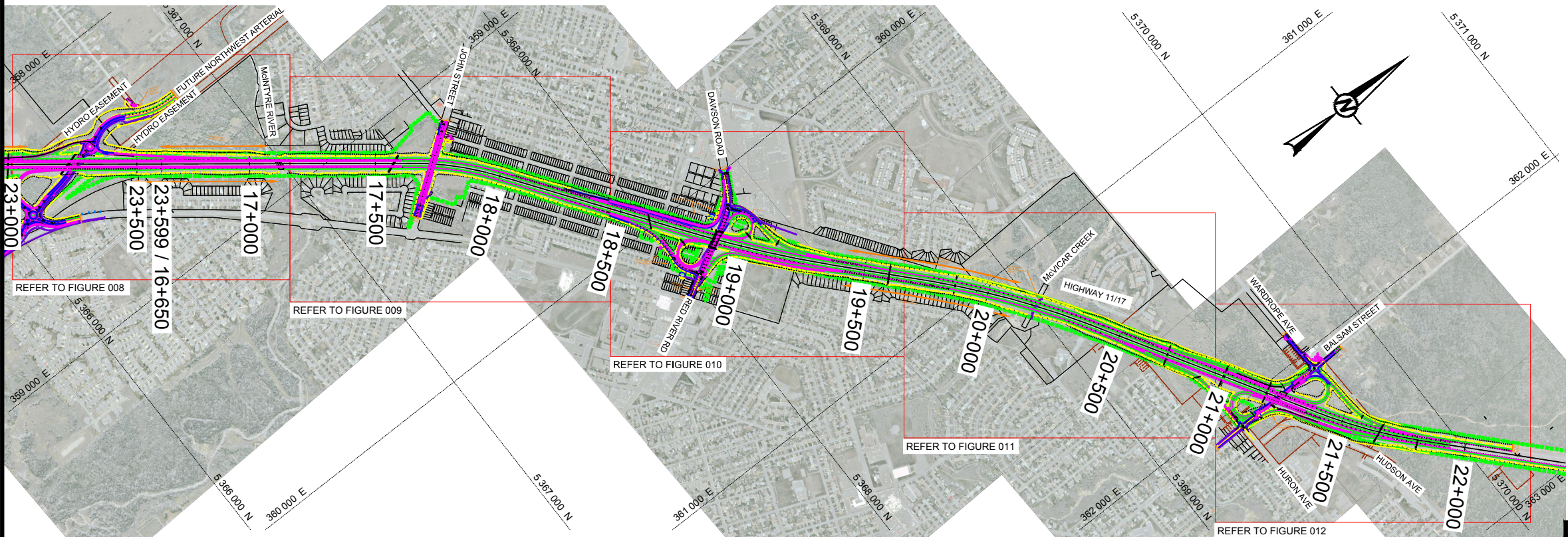
Notes:

- List of structures developed from General Arrangement Drawings provided by AECOM.
- Depth of Boreholes to be consistent with MTO Standard Terms of Reference for Structures both shallow and deep foundations, approach embankments and retaining wall heights.

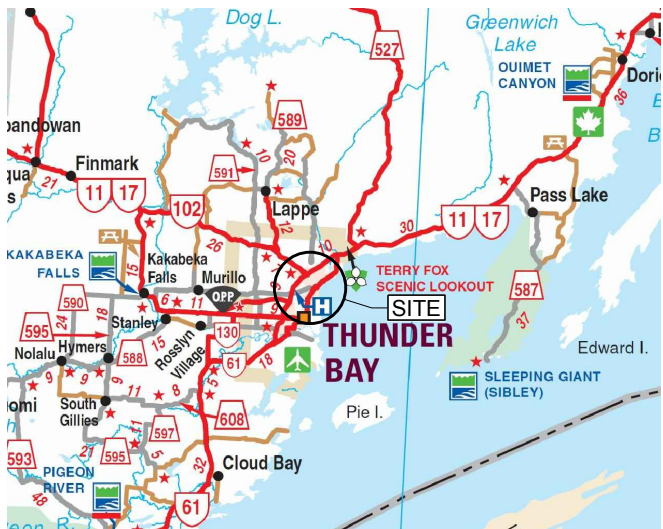
Prepared by: AC
Checked by: AB
Approved by: JMAC



PLAN VIEW



PLAN VIEW




KEY PLAN

GWP: 6001-13-00
GEOCREs No.: 52A-225

REV	DATE	REVISION DESCRIPTION	JH	GY	DES	CADD	CHK	RWW
1	2015-08-06	UPDATED WITH PROPOSED PROPERTIES	JH	GY				
2	2014-04-01	ISSUED FOR REVIEW	JH	GY				

PROJECT
HIGHWAY 11/17 AND 61
THUNDER BAY EXPRESSWAY
PRELIMINARY DESIGN

TITLE
INDEX PLAN
FROM 1 KM SOUTH OF AUTHUR STREET TO
1 KM NORTH OF BALSAM STREET

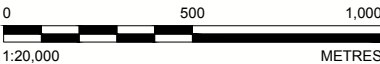
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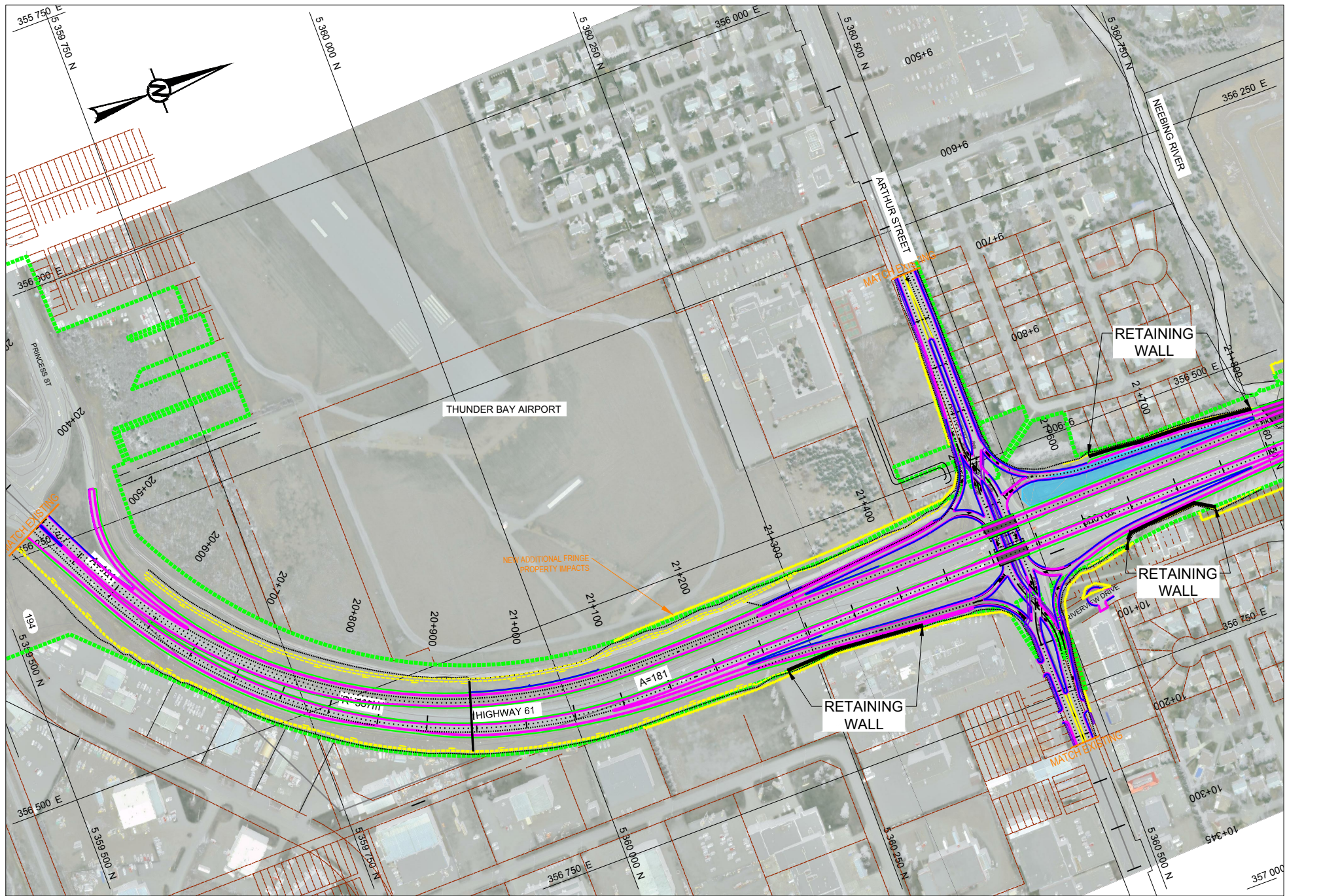
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 - PROPOSED MTO RIGHT-OF-WAY
 - EXISTING PROPERTY LOT LINES
 - RELOCATED PROPERTY LOT LINES
 - PROPOSED DESIGN
 - PROPOSED HIGHWAY 11/17/61 MAIN LANES (APPROXIMATE LIMITS)

- NOTES
- PROJECTION: UTM ZONE 16N, DATUM: NAD83
 - ALL DIMENSIONS, COORDINATES ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.

- REFERENCES / SPECIFICATIONS
- ALL BACKGROUND DRAWINGS: SURFACE, ALIGNMENT, PROPERTY AND ORTHOPHOTOS PROVIDED BY URS, MARCH 2014.
 - THE PROPOSED MTO RIGHT-OF-WAY, NEW DESIGN MAIN LANES AND CROSS SECTIONS PROVIDED BY URS, JUNE 2015.



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PLAN VIEW



LEGEND

- EXISTING MTO RIGHT-OF-WAY
- PROPOSED MTO RIGHT-OF-WAY
- EXISTING PROPERTY LOT LINES
- PROPOSED DESIGN
- PROPOSED HIGHWAY 11/17/61 MAIN LANES
- RETAINING WALL
- APPROXIMATE EXCESS MATERIAL BERM (OBSERVED ON SITE BY GOLDER SEPT/14)
- APPROXIMATE PAVEMENT DISTRESS



NOTES

- PROJECTION: UTM ZONE 16N, DATUM: NAD83
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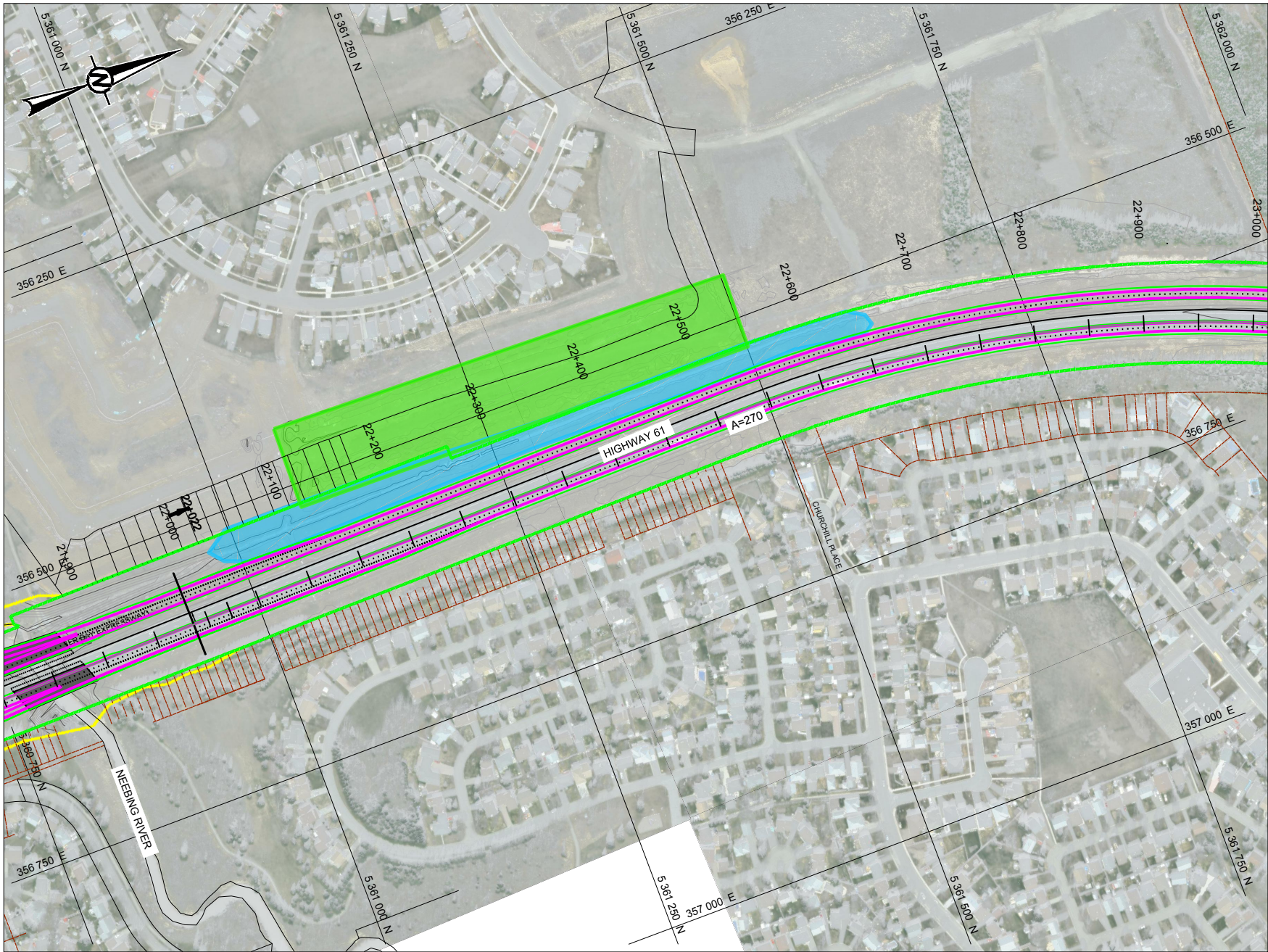
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- ALL BACKGROUND DRAWINGS: SURFACE, ALIGNMENT, PROPERTY AND ORTHOPHOTOS PROVIDED BY URS, MARCH 2014.
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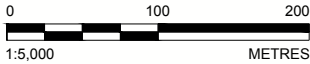
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		REVIEW	JMAC	2017-03-21					





PLAN VIEW



LEGEND

- EXISTING MTO RIGHT-OF-WAY
- PROPOSED MTO RIGHT-OF-WAY
- EXISTING PROPERTY LOT LINES
- PROPOSED DESIGN
- PROPOSED HIGHWAY 11/17/61 MAIN LANES
- APPROXIMATE EXCESS MATERIAL BERM (OBSERVED ON SITE BY GOLDER SEP/14)
- APPROXIMATE SWAMP (OBSERVED ON SITE BY GOLDER SEP/14)

NOTES

- PROJECTION: UTM ZONE 16N, DATUM: NAD83
- ALL DIMENSIONS, COORDINATES ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.

REFERENCES / SPECIFICATIONS

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- THE PROPOSED MTO RIGHT-OF-WAY, NEW DESIGN MAIN LANES AND CROSS SECTIONS PROVIDED BY URS, JUNE 2015.

GWP: 6001-13-00
GEOCRES No.: 52A-225

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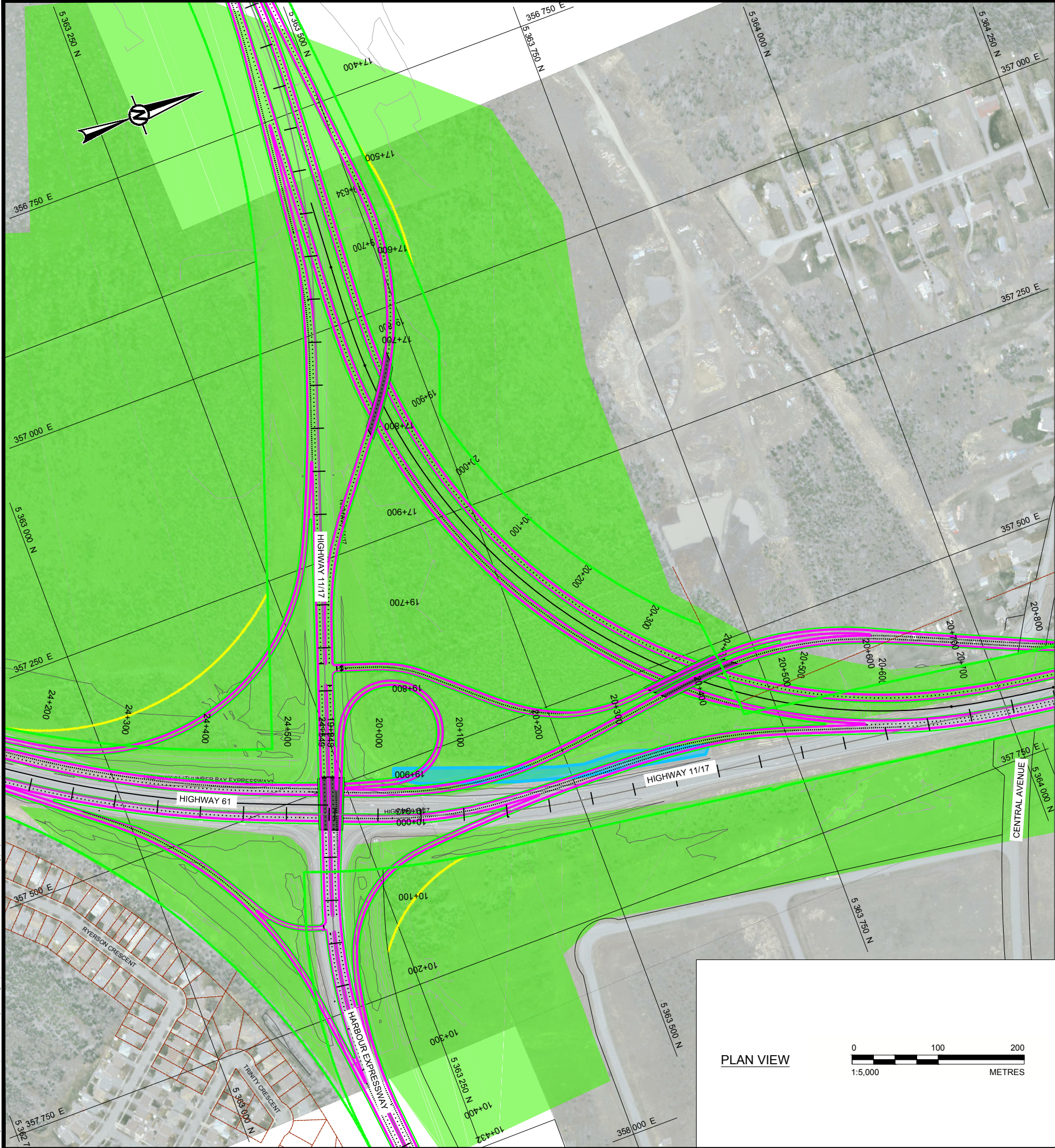
HIGHWAY 11/17 AND 61
THUNDER BAY EXPRESSWAY
PRELIMINARY DESIGN

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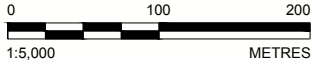
PLAN VIEW
HIGHWAY 61
STATION 21+800 TO 23+000

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CADD	GY	2016-04-18	FIGURE		
CHECK	AB	2017-03-21			
REVIEW	JMAC	2017-03-21			

003



PLAN VIEW



LEGEND

- EXISTING MTO RIGHT-OF-WAY
- PROPOSED MTO RIGHT-OF-WAY
- EXISTING PROPERTY LOT LINES
- PROPOSED DESIGN
- PROPOSED HIGHWAY 11/17/61 MAIN LANES
- APPROXIMATE EXCESS MATERIAL BERM (OBSERVED ON SITE BY GOLDER SEP/14)
- APPROXIMATE SWAMP (OBSERVED ON SITE BY GOLDER SEP/14)




NOTES

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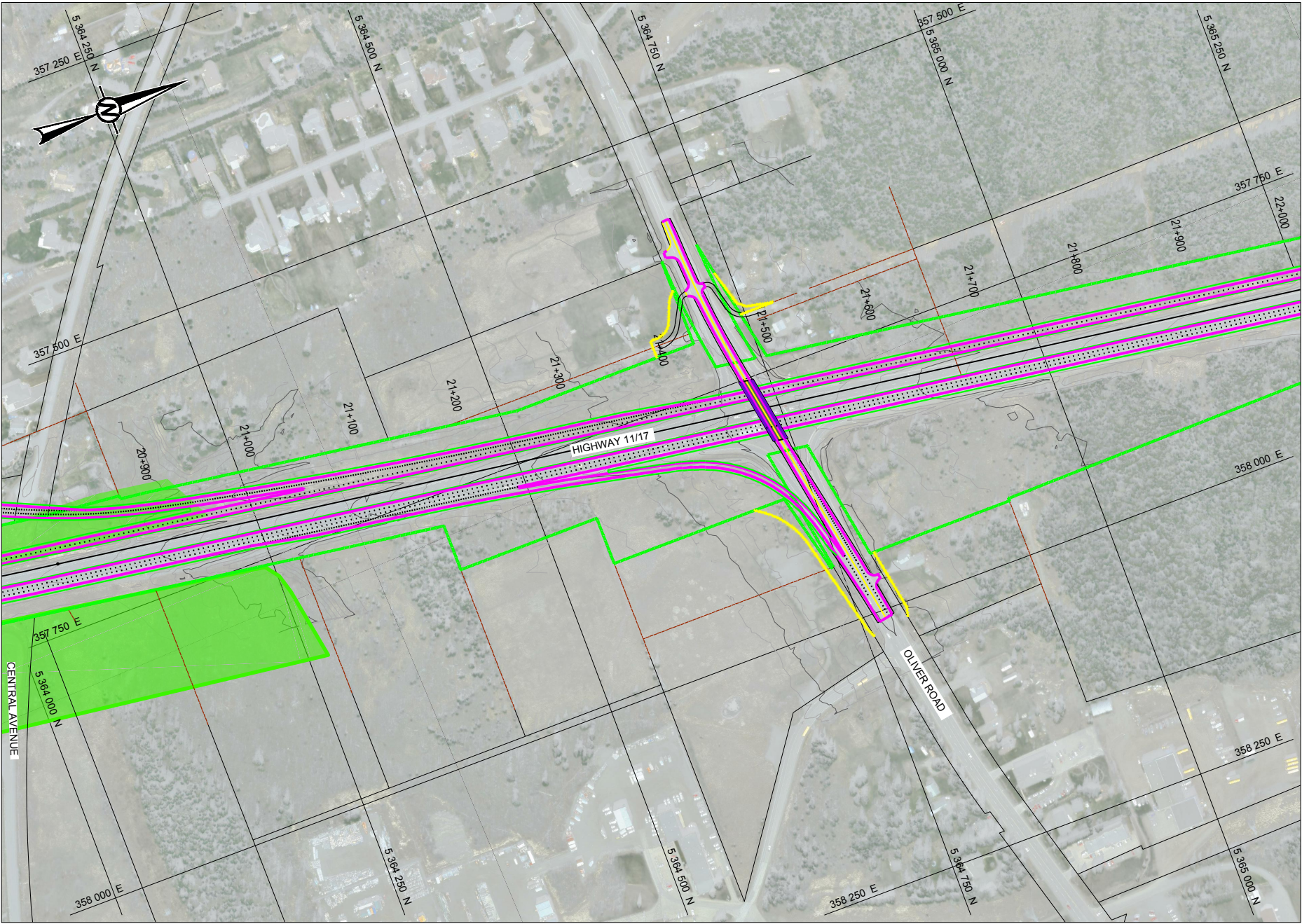
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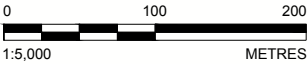
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PLAN VIEW



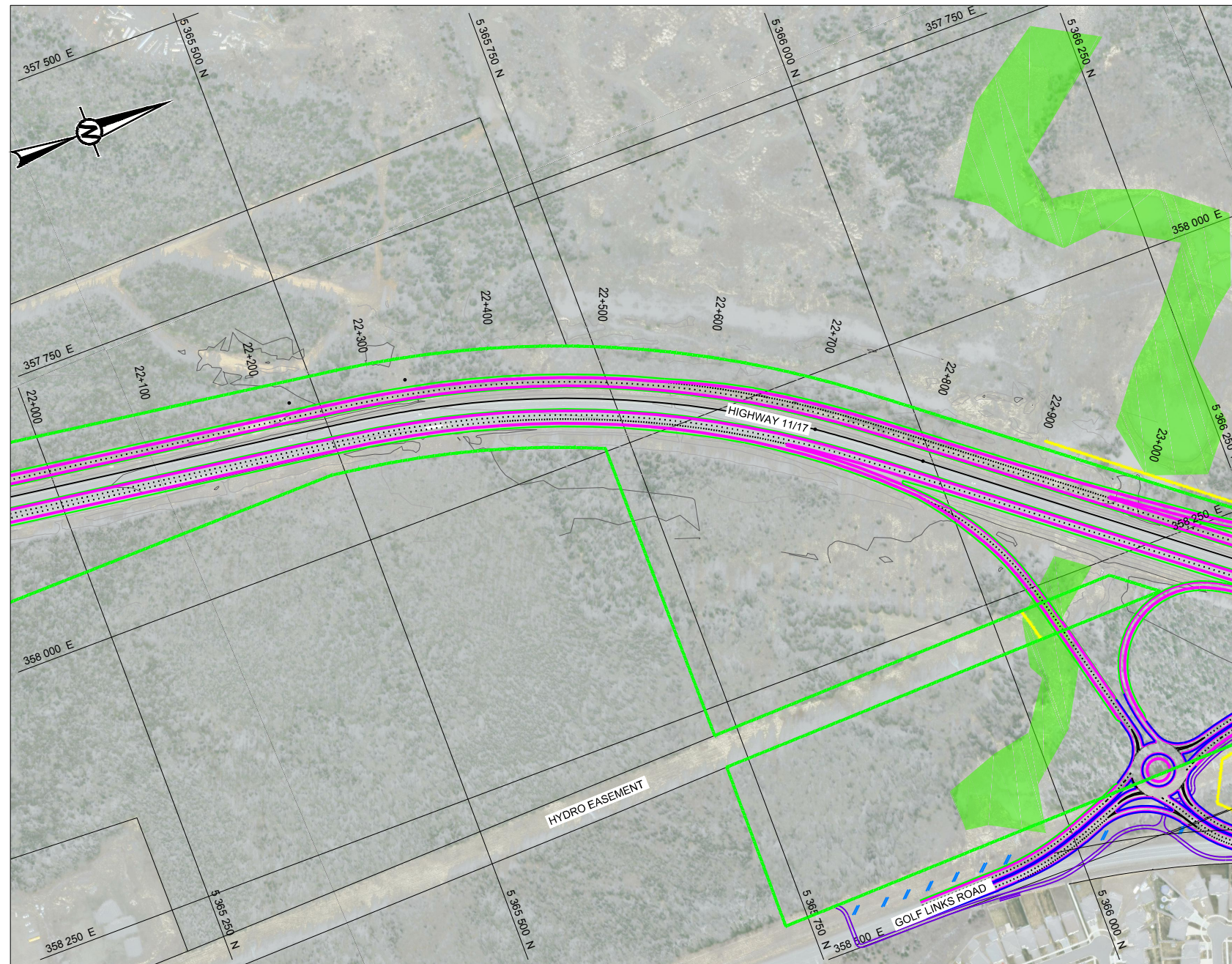
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	EXISTING PROPERTY LOT LINES
	PROPOSED DESIGN
	PROPOSED HIGHWAY 11/17/61 MAIN LANES
	APPROXIMATE SWAMP (OBSERVED ON SITE BY GOLDER SEP/14)

NOTES	
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2.	ALL DIMENSIONS, COORDINATES ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.

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1.	ALL BACKGROUND DRAWINGS: SURFACE, ALIGNMENT, PROPERTY AND ORTHOPHOTOS PROVIDED BY URS, MARCH 2014.
2.	THE PROPOSED MTO RIGHT-OF-WAY, NEW DESIGN MAIN LANES AND CROSS SECTIONS PROVIDED BY URS, JUNE 2015.

GWP: 6001-13-00
GEOCRES No.: 52A-225





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	REVIEW	JMAC	2017-03-21	



PLAN VIEW



LEGEND

- EXISTING MTO RIGHT-OF-WAY
 PROPOSED MTO RIGHT-OF-WAY
 EXISTING PROPERTY LOT LINES
 PROPOSED DESIGN
 PROPOSED HIGHWAY 11/17/61 MAIN LANES
 APPROXIMATE SWAMP (OBSERVED ON SITE BY GOLDER SEP/14)


NOTES

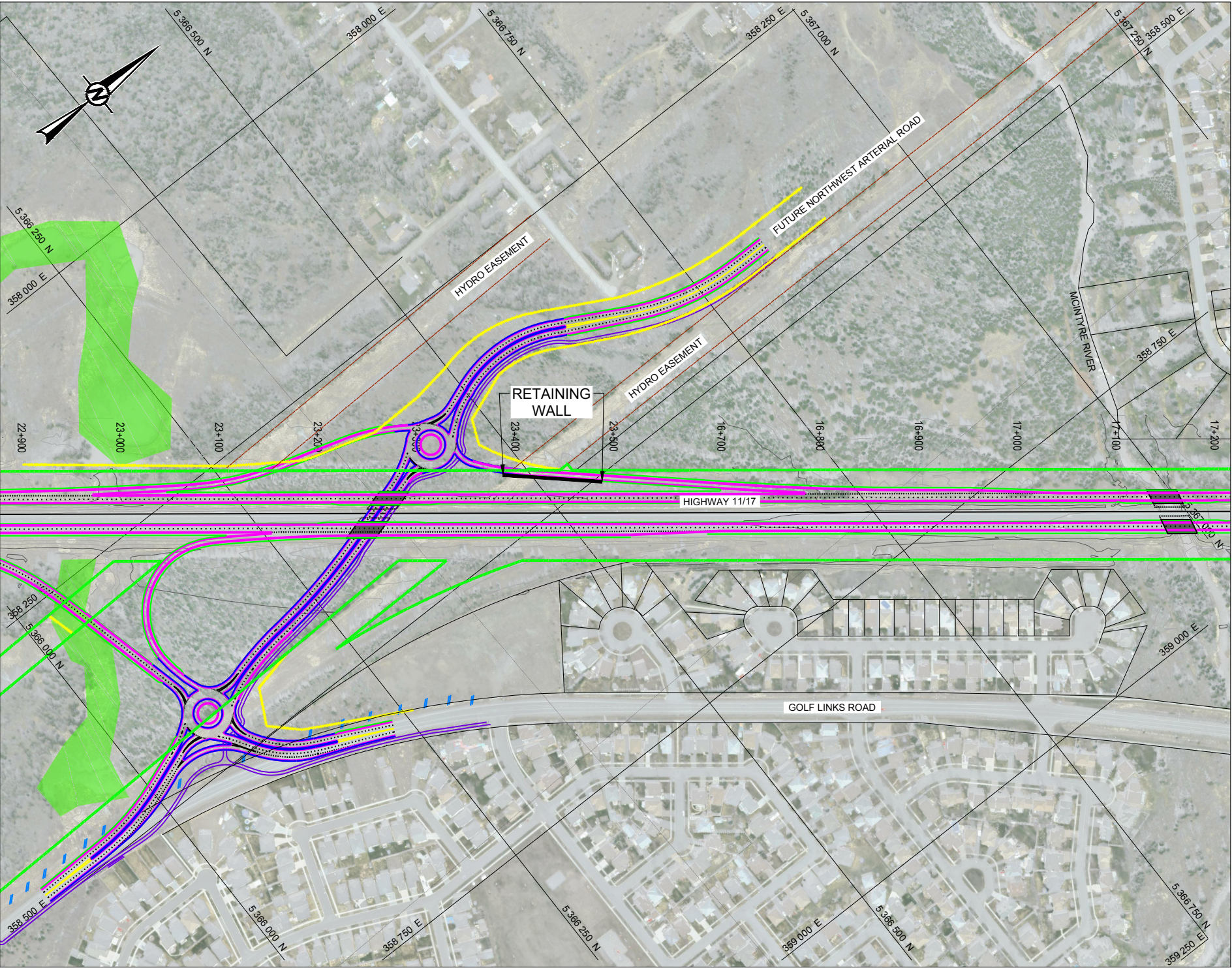
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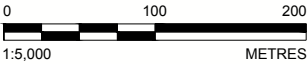
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GWP: 6001-13-00
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<p>TITLE</p> <p>PLAN VIEW HIGHWAY 11/17 STATION 22+000 TO 23+100</p>						
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	CADD	GY	2016-12-13		FIGURE	
	CHECK	AB	2017-03-21		007	
	REVIEW	JMAC	2017-03-21			



PLAN VIEW





LEGEND	
	EXISTING MTO RIGHT-OF-WAY
	PROPOSED MTO RIGHT-OF-WAY
	EXISTING PROPERTY LOT LINES
	PROPOSED DESIGN
	PROPOSED HIGHWAY 11/17/61 MAIN LANES
	RETAINING WALL
	APPROXIMATE SWAMP (OBSERVED ON SITE BY GOLDER SEP/14)

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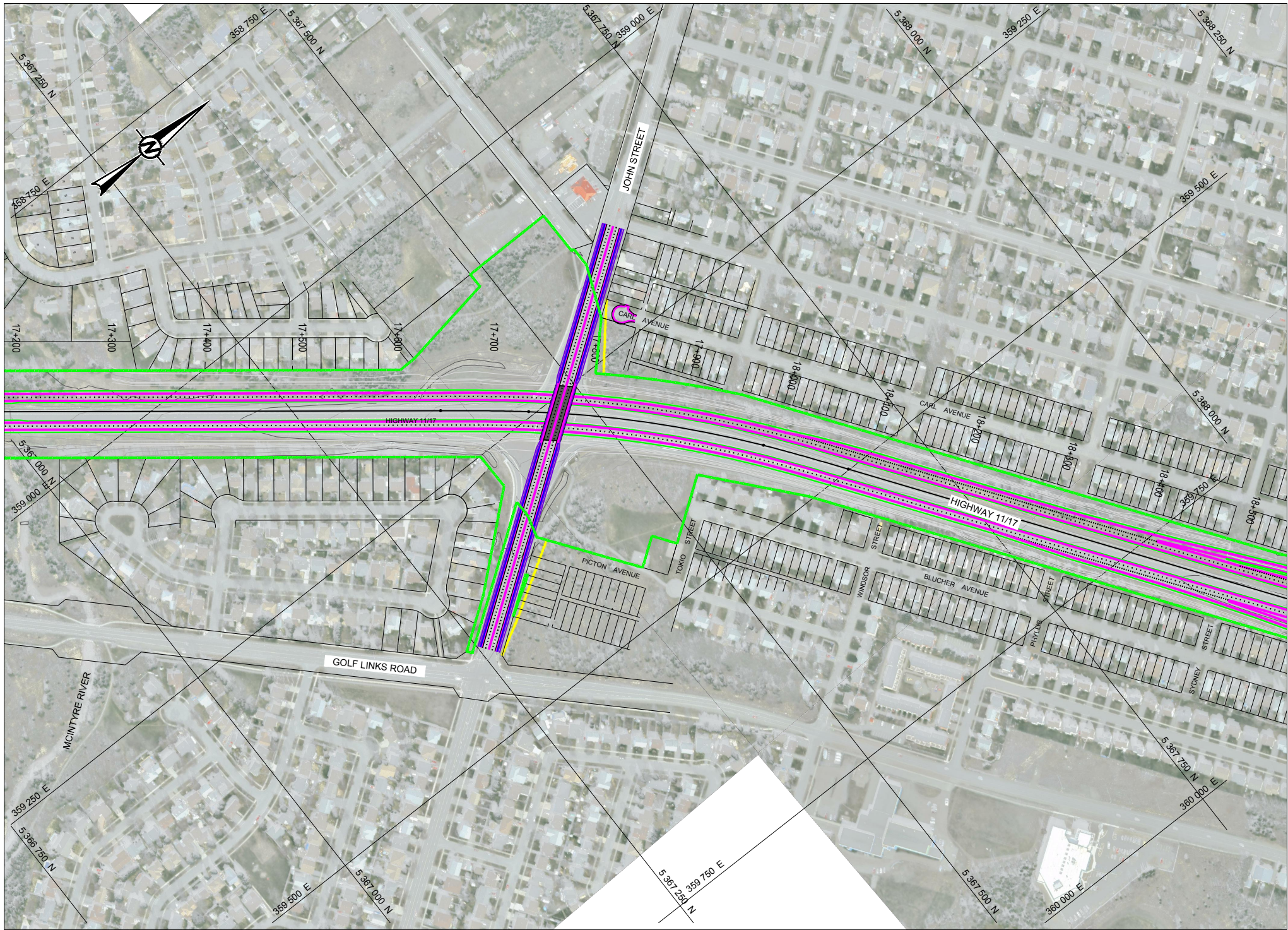
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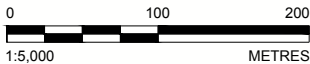
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PLAN VIEW



LEGEND

- EXISTING MTO RIGHT-OF-WAY
- PROPOSED MTO RIGHT-OF-WAY
- EXISTING PROPERTY LOT LINES
- PROPOSED DESIGN
- PROPOSED HIGHWAY 11/17/61 MAIN LANES



NOTES

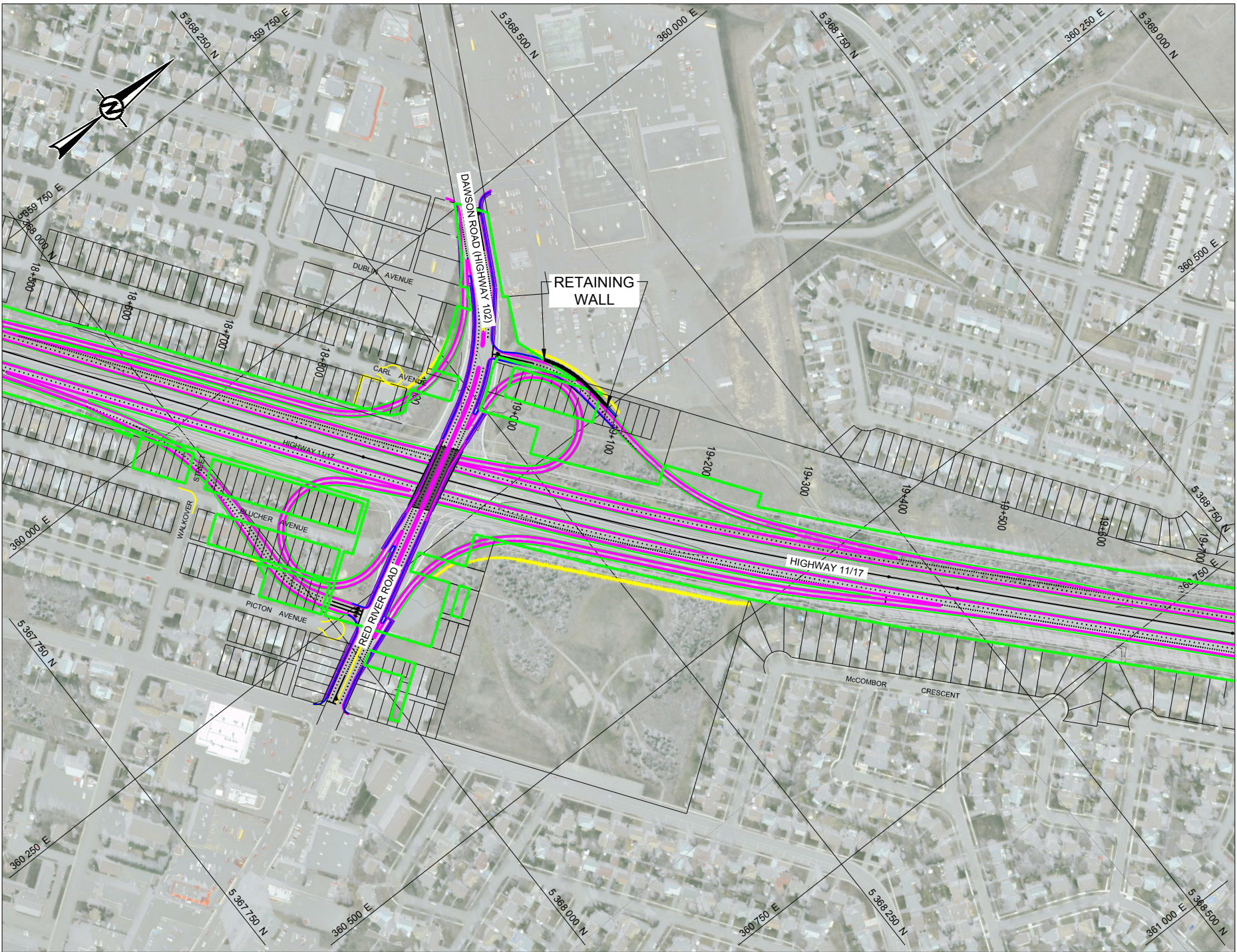
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- ALL DIMENSIONS, COORDINATES ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.

REFERENCES / SPECIFICATIONS

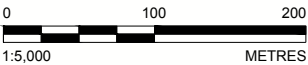
- ALL BACKGROUND DRAWINGS: SURFACE, ALIGNMENT, PROPERTY AND ORTHOPHOTOS PROVIDED BY URS, MARCH 2014.
- THE PROPOSED MTO RIGHT-OF-WAY, NEW DESIGN MAIN LANES AND CROSS SECTIONS PROVIDED BY URS, JUNE 2015.

GWP: 6001-13-00
GEOCRES No.: 52A-225

	2015-08-06	ISSUED FOR REVIEW	JH	GY				
	2014-04-01	ISSUED FOR REVIEW	JH	GY				
REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RWW		
PROJECT								
HIGHWAY 11/17 AND 61 THUNDER BAY EXPRESSWAY PRELIMINARY DESIGN								
TITLE								
PLAN VIEW HIGHWAY 11/17 STATION 17+200 TO 18+500								
		PROJECT No.		13-1184-0113		FILE No.	1311840113AB009	
		DESIGN	JH	2016-04-18		SCALE	AS SHOWN	
		CADD	GY	2016-04-18		FIGURE		
		CHECK	AB	2017-03-21		009		
		REVIEW	JMAC	2017-03-21				



PLAN VIEW



LEGEND	
	EXISTING MTO RIGHT-OF-WAY
	PROPOSED MTO RIGHT-OF-WAY
	EXISTING PROPERTY LOT LINES
	PROPOSED DESIGN
	PROPOSED HIGHWAY 11/17/61 MAIN LANES
	RETAINING WALL

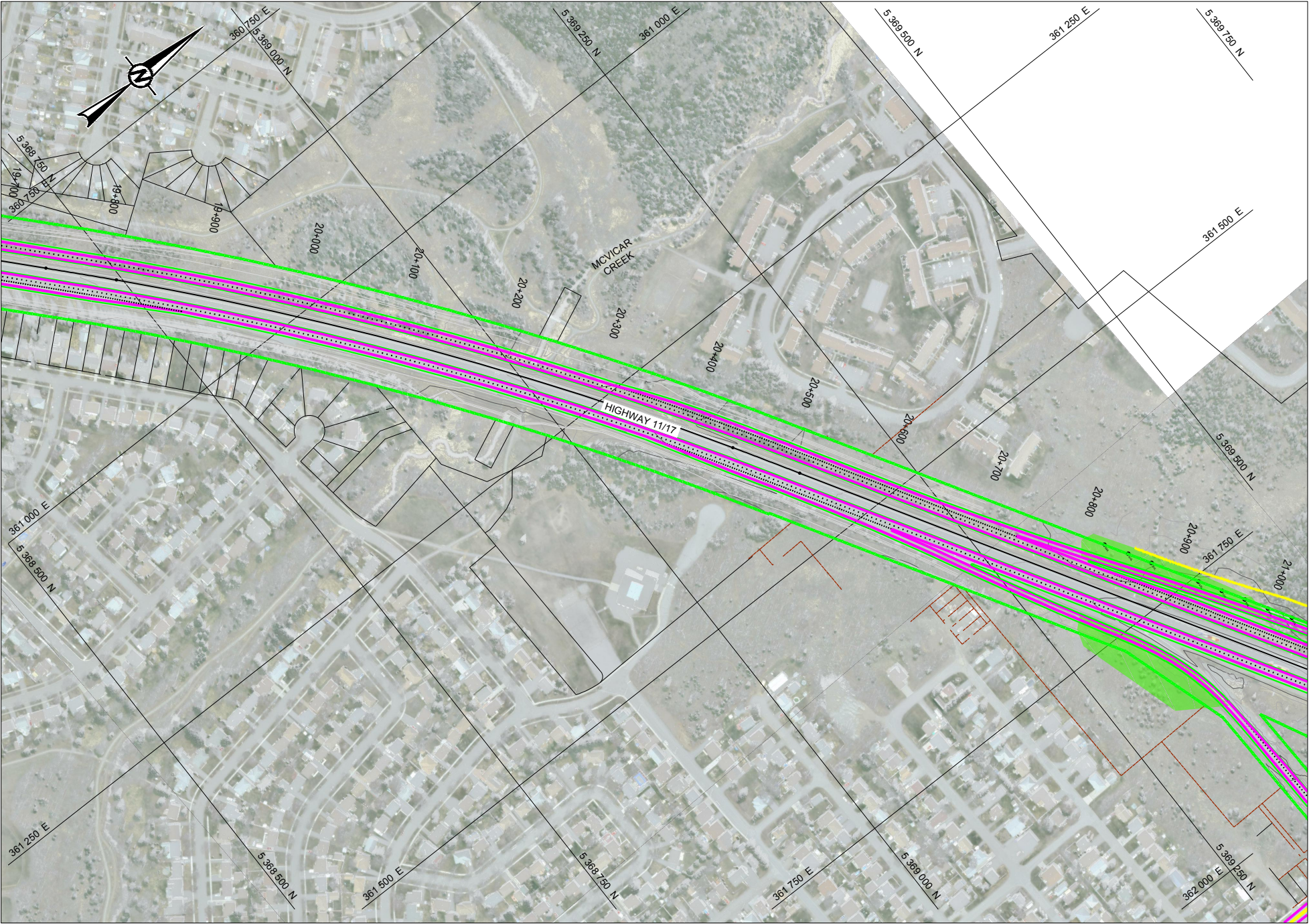
- NOTES
1. PROJECTION: UTM ZONE 16N, DATUM: NAD83
 2. ALL DIMENSIONS, COORDINATES ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.

- REFERENCES / SPECIFICATIONS
1. ALL BACKGROUND DRAWINGS: SURFACE, ALIGNMENT, PROPERTY AND ORTHOPHOTOS PROVIDED BY URS, MARCH 2014.
 2. THE PROPOSED MTO RIGHT-OF-WAY, NEW DESIGN MAIN LANES AND CROSS SECTIONS PROVIDED BY URS, JUNE 2015.

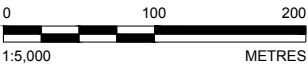
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GEOCRES No.: 52A-225

REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RWW
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2	2014-04-01	ISSUED FOR REVIEW	JH	GY		
PROJECT						
HIGHWAY 11/17 AND 61 THUNDER BAY EXPRESSWAY PRELIMINARY DESIGN						
TITLE						
PLAN VIEW HIGHWAY 11/17 STATION 18+500 TO 19+700						
PROJECT No. 13-1184-0113			FILE No. 1311840113AB010			
DESIGN	JH	2016-12-12	SCALE AS SHOWN			
CADD	GY	2016-12-12	FIGURE			
CHECK	AB	2017-03-21				
REVIEW	JMAC	2017-03-21				





PLAN VIEW



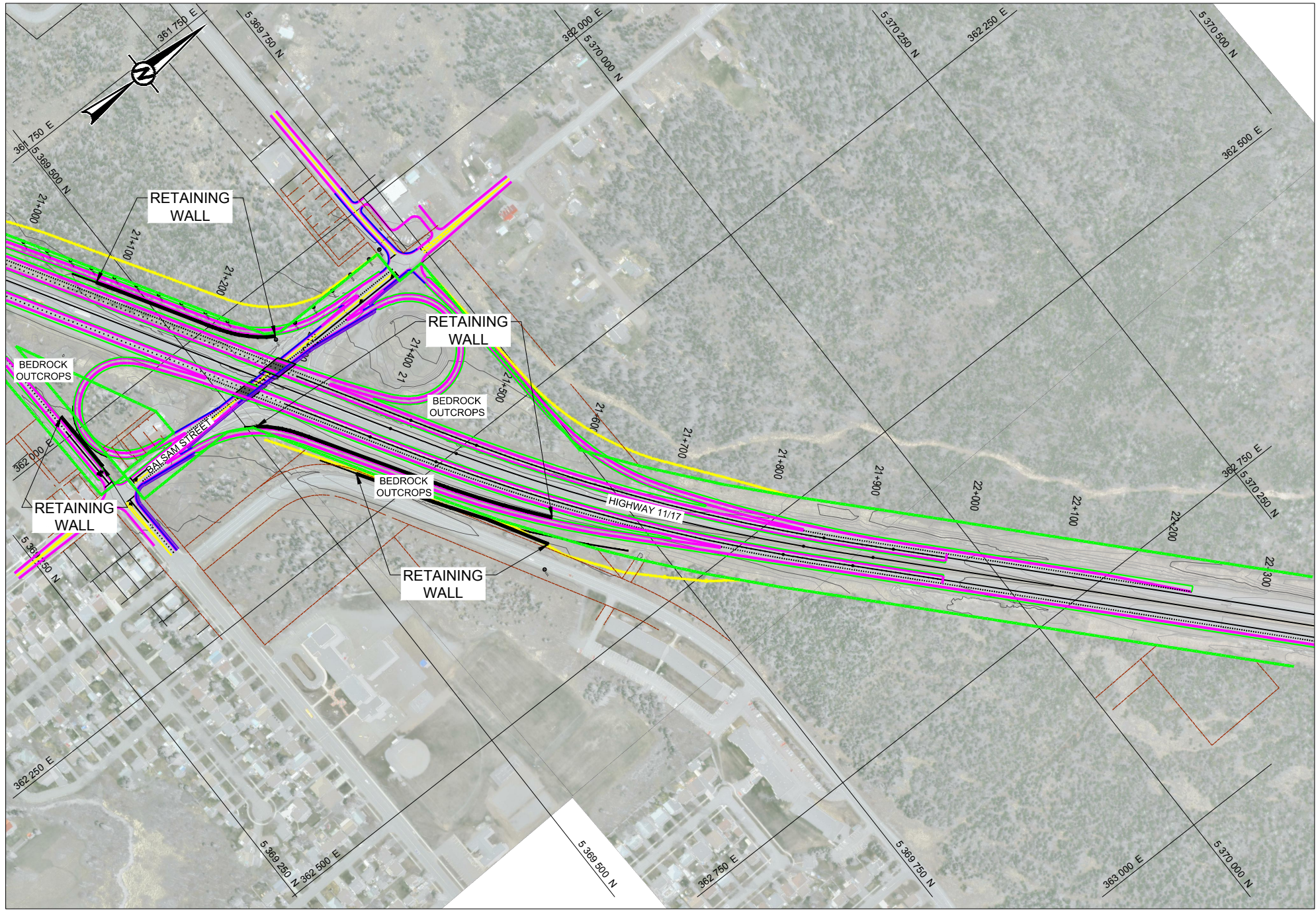
LEGEND	
	EXISTING MTO RIGHT-OF-WAY
	PROPOSED MTO RIGHT-OF-WAY
	EXISTING PROPERTY LOT LINES
	PROPOSED DESIGN
	PROPOSED HIGHWAY 11/17/61 MAIN LANES
	APPROXIMATE SWAMP (OBSERVED ON SITE BY GOLDER SEP/14)

- NOTES
- PROJECTION: UTM ZONE 16N, DATUM: NAD83
 - ALL DIMENSIONS, COORDINATES ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.

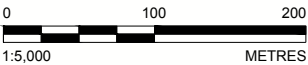
- REFERENCES / SPECIFICATIONS
- ALL BACKGROUND DRAWINGS: SURFACE, ALIGNMENT, PROPERTY AND ORTHOPHOTOS PROVIDED BY URS, MARCH 2014.
 - THE PROPOSED MTO RIGHT-OF-WAY, NEW DESIGN MAIN LANES AND CROSS SECTIONS PROVIDED BY URS, JUNE 2015.

GWP: 6001-13-00
GEOCRES No.: 52A-225

	2015-08-06	ISSUED FOR REVIEW	JH	GY		
	2014-04-01	ISSUED FOR REVIEW	JH	GY		
REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RWW
PROJECT						
HIGHWAY 11/17 AND 61 THUNDER BAY EXPRESSWAY PRELIMINARY DESIGN						
TITLE						
PLAN VIEW HIGHWAY 11/17 STATION 19+700 TO 21+000						
			PROJECT No.		13-1184-0113	
			FILE No.		1311840113AB011	
			DESIGN	JH	2016-04-18	SCALE
			CADD	GY	2016-04-18	AS SHOWN
			CHECK	AB	2017-03-21	FIGURE
			REVIEW	JMAC	2017-03-21	011



PLAN VIEW



LEGEND

- EXISTING MTO RIGHT-OF-WAY
- PROPOSED MTO RIGHT-OF-WAY
- EXISTING PROPERTY LOT LINES
- PROPOSED DESIGN
- PROPOSED HIGHWAY 11/17/61 MAIN LANES
- RETAINING WALL

NOTES

- PROJECTION: UTM ZONE 16N, DATUM: NAD83
- ALL DIMENSIONS, COORDINATES ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN.

REFERENCES / SPECIFICATIONS

- ALL BACKGROUND DRAWINGS: SURFACE, ALIGNMENT, PROPERTY AND ORTHOPHOTOS PROVIDED BY URS, MARCH 2014.
- THE PROPOSED MTO RIGHT-OF-WAY, NEW DESIGN MAIN LANES AND CROSS SECTIONS PROVIDED BY URS, JUNE 2015.

GWP: 6001-13-00
GEOCRES No.: 52A-225

2015-08-06	ISSUED FOR REVIEW	JH	GY				
2014-04-01	ISSUED FOR REVIEW	JH	GY				
REV	DATE	REVISION DESCRIPTION	DES	CADD	CHK	RWW	
PROJECT							
HIGHWAY 11/17 AND 61 THUNDER BAY EXPRESSWAY PRELIMINARY DESIGN							
TITLE							
PLAN VIEW HIGHWAY 11/17 STATION 21+000 TO 22+300							
		PROJECT No.		13-1184-0113	FILE No.		1311840113AB012
		DESIGN	JH	2016-12-12	SCALE	AS SHOWN	
		CADD	GY	2016-12-12	FIGURE		
		CHECK	AB	2017-03-21			
		REVIEW	JMAC	2017-03-21			

012



**PRELIMINARY FOUNDATION REPORT
HIGHWAY 11/17 & 61 TBE, GWP 6001-13-00**

APPENDIX A

SITE PHOTOGRAPHS



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 1 - ARTHUR STREET SITE PHOTOGRAPHS



Photo 1: Looking west along Arthur Street



Photo 2: Looking southwest at Arthur Street – Highway 61 Intersection

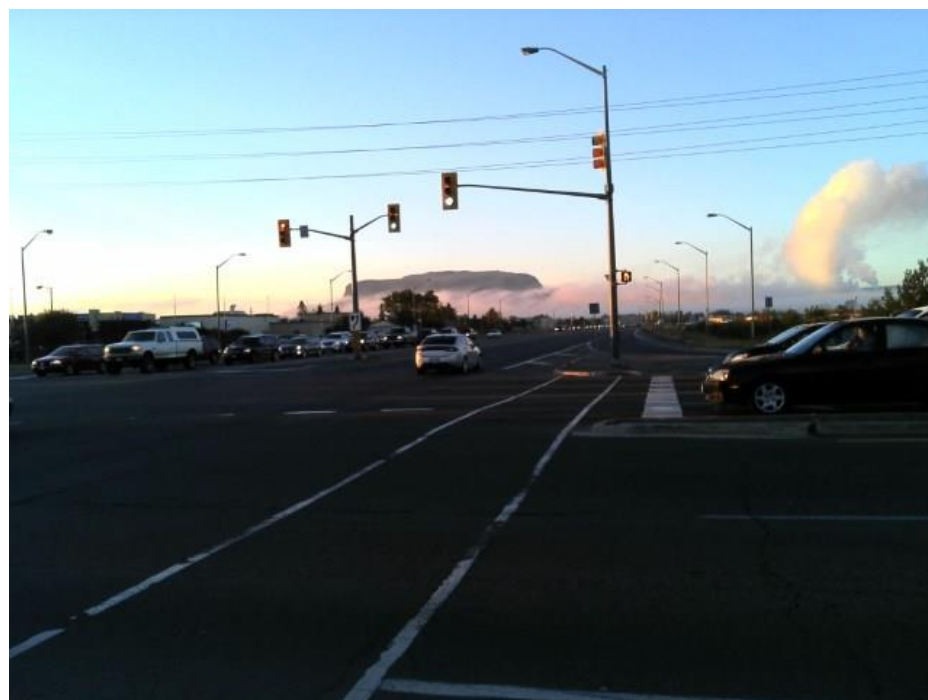


Photo 3: Looking south along Highway 61 from Arthur Street

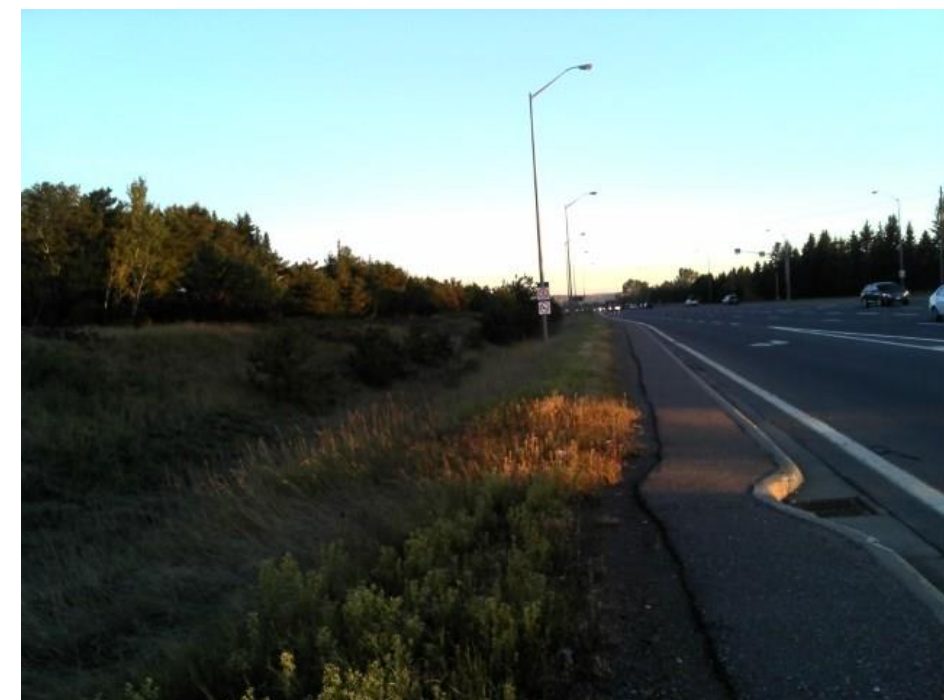


Photo 4: Looking north along Highway 61 from Arthur Street



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 2 - NEEBING RIVER SITE PHOTOGRAPHS



Photo 1: Looking north along Highway 61



Photo 2: Looking south



Photo 3: Looking north at the abutment



Photo 4: Looking north along the east side of Highway 61



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 3 - HARBOUR EXPRESSWAY SITE PHOTOGRAPHS



Photo 1: Looking north along Highway 11/17



Photo 2: Looking south along Highway 61



Photo 3: Looking east along Harbour Expressway Ramp



Photo 4: Looking south at Highway 61



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 4 - OLIVER ROAD SITE PHOTOGRAPHS



Photo 1: Looking east (Google Earth image, May 2016) along Oliver Road



Photo 2: Looking north (Google Earth image, May 2016) along Highway 11/17



Photo 3: Looking south (Google Earth image, May 2016) at Intersection of Oliver Road and Highway 11/17



Photo 4: Looking west (Google Earth image, May 2016) along Oliver Road



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 5 - FUTURE NORTHWEST ARTERIAL SITE PHOTOGRAPHS



Photo 1: Looking south along Highway 11/17 from Hydro Easement



Photo 2: Looking north from/along Golf Links Road at recent ditching excavation



Photo 3: Looking north along Highway 11/17 from Hydro Easement to Future Interchange



Photo 4: Looking east along Hydro Easement



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 6 - MCINTYRE RIVER SITE PHOTOGRAPHS



Photo 1: Looking south along Highway 11/17 from McIntyre River Bridge



Photo 2: Looking west upstream at McIntyre River Bridge



Photo 3: Looking west upstream under McIntyre River Bridge



Photo 4: Looking east downstream of McIntyre River Bridge



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 7 - JOHN STREET SITE PHOTOGRAPHS



Photo 1: Looking east at Intersection of John Street and Highway 11/17



Photo 2: Looking north along Highway 11/17 from John Street

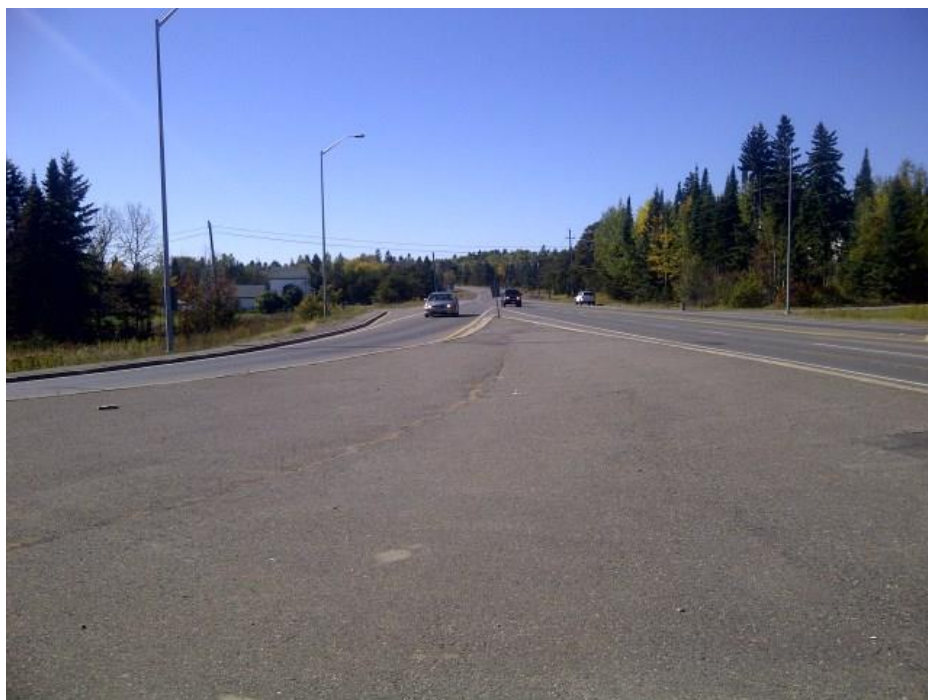


Photo 3: Looking west along John Street from Highway 11/17 Intersection



Photo 4: Looking south along Highway 11/17 from John Street Intersection



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 8 - HIGHWAY 102 / RED RIVER ROAD SITE PHOTOGRAPHS



Photo 1: Looking east along Red River Road from Highway 11/17

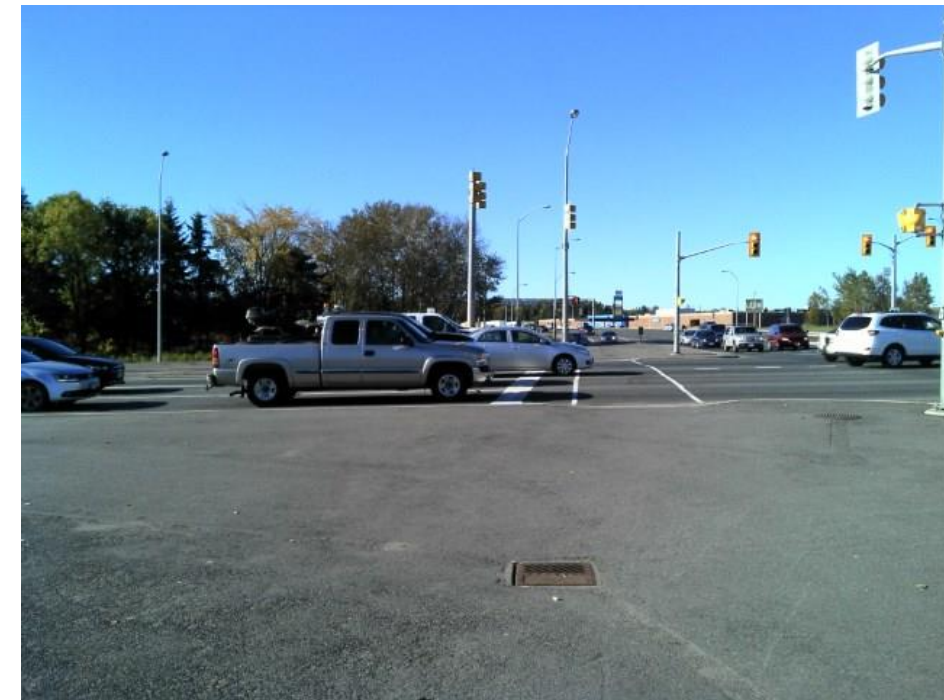


Photo 2: Looking west along Highway 102 from Highway 11/17



Photo 3: Looking north along Highway 11/17 from Red River Road



Photo 4: Looking east along Red River Road from Highway 11/17



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 9 - MCVICAR CREEK SITE PHOTOGRAPHS



Photo 1: Looking north along Highway 11/17 from McVicar Creek Culvert



Photo 2: Looking east downstream from Highway 11/17 crossing McVicar Creek



Photo 3: Looking north along east side of Highway 11/17 Embankment approach to McVicar Creek Culvert



Photo 4: Looking west upstream from Highway 11/17 crossing McVicar Creek



HIGHWAY 11/17 & 61 THUNDER BAY EXPRESSWAY, GWP 6001-13-00
SHEET 10 - BALSAM STREET SITE PHOTOGRAPHS



Photo 1: Looking southeast at Highway 11/17 – Balsam Street Intersection



Photo 2: Looking east at Highway 11/17 – Balsam Street Intersection



Photo 3: Looking east at Highway 11/17 from Balsam Street

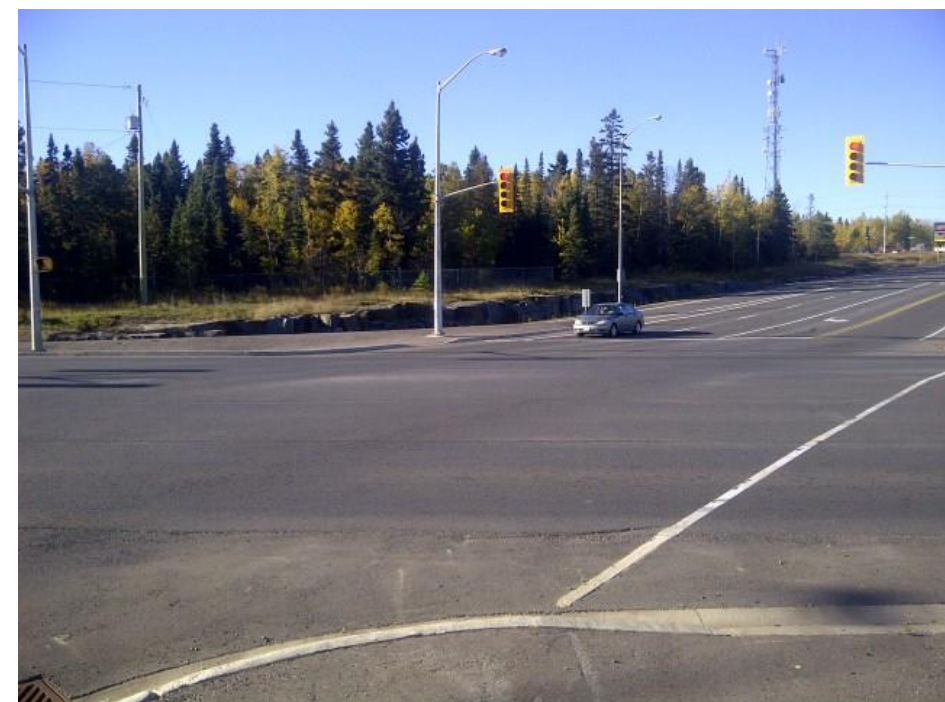


Photo 4: Looking west at Highway 11/17 – Balsam Street Intersection



APPENDIX B

SAMPLE CALCULATIONS OF FOUNDATION EVALUATION ALTERNATIVES



CRITERIA FOR EVALUATION TABLE CALCULATIONS - FOUNDATIONS

Interchange Alternatives

For each of the interchange alternatives, an overall score (or total weighted ranking) was calculated based on expected topographic variability/terrain ruggedness within the interchange footprint and along access road alignments, overall drainage ability and extent of swamp and/or soft ground areas that may have to be traversed (designated major or minor based on extent of further investigation required). Additional to this, comparative rankings were compiled for expected foundation types of bridge structures, and potential embankment settlement and stability issues. These rankings are summarized and described below.

Geotechnical Factors	Indicator	Measure
General Topography	Extent of Topographic/Terrain Variation	Quantitative Assessment / Estimate of Conditions: (Difficult/Very Rugged, Neutral, Open) (% of Ramp Footprint/Service Road Alignment)
Overall Drainage Pattern	Drainage Ability/Extent of Ponded Water	Quantitative Assessment: (Rapid, Fair, Poor/Ponded Water Present) (% of Ramp Footprint/Service Road Alignment)
Swamp and Soft Ground	Extent of Swamp and Soft Ground	Quantitative Assessment: (Major Deep Swamps/Difficult Conditions, Minor / Shallow Swamps, No Swamps Expected) (% of Ramp Footprint/Service Road Alignment)
Potential for embankment stability/settlement issues	Extent and severity of soft ground conditions	Quantitative Assessment: (Difficult embankment conditions (Very soft/Deep Clay Deposits) or Favourable embankment conditions (Thin or No Clay Deposits)) (% of Ramp Footprint/Service Road Alignment)
Foundation Types at Structure Locations	Anticipated depth to Bedrock (Shallow or Deep)	Qualitative Assessment: (Exposed Bedrock/Shallow Foundations, Unknown/Possible Deep or Very Deep Foundations) (Estimated number of each)

1. Extent of topographic/terrain variation:

Scores based on percentage of difficult terrain versus open area were calculated. Difficult terrain was considered to refer to rolling, undulating and rugged topography, possibly heavily treed. Difficult terrain was assigned a value of 1, neutral terrain conditions were assigned a value of 2 and open, favourable area was assigned a value of 3. These numbers were multiplied by the respective percentage of the terrain type within the interchange footprint and along access road alignments. The following provides a sample calculation for an interchange having 90% defined as difficult terrain and 10% as favourable/open terrain:

$$\begin{aligned}\text{Indicator Score} &= 1 \times 0.90 + 2 \times 0.00 + 3 \times 0.10 \\ &= 1.20\end{aligned}$$



2. *Drainage ability/extent of ponded water:*

Scores based on the percentage of area having rapid, fair or poor drainage ability were calculated. For the interchange evaluation, fair to rapid drainage abilities were combined together and assigned a value of 2.5 while poor drainage was assigned a value of 1. These weighted numbers were multiplied by the percentage of drainage ability type within the interchange footprint and along access road alignments. The indicator score for an interchange with 80% rapid-fair drainage and 20% poor drainage would be calculated as follows:

$$\begin{aligned}\text{Indicator Score} &= 2.5 \times 0.80 + 1 \times 0.20 \\ &= 2.20\end{aligned}$$

3. *Extent of swamps and soft ground:*

Scores based on the percentage of swamp/soft ground area(s) within the interchange footprint and along access road alignments were calculated. Major swamps were assigned a value of 1, minor swamps were assigned a value of 2 and areas containing no swamp or soft ground were assigned a value of 3. The indicator score for an alternative containing 15% major swamps and 5% minor swamps would be calculated as follows:

$$\begin{aligned}\text{Indicator Score} &= 1 \times 0.15 + 2 \times 0.05 + 3 \times 0.80 \\ &= 2.65\end{aligned}$$

4. *Potential soft clay foundation / embankment settlement and stability issues*

Scores based on the percentage of difficult embankment foundation conditions within the interchange footprint and along access road alignments were calculated. Areas with near surface, soft and/or deep clay deposits where difficult foundation conditions were expected were assigned a value of 1; areas with neutral embankment foundation conditions were assigned a value of 2; and areas containing no surficial clay deposits were assigned a value of 3. The indicator score for an alternative containing 20% difficult embankment foundation conditions and 20% neutral embankment foundation conditions would be calculated as follows:

$$\begin{aligned}\text{Indicator Score} &= 1 \times 0.20 + 2 \times 0.20 + 3 \times 0.70 \\ &= 2.70\end{aligned}$$

5. *Anticipated depth to competent foundation soils (shallow , or deep)*

Scores based on the expected number of each foundation type were calculated. Deep foundation units were assigned a value of 0.25; and shallow foundation units were assigned a value of 0.75 and the calculated scores were divided by the number of foundation units to calculate an average score for each foundation unit. The indicator score for an alternative containing 1 shallow and 2 deep foundation units would be calculated as follows:



FOUNDATION DESIGN REPORT HIGHWAY 61 & 11/17 THUNDER BAY EXPRESSWAY

$$\begin{aligned}\text{Indicator Score} &= (2 \times 0.25 + 1 \times 0.75)/3 \\ &= .42\end{aligned}$$

The overall score used for comparing the route alternatives was calculated as the sum of the indicator scores numbers from the five criteria listed above.

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
33 Mackenzie Street, Suite 100
Sudbury, Ontario, P3C 4Y1
Canada
T: +1 (705) 524 6861

