PROJECT NO.: SM 220069-G

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CENTENNIAL CONSTRUCTION AND CONTRACTING (NIAGARA) INC.
353 Townline Road
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Attention: Mr. Joseph Candeloro

SUPPLEMENTAL GEOTECHNICAL ASSESSMENT
RIVERFRONT RESIDENTIAL DEVELOPMENT LANDS
NIAGARA FALLS, ONTARIO

Dear Mr. Candeloro,

Further to your authorisation, SOIL-MAT ENGINEERS & CONSULTANTS LTD. has prepared the following geotechnical investigation report based on the fieldwork completed to date. The investigation and reporting were undertaken in general accordance with our proposal SM 220069-GE dated May 20, 2022, and further to discussions and coordination with your forces. Our comments and recommendations, based on our findings at the borehole and test pit locations as well as from a review of the provided work completed by others, are presented in the following paragraphs.

1. INTRODUCTION

We understand that the subject site, located on the property located north of Chippawa Parkway, east of Dorchester Road, and south of the railway lines, is proposed for construction of a residential development. More specifically, the proposed development lands cover roughly the eastern two thirds of the overall parcel, and are further divided into two sections referred to the West Pod and East Pod. The development is proposed to involve single family lots, along asphalt paved roadways, including the installation of associated underground services.

The purpose of this supplemental geotechnical investigation work was to assess the subsurface soil conditions, further to information presented in prior investigations by others, and to provide our comments and recommendations with respect to the design and construction earthworks for the proposed development, from a geotechnical point of view.

This report is based on the above summarised project description, and on the assumption that the design and construction will be performed in accordance with applicable codes and standards. Any significant deviations from the proposed project design may void the recommendations given in this report. If significant changes are made to the proposed design, this office must be consulted to review the new design with respect to the results of this investigation. It is noted that the information contained in this report does not reflect upon the environmental aspects of the site. The results of environmental sampling conducted for this site been provided under a separate cover.

2. BACKGROUND

The subject lands are located north of the Chippawa Parkway, east of Dorchester Road, west of existing industrial lands, and south of the railway lines. The area is previously undeveloped, and has evidently been subject to various fill placement overtime. In particular, in prior reporting by others it has been suggested that the alignment of the Welland River might have previously crossed the southern portion of the site, possibly having been realigned and infilled sometime between 1908 and 1934. A comparison of available topographic maps from 1920, 1928, 1938 and 1996 is shown in Drawing No. 1 attached, with the location of the subject lands illustrated. The maps depict the alignment of the Welland River changing from 1928 to 1938. It is also noted that aerial photos from 1934 show the river in a similar position as the 1938 and 1996 topo maps. It is not clear that the alignment of the river did in fact change, or if this is perhaps more likely a revision made to the more recent topographic maps. As well, the potential realignment of the river, if it occurred, would appear to be outside the limits of the subject site.

Separately from the possible realignment of the River, it is likely that fill from the construction of the nearby hydro canal to the west of the property, between 1920 and 1928, was placed over significant portions of the site. It is noted as well that the 1920 and 1928 topographic maps show a tributary of the Welland River traversing the site, which is not present in the 1938 or 1996 maps. The hydro canal is present in 1928, with the tributary still illustrated, though it is likely that the tributary crossing the site had actually been filled in at that time. Review of available aerial photos show indications of fill placement over the western portion of the site prior to 1934, and evidence of further fill placement in the 1954 photo.

In addition, it is evident that there has been more recent historical fill placement on the southeastern portion of the site, in a separate stockpile within the East Pod. This fill placement is likely associated with surplus soil from various construction projects from roughly the 1970s to present.

The condition and details of this fill placement on the site is largely unknown.

It is noted that geotechnical investigations have previously been conducted on portions of this site by others. These reports indicated depths of fill on the order of 1 to 7 metres, underlain by native silty clay.

Our office was provided with the following materials which were referenced in the preparation of this report:

- Supplemental Investigation and Risk Assessment to Support Record of Site Conditions, Proposed Riverfront Community Development, Niagara Falls, Ontario, Project No. TPB 184078 Phase 116, prepared by Wood.
- Site Plan, Proposed Riverfront Community Development, Niagara Falls, Ontario, Project No. TPB 184078, prepared by Wood.
- Geotechnical Investigation – Phase 1 Residential, Proposed Riverfront Community Development, Niagara Falls, Ontario, Project No. TPB 184078, prepared by Wood.
- Phase Two Environmental Site Assessment, Proposed Riverfront Community Development, Niagara Falls, Ontario, Project No. TPB 184078, prepared by Wood.

These reports have been referenced to provide background information in establishing the scope of this investigation and the writing of this report to supplement the test pit information recovered during the scope of this investigation, however these reports are not being expressly relied upon and Soil-Mat Engineers does not accept any responsibility for the correctness and accuracy of the field and laboratory information conducted by others and provided by the client.

Previous investigations conducted by others suggest the fill has been found to be reasonably consistent silty clay/clayey silt. Some evidence of organic inclusions within portions of the fill, and possible organic seams in the lower levels of the fill at the transition to the native silty clay soils has been indicated in the previous investigations noted above.

3. PROCEDURE

To date a total of forty-two [42] test pits were advanced via excavator equipment to depths of approximately 1.8 to 8.5 metres below the existing grade at the locations illustrated in Drawing Nos. 2 and 3 Test Pit Location Plan. Test Pit Nos. 1 to 30, inclusive were advanced on June 8, 9 and 10, 2022. At that time the eastern portion of the East Pod was restricted from access as part of ecological assessment work. This portion of the site was cleared for access and Test Pit Nos. 101 to 112, inclusive, were advanced on October 19 and 20, 2022.

Upon completion, all test pits were backfilled to reinstate the existing grade. It is noted that no rigorous compaction efforts were provided for the backfilled materials in the test pits and the excavated soils were mounded up at the test pit locations, and as such, settlements of the backfill material should be expected.

Representative samples of the subsoils were recovered from the test pits at selected depths. After undergoing a general field examination, the soil samples were preserved and transported to the SOIL-MAT laboratory for visual, tactile, and olfactory classifications. Routine moisture content tests were performed on all soil samples recovered.

The test pit locations were marked in the field by a representative of Upper Canada Consultants in general accordance with the drawing from our office. Certain test pit location were adjust slightly in the field where required based on access restrictions, and restricted access due to endangered species of grass. However, the test pit locations are generally consistent with the field marked locations. Geodetic information of the ground surface elevation at the proposed borehole locations was also provided by a representative of Upper Canada Consultants.

4. SITE DESCRIPTION AND SUBSURFACE CONDITIONS

The subject property is located north of Chippawa Parkway, east of Dorchester Road, west of existing industrial lands, and south of the railway lines. As noted above, the majority of the site consists of historical fill deposits which is a result of unknown fill placement over time. The majority of the site has been deforested, with older growth woodlots surrounding the subject site on the north, east and west sides. The subject site is bound to the south by Chippawa Parkway

Details of the conditions encountered in the test pits are summarized in Table A appended to this report, and described as follows. It is noted that the boundaries are intended to reflect transition zones for the purpose of geotechnical design and therefore should not be construed as the exact planes of geological change.

Topsoil

A surficial veneer of topsoil up to approximately 600 millimetres in thickness was encountered at all test pit locations, with a typical average thickness on the order of 300 to 400 millimetres. It is noted that the depth of topsoil may vary across the site and from the depths encountered at the test pit locations. It is noted that the term ‘topsoil’ has been used from a geotechnical point of view, and does not necessarily reflect its nutrient content or ability to support plant life.

Clayey Silt/Silty Clay Fill

Clayey silt/silty clay fill was present below the topsoil veneer at all test pit locations with the exception of Test Pit Nos. 10, 11, 12, 16 to 19, and 23. The fill is brown to grey in colour, with traces of sand and gravel with occasional to frequent tree roots in the upper levels. The clayey silt/silty clay fill encountered was generally stiff to firm in consistency and proven to depths of approximately 1.0 to 6.1 metres below the existing ground surface.

Silty Sand Fill

Silty sand fill was present below the topsoil veneer and layered between the silty clay fill materials at Test Pit Nos. 9 to 11, and 15 to 20. The fill is brown in colour, with trace clay and occasional roots. The silty sand fill was generally compact in consistency and proven to depths of approximately 0.2 to 3.9 metres below the existing ground surface.

Silty Clay Fill

Silty clay fill was encountered beneath the silty clay/clayey silt fill and silty sand fill materials at Test Pit Nos. 3 to 6, 8 to 12, 14 to 20, and 28. The fill is brown to grey in colour, with trace gravel, some sand seams, occasional organic inclusions and seams. The silty clay fill was generally soft to firm in consistency and proven to depth and termination at depths of approximately 2.1 to 6.4 metres below the existing ground surface.

Organic Material/Topsoil

Organic topsoil material was encountered was beneath the silty clay fill material in Test Pit Nos. 15, 19, 101, 103, 105, 106, 110, 111, and 112. The thickness of these topsoil deposits is summarized in the following table.

TP 15	TP19	TP 101	TP 103	TP 105	TP 106	TP 110	TP 111	TP 112
0.15m	0.2m	0.5m	3.5m	2.0m	0.3m	5.5m	5.5m	3.0m

In Test Pit Nos. 15 and 19, within the West Pod, the topsoil layer was approximately 150 to 200 millimetres thick, and is most likely associated with topsoil not stripped prior to historical fill placement. The thickness and presence of such topsoil seams may vary over the area.

Within the East Pod, Test Pit Nos. 101, 103, 105 and 106 encountered topsoil seams 0.5 to 3.5 metres thick, beneath the eastern stockpile. This is most likely topsoil that was pushed into the eastern stockpile prior to fill placement, and as then had additional fill placed on top.

Also within the East Pod, Test Pit Nos. 110, 111 and 112 encountered significant depths of topsoil within the western stockpile of approximately 3 to 5.5 metres thick. This is evidently a topsoil stockpile, perhaps generated from stripping of other areas of the site prior to placement of fill.

The depth and lateral limits of this evidently stockpiled topsoil may vary from that encountered at the test pit locations.

Of note, referencing the prior geotechnical investigation report, the boreholes and reports do not make note of the presence of significant organic inclusions, or more specifically organic or peat seams within or at the bottom of the fill layers. The noted exception is at the location of BH101, at the northwest corner of the West Pod area, where a layer of peat was encountered at a depth of 4.4 metres.

Clayey Silt/Silty Clay

Native clayey silt/silty clay was encountered below the fill deposits, and/or organic/topsoil where present at Test Pit Nos. 9, 13 to 30, 101, 103, and 105 to 112, at depths of between 1.2 and 6.1 metres below the existing ground surface. The native cohesive soils are brown to grey in colour and contained traces of sand and gravel. The native clayey silt/silty clay soils are generally very stiff to stiff in consistency. The native clayey silt/silty clay was proven to termination at depths of 1.8 and 6.4 metres below the existing grade.

Silty Sand

Native silty sand was encountered below the silty clay fill at Test Pit No. 4 at a depth of 5.4 metres below the existing ground surface. The native soils were brown in colour and contained trace clay. The native silty sand was generally compact in consistency and proven to termination at a depth of 5.6 metres.

Groundwater Observations

All test pits were noted to be dry upon the completion of excavation with the exception of Test Pit Nos. 2, 13, 18, and 24 where perched water conditions in the upper more permeable fill layers was present. It is noted that insufficient time would have passed for the standing groundwater level to stabilize in the open test pits.

Referencing the prior geotechnical investigation report by others, groundwater was reported in the boreholes at depths of 2.5 to 6.1 metres below grade during drilling. Monitoring well readings indicate the static groundwater level to be typically at depths in the range of 1.2 to 4.8 metres, or elevation 174.6 to 180.0 metres. The water level readings were summarised in the Wood geotechnical report in the following table.

Table 5: Monitoring Well Summary

BH ID	Installation Date	Well Screen Depth Below Ground Surface (m)	Ground Surface Elevation (m)	Water Level Below Ground Surface / Elevation (mbgs) / (m)						
				Prior to Installation	January 20, 2016	March 1, 2016	June 30, 2019[1]	July 4, 2019[1]	July 29, 2019	July 31, 2019
BH/MW-201	Feb 2, 2006	3.0 – 6.1	179.3	1.0 / 178.3		0.2 /179.1		0.7 / 178.6	2.7 / 176.6	
BH/MW-202	Jan 31, 2006	3.0 – 4.8	179.6	3.1 / 176.5		0.6 / 179.0		1.2 / 178.4	2.4 / 177.4	
BH/MW-101	Dec 3, 2015	2.5 – 5.5	180.8	5.2 / 175.6	3.1 / 177.7	1.2 / 179.6			2.8 / 178.0	
BH/MW-102	Dec 2, 2015	2.5 – 5.5	183.0	Dry	3.7 / 179.3				3.0 / 180.0	
BH/MW-103	Dec 2, 2015	2.5 – 5.5	175.3	Dry	4.8 / 170.5	3.5 / 171.8				
BH/MW-412	Aug 23, 2018	3.0 – 6.1	181.3	18.3				1.4 / 179.9	1.8 / 179.5	
BH/MW-421	Jun 21, 2019	3.0 – 6.1	179.0	Dry			0.8 [2]/ 178.2	1.2 [2]/ 177.8	1.2 / 177.8	
BH/MW-431	Jun 24, 2019	3.0 – 6.1	176.4	Dry			0.8 [2]/ 176.4	1.0 [2]/ 175.4		1.8 / 174.8
BH/MW-438	Jun 21, 2019	3.0 – 6.1	177.6	7.6			1.5 [2]/ 176.1	1.6 [2]/ 176.0		2.2 / 175.4
BH/MW-440	Sep 11, 2018	10.7 – 13.8	179.8	Dry				3.5 / 176.3		3.4 / 176.4
BH/MW-441	Jun 21, 2019	3.0 – 6.1	179.4	9.1			6.1 [2]/ 173.4	5.7 [2]/ 173.7		4.8 / 174.6

Notes:
(1) wells purged after water level reading
(2) may not represent a fully stabilized level as readings taken roughly one week after installation and purging

It is noted that during our more recent site visits the majority of the monitoring wells either could not be found, or were damaged. Groundwater monitoring wells BH/MW-201, BH/MW-431, and BH/MW-441 were in sound enough condition to obtain the following groundwater readings

Monitoring Well	Ground Surface Elevation	June 10, 2022	
		GW Depth	GW Elevation
201	179.3	1.79	177.5
431	176.4	0.56	175.8
441	179.4	3.28	176.1

The available monitoring well data indicates that groundwater tends to vary across the site, roughly following the topography, though in some cases being at shallower depths in higher elevation area of the site. Based on this, it appears that water is 'perched' or trapped' within the fill deposits, and so measured levels may not in fact be reflective of the true static groundwater level.

5. HYDROGEOLOGICAL CONSIDERATIONS

Three [3] selected samples of the fill and native subsurface soils from the test pits, considered to be generally representative of the soil conditions encountered on site, were returned to our laboratory for grain size analysis testing. The results of this grain size analysis have been appended to the end of this report and summarized as follows:

TABLE B – GRAIN SIZE ANALYSIS

Sample ID	Depth [m]	% Clay	% Silt	% Sand	% Gravel	Estimated Permeability, k [cm/sec]	Estimated Infiltration Rate [mm/hr]
TP1 S1	2.2	35	52	13	0	10^{-7}	<10
TP1 S2	3.0	32	68	0	0	10^{-7}	<10
TP1 S3	7.5	35	63	2	0	10^{-7}	<10

According to the Unified Soil Classification System the soil is classified as M.L. – clayey silts with slight plasticity, inorganic silts and very fine sands. This is consistent with the grain size analysis results in Phase One Geotechnical Report completed by wood forwarded to us. [Geotechnical Investigation – Phase 1 Residential, Proposed Riverfront Community Development, Niagara Falls, Ontario, Project No. TPB 184078, prepared by Wood.] The subsurface soils are estimated to have a permeability of 10^{-7} cm/sec. This would correlate to an estimated infiltration rate on the order of <10 mm/hr being effectively impermeable and not suitable for LID stormwater management solutions or other areas where infiltration is required. It is noted that some of the test pits encountered silty sand soils. These soils would likely offer higher infiltration rates though as the fill mass is varied in composition and the sand deposits isolated, they cannot be confidently be relied on for the purpose of infiltration.

The area surrounding the subject site consists primarily of wooded wet lands. Due to the relative impermeability of the fill mass and the higher relative elevation of the subject site, it is likely the wooded wet lands are a result of perched water and surficial run off then the result of elevated groundwater. This is congruent with the groundwater observations conducted during the field work.

6. ENGINEERED FILL AND EARTHWORKS CONSIDERATIONS

The presence of a large mass of pre-existing fill presents an unusual challenge for development of the site. While there is some understanding of the fill placement based on available historical information, outlined above, it is not known exactly how the fill mass was placed or when. As such, it cannot be presumed to have been conducted as engineered fill. The boreholes and test pits found the fill to be fairly consistent clayey silt/silty clay in a stiff to firm condition, silty sand fill in a compact condition, as well as silty clay in a soft condition. There is evidence of variable organic inclusions within portions of the fill, with organic seams in some locations. In general it does not appear that there is widespread buried organic/topsoil over the full site, but rather tends to be present on portions of the site.

Given the established condition of the fill and the significant span of time it has been in place, it will reasonably have reached an equilibrium condition in its current stress environment. As such, it would be possible to make use of the existing fill, with a targeted program of re-engineering, in order to provide adequate support for relatively lightly loaded residential structures proposed. Of course, this assessment would also need to consider the relative depth of fill, proposed grading, and elevation of new foundations relative to the existing fill or native soils. As well, the timing of work will be a significant consideration, both in terms of time of year and time between stages of construction. There should be a delay between the broad engineered fill earthworks and servicing and roadway construction, and ultimately house construction, to allow for fill to reach equilibrium condition. The appropriate delay with depend on the extent of earthworks and depth of fill placement, and so should be further assessed as the design proceeds. On a preliminary basis, a delay on the order of 3 to 4 months between engineered fill works and site servicing, and a further 3 to 4 months to foundation construction, and ideally over a winter season, is recommended. In most cases the normal sequencing of construction would achieve these.

The fill depths at each test pit location, as well as the prior boreholes reported by Wood, are presented on the attached Drawing Nos. 2 and 3. As well, the groundwater information previously reported by Wood is noted.

WEST POD

Within the West Pod the fill deposit ranges from approximately 1.4 metres to 7.2 metres. The fill deposits generally consist of silty clay/clayey silt, with varying evidence of organic inclusions. These soils are generally suitable for use as engineered fill, though with some sorting required. Locations where such sorting are specifically expected are noted on the attached Drawings, though it is noted that conditions may vary from the test pit locations.

EAST POD

Within the East Pod, there is more concentrated presence of topsoil as noted above. What appears to be a topsoil stockpile [western], and buried topsoil within the fill stockpile [eastern]. The fill stockpile [eastern] is noted to be more variable material, suspected to be more recently placed from different sources since the 1970s. This stockpile will require complete removal, sorting to removal topsoil, and then suitable soil replaced and compacted as engineered fill.

For lightly loaded residential footings, the principal depth of stress influence is on the order of 2 to 3 times the footing width. Considering a typical footing width of 0.5 metres, this results in a principal depth of stress influence of 1 to 1.5 metres. Meaning that the majority of stress change as a result of a loaded strip footing will be experienced by the soil within 1.5 metres of the founding level. Below this level there would be negligible stress change experienced by the in-situ soils.

Based on the above discussion, it is recommended that the site may be made adequate for the support of spread footings for proposed single family dwellings by undertaking a program to re-engineer the existing fill materials to a depth of 1.2 metres below the design founding level. In this regard the minimum founding level would reasonably be taken as 2.0 metres below the road grade for a given lot. Following this, the existing fill would be excavated to a depth of up to roughly 3.2 metres below the finished road grade, the exposed surface well compacted and evaluated, and then engineered fill placed up to the required grades. Some sorting of the existing fill materials may be required to ensure no significant inclusions of debris, organics, etc. are present within material to be placed as engineered fill.

The existing fill material across the site is generally considered to be near to well 'wet' of standard Proctor optimum moisture content in the upper levels, with the silty clay soils being generally well 'wet' below the upper levels, and would generally require significant moisture conditioning [drying] in order to achieve an efficient compaction operation. Given this, it would be most effective to undertake the engineered fill operation during the hot, dry, summer months, from June to September. During cooler and wetter periods compaction operations would need to be modified to account for conditions, such as limiting the use of vibration and conducting additional passes with static compaction equipment. Management of the on-site fill materials will also be important, working excavated fill to reduce the moisture content during sunny, warm and windy days, and then stockpiling to provide protection in the event of rain. It is also noted that fill placed wet of optimum, while it has lesser strength characteristics, would typically have a lesser long-term settlement potential. In this regard, monitoring of the moisture content, moisture conditioning, etc. will be critical for the effectiveness of the engineered fill program.

During significant rainfall events, and for a period after, effective compaction of the wet silty clay and silty clay/clayey silt soils could become practically impossible. The provision of an initial layer of Granular B material would be effective in providing a more stable base, in particular in wet weather conditions or cooler times of year, helping to facilitate effective compaction of subsequent lifts of soil fill above. Given the conditions, the engineered fill operations will require active assessment and adjustment based on specific conditions in the field, which is best achieved with clear communication and coordination between the contractor and our field staff.

The condition of the fill present over the site with the exception of noted areas, illustrated in Drawing Nos. 2 and 3 Test Pit Location Plan, with appreciable organic inclusions, is generally in good condition, and would generally be feasible for reuse as engineered fill provided that their moisture content can be lowered to within about 3% of their standard Proctor optimum moisture content. Given the established conditions, it is anticipated that a coordinated earthworks program would be feasible to excavate, sort and moisture condition as necessary, and reuse the majority of the on-site materials as either engineered fill or grading fill where required. This process would incorporate the removal of any significant organic seams where the thickness, significance, and depth of the organic deposit is of concern and needs to be investigated further and possibly removed in order to avoid concerns of potential associated long-term settlements. Such areas where further investigation of the noted organic deposit would be required include the area between Test Pit Nos. 6, 9, and 10, and the areas around Test Pit Nos. 13, 15 and 19 in the west pod. Test Pit No. 28, the areas surrounding Test Pit Nos. 101, 103, 105, 106, 110, 111, and 112, in the east pod. It is noted the large depth of organic fill located at Test Pit Nos. 110 to 112 is significantly deeper than other locations across the site. as roughly illustrated in the location plan.

Based on the extent and condition of the limited organic seam [where present] as well as it's proximity to foundations and services, it is considered feasible to remain in place over the majority of the site with the exception of the above noted areas and any areas of concern determined during construction activities depending on the final elevation of the grading plan. Areas with more severe organic inclusions, in particular the area of around Test Pit Nos. 13, 19, and 28, and the more significant topsoil within the stockpiles in the East Pod, would require the removal of the organic deposit before building the grade back up to the design elevation with engineered fill. The proposed site plan must be reviewed to determine the proximity of the organic seams to the proposed foundations and services.

The fill material at the anticipated design elevations generally lack a consistent stiff crust in the upper levels. It is anticipated that excavating material and placing a minimum of 1.2 metre thick engineered fill 'pad' below the founding elevations of the proposed dwellings will be the optimal solution for the construction of the development, in the deeper regions of fill located to the south west in the west pod, providing sufficient support for residential structures, services and roadways, while reducing the risk of settlements and damage to the structures in the fill material. The fill soils on the site may be excavated, and the vast majority of the material may be reused on site as engineered or grading fill. Any surficial topsoil should be stripped and may be reused as grading fill or as topsoil. It is noted that the Test Pits encountered a relatively limited depth of surface topsoil over most of the site.

It is noted that any engineered fill pads should extend a minimum of 0.6 metres horizontally beyond the footings, and sloped down and away at an inclination of 10 horizontal to 7 vertical. Given this requirement and the site plan of the proposed development, it is recommended that the proposed building envelops be clearly established in advance of the earthworks to allow for targeted construction of the engineered fill pads. Re-engineering of fill within roadways could be reasonably addressed during the site servicing works.

As noted above, the majority of the fill material has a higher moisture content resulting in a soft consistency. These soils are considered suitable for reuse as engineered fill, however they would require sufficient moisture conditioning efforts to lower this moisture to within about 4 per cent of the standard Proctor optimum moisture content. As noted above, a base lift of Granular B material may be placed to improve the compaction of the clayey soils, particularly where the moisture content of the clayey silt/silty clay fill soils are slightly 'wet' of the optimal moisture content range of within about 4 per cent of the standard Proctor optimum moisture content. This approach will not be suitable for soils beyond a certain moisture range and would be determined during construction based on compaction results.

It is noted that soils considered suitable for reuse as engineered fill may also be used as grading fill. Material considered unsuitable for use as engineered fill would generally be suitable for use as grading fill, i.e. not supporting structures, services or roadways. In this regard, it may be feasible to generate sufficient quantity of quality engineered fill through 'borrow pits' strategically located on the site from which quality engineered fill material can be mined and replaced with unsuitable fill material. Such borrow pits should be carefully located so as not to interfere with the support conditions of proposed structures, service or roadways.

It is noted that the cohesive clayey silt/silty clay and silty clay fill soils encountered are not considered to be free draining and should not be used where this characteristic is necessary. It is also noted that these soils will present difficulties in achieving effective compaction where access with compaction equipment is restricted. This would include as backfill against foundation walls, within garages, etc. Against foundation walls, in non-settlement sensitive landscaped areas, this is likely not a significant concern. However, where engineered fill is required within confined areas, such as beneath garage slabs, it may be necessary to make use of alternative fill materials or methods of placement.

We note that where fill material is placed near or slightly above its optimum moisture content, the potential for long term settlements due to the ingress of groundwater and collapse of the fill structure is reduced. Correspondingly, the shear strength of the 'wet' backfill material is also lowered, thereby reducing its ability to support construction traffic and therefore impacting roadway construction. If the soil is well dry of its optimum value, it will appear to be very strong when compacted, but will tend to settle with time as the moisture content in the fill increases to equilibrium condition. The clayey silt/silty clay soils may require high compaction energy to achieve acceptable densities if the moisture content is not close to its standard Proctor optimum value. It is therefore very important that the placement moisture content of the backfill soils be within 3 per cent of their standard Proctor optimum moisture content during placement and compaction to minimise long term subsidence [settlement] of the fill mass. Any imported fill required in service trenches or to raise the subgrade elevation should have its moisture content within 3 per cent of its optimum moisture content and meet the necessary environmental guidelines.

A representative of SOIL-MAT should be present on-site during the backfilling and compaction operations to confirm the uniform compaction of the backfill material to project specification requirements. Close supervision is prudent in areas that are not readily accessible to compaction equipment, for instance near the end of compaction 'runs'. All structural fill should be compacted to 100 per cent of its standard Proctor maximum dry density [SPMDD]. Backfill within service trenches, areas to be paved, etc., should be compacted to a minimum of 95 per cent of SPMDD, and to 98 per cent in the upper 1 metre. The appropriate compaction equipment should be employed based on soil type, i.e. pad-toe for cohesive soils and smooth drum/vibratory plate for granular soils. A method should be developed to assess compaction efficiency employing the on-site compaction equipment and backfill materials during construction.

7. EXCAVATIONS

Excavations for earthworks and the installation of the foundations and underground services are generally expected to extend to depths of up to about 2 to 4 metres below the grade once the engineered fill operations have been completed. Excavations into the clayey silt/silty clay fill and native clayey silt/silty clay soils may be expected to remain stable for the short construction period at inclinations of up to 60 degrees to the horizontal, or steeper. Excavations into the sandy silt/silty sand fill soils may be expected to remain stable for the short construction period at inclinations of up to 45 degrees to the horizontal. Where wet seams are encountered, during periods of extended precipitation, or where excavations extend below the static groundwater level, the sides of excavations may have a tendency to 'slough in' to as flat as 3 horizontal to 1 vertical, or flatter. Nevertheless, all excavations must comply with the current Occupational Health and Safety Act and Regulations for Construction Projects. Excavation slopes steeper than those required in the Safety Act must be supported or a trench box must be provided, and a senior geotechnical engineer from this office should monitor the work. With respect to the act, the fill soils would be considered as Type 3 material.

As noted above it is expected that shallow 'perched' water is present within the existing fill deposits, with groundwater estimated at depths of 2 to 4 metres below the existing grade. As such, some infiltration of groundwater 'perched' within the fill, through permeable seams, as well as surface runoff into open excavations, should be anticipated. The rate of infiltration in the low permeability clayey silt/silty clay soils are anticipated to be relatively low, such that it should be possible to adequately control groundwater infiltration for the short construction period using conventional construction dewatering methods, such as pumping from sumps in the base of the excavation. More groundwater control should be anticipated when connections are made to existing services, and excavations through the areas of existing structures and service trenches. Surface water should be directed away from the excavations.

The base of the excavations in any engineered fill and native silty clay/clayey silt encountered in the boreholes and test pits should generally remain firm and stable. However, for storm and sanitary sewers extending into the non-engineered clayey silt/silty clay it will be necessary to undertake additional efforts to provide a stable base for support of services. This would involve sub-excavation to remove any organic material [if present] from beneath the pipe, and replacement with quality engineered fill. The use of crushed aggregate, such as OPSS Granular A or B, High Performance Bedding [HPB] material, or 19-millimetre clear stone, would be appropriate options. In the case of 19-millimetre clear stone it would be necessary to encase the clear stone in a heavy geofabric to prevent the intrusion of fines and potential settlements.

With a stable base condition, standard pipe bedding, as typically specified by the Ontario Provincial Standard Specification will be satisfactory, compacted to a minimum of 95 per cent of its standard Proctor maximum dry density [SPMDD], should suffice.

8. MANHOLES, CATCH BASINS AND THRUST BLOCKS

Properly prepared bearing surfaces for manholes, valve chambers, etc. in the competent soils or engineered fill, stabilised where required, will be practically non-yielding under the anticipated loads. As noted above it is anticipated that stabilisation and/or sub-excavation below some manhole structures will be necessary to remove the organic soils beneath the structure. Similar stabilisation measures as recommended above should be implemented where required. Proper preparation of the founding soils will tend to accentuate the protrusion of these structures above the pavement surface if compaction of the fill around these structures is not adequate, causing settlement of the surrounding paved surfaces. Conversely, the pavement surfaces may rise above the valve chambers and around manholes under frost action. To alleviate the potential for these types of differential movements, free-draining, non-frost susceptible material should be employed as backfill around the structures located within the paved roadway limits, and compacted to 100 per cent of its standard Proctor maximum dry density.

The thrust blocks in the competent fill soils may be conservatively sized as recommended by the applicable Ontario Provincial Standard Specification conservatively using a horizontal allowable bearing pressure of up to 100 kPa [~2,000 psf]. Any backfill required behind the blocks should be a well-graded granular product and should be compacted to 100 per cent of its standard Proctor maximum dry density.

It is recommended that watermains be designed to have restrained joints.

It is recommended that rear yard catch basins be designed such the pipe is at an elevation at or above the anticipated founding elevation, in order to avoid conflict during foundation construction. Where rear yard CB lines are located at an elevation below the design founding level it would be necessary to local lower the foundation to be below the line of influence to the pipe. Alternatively, the rear yard CB line could be provided with an initial lift of backfill using 'lean mix' [~5 MPa concrete] up to the anticipated adjacent house founding level. This would eliminate any conflict or need to locally lower foundations.

9. PAVEMENT STRUCTURE DESIGN CONSIDERATIONS

All areas to be paved must be cleared of all organic and otherwise unsuitable materials, and the exposed subgrade proof rolled with 3 to 4 passes of a loaded tandem-axle truck in the presence of a representative of SOIL-MAT ENGINEERS & CONSULTANTS LTD., immediately prior to the placement of the sub-base material. Any areas of distress revealed by this or other means should be sub-excavated and replaced with suitable backfill material. Where the subgrade condition is poorer it may be necessary to implement more aggressive stabilisation methods, such as the use of coarse aggregate [50-millimetre clear stone, 'rip rap' stone, etc.] 'punched' into the soft areas. It may also be prudent to consider the provision of a heavy geofabric over the subgrade to act as a separator between the subgrade and granular base materials.

Good drainage provisions will optimise the long-term performance of the pavement structure. The subgrade must be properly crowned and shaped to promote drainage to the subdrain system. Subdrains should be installed to intercept excess subsurface water and to prevent softening of the subgrade material. Surface water should not be allowed to pond adjacent to the outer limits of the paved areas.

The most severe loading conditions on the subgrade typically occur during the course of construction, therefore precautionary measures may have to be taken to ensure that the subgrade is not unduly disturbed by construction traffic. SOIL-MAT should be given the opportunity to review the final pavement structure design and subdrain scheme prior to construction to ensure that they are consistent with the recommendations of this report.

If construction is conducted under adverse weather conditions, additional subgrade preparation may be required. During wet weather conditions, such as during the fall and spring months, it should be anticipated that additional subgrade preparation will be required, such as additional depth of Ontario Provincial Standard Specification [OPSS] Granular 'B', Type II (crushed limestone) sub-base material. It is also important that the sub-base and base granular layers of the pavement structure be placed as soon as possible after exposure, preparation and approval of the subgrade level.

The proposed roadways within the residential subdivision would be required to adequately support cars, trucks, and intermittent delivery and garbage trucks. The pavement structure should be consistent with the applicable City of Niagara Falls standards where the roadways are to be assumed by the City. It is understood that the City of Niagara Falls standards for local residential roadways consists of 450 millimetres of Granular A base course, 75 millimetres of HL8 binder course asphaltic concrete, and 40 millimetres of HL3 surface course asphaltic concrete. It is our experience that pavement structures typically perform better in the short-term during construction and long-term when a sub-base course layer of Granular 'B' Type II (crushed limestone bedrock) is provided. Consideration should be given to revised granular layers consisting of 300 millimetres of Granular 'B' Type II sub-base course and 150 millimetres of Granular 'A' base course material. It is our opinion that this design is suitable for use on a residential roadway section, provided that the subgrade has been prepared as specified and is good and firm before the sub-base course material is placed. If the subgrade is soft, remedial measures as discussed above may have to be implemented and/or the sub-base thickness may have to be increased.

The granular sub-base and base courses and asphaltic concrete layers should be compacted to OPSS or City of Niagara Falls requirements. Typically, a minimum of 98% SPMDD for granular base and a minimum of 92 per cent of their Marshall maximum relative density [MRD]. A program of in-place density testing must be carried out to monitor that compaction requirements are being met. We note that this pavement structure is not considered suitable for use as a construction roadway.

To minimise segregation of the finished asphalt mat, the asphalt temperature must be maintained uniform throughout the mat during placement and compaction. All too often, significant temperature gradients exist in the delivered and placed asphalt with the cooler portions of the mat resisting compaction and presenting a honeycomb surface. As the spreader moves forward, a responsible member of the paving crew should monitor the pavement surface, to ensure a smooth uniform surface. The contractor can mitigate the surface segregation by 'back-casting' or scattering shovels of the full mix material over the segregated areas and raking out the coarse particles during compaction operations. Of course, the above assumes that the asphalt mix is sufficiently hot to allow the 'back-casting' to be performed.

Asphalt paving of driveways should be consistent with the general recommendations provided above. Proper preparation of the subgrade soils is essential to good long-term performance of the pavement. Likewise, sufficient depth and compaction of granular base materials and adequate drainage will be important in achieving good long-term performance, i.e. preventing/limiting premature cracking, subgrade failure, rutting, etc. A recommended light duty pavement structure for residential driveways would consist of a minimum of 200 millimetres of OPSS Granular 'A' base course, compacted to 100 per cent standard Proctor maximum dry density, followed by a minimum of 50 millimetres of HL3 or HL3F asphaltic concrete, compacted to a minimum of 92 per cent of their Marshall maximum relative density [MRD].

10. HOUSE CONSTRUCTION

Based on the conditions encountered in the boreholes reported by Wood, and more recent test pits, as described above, the fill material present at and within the zone of influence of the proposed foundations is generally stiff to soft in consistency. As outlined above, sorting and re-engineering of existing fill would be suitable to afford adequate support conditions for foundations. Depending on the final grading this may result in founding levels within the native soils, or new engineered fill.

Where the founding level is within the depth of existing fill, it is recommended to excavate and replace a minimum of 1.2 metres of engineered fill as described above in order for the founding soils within the zone of influence to be considered capable of supporting the loads typically associated with light residential structures. Where the engineered fill is conducted using entirely on-site silty clay soil, the depth of engineered fill ‘cap’ should be a minimum of 1.2 metres below the design founding level. Where a minimum 0.3 metre base lift of Granular B is provided, achieving a more stable condition for subsequent fill placement, the total depth of the engineered fill ‘cap’ could be reduced to 1.0 metres [inclusive of the Granular B]. This is best assessed in the field during the course of the earthworks, based on prevailing weather conditions, etc. It could also be considered to provide an engineered fill ‘cap’ consisting entirely of Granular B, or similar. This would be an effective approach to account for fill placement in poor weather conditions, and would allowing for a reduction of the total depth of engineered fill ‘cap’ to 0.9 metres. Again, this is best assessed in the field based on actual conditions at the time of placement.

The proposed structures may be supported with conventional spread footings founded on an engineered fill pad, as described above, below any otherwise unsuitable material. Spread footings founded on engineered fill as noted above may be conservatively designed using a factored Ultimate Limit State [ULS] bearing capacity of 115 kPa [~2,500 psf]. The allowable bearing stress at Serviceability Limit State [SLS] should be limited to 75 kPa [~1,500 psf], based on the total and differential settlements not exceeding 25 and 20 millimetres, respectively. Where footings extend to the underlying native silty clay, increased bearing values of 100 kPa [2,000 psf] SLS and 150 kPa [~3,000 psf] ULS may be considered.

It is noted that the SLS value represents the Serviceability Limit State, which is governed by the tolerable deflection [settlement] based on the proposed building type, using unfactored load combinations. The ULS value represents the Ultimate Limit State and is intended to reflect an upper limit of the available bearing capacity of the founding soils in terms of geotechnical design, using factored load combinations. There is no direct relationship between ULS and SLS; rather they are a function of the soil type and the tolerable deflections for serviceability, respectively. Evidently, the bearing capacity values would be lower for very settlement sensitive structure and larger for more flexible buildings.

The support conditions afforded by the pre-existing fill soils and engineered fill founding soils are generally not uniform across the site, neither are the loads on the various foundation elements. It is recommended that the footings and foundations walls should be nominally reinforced to account for the variable support conditions afforded by the fill soils and loading conditions. Such reinforcement will act to reduce the potential for cracking in the foundation walls due to minor settlements, heaving, shrinkage, etc. and will assist in resisting the earth pressures generated against the foundation walls by the backfill. This nominal reinforcement is an economical approach to the reduction or prevention of costly foundation repairs after completion and later in the life of the buildings. As well it is recommended that the minimum footing dimensions be specified as 600 millimetres [24 inches] wide by 200 millimetres [8 inches] deep.

The reinforcing detail should be as specified by the structural engineer. At a minimum, nominal reinforcement should consist of two continuous 15M steel bars placed in the footings [directly below the foundation wall] and a similar two continuous 15M steel bars placed approximately 300 millimetres from the top of the foundation walls. The reinforcing bars should be bent to reinforce all corners and under basement windows, and be provided with sufficient overlap at staggered splice locations. At 'steps' in the foundations and at window locations, the reinforcing steel should be bent to follow the step diagonally, rather than at 90 degrees, to maintain the continuous tensile capacity of the reinforcement.

All footings exposed to the environment must be provided with a minimum of 1.2 metres of earth cover or equivalent insulation to protect against frost damage. This frost protection would also be required if construction were undertaken during the winter months. All footings and foundations should be designed and constructed in accordance with the current Ontario Building Code.

All basement walls should be suitably damp-proofed, including a 'dimple type' drainage boarding leading to a perimeter drainage tile system. The perimeter weeping tile should consist of a perforated plastic pipe with a geofabric sock, surrounded with a minimum of 200 millimetres [top and sides] of 20-millimetre clear stone, in turn encased in a heavy geofabric. The perimeter drainage system should outlet to a gravity storm sewer connection or sump pit, fitted with a suitable back-flow prevention valve.

It is imperative that a soils engineer be retained from this office to provide geotechnical engineering services during the excavation and foundation construction phases of the project. This is to observe compliance with the design concepts and recommendations of this report and to allow changes to be made in the event that subsurface conditions differ from the conditions identified at the borehole locations.

11. GENERAL COMMENTS

The comments provided in this document are intended only for the guidance of the design team. The material in it reflects SOIL-MAT ENGINEERS' best judgement in light of the information available to it at the time of preparation. The subsurface descriptions and test pit information are intended to describe conditions at the test pit locations only. It is the contractors' responsibility to determine how these conditions will affect the scheduling and methods of construction for the project. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. SOIL-MAT ENGINEERS accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

We trust that this geotechnical report is sufficient for your present requirements. Should you require any additional information or clarification as to the contents of this document, please do not hesitate to contact the undersigned.

Yours very truly,
SOIL-MAT ENGINEERS & CONSULTANTS LTD.

Kevin Reid, B.Eng., EIT

Ian Shaw, P.Eng., QP_{ESA}
Senior Engineer

LICENSED PROFESSIONAL ENGINEER
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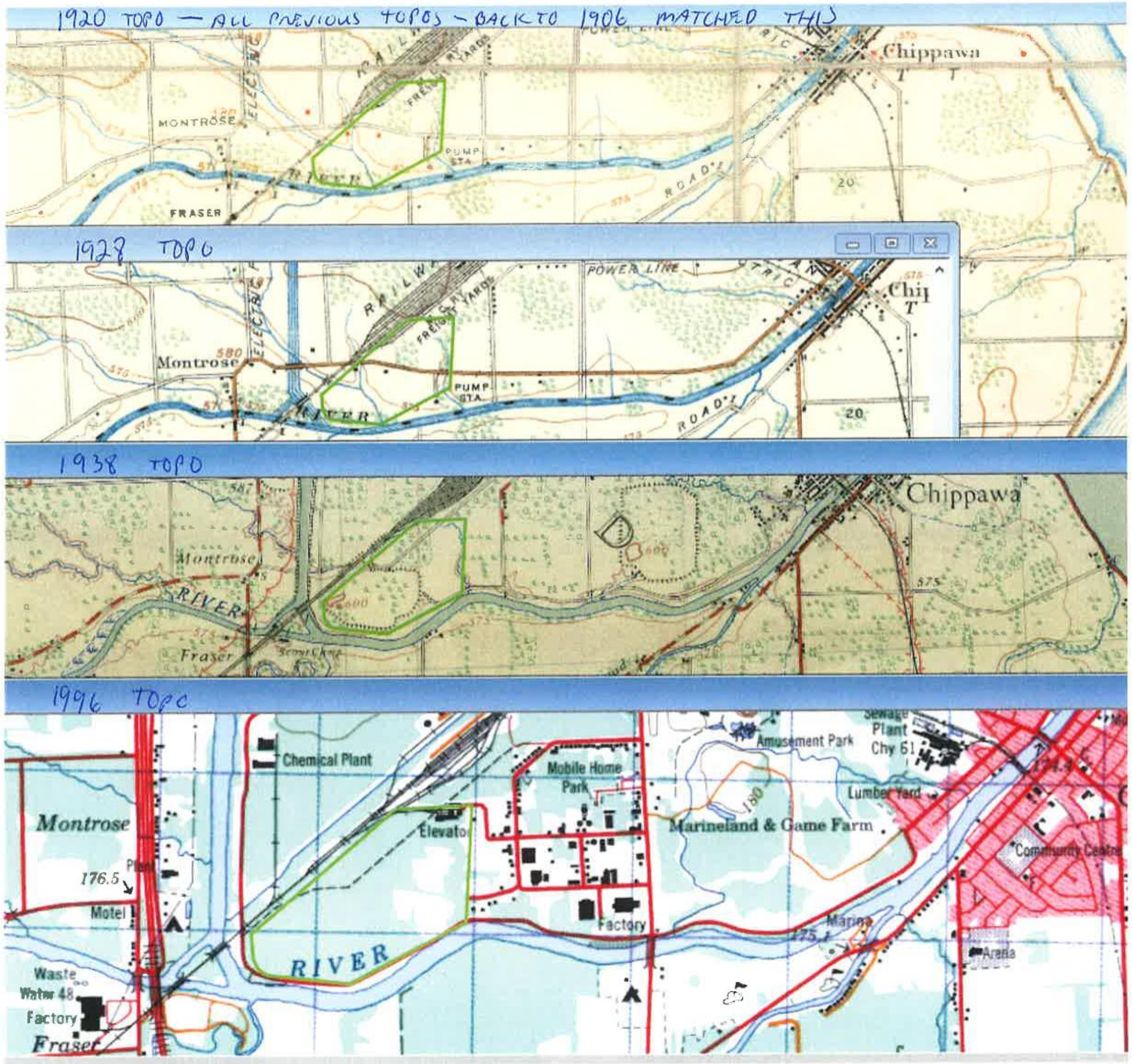
PROVINCE OF ONTARIO

Enclosures: Drawing No. 1, Historical Topographic Map Comparison
Drawing Nos. 2 and 3, Test Pit Location Plan
Table A: Summary of Test Pit Conditions

Distribution: Centennial Construction and Contracting (Niagara) Inc. [1, by pdf]



LEGEND

NOTES

1. This drawing should be read in conjunction with Soil-Mat Engineers & Consultants Ltd. Geotechnical Report SM 220069-G.

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Supplemental Geotechnical Assessment
Riverfront Residential Development Lands
Niagara Falls, Ontario

Historical Topographic Map Comparison

Project No. SM 220069-G

Date: January 2023

Drawn: KJR | Checked: IS

SM 220069-GE Historical Comparison

Drawing No. 1

LEGEND
Test Pit Location
Test Pit Information
Borehole Information (wood)
Groundwater Information (wood)
Reusable Fill
Unsuitable/Requires Sorting
SOIL-MAT
ENGINEERS & CONSULTANTS LTD.
Test Pit and Fill Depth Location Plan
To be read with Geotechnical Report SM 220069-G
Test Pit Location Plan
Project No. SM 220069-G
Date: December 2022
Drawn: KJR
Checked: IS
SM 220069-G Test Pit Location Plan
Drawing No. 2
CONRAIL DRAIN
EXISTING RAILWAY(C.N.R)
CHIPPAWA PKWY.
WELLAND RIVER
BH/MW-447
FILL Depth - 0m
Elevation - 178.4
BH-414
FILL Depth - 0.2m
Elevation - 178.0
TP 22
FILL Depth - 1.2m
TP 21
FILL Depth - 3.2m
TP 20
FILL Depth - 6.1m
BH-406
FILL Depth - 2.5m
Elevation - 176.4
TP 14
FILL Depth - 3.4m
BH/MW-446
FILL Depth - 1.1m
Elevation - 177.7
Water Level:
2.8 / 178.0
BH/MW-101
FILL Depth - 4.6m
Elevation - 176.2
*Peat layer at 4.4m
BH-403
FILL Depth - 4.0m
Elevation - 175.5
FILL Depth - 3.1m
Elevation - 175.7
TP 13
FILL Depth - 3.0m
BH-415
FILL Depth - 5.6m
Elevation - 172.4
TP 19
FILL Depth - 2.3m
BH-416
FILL Depth - 3.6m
Elevation - 174.3
TP 12
FILL Depth > 5.5 m
BH-404
FILL Depth - 2.9m
Elevation - 178.2
TP 18
FILL Depth - 5.6m
FILL Depth - 5.6m
Elevation - 172.2
BH-405
FILL Depth - 1.4 to 5.6*m
Elevation - 177.6 to 173.4*
BH-408
FILL Depth - 1.4 to 5.6*m
Elevation - 179.1 to 174.9*
TP 11
FILL Depth > 5.5m
FILL Depth - 7.2m
Elevation - 171.8
BH-420
BH-425
FILL Depth - 2.4m
Elevation - 175.8
TP 10
FILL Depth > 6.4m
BH-413
FILL Depth - 2.5m
Elevation - 177.3
TP 09
FILL Depth - 4.0m
BH-426
FILL Depth - 3.4m
Elevation - 174.7
BH/MW-421
FILL Depth - 3.4m
Elevation - 175.7
Water Level:
1.2 / 177.8
TP 08
FILL Depth > 5.2m
BH-402
FILL Depth - 4.0m
Elevation - 176.7
TP 06
FILL Depth > 4.6m
TP 17
FILL Depth - 3.6m
BLOCK 1
BLOCK 3
BLOCK 5
BLOCK 6
STREET C
STREET D
TP 05
FILL Depth > 4.3m
BH-411
FILL Depth - 1.4 to 4.0*m
Elevation - 179.1 to 176.5*
TP 07
FILL Depth > 4.6m
BH/MW-102
Water Level:
3.7 / 179.3 ?
BH-410
FILL Depth - 2.1m
Elevation - 176.6
FILL Depth - 4.3m
Elevation - 174.5
BH-427
TP 04
FILL Depth - 5.4m
BH/MW-202
FILL Depth - m
Elevation -
Water Level:
2.4 / 177.4
BH/MW-412
FILL Depth - 5.6m
Elevation - 175.7
Water Level:
1.8 / 179.5
BH-418
FILL Depth - 1.4m
Elevation - 181.0
TP 16
FILL Depth - 5.2m
TP 02
FILL Depth > 4.6m
FILL Depth - 5.1m
Elevation - 173.1
BH-428
TP 15
FILL Depth - 5.9m
TP 03
FILL Depth > 4.0m
BH-419
N.A. in report
table?
BH-422
FILL Depth - 1.4m
Elevation - 179.8
BH/MW-201
Water Level:
2.7 / 176.6
BH-424
FILL Depth - 0m
Elevation - 178.9
TP 01
FILL Depth > 4.3m

LEGEND

- TP ## — Test Pit Location
- Test Pit Information
- Borehole Information (wood)
- Groundwater Information (wood)
- Reusable Fill
- Unsuitable/Requires Sorting
- Topsoil

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Test Pit and Fill Depth Location Plan
To be read with Geotechnical Report SM 220069-G

Test Pit Location Plan

Project No. SM 220069-G

Date: December 2022

Drawn: KJR	Checked: IS

SM 220069-G Test Pit Location Plan

Drawing No. 3

TABLE A: SUMMARY OF TEST PIT CONDITIONS
TEST PIT NOS. 1 TO 30

Test Pit	Depth (m)	Description
1	0 – 0.9	**Silty Clay/Clayey Silt Fill** – Brown, frequent tree roots, reworked in appearance.
	0.9 – 4.3	**Silty Clay/Clayey Silt Fill** – Mottled brown and grey, stiff.
2	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 1.4	**Silty Clay/Clayey Silt Fill** – Brown, frequent tree roots, reworked in appearance.
	1.4 – 4.6	**Silty Clay/Clayey Silt Fill** – Mottled brown and grey, occasional organics (treated fencepost at 3.3 m), stiff.
3	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.4 – 1.4	**Silty Clay/Clayey Silt Fill** – Brown, occasional tree roots, trace to some sand.
	1.4 – 4.0	**Silty Clay Fill** – Brown, occasional roots, soft.
4	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil
	0.4 – 1.4	**Silty Clay/Clayey Silt Fill** – Brown, occasional tree roots, trace to some sand, trace gravel.
	1.4 – 5.4	**Silty Clay Fill** – Brown, frequent silty sand seams in the lower levels, stiff
	5.4 – 5.6	**Native Silty Sand** – Brown, some clay, compact.
5	0 – 0.5	**Topsoil** – Approximately 500 millimetres of topsoil.
	0.5 – 1.0	**Silty Clay/Clayey Silt Fill** – Brown, trace to some gravel, occasional tree roots, reworked in appearance.
	1.0 – 4.3	**Silty Clay Fill** – Brown, trace gravel, soft.
6	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.4 – 1.2	**Silty Clay/Clayey Silt Fill** – Brown, frequent organics, reworked in appearance.
	1.2 – 4.6	**Silty Clay Fill** – Brown, trace organics, occasional sand seams, soft.
7	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 4.6	**Silty Clay/Clayey Silt Fill** – Brown, occasional organics, trace sand.
8	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 1.7	**Silty Clay/Clayey Silt Fill** – Brown, occasional organics.
	1.7 – 5.2	**Silty Clay Fill** – Grey, trace gravel, soft.

9	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.4 – 1.2	**Silty Clay/Clayey Silt Fill** – Brown, trace to some sand, occasional organics.
	1.2 – 3.0	**Silty Clay Fill** – Brown, some gravel, soft.
	3.0 – 3.2	**Silty Sand Fill** – Grey, some clay, moderate organic staining and odor.
	3.2 – 4.0	**Silty Clay Fill** – Brown, some gravel, soft.
	4.0 – 4.5	**Native Silty Clay/Clayey Silt** – Mottled brown and grey, stiff.
10	0 - 0.5	**Topsoil** – Approximately 500 millimetres of topsoil.
	0.5 – 1.8	**Silty Sand Fill** – Brown, some clay.
	1.8 – 6.4	**Silty Clay Fill** – Gray, frequent layers of silty sand, occasional large organic inclusions, wet and soft.
11	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.4 – 2.1	**Silty Sand Fill** – Brown, some clay, trace organics, compact.
	2.1 – 5.5	**Silty Clay Fill** – Brown, some sand, trace gravel, firm to stiff.
12	0 – 5.2	**Cobbles** – Some sand and gravel.
	5.2 – 5.5	**Silty Clay Fill** – Grey, soft.
13	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.4 – 2.1	**Silty Clay/Clayey Silt Fill** – Brown, frequent roots.
	2.1 – 3.0	**Silty Clay/Clayey Silt Fill** – Grey, significant organic staining and odor.
	3.0 – 3.3	**Native Silty Clay/Clayey Silt** – Brown, trace sand, stiff.
14	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.4 – 1.2	**Silty Clay/Clayey Silt Fill** – Brown, trace roots, occasional organics.
	1.2 – 3.4	**Silty Clay Fill** – Brown, occasional seams of organic material
	3.4 – 3.7	**Native Silty Clay/Clayey Silt** – Brown, trace sand, stiff.
15	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 1.2	**Silty Clay/Clayey Silt Fill** – Brown, trace sand.
	1.2 – 2.7	**Silty Clay Fill** – Grey, soft.
	2.7 – 3.9	**Sand Fill** – Grey, compact.
	3.9 – 5.8	**Silty Clay Fill** – Grey, soft.
	5.8 – 5.9	**Organic Material** – approximately 150-millimeter band of organic material
	5.9 – 6.1	**Native Silty Clay/Clayey Silt** – Brown, stiff.

16	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.4 – 1.5	**Silty Sand Fill** – Brown, trace sand, occasional roots.
	1.5 – 5.2	**Silty Clay Fill** – Grey, trace organics, soft.
	5.2 – 5.4	**Native Silty Clay/Clayey Silt** – Brown, trace sand, stiff.
17	0 – 0.2	**Topsoil** – Approximately 200 millimetres of topsoil.
	0.2 – 1.8	**Silty Sand Fill** – Brown, trace clay, occasional roots.
	1.8 – 3.6	**Silty Clay Fill** – Grey, occasional roots, soft.
	3.6 – 3.9	**Native Silty Clay/Clayey Silt** – Brown, some sand, stiff.
18	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 1.8	**Silty Sand Fill** – Brown, trace clay, occasional roots.
	1.8 – 5.6	**Silty Clay Fill** – Grey, trace sand, soft to stiff.
	5.6 – 5.9	**Native Silty Clay/Clayey Silt** – Brown, trace sand and gravel, 50-millimetre seam of organic material at 5.6 metres.
19	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 1.5	**Silty Sand Fill** – Brown, occasional roots.
	1.5 – 2.1	**Silty Clay** – Grey, stiff.
	2.1 – 2.3	**Organic Material** – Approximately 200 millimetres of organic material.
	2.3 – 3.0	**Native Silty Clay/Clayey Silt** – Grey and brown mottling, some gravel, occasional cobbles, stiff.
20	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 2.4	**Silty Sand/Sandy Silt Fill** – Brown, compact.
	2.4 – 5.8	**Silty Clay Fill** – Brown, soft.
	5.8 – 6.1	**Silty Clay/Clayey Silt Fill** – Brown, moderate organic staining and odor.
	6.1 – 6.4	**Native Silty Clay/Clayey Silt** – trace sand, stiff.
21	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil and wood mulch.
	0.4 – 3.2	**Silty Clay/Clayey Silt Fill** – Brown, occasional organics in upper levels, firm.
	3.2 – 3.6	**Native Silty Clay/Clayey Silt** – Brown, stiff.
22	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.4 – 1.2	**Silty Clay/Clayey Silt Fill** – Brown, stiff.
	1.2 – 1.8	**Native Silty Clay/Clayey Silt** – Brown, stiff.

23	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 0.8	**Native Silty Clay/Clayey Silt** – Brown, trace sand, stiff.
24	0 – 0.6	**Topsoil** – Approximately 600 millimetres of topsoil.
	0.6 – 2.7	**Silty Clay/Clayey Silt Fill** – Brown, frequent roots in upper levels, perched water, stiff.
	2.7 – 3.0	**Native Silty Clay/Clayey Silt** – Brown, stiff.
25	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.6 – 1.5	**Silty Clay/Clayey Silt Fill** – Brown, trace sand and gravel, stiff.
	1.5 – 1.8	**Native Silty Clay/Clayey Silt** – Brown, stiff.
26	0 – 0.4	**Topsoil** – Approximately 400 millimetres of topsoil.
	0.4 – 1.5	**Silty Clay/Clayey Silt Fill** – Brown, trace sand and gravel, stiff.
	1.5 – 1.8	**Native Silty Clay/Clayey Silt** – Brown and grey mottling, stiff.
27	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 1.5	**Silty Clay/Clayey Silt Fill** – Brown, trace sand and gravel, stiff.
	1.5- 2.4	**Native Silty Clay/Clayey Silt** – Brown, stiff.
28	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 1.0	**Silty Clay/Clayey Silt Fill** – Brown, stiff.
	1.0 – 3.0	**Silty Clay Fill** – Brown, stiff.
	3.0 – 3.9	**Native Silty Clay/Clayey Silt** – Brown, stiff, significant organic staining in upper 0.2 metres, reworked in appearance in upper levels.
29	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 1.5	**Silty Clay/Clayey Silt Fill** – Brown, moderate roots in the upper levels.
	1.5 – 1.8	**Native Silty Clay/Clayey Silt** – Brown, stiff.
30	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 1.5	**Silty Clay/Clayey Silt** – Brown, occasional organics, stiff.
	1.5 – 2.4	**Native Silty Clay/Clayey Silt** – Brown, stiff.

TABLE B: SUMMARY OF TEST PIT CONDITIONS
TEST PIT NOS. 101 TO 112

Test Pit	Depth (m)	Description
101	0 – 0.1	**Topsoil -** Approximately 100 millimetres of topsoil.
	0.1 – 3.0	**Silty Clay/Clayey Silt Fill –** Brown, trace to some organics, trace

		to some sand, trace gravel.
	3.0 – 3.5	**Organic Material –** Approximately 500 millimetres of organic material.
	3.5 – 5.0	**Native Silty Clay/Clayey Silt –** Mottled Brown and Grey, occasional rootlets, trace sand, trace gravel, hard.
102	0 – 5.0	**Silty Clay/Clayey Silt Fill** – Brown, trace organics, trace to some sand, trace gravel, reworked in appearance.
103	0 – 0.3	**Topsoil** – Approximately 300 millimetres of topsoil.
	0.3 – 4.0	**Silty Clay/Clayey Silt Fill** – Brown, occasional tree roots, trace to some sand.
	4.0 – 7.5	**Organic Material –** Approximately 3.5 metres of organic material.
	7.5 – 8.5	**Native Silty Clay/Clayey Silt** – Mottled Brown and Grey, trace to some sand, trace gravel, trace organics.
104	0 – 0.15	**Topsoil** – Approximately 150 millimetres of topsoil.
	0.15 – 5.0	**Silty Clay/Clayey Silt Fill** – Brown, occasional tree roots, trace to some sand, trace gravel.
105	0 – 0.15	**Topsoil** – Approximately 150 millimetres of topsoil.
	0.15 – 4.0	**Silty Clay/Clayey Silt Fill** – Brown, trace to some gravel, occasional tree roots, reworked in appearance.
	4.0 – 6.0	**Organic Material** – Approximately 2 metres of organic material.
	6.0 – 6.5	**Native Silty Clay/Clayey Silt** – Mottled brown and grey, trace to some sand, trace gravel.
106	0 – 0.15	**Topsoil** – Approximately 150 millimetres of topsoil.
	0.15 – 2.1	**Silty Clay/Clayey Silt Fill** – Brown, frequent organics, reworked in appearance.
	2.1 – 2.4	**Organic Material** – Approximately 300 millimetres of organic material.
	2.4 – 3.0	**Native Silty Clay/Clayey Silt** – Mottled brown and grey, trace to some sand, trace gravel.
107	0 – 0.15	**Topsoil** – Approximately 150 millimetres of topsoil.
	0.15 – 3.0	**Silty Clay/Clayey Silt Fill –** Brown, occasional organics, trace sand.
	3.0 – 4.0	**Native Silty Clay/Clayey Silt** – Mottled Brown and Grey, trace to some sand, trace gravel.
108	0 – 0.15	**Topsoil** – Approximately 150 millimetres of topsoil.
	0.15 – 3.0	**Silty Clay/Clayey Silt Fill** – Brown, occasional organics, trace to some sand, trace gravel.
	3.0 – 4.0	**Native Silty Clay/Clayey Silt** – Grey, trace gravel, stiff.

109	0 – 0.15	**Topsoil** – Approximately 150 millimetres of topsoil.
	0.15 – 1.2	**Native Silty Clay/Clayey Silt** – Mottling brown and grey, trace to some sand, occasional organics, trace gravel.
110	0 – 5.5	**Organic Material** – Approximately 5.5 metres of organic material.
	5.5 – 6.0	**Native Silty Clay/Clayey Silt** – Mottled Brown and Grey, trace to some sand, trace gravel, trace organics.
111	0 – 5.5	**Organic Material** – Approximately 5.5 metres of organic material .
	5.5 – 6.0	**Silty Clay/Clayey Silt** – Brown, some clay, trace organics, trace to some sand, trace gravel.
112	0 – 0.15	**Topsoil** – Approximately 150 millimetres of topsoil.
	0.15 – 1.0	**Silty Clay/Clayey Silt Fill** – Brown, trace to some sand, trace gravel, reworked in the upper levels.
	1.0 – 3.0	**Organic Material –** Approximately 2.0 metres of organic material.
	3.0 – 3.5	**Native Silty Clay/Clayey Silt –** Mottled brown and grey, trace organics, trace to some sand, trace gravel.