The CFA piles should be founded in the compact silt till (below Elevation 371.8 m). This is approximately 6.5 m below the lowest finished floor level of 379.53 m and 4 m below the concrete channel at Elevation 377.2 m. CFA piles assumed to be 600 mm in diameter extending to these depths may be designed for a factored geotechnical bearing resistance at Ultimate Limit States of 325 kN, and a soil bearing resistance at Serviceability Limit States of 250 kN for 25 mm of settlement. Uplift resistance should be considered in the design of the piles due to the perched groundwater table at the site.

Cobbles were noted in the sand and gravel fill and may affect the rate of installation of the CFA piles.

If a pile cap is constructed below grade and outside of heated areas, a minimum 1.5 m of earth cover, or equivalent insulation, must be provided for adequate protection against potential frost damage.

It is recommended that full-time geotechnical monitoring be provided during the installation of the CFA piles so that an accurate record of drilled shaft sizes, alignment, locations, lengths, cut-off elevations, and installation procedures can be kept. Sampling and testing of concrete compressive strength cylinders to the requirements of CSA A23.1 and A23.2 is recommended. At least one set of concrete cylinders should be taken for each day that CFA piles are installed. The tops of the CFA piles should be protected against cold weather in accordance with the requirements of CSA A23.1

Additionally, it is recommended that several CFA piles should be subject to a static load test in accordance with ASTM D1143 "Standard Test Methods for Deep Foundations Under Static Axial Compressive Load" and ASTM D3689 "Standard Test Methods for Deep Foundations Under Static Axial Tensile Load." These tests are typically performed by the deep foundations contractor and thus it is recommended that qualified geotechnical personnel be present during these tests to independently record and verify the results.

## 4.3 TRANSFORMER SLAB

The existing fill at transformer slab (refer to Borehole BH-08-16) should be suitable to support the concrete base slab subject to inspection by a qualified geotechnical engineer at the time of construction. A 150 mm thick layer of well compacted Granular 'A' materials is recommended to be placed directly beneath the base slab. The subgrade should be proof-rolled and compacted, and the results observed by a geotechnical inspector prior to placing the Granular 'A' base material.

## 4.4 SULPHATE ATTACK ON CONCRETE

Representative soil samples were tested for pH, water soluble sulphate as SO4, and chloride, and the test results are summarized on the following table:

Table 2: Soil Sulphate Test Results

| BOREHOLE NUMBER | SAMPLE DEPTH (m) | pH VALUE | WATER SOLUBLE SULPHATES (AS $SO_4$) IN SOIL SAMPLES (mg/kg) | CHLORIDE (µg/g) | DEGREE OF EXPOSURE FOR BURIED CONCRETE STRUCTURES |
|---|---|---|---|---|---|
| BH-101-16 | 7.62 – 8.23 | 7.96 | 50 | 31.4 | negligible |
| BH-102-16 | 5.33 – 5.94 | 7.59 | 39 | 24.4 | negligible |
| BH-103-16 | 3.05 – 3.65 | 7.76 | 47 | 40.2 | negligible |

Note: Laboratory testing by ALS Environmental.

Based on the test results there is a negligible potential for sulphate attack on concrete. Therefore, according to CSA A23.1-09 blended general use hydraulic cement may be used. A corrosion specialist should review this data with respect to concrete and metal structures.

## 4.5 EXCAVATIONS AND DEWATERING

Temporary excavation to conventional depths for construction of foundations and services must comply with Regulation 213/91 (Construction Projects) under the Ontario Occupational Health and Safety Act. The predominant soil encountered in the boreholes would be classified as Type 4 soils, and temporary side slopes and must be trimmed back at 3 horizontal to 1 vertical (as per O. Reg. 213/91, S.234(2)). If groundwater seepage is occurring into the excavations, then slopes may need to be trimmed back at a flatter angle to achieve stability.

Because of the perched groundwater tables within the fill and sand, moderate groundwater inflow is expected. Where the excavations extend through these perched groundwater regimes, the side slopes should be trimmed back at approximately 3 horizontal to 1 vertical to ensure stability. It is believed that this groundwater flow can be controlled using a gravity dewatering system with interceptor ditches and pumps. It is recommended construction begin in the dry summer months when water levels are lower.

## 4.6 CONCRETE SLAB-ON-GRADE

It is anticipated that the building slab at the WWTP will be designed as a structural slab. We suggest that a 50 mm thick layer of insulation be placed below the structural slab to provide frost protection and separation from the subgrade soil.

Alternatively, concrete slabs for buildings required for the upgrades may be constructed using conventional concrete slab-on-grade techniques following the removal of all existing fill and placement of well-compacted sand and gravel structural fill (OPSS Type 1 Granular 'B' recommended). It is understood the finished floor of the proposed buildings will be Elevation 379.53 m and an interior concrete channel base slab will be at Elevation 377.20 m as provided by Matt Ash of GM BluePlan Engineering Limited.

The structural fill material must be compacted to 100% SPMDD. A minimum 200 mm thick layer of OPSS 1010 Granular 'A' material compacted to 100% SPMDD should be provided directly beneath the slab for levelling and uniform support purposes. No special underfloor drains are required provided that the exterior grades are lower than the slab and positively sloped away from the slab.

The modulus of subgrade reaction (K) for the site would be 30 MPa/m.

If the slab is exposed (unheated) then we recommend that insulation be placed beneath the slab in order to prevent differential frost heaving. The insulation should comprise minimum 50 mm thick rigid high density polystyrene, and must extend outwards at least 1.0 m beyond the edges of the slab.

The water-to-cement ratio and slump of concrete utilized in the slabs should be strictly controlled to minimize shrinkage of the slabs. Control joints should be sawed into the slabs at maximum 4 m spacings within 12 hours of initial concrete placement in order to pre-locate shrinkage cracks. The sawcut depth should be 1/4 of the slab thickness.

The slabs should be wet-cured for 7 to 28 days to minimize problems associated with shrinkage and curling. The wet-curing procedure involves placing water over the slab then covering the slab with plastic.

All weather exposed concrete shall have 5 to 8% air entrainment or as otherwise specified by the Table 1 CSA – A23.1 Concrete Materials & Methods of Construction.

During placement of concrete at the construction site, testing should be performed to determine the slump, temperature, and air entrainment of the concrete, and concrete cylinders should be cast for compressive strength testing.

## 4.7 SEISMIC SITE CLASSIFICATION

The parameters used to represent seismic hazard for specific geographic locations are the 5% damped horizontal spectral acceleration ($S_a$) values for 0.2, 0.5, 1.0 and 2.0 second periods and the horizontal Peak Ground Acceleration (PGA) value that have a 2% probability of being exceeded in 50 years as per Supplementary Standard SB-1 of the Ontario Building Code (2006). The seismic design values for the site are $S_a$ (0.2) = 0.093, $S_a$ (0.5) = 0.065, $S_a$ (1.0) = 0.040, $S_a$ (2.0) = 0.021, and PGA = 0.054.

A Site Classification of 'D' may be used for earthquake load and effects in accordance with Table 4.1.8.4.A. of the National Building Code of Canada (2015) and the Ontario Building Code (2012).

## 4.8 BACKFILLING

The foundations should be backfilled with OPSS Type 1 Granular 'B' and the services should be backfilled with approved inorganic soil placed in 300 mm thick lifts and compacted to minimum 95% standard Proctor maximum dry density as verified by insitu density testing. Consideration should be given to using hydraulically secure soil near the lagoon berms.

The majority of the excavated soils will be fill. Based on the results of the moisture content tests, the majority of the excavated inorganic fill will be suitable for use as backfill for services if the work is carried out during the dry summer months. Any wet fill should be dried or discarded prior to reuse as backfill. Also all cobbles or boulders should be sorted out and not used in the backfill.

Also if backfilling is carried out during the wet weather or during the winter then it is recommended that imported sand and gravel be used for exterior backfill rather than the on-site fill and sand material. The backfill should be protected from freezing by being covered with a thin layer of loose soil at the end of each day. The loose soil layer should be cleared prior to placing additional backfill the next day. Placement and compaction of backfill should not be carried out if the air temperature falls below -10° C. Ice and snow must be removed from any areas where fill is to be placed.

## 4.9 PIPE BEDDING AND SUPPORT

The subgrade soils beneath the new services will likely comprise fill it is anticipated the majority of fill will be suitable to support pipes without undergoing possible detrimental post-construction settlement. It is strongly recommended the fill be inspected at the time of pipe laying.

If loose and/or organic fill soils are contacted at the site for non-critical pipes, we recommend the following procedure to limit potential settlement:

- excavate to 300 mm below pipe invert;
- place bi-axial geogrid on subgrade; and,
- place and compact Granular 'A' pipe bedding, as required.

If the loose and/or organic fill soils remains below the critical piping then there is the possibility that the pipe may experienced both differential and total settlements and therefore helical pier supports (pipe cradles) should be used for the support of the critical piping.

Pipe bedding for sewer services should be conventional Class 'B' pipe bedding comprising a minimum 150 mm thick layer of OPSS Granular 'A' aggregate below the pipe invert. The bedding course may be thickened if portions of the subgrade become unduly wet during excavation. Granular 'A' type aggregate should be provided around the pipe to at least 300 mm above the pipe. The bedding aggregate should be compacted to a minimum 95% standard Proctor maximum dry density (SPMDD).

A well-graded clear stone such as Coarse Aggregate for HL4 Asphaltic Concrete (OPSS 1003) could be used in the sewer trenches as bedding below the spring line of the pipe to facilitate sump pump dewatering, if necessary. The clear stone should be compacted with a plate tamper.

The majority of the excavated inorganic soil from the trenches above the groundwater table should be reused as backfill. The backfill should be placed in 300 mm thick lifts and compacted to 95% standard Proctor maximum dry density (SPMDD). The organic and saturated granular soils should not be used for trench backfill.

Compaction testing by experienced geotechnical personnel should be carried out to examine and approve backfill materials, and to verify that the specified degree of compaction has been achieved.

## 4.10 CORROSION POTENTIAL

Three selected soil samples were tested for various parameters, including resistivity, pH, redox potential, and sulphides to assess the potential for corrosion of ductile pile. The test results, along with the Cast Iron Pipe Research Association (CIPRA) soil test evaluation rating system are shown on Table 3. A total point value of less than ten (10) was determined for the soils at the site and, therefore no corrosion protection is necessary for ferrous pipe according to the rating system. This information should be reviewed by a corrosion specialist.

Table 3: Corrosion Potential Test Results

| SOIL CHARACTERISTICS | CIPRA RATING SYSTEM | | BH-08-15 2.29 TO 2.74 m DEPTH | | BH-15-15 2.29 TO 2.74 m DEPTH | | BH-15-15 2.29 TO 2.74 m DEPTH | |
|---|---|---|---|---|---|---|---|---|
| | RESULTS | POINTS | RESULTS | POINTS | RESULTS | POINTS | RESULTS | POINTS |
| Resistivity (ohm-cm) | <700 | 10 | 3650 | 0 | 4880 | 0 | 3720 | 0 |
| | 700-1000 | 8 | | | | | | |
| | 1000-1200 | 5 | | | | | | |
| | 1200-1500 | 2 | | | | | | |
| | 1500-2000 | 1 | | | | | | |
| | >2000 | 0 | | | | | | |
| pH | 0-2 | 5 | 7.96 | 0 | 7.59 | 0 | 7.76 | 0 |
| | 2-4 | 3 | | | | | | |
| | 4-6.5 | 0 | | | | | | |
| | 6.5-7.5 | 0 | | | | | | |
| | 7.5-8.5 | 0 | | | | | | |
| | >8.5 | 3 | | | | | | |
| Redox Potential (mV) | >+100 | 0 | 166 | 0 | 170 | 0 | 187 | 0 |
| | +50-+100 | 3.5 | | | | | | |
| | 0-+50 | 4 | | | | | | |
| | negative | 5 | | | | | | |
| Sulphides | positive | 3.5 | <0.20 | 2 | <0.20 | 2 | <0.20 | 2 |
| | trace | 2 | | | | | | |
| | negative | 0 | | | | | | |
| Moisture | wet | 2 | 12.3 | 1 | 19.4 | 2 | 13.8 | 1 |
| | moist | 1 | | | | | | |
| | dry | 0 | | | | | | |
| **TOTAL POINTS** | | | | **3** | | **4** | | **3** |

## 4.11 TRENCHLESS TECHNOLOGY

It is understood that the 500 mm diameter PVC forcemain sewer will be installed beneath Highway 23 in the area of Boreholes BH-06-16 and BH-07-16 by trenchless technology. It is assumed the new sewer will be installed at invert Elevation 372.28 m (refer to GM BluePlan Engineering Limited Plan and Profile, Project No. 315047, Drawing 7, dated December 2015).

The subsurface soils contacted near the expected invert elevation will comprise sandy clayey silt fill deposits. Perched groundwater measured during drilling at 1.5 to 2.3 m below existing ground surface within the fill.

Installing the sewer by horizontal directional drilling (HDD), microtunnelling or jack and bore would be geotechnically feasible based on the soil deposits encountered at the borehole locations; however, minor to moderate groundwater inflow may be encountered (refer to Borehole BH-07-16). The dewatering system should be designed and installed by a specialist dewatering contractor. The contractor for the HDD should be aware of the fill/native soil interface 0.2 m below the proposed invert.

If a jack and bore procedure is used, the casing must be continuously advanced to the tunnel/bore face and the contractor must ensure no over-mining of soil at the face, which may create voids above the casing. During installation of the casing, careful inspection should be conducted by a geotechnical engineer. The casing should have an appropriate wall thickness to withstand both the jacking forces during construction as well as loading from the overburden.

Tunnels and shafts must comply with O.Reg. 213/91, sections 243 to 331. The work must be undertaken in compliance with the relevant Ontario Provincial Standard Specification OPSS 415 for Tunnelling and OPSS 416 for Jacking and Boring.

The trenchless pipe installation should be conducted by a specialist directional drilling contractor. The encountered subsurface stratigraphy should be considered by the bidding contractor when assessing production rates and project costs.

It is recommended that the trenchless installation system be left to the contractor's discretion, but the contractor must be required to submit a detailed summary of the procedures for review and approval.

Excavations for the sending and receiving pits must be carried out in compliance with O.Reg. 213/91 under the Occupational Health and Safety Act. The predominant soils encountered will be classified as Type 3 soils (O.Reg. 213/91, s. 226(4)) and temporary side slopes must be cut at an inclination of 1 horizontal to 1 vertical or less from the base of the excavation. Steeper cut slopes can be employed if trench liner boxes and/or shoring are used to protect workers.

Some minor ground movement adjacent to the trench box should be expected if this option is used. The support system shall be designed by a professional engineer and shall be constructed, installed, used and maintained in accordance with its design drawings and specifications (O.Reg. 213/91, s. 236).

Groundwater above Elevation 371.0 m should be controlled using interceptor ditches and/or sump pumps. Where groundwater seepage is occurring into the pits, the slopes should be trimmed back to a flatter angle to achieve stability.

A Permit to Take Water (PTTW) is required by the Ministry of Environment in the event that the daily taking of groundwater exceeds 50,000 L per day. If the contractor carefully plans and stages his work, it should be possible to complete this project without the need for a PTTW. The contractor should evaluate this latter recommendation to ensure that he is in agreement, and he should notify the prime consultant in the event that a PTTW will be needed (on the basis of his excavation schedule).

It is recommended that several test pits be dug during the tendering stage of the project in order that prospective contractors may familiarize themselves with the soil and groundwater conditions to be contacted (including the frequency of cobbles and boulders).

# 5 STATEMENT OF LIMITATIONS

The geotechnical recommendations provided in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known at the time of report preparation, we recommend that we be retained during the final design stage to verify that the geotechnical recommendations have been correctly interpreted in the design. Also, if any further clarification and/or elaboration are needed concerning the geotechnical aspects of the project, Englobe should be contacted. We recommend that we be retained during construction to confirm that the subsurface conditions do not deviate materially from those encountered in the test holes and to ensure that our recommendations are properly understood.

The geotechnical recommendations provided in this report are intended for the use of the owner and its retained designer. They are not intended as specifications or instructions to contractors. Any use which a contractor makes of this report, or decisions made based on it, are the responsibility of the contractor. The contractor must also accept the responsibility for means and methods of construction, seek additional information if required, and draw their own conclusions as to how the subsurface conditions may affect their work. Englobe accepts no responsibility and denies any liability whatsoever for any damages arising from improper or unauthorized use of the report or parts thereof.

It is important to note that the geotechnical investigation involves a limited sampling of the site gathered at specific test hole locations and the conclusions in this report are based on this information gathered. The subsurface geotechnical, hydrogeological, environmental and geologic conditions between and beyond the test holes will differ from those encountered at the test holes. Also such conditions are not uniform and can vary over time. Should subsurface conditions be encountered which differ materially from those indicated at the test holes, we request that we be notified in order to assess the additional information and determine whether or not changes should be made as a result of the conditions.