Report
Project: 39606-5.2.2

RICHARDSON RIDGE PHASE 4 SERVICEABILITY REPORT

Prepared for the City of Ottawa
by IBI Group

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1 INTRODUCTION

The land owners of the properties located in the Kanata North neighbourhood of Richardson Ridge are proceeding with developing Phase 4 of their lands. The land owner's co-tenancy is comprised of the following developers: Braebury Homes, Cardel Homes, and Uniform Urban Developments. Regional Group has been retained by the Co-Tenancy to complete planning and project management of the development. IBI Group has been retained to provide professional engineering services for the subject lands, which the owners have called Richardson Ridge.

Richardson Ridge lands are approximately 85 ha and consist of the Richardson farm and homestead. Of the 83 ha parcel, approximately 24.4 ha will comprise Phase 1, 4.6 ha in Phase 2A (Co-Tenancy), 6.3 ha in Phase 2B and 2C (Uniform Urban Developments), 15.17 ha in Phase 3, 9.0 ha Phase 4, 5.9 ha reserved for SWM pond, 5.5 ha for Terry Fox Drive and approximately 14 ha of open space lands adjacent to the Carp River which are to be deeded to the City.

The lands have received draft approval and zoning, Phase 1 has been constructed including the interim stormwater management pond; Phases 2A, 2B, 2C, 3A and 3B have been approved by the City of Ottawa and are currently under construction, including several occupancies in Phase 3. Lands identified as Phase 3C currently houses the interim stormwater management facility which has been constructed to service Phases 1, 2A, 2B, 2C, 3A & 3B. When the ultimate stormwater management facility is constructed the interim pond will be decommissioned and Phase 3C will be developed as a high density block. Phase 4 consists of 41 single family homes, 156 townhouse units and neighbourhood park block. The proposed draft plan for the development is included in **Appendix A**.

As illustrated in the Key Plan, Phase 4 of Richardson Ridge is bounded to the south by natural environment area (NEA) which consists of provincially significant wetlands (PSW) to the west by existing Terry Fox Drive, to the North by future Kanata North Commercial and Residential lands owned by Richcraft Homes, and to the East by an existing unopened municipal road allowance.

In addition to this report, IBI has prepared a Stormwater Management Report dated August 2010 (Revised March 2012) and detailed design of the interim stormwater management facility to support the proposed development. IBI also prepared and submitted:

- Detailed design report dated November 2010 for the sanitary and watermain to be constructed within Terry Fox Drive
- Servicing report dated March 2012 for Phase 1C
- Update to: Signature Ridge Pump Station Hydraulic Grade Line Analysis for Minto Communities Arcadia Stage 2, dated September 2014
- Servicing report dated June 2012 for Phases 1A, 1B and 1D
- Servicing report dated March 2015 for Phases 3A and 3B
- Servicing report dated March 2015 for Phase 2A
- Servicing report dated November 2015 for Phase 2B
- Servicing report dated May 2016 for Phase 2C

The interim stormwater management facility has been constructed and is operational. The servicing works within Terry Fox Drive have been constructed and are operational. Servicing works in Phase 1, 2A and 3 have been completed, and are in service. Phases 2B and 2C are currently under construction.

At the initiation of the Richardson Development, pre-consultation meetings were held with MVCA and MOE regarding the overall development. Meetings were held with Jason Schaefer of MOE and Doug Nuttall of the MVCA; both agencies reviewed the proposed draft plan and commented on the requirements to advance this project. The main requirement from both agencies was to meet the Third Party Review requirements, specifically for SWM facility discharging to the Carp River and sanitary sewer discharge to the Signature Ridge Pump Station. Phase 4 follows the requirements set out by the above agencies during the design and approval of Phase 1.

Additional consultation with MVCA and OMNR has proceeded for the Phase 4 development. Below is a list of environmental topics surrounding the Phase 4 development;

- Blanding's Turtle Habitat
- Butternut tree preservation
- Proximity to Provincially Significant Wetland (PSW)

MVCA and OMNR have been consulted, and solutions have been presented with regards to the above noted topics and are addressed in the following reports;

- Bowfin Environmental Consulting (2014a) Blanding's Turtle Survey Results – Spring 2014 for Bernie Muncaster (Mun_Kanata_North).
- Bowfin Environmental Consulting (2014b) Butternut Health Assessment - Lot 7, Concession 1, Geographic Township of March, City of Ottawa.
- DST Consulting Engineers (April 2016) Richardson Ridge Phase 4 Blanding's Turtle Overall Benefit Permit Application - REVISED.
- DST Consulting Engineers (February 2016) Richardson Ridge Phase 4 Overall Benefit Permit Application Summary Letter.
- McKinley Environmental Solutions (2016) Richardson Ridge Phase 4 Tree Conservation Report (Final)
- McKinley Environmental Solutions (2016) Richardson Ridge Phase 4 Environmental Impact Statement (In Draft)
- Paterson Group, MES, IBI, and Novatech (2016) Water Balance - Impact on PSW - Richardson Ridge Phase 4 (In Progress)

2 WATER DISTRIBUTION

2.1 Existing Conditions

The City of Ottawa commissioned a neighbourhood water distribution system planning study; see Pressure Zone 3 – Kanata North Potable Water Planning Study, dated November 2007 by Stantec Consulting Ltd. This study provided recommendations for Kanata Lakes North (Phases 1-4), Broughton, Richardson Ridge, and Kanata highlands development areas to meet the projected 20 year growth requirements. This study concluded that under full build-out, the neighbourhood water distribution system was able to meet all requirements.

As part of the development of Phase 1 and the Terry Fox Drive extension, a 300 mm diameter watermain was constructed on Huntsville Drive to Terry Fox Drive. The 300 mm main was extended northwest along Terry Fox adjacent to the Phase 4 site. Existing 200 mm mains have been constructed on Terrance Place and Boundstone Way extending from the Huntsville Drive watermain as part of the Phase 2A development.

Recently Stantec Consulting completed the Kanata North Potable Water Servicing Analysis for the City of Ottawa and Urbandale Corporation for the adjacent KNL Lands. In Figure 2-2: Proposed Pipe Sizing and Alignment of the servicing analysis, a 300 mm watermain is shown on Terry Fox extending through the Phase 4 site to connect to a proposed 300 mm watermain on future Walden Drive in the KNL lands.

2.2 Design Criteria

2.2.1 Water Demands

Phase 4 residential development consists of single family homes, semi-detached units and street townhomes. Per unit population density and consumption rates are taken from **Tables 4.1** and **4.2** at the Ottawa Design Guidelines – Water Distribution and are summarized as follows:

- Single Family 3.4 person per unit
- Townhouse and Semi-Detached 2.7 person per unit
- Average Apartment 1.8 person per unit

- Average Day Demand 350 l/cap/day
- Peak Daily Demand 875 l/cap/day
- Peak Hour Demand 1,925 l/cap/day

A water demand calculation sheet is included in **Appendix A** and the total water demands are summarized as follows:

- Average Day 2.27 l/s
- Maximum Day 5.68 l/s
- Peak Hour 12.49 l/s

2.2.2 System Pressures

The 2010 City of Ottawa Water Distribution Guidelines states that the preferred practice for design of a new distribution system is to have normal operating pressures range between 345 kPa (50 psi) and 552 kPa (80 psi) under maximum daily flow conditions. Other pressure criteria identified in the guidelines are as follows:

Minimum Pressure	Minimum system pressure under peak hour demand conditions shall not be less than 276 kPa (40 psi).
Fire Flow	During the period of maximum day demand, the system pressure shall not be less than 140 kPa (20 psi) during a fire flow event.
Maximum Pressure	Maximum pressure at any point in the distribution system in unoccupied areas shall not exceed 689 kPa (100 psi). In accordance with the Ontario Building/Plumbing Code the maximum pressure should not exceed 552 kPa (80 psi) in occupied areas. Pressure reduction controls may be required for buildings where it is not possible/feasible to maintain the system pressure below 552 kPa.

2.2.3 Fire Flow Rate

In the recent Technical Bulletin 'ISDTB-2014-02, Revisions to Ottawa Design Guidelines – Water,' the fire flow requirements for single detached dwellings and traditional town and row houses can be capped at 10,000 l/min providing that there is a minimum separation of 10 meters between the backs of adjacent units and that the town and row house blocks are limited to 600 square meters of building areas and seven dwelling units. As the residential units in Phase 4 Kanata Lakes North are expected to meet the requirements of ISDTB-2014-02, the fire flow rate of 10,000 1/min (166.7 l/s) is used in the fire flow analysis.

2.2.4 Boundary Conditions

The City of Ottawa has provided a hydraulic boundary condition at the intersection of Huntsville Drive and Terry Fox Drive. For the Maximum day plus fire flow criteria two boundary conditions were provided for two rates of fire flow. A copy of the Boundary Condition is included in **Appendix A** and summarized as follows:

Criteria	Hydraulic Head
Max HGL (Basic Day)	162.2 m
Peak Hour	155.2 m
Max Day + Fire (250 l/s)	135.4 m
Max Day + Fire (184 l/s)	143.9 m

2.2.5 Hydraulic Model

A computer model for the Phase 4 water distribution system has been developed using the H_2O Map Version 6.0 program produced by MWH Soft Inc. The model includes the boundary conditions at Terry Fox and Huntsville Drives and the 300 mm main on Terry Fox Drive. As a second feed to the future KNL lands will not be available for several years a second connection is proposed by constructing a watermain on the west side of Terry Fox Drive from the Phase 4 site to connect with the existing 200 mm watermain on Boundstone Way in Phase 2A. The existing watermains on Huntsville Drive, Terrance Place and Boundstone Way required to complete this connection we included in the model.

2.3 Proposed Water Plan

2.3.1 Hydraulic Analysis

Hydraulic analysis was completed using the computer model with the water demands and fire flow rates determined in Sections 2.2.1 and 2.2.3. The hydraulic model is run under basic day and peak hour scenarios to determine the maximum and minimum pressures in the water distribution system. Fire flows are evaluated under the maximum day scenario.

The 300 mm diameter watermain is extended from Terry Fox Drive to the first intersection where it will be extended north and east through future development to connect to the KNL lands per the Stantec servicing analysis identified in Section 2.1.2. A combination of 200 and 250 mm mains are required for the remainder of Phase 4 in order to meet the fire flow requirement. The fire flow analysis was conducted with the boundary condition for a fire flow rate of 184 l/s. The fire flow requirement for the site is 166.7 l/s as stated in Section 2.2.3. A 150 mm diameter main is required on Terry Fox Drive to provide a second watermain feed from Phase 2A.

The proposed water distribution system for Phase 4 is shown on the Conceptual Servicing Plans. Until the adjacent development to the north is constructed, there will be approximately 84 residential units on Street Nos. 1 and 4 temporarily on a single feed. A temporary watermain connection may be required between Street Nos. 3 and 4 if the adjacent development is not constructed in a timely manner.

Results of the hydraulic analysis including schematic drawings of the pipe sizes, pipe and node identifications, and node elevations are included in **Appendix A**.

2.3.2 Summary of Results

Results of the hydraulic analysis is summarized as follows:

Pressures (kPa)	
- Basic Day (Max HGL)	540.9 – 632.9
- Peak Hour	471.3 – 567.6

Minimum Fire Flow @ 140 kPa Residual Pressure (l/s) 166.9

A comparison of the results and design criteria is summarized as follows:

Maximum Pressure	In the analysis only one node has a pressure below 552 kPa due to the high proposed elevation at that location. It is recommended that that all residential units in Phase 4 require pressure reducing valves. The maximum system pressure recorded in the model is 632.9 kPa, the maximum allowable pressure of 689 kPa has not been exceeded in the water distribution system.
Minimum Pressure	All nodes exceed the minimum requirement of 276 kPa during peak hour conditions.
Fire Flow	The minimum design fire flow with a minimum residual pressure of 140 kPa in Phase 4 is 166.9 l/s which matches the requirement of 166.7 l/s (10,000 l/min).

3 WASTEWATER

3.1 Existing Conditions

The City of Ottawa commissioned a Master Sanitary Sewer Plan for the Kanata Lakes, Broughton & Interstitial Lands, see Stantec Report dated December 2007. This report reviewed the potential servicing of these development areas and reviewed the adequacy of the downstream sanitary sewers to service the area including the sanitary sewers along Terry Fox Drive and the Kanata Lakes Trunk. The Stantec report used projected population data available at the time including a population of **2455** for the Richardson Lands to the Terry Fox Drive trunk sewer, and a population of 2141.2 for the Richardson Lands to the Kanata Lakes trunk sewer.

Since that report, the Richardson Ridge development has been fine-tuned and the Broughton lands have been fully constructed. The design population for the currently approved phases in Richardson Ridge is 1156.4, as noted below. A residual population of 1088.6 is allocated for Phases 3C, Phase 4 and an allocation for Richcraft Homes. To this end, the downstream sewers which were designed and constructed to accommodate a larger population are of sufficient size to accommodate the population design flows from the draft approval areas.

Table 3.3 – Summary of Flows to Terry Fox Drive

PHASE	POPULATION	AVERAGE FLOW	AREA	INFILTRATION FLOW	TOTAL FLOW
Phase 1B	190.4	0.77 /ls	4.95 Ha	1.39 l/s	**2.15 l/s**
Phase 1C	125.8	0.51 l/s	2.99 Ha	0.84 l/s	**1.35 l/s**
Phase 1D	27.2	0.11 l/s	0.58 Ha	0.16 l/s	**0.27 l/s**
Phase 2A	254.6 (incl. 8.1 from 2B)	1.03 l/s	4.95 Ha	1.39 l/s	**2.42 l/s**
Phase 2B	187	0.76 l/s	2.63 Ha	0.74 l/s	**1.50 l/s**
Phase 2C	201.6	0.82 l/s	2.27 Ha	0.64 l/s	**1.46 l/s**
Phase 3A	169.8	0.69 l/s	3.37 Ha	0.94 l/s	**1.63 l/s**
TOTAL	**1156.4**	**4.67 l/s**	**21.74 Ha**	**6.10 l/s**	**10.79 l/s**
Phase 4	560.6	2.27 l/s	6.44 Ha	1.80 l/s	**4.07 l/s**
Richcraft Frontage	99	0.40 l/s	1.08 Ha	0.30 l/s	0.70 l/s
TOTAL	**1816**	**7.34**	**29.26 Ha**	**8.20 l/s**	**15.56 l/s**
Phase 3C	*445.5*				
Add. Capacity for RRI	*93.8*				
Add. Capacity for RC	*99.7*				
TOTAL	**2455**				

Average flow and Tributary Area to be Refined upon Detail Design and Determination of Unit Types

**Above does not include Peaking Factors. Populations for Phase 3C based on preliminary concept plan, and are subject to change, the remaining balance of population can be allocated to Richcraft (RC), upon agreement with Richardson Ridge Inc. (RRI) to share in the costs of constructing the Terry Fox Drive trunk sewer.*

3.2 Proposed Sewers

All sewers have been designed to City of Ottawa and MOE design criteria which include but are not limited to the below listed criteria. A copy of the detailed sanitary tributary area plan 511 and the sanitary sewer design sheets are included in **Appendix B** illustrate the population densities and sewers which provide the necessary outlets.

3.2.1 Design Flow:

Average Residential Flow	-	350 l/cap/day
Average Commercial/Institution Flow	-	50,000 l/Ha/day
Peak Residential Factor	-	Harmon Formula
Peak Commercial/Institution Factor	-	1.5
Infiltration Allowance	-	0.28 l/sec/Ha

3.2.2 Population Density:

Single Family	-	3.4 person/unit
Townhouse Units	-	2.7 person/unit
Apartment Units	-	1.8 person/unit
External Low Density Land	-	120 units/gross Ha

3.3 Signature Ridge Pump Station

In the earlier phases within this development, the City of Ottawa had implemented a holding provision to restrict average flow from Richardson Ridge to the Signature Ridge Pump Station until a series of upgrades were completed. As part of the Phase 2B detail design process, the City of Ottawa has confirmed that the upgrades are complete and that the holding provision has been lifted.

The City of Ottawa commissioned a Functional Design Report for the Signature Ridge Pump Station, see R.V. Anderson Report of May, 2010. This report noted that for the preferred option which included an emergency overflow at the SRPS, some areas of the Interstitial Lands (Richardson Ridge) and Minto Lands would not be protected in the event of a full system failure and that the developers were to review their options. To address this issue, IBI completed a hydraulic grade-line analysis for the Development lands to be serviced by the SRPS, see IBI report dated March 2014 (revised September 2014). The report reviews overflow configurations for the interim and ultimate development conditions and proposes additional emergency overflows. The addition of these overflows results in the lowering of the sanitary HGL within the development lands, including along the Terry Fox Drive sanitary sewer. The subdivision makes two connections to Terry Fox Drive at the labelled Nodes “Baylis” and “Richardson North” from the above-mentioned report. The ultimate buildout HGL is 94.65 for the Baylis connection and 94.60 for the Richardson North connection. Both HGL’s are slightly higher than the obvert of the pipe, thus Hydraulic grade line calculations will need to be carried back into the subdivision during detail design. The analysis will be performed until such a point as the HGL is at or below the springline of the proposed sewer network. All footings will be required to meet a 300 mm greenboard from the final HGL.

4 SITE STORMWATER MANAGEMENT

4.1 Objective

The purpose of this section is to present an overview of dual drainage design, including the minor and major system, for the Richardson Ridge Phase 4 development.

4.2 Synopsis of Previous Reports

In May 2012, IBI Group prepared the "Richardson Ridge Stormwater Management Report and Interim Design Brief". That approved report outlined the overall stormwater management strategy for the approximate 43 ha of new development tributary to the SWM facility. That report presented the detailed design of the dual drainage system for the Phase 1 development; outlined the detailed design for the Interim SWM facility which was sized to service the Phase 1, 2, and 3 developments; and confirmed the design for the trunk storm sewer for Phase 1 into the Interim SWM facility.

In July 2013, IBI Group prepared the "Richardson Ridge Phase 2 Servicing Report" (updated March 2015). That report outlined the detailed site stormwater management design and analysis for the Phase 2 development. That report carried forward with the detailed design from Phase 1 and the Interim SWM facility, and confirmed the detailed site stormwater management design for Phase 2.

In November 2013, IBI Group prepared the "Richardson Ridge Ultimate Stormwater Management Facility – Preliminary Design Brief". That report outlined the detailed ultimate stormwater management scheme for the entirety of the Richardson Lands. The report described that Phase 4 would be a stand-alone phase serviced by an Oil and Grit Separator to level 2 control (70%).

In March 2015, IBI Group prepared the "Richardson Ridge Phase 3 Servicing Report". This report carries forward with the detailed design from the Phase 1 and Phase 2 developments tributary to the existing Interim SWM facility and is intended to aid in the review and approval of the servicing for Phase 3A and 3B of the proposed development. This report builds upon the findings of the July 2013 Phase 2 Servicing report (updated March 2015), the May 2012 Richardson Ridge SWM report, the City of Ottawa Sewer Design Guidelines (OSDG 2012), and the June 2012 "Technical Bulletin" ISDTB-2012-4.

In July 2016, Paterson Group, McKinley Environmental Solutions, and IBI Group collberated together to prepare the "Richardson Ridge Water Budget Assessment" found in Section 5 of the Paterson Group Hydrogeological Study dated July 2016. This study identifies the water sources from the site and their impacts on the surround lands, and more importantly the nearby Provincially Significant Wetland (PSW). The report highlights the impact of the development on the regional water balance, and suggests a second, treated stormwater outlet at the eastern portion of the site. This is mostly due to the native bedrock conditions which direct sheet drainage towards the PSW. These pre-existing flows would be intercepted by a storm sewer system and conveyed to an outlet. The second outlet provides an opportunity to maintain some flows per the pre-existing conditions at the eastern points of the development. The report also recommends that the western outlet be directed to the PSW to maintain the pre and post development water balance.

4.3 Stormwater Management System

The proposed Phase 4 site is a part of the overall Richardson Ridge Development, but not a part of the stormwater management system which was outlined within the approved 2012

Stormwater Management Report. The existing Interim SWM facility was designed to provide service for the Phases 1, 2, and 3 of the development.

Minor system flows from the proposed Phase 4 storm sewer system will be conveyed to two new Oil Grit Separators, one at each the East and West limits of the development. Although previous studies required a normal level of treatment (level 2, 70%), due to the proximity to the PSW, enhanced level of treatment (level 1, 80%) will be provided by oil and grit separators at each outlet.

4.3.1 Interim versus Ultimate Stormwater Management Solution

The interim drainage scheme consists of a single stormwater management facility for Phases 1, 2, and 3 located to the northwest of the initial phases of the Richardson Ridge development, outside of the 1:100 year flood plain of the Carp River. The existing interim SWM facility provides water quality control to MOE Level 2 protection (70% removal of TSS) for the approximate 45 ha interim development and discharges to the Carp River.

At the present time, the ultimate drainage scheme consists of a single stormwater management facility located adjacent to the Carp River West of Terry Fox Drive servicing the Richardson Ridge development. The facility will provide water quality control to MOE Level 2 protection (70% removal of TSS) for the ultimate development and will discharge to the Carp River.

Phase 4 of the Richardson Ridge development will stand alone and not be serviced by the interim, or future ultimate stormwater management solution. As previously noted, Phase 4 will discharge its minor system flow through 2 oil and grit separators.

4.4 Dual Drainage Design

The dual drainage system proposed for the subject site will accommodate both major and minor stormwater runoff. Minor flow from the subject site will be conveyed through two new storm sewer networks and discharge into the natural environmental area (NEA) adjacent to the PSW. The treated discharge water will outlet at the west property limit and at the eastern property limit.

The balance of the surface flow not captured by the minor system will be conveyed via the major system. Where possible, storage will be provided in street sags or low points within the roadway and once the maximum storage is utilized, the excess flow will cascade to the next downstream street sag. Major flow from the proposed Phase 4 development is conveyed to the Natural Environment Area (NEA) dedicated overland spillways utilizing the pathway network.

Further details on the minor and major system design are outlined below.

4.4.1 Minor System

The minimum minor system capture of ICDs for the Richardson Ridge Phase 4 site will be based on 5 year SWMHYMO generated flows for individual areas. The subject site will be modelled using SWMHYMO to confirm minor and major system flows. Hydrographs from the site will be downloaded to XPSWMM hydraulic model to confirm hydraulic grade line within the proposed storm sewers, and will confirm the function of the Oil and Grit Separators.

4.4.2 Major System

Inlet control devices (ICDs) will be proposed to control the surcharge in the minor system during infrequent storm events and maximize the use of available on site storage. Due to the relatively steep topography of the site, on-site storage is mainly limited to the South-Western portion of the site. Surface runoff in excess of the minor system capture will cascade via street segments and rear yard swales to the outlets from the site, released to the NEA.

4.5 Hydrological Analysis

Hydrological analysis of the proposed dual drainage system of the subject site will be conducted using SWMHYMO. This technique offers a single storm event flow generation and routing.

The primary focus of the hydrological analysis will be to evaluate surface flow and ponding conditions during the 100 year storm event in order to satisfy City of Ottawa Sewer Design Guidelines (2012) in terms of velocity x depth. The 5 year simulation will be performed to assure that after the storm is over there will be no ponding on the streets. The parameters used to model the subject site are presented in Table 4.1 and calculations are provided within **Appendix C**.

4.5.1 Design Storms and Drainage Area Parameters

The following design parameters will be used in the evaluation of the stormwater management system for the subject site:

4.5.2 Design Storms

- 2, 5 and 100 year, 12 hour SCS type II storm event, consistent with the Carp River Model Calibration Validation Exercise Draft Final Report (Greenland, April 29, 2011);
- 5 and 100 year, 3 hour Chicago storm event with a 10 minute time step;
- July 1, 1979 and August 8, 1996 Historical storms as per the City of Ottawa Sewer Design Guidelines (2012).
- 100 year, 12 hour SCS type II storm event with a 20% increase in intensity, as per the Technical Memorandum.

4.5.3 Run-Off Coefficients

The run-off coefficients utilized for the minor system design were derived from an analysis of a representative sample of the proposed single family and townhouse units. Coefficients of 0.25 and 0.9 were utilized in the analysis to represent landscaped versus hard surface areas. The analysis resulted in the following run-off coefficients:

	Front-Yard	Rear-Yard
Single	0.70	0.50
Town Homes	0.76	0.50
Park Block		0.40

It should be noted that the rear-yard coefficients were slightly adjusted for irregular drainage areas resulting from larger lots, and that the coefficient values will be re-evaluated during detail design to ensure consistency with the house siting's and legal fabric. A drainage area plan is presented on Drawing 510 and modified rational method design sheets are located in **Appendix C.**

4.5.4 Time of Concentration

Inlet times of 10 min. for street segments and rear yard inlets where utilized as per the City of Ottawa Sewer Design Guidelines (2012).

4.5.5 Area and Imperviousness:

The catchment areas and imperviousness values are based on the rational method spreadsheet. The total and directly connected imperviousness ratios were based upon the pervious and impervious areas for the front yard and rear yard catchment areas.

5 SOURCE CONTROLS

5.1 General

As noted previously oil and grit separators will provide quality control for the subject lands. In addition to the oil and grit separators, on site level or source control management of runoff will be provided. Such controls or mitigative measures are proposed for the development not only for final development but also during construction and build out. Some of these measures are:

- flat lot grading;
- split lot drainage;
- Roof-leaders to vegetated areas;
- vegetation planting; and
- groundwater recharge.

5.2 Lot Grading

Residential lots within the development will typically make use of the split drainage runoff concept. In accordance with local municipal standards, all lot grading will be between two and seven percent. All front yard drainage will be directed over landscaped front yards to the roadway system and all rearyard drainage will be directed to a swale drainage system. Typically swales will have slopes of 2%. These measures all serve to encourage individual lot infiltration.

5.3 Roof Leaders

Phase 4 of the development will consist of single family lots and townhomes. It is proposed that roof leaders from these units be constructed such that runoff is directed to grass areas adjacent to the units. This will promote water quality treatment through settling, absorption, filtration and infiltration and a slow release rate to the conveyance network.

5.4 Vegetation

As with most subdivision agreements, the developer will be required to complete a vegetation and planting program. Vegetation throughout the development including planting along roadsides and within public parks provides opportunities to re-create lost natural habitat.

6 CONVEYANCE CONTROLS

6.1 General

Besides source controls, the development also proposes to use several conveyance control measures to improve runoff quality. These will include:

- flat vegetated swales;
- catchbasin and maintenance hole sumps; and
- pervious rearyard drainage.

6.2 Flat Vegetated Swales

The development will make use of relatively flat vegetated swales where possible to encourage infiltration and runoff treatment.

6.3 Catchbasins

All catchbasins within the development, either rear yard or street, will be constructed with minimum 600 mm deep sumps. These sumps trap pollutants, sand, grit and debris which can be mechanically removed prior to being flushed into the minor pipe system. Both rear yard and street catchbasins will be fabricated to OPSD 705.010 or 705.020. All storm sewer maintenance holes servicing local sewers less than 900 mm diameter shall be constructed with a 300 mm sump as per City standards.

6.4 Pervious Rear Yard Drainage

Some of the rearyard swales make use of a filter wrapped perforated drainage pipe constructed below the rear yard swale. This perforated system is designed to provide some ground water recharge and generally reduce both volumetric and pollutant loadings that enter the minor pipe system. Typically, a 250 mm diameter perforated pipe wrapped in filter sock is constructed in a crushed clear stone surround at an invert elevation of approximately 0.8 m below grade. These pipes are in turn directly connected to rear yard catchbasins at regular intervals as per City Standards.

7 SEDIMENT AND EROSION CONTROL PLAN

7.1 General

During construction, existing stream and conveyance systems can be exposed to significant sediment loadings. Although construction is only a temporary situation, it is proposed to introduce a number of mitigative construction techniques to reduce unnecessary construction sediment loadings. These will include:

- groundwater in trench will be pumped into a filter mechanism prior to release to the environment;
- bulkhead barriers will be installed at the nearest downstream manhole in each sewer which connects to an existing downstream sewer;
- seepage barriers will be constructed in any temporary drainage ditches; and
- filter cloths will remain on open surface structure such as manholes and catchbasins until these structures are commissioned and put into use.

7.2 Trench Dewatering

During construction of municipal services, any trench dewatering using pumps will be discharged into a filter trap made up of geotextile filters and straw bales similar in design to the OPSD 219.240 Dewatering Trap. These will be constructed in a bowl shape with the fabric forming the bottom and the straw bales forming the sides. Any pumped groundwater will be filtered prior to release to the existing surface runoff. The contractor will inspect and maintain the filters as needed including sediment removal and disposal and material replacement as needed.

7.3 Bulkhead Barriers

At the first manhole constructed immediately upstream of an existing sewer, a ½ diameter bulkhead will be constructed over the lower half of the outletting sewer. This bulkhead will trap any sediment carrying flows, thus preventing any construction –related contamination of existing sewers. The bulkheads will be inspected and maintained including periodic sediment removal as needed.

7.4 Seepage Barriers

The presence of road side ditches along Terry Fox Drive, Richardson Road and the proximity of the Carp River necessitates the installation of seepage barriers. These barriers will consist of both the Light Duty Straw Bale Barrier as per OPSD 219.100 or the Light Duty Silt Fence Barrier as per OPSD 219.110 and will be installed in accordance with the sediment and erosion control drawing. The barriers are typically made of layers of straw bales or geotextile fabric staked in place. All seepage barriers will be inspected and maintained as needed.

7.5 Surface Structure Filters

All catchbasins, and to a lesser degree manholes, convey surface water to sewers. However, until the surrounding surface has been completed these structures will be covered to prevent sediment from entering the minor storm sewer system. Until rearyards are sodded or until streets are asphalted and curbed, all catchbasins and manholes will be equipped with geotextile filter socks. These will stay in place and be maintained during construction and build until it is appropriate to remove them.

7.6 Stockpile Management

During construction of any development similar to that being proposed both imported and native soils are stockpiled. Mitigative measures and proper management to prevent these materials entering the sewer systems is needed.

During construction of the deeper municipal services, water, sewers and service connections, imported granular bedding materials are temporarily stockpiled on site. These materials are however quickly used up and generally before any catchbasins are installed. Street catchbasins are installed at the time of roadway construction and rearyard catchbasins are usually installed after base course asphalt is placed.

Contamination of the environment as a result of stockpiling of imported construction materials is generally not a concern since these materials are quickly used and the mitigative measures stated previously, especially the use of filter fabric in catchbasins and manholes help to manage these concerns.

The roadway granular materials are not stockpiled on site. They are immediately placed in the roadway and have little opportunity of contamination. Lot grading sometimes generates stockpiles of native materials. However, this is only a temporary event since the materials are quickly moved off site.

8 ROADS AND NOISE ATTENUATION

Vehicular access to Phase 4 is provided by a single connection to Terry Fox Drive. The draft plan identifies all roads within Phase 4 are to be constructed within 18 m ROW, with the exception of where Street No. 1 connects to Terry Fox Drive.

There are no bus routes proposed within Phase 4.

In consultation with the local utility providers, Phase 3 of the development will continue to be serviced as per Phase 1, 2 and 3, which have been designed based on a 3 party joint use utility trenching configuration. To this end, the City's standard cross section, ROW 18 will be used for the 18m ROW in Phase 4.

In support of detail design, an environmental noise impact assessment will be prepared to assess the noise impact from traffic along adjacent roads. While the draft plan makes every effort to minimize noise abatement measures by incorporating window streets and open space toward Terry Fox Drive, there will need to be a short length of noise wall for the sideyards of the units fronting Street 1 and 3. Typical indoor noise is expected to be exceeded and special noise clauses will be determined by the environmental noise impact assessment.

9 SOILS

Paterson Group geotechnical report dated July 15, 2016 provides details on the existing soils within the development. A copy of the report is included in **Appendix D**. The report contains recommendations which include but are not limited to the following:

- Grade raise constraints are recommended for Phase 4 and are identified within the report PG3695-1
- In areas where finished grade exceeds grade raise limits, preloading and surcharging can be employed to induce required settlement, light weight fill may also be used, or a combination or surcharging and light weight fill, as per the Geotechnical recommendations
- Fill placed below the foundations to meet OPSS Granular ‘A’ or Granular ‘B’ Type II placed in 300 mm lifts compacted to 98% SPMDD.
- Fill for roads to be suitable native material in 300mm lifts compared to 95% SPMDD
- Pavement Structure: **Local Road**

  40mm HL3 superpave 12.5mm

  50mm superpave 19mm

  150mm Granular ‘A’

  450mm Granular ‘B’ Type II
- Pipe bedding and cover; bedding to be minimum 150 mm OPSS Granular ‘A’ up to spring line of pipe. Cover to be 300 mm OPSS A (PUC and concrete pipes) or sand for concrete pipes. Both bedding and cover to be placed in maximum 225 mm lifts compacted to 95% SPMDD.

In general the grading plan for Phase 4 adheres to the grade raise constraints noted above. For areas that exceed the grade raise limit a preload program under the supervision of the geotechnical engineer will be undertaken. A copy of the **Macro Grading Plan 211** is included in **Appendix D**.

10 RECOMMENDATIONS

Water, wastewater and stormwater systems required to develop Phase 4 of Richardson Ridge will be designed in accordance with MOE and City of Ottawa's current level of service requirements.

The use of lot level controls, conveyance controls and end of pipe controls outlined in the report will result in effective treatment of surface stormwater runoff from the site. Adherence to the proposed sediment and erosion control plan during construction will minimize harmful impacts on surface water.

Final detail design will be subject to governmental approval prior to construction, including but not limited to the following:

- Phase 4 Commence Work Order: City of Ottawa
- Phase 4 ECA (sewers): MOE
- Phase 4 Watermain Approval: City of Ottawa
- Phase 4 Municipal Consent: City of Ottawa
- Phase 4 Commence Work Order (utilities): City of Ottawa

This report was prepared in accordance with the City's Development Servicing Study Guideline, see study checklist in **Appendix E**.

Report prepared by:

Demetrius Yannoulopoulos, P.Eng.
Associate Director

Ryan Magladry
Project Designer

J:\39606-RichdRdgPh4\5.2 Reports\5.2.2 Civil\5.2.2.1 Sewers\Submission #1_not submitted\CTR-Serviceability Report_2016-07-25.docx\2016-08-17\MI

APPENDIX A

APPROVED UNDER SECTION 51 O THE PLANNING ACT
BY THE CITY O OTTA A

THIS DAY O

MICHAEL MI I MCIP RPP ACTING GENERAL MANAGER
PLANNING AND GRO TH MANAGEMENT DEPARTMENT
PLANNING AND IN RASTRUCTURE PORT OLIO
CITY O OTTA A

PLAN 4M-

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OR THE LAND TITLES DIVISION O OTTA A-CARLETON NO 4
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AND ENTERED IN THE PARCEL REGISTER OR
PROPERTY IDENTI IERS
AND THE RE UIRED CONSENTS ARE REGISTERED AS
PLAN DOCUMENT NO

LAND REGISTRAR

PLAN OF SUBDIVISION OF
PART OF LOTS 7 A d 8
CONCESSION 1
G r T M r
CITY OF OTTAWA

S r d A O S V L d

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DISTANCES AND COORDINATES SHOWN ON THIS PLAN ARE IN METRES AND CAN BE CONVERTED TO FEET BY DIVIDING BY 0.3048.

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NOTES AND LEGEND

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B r r r d r d r C -N 0 R T N r GPS r r A d B r bearing of Nxx°xx'xx"W and are referenced to Specified Control Points 01919791338 and 01919871649, MTM Zone 9 (76°30' West Longitude) NAD-8 r

C rd r d r d r C -N 0 R T N r GPS r r r d S d C r P 01 1 1 8 d 01919871649, MTM Zone 9 (76°30' West Longitude) NAD-83 (original).

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ANNIS, O'SULLIVAN, VOLLEBEKK LTD.
14 Concourse Gate, Suite 500
Nepean, Ont. K2E 7S6
Phone: (613) 727-0850 / Fax: (613) 727-1079
Email: Nepean@aovltd.com
Ontario Land Surveyors

Job No. 16364-15 Regional Pt Lts 7 8 CI MA Ph4 SUB D6 | N

<u>**Boundary Conditions at Richardson Ridge.**</u>

Information Provided:

Date provided: 20 May 2016

For Residential and School	
Criteria	**Demand (L/s)**
Average Demand	2.56
Maximum Daily Demand	6.39
Peak Hourly Demand	14.07
Fire Flow Demand	250, 184
Maximum Daily + Fire Flow Demand	256.39, 190.39

Location:

Results:

Connection-1:

Criteria	Head (m)	Pressure (psi)
Max HGL	162.2	94.2
PKHR	155.2	84.3
MXDY + Fire Flow (250 L/s)	135.4	56.0
MXDY + Fire Flow (184 L/s)	143.9	68.2

Note: The client requested BCs at two connections. Generally, the City does not provide boundary conditions beyond the existing watermain network. In this case, BC is provided for only one connection as there is no available information for the second connection.

Considerations:

1. According to the City of Ottawa Water Design Guidelines as well as the Ontario Building Code, the maximum pressure at any point within a distribution system shall not exceed 80 psi in occupied areas. In scenario-2, measures should be taken to try to reduce the residual pressure below 80 psi without the use of special pressure control equipment. In circumstances where the residual pressure cannot be reduced below 80 psi without the use of pressure control equipment, a pressure reducing valve (**PRV**) should be installed at site.
2. The site will not be permitted to develop more than 49 units until getting the second connection which will supply to the development as per Section 4.3.1 of the City's water design guidelines. The proponent must need to wait until availability of this second feed.

Disclaimer

The boundary condition information is based on current operation of the city water distribution system. The computer model simulation is based on the best information available at the time. The operation of the water distribution system can change on a regular basis, resulting in a variation in boundary conditions. The physical properties of watermains deteriorate over time, as such must be assumed in the absence of actual field test data. The variation in physical watermain properties can therefore alter the results of the computer model simulation. Fire Flow analysis is a reflection of available flow in the watermain; there may be additional restrictions that occur between the watermain and the hydrant that the model cannot take into account.

WATERMAIN DEMAND CALCULATION SHEET

IBI GROUP
333 PRESTON STREET
OTTAWA, ONTARIO
K1S 5N4

PROJECT : RICHARDSON RIDGE PHASE 4
CLIENT : RICHARDSON RIDGE INC.

FILE: 39606-5.7
DATE PRINTED: 26-Jul-16
DESIGN: L.E.

NODE	RESIDENTIAL				NON-RESIDENTIAL (ICI)			AVERAGE DAILY DEMAND (l/s)			MAXIMUM DAILY DEMAND (l/s)			MAXIMUM HOURLY DEMAND (l/s)			FIRE DEMAND (l/min)
	SINGLE FAMILY UNITS	TOWN HOUSE UNITS	MEDIUM DENSITY (ha)	POPULATION	INDUST. (ha)	COMM. (ha)	INSTIT. (ha)	RESIDENTIAL	ICI	TOTAL	RESIDENTIAL	ICI	TOTAL	RESIDENTIAL	ICI	TOTAL	
PHASE 4																	
RR-400		4		11				0.04		0.04	0.11		0.11	0.24		0.24	10,000
RR=405		8		22				0.09		0.09	0.22		0.22	0.48		0.48	10,000
RR-410		9		24				0.10		0.10	0.25		0.25	0.54		0.54	10,000
RR-415		20		54				0.22		0.22	0.55		0.55	1.20		1.20	10,000
RR-420		16		43				0.18		0.18	0.44		0.44	0.96		0.96	10,000
RR-425		11		30				0.12		0.12	0.30		0.30	0.66		0.66	10,000
RR-430		9		24				0.10		0.10	0.25		0.25	0.54		0.54	10,000
RR-435		6		16				0.07		0.07	0.16		0.16	0.36		0.36	10,000
RR-440		22		59				0.24		0.24	0.60		0.60	1.32		1.32	10,000
RR-445		8		22				0.09		0.09	0.22		0.22	0.48		0.48	10,000
RR-450		14		38				0.15		0.15	0.38		0.38	0.84		0.84	10,000
RR-455		29		78				0.32		0.32	0.79		0.79	1.74		1.74	10,000
RR-460	15			51				0.21		0.21	0.52		0.52	1.14		1.14	10,000
RR-465	10			34				0.14		0.14	0.34		0.34	0.76		0.76	10,000
RR-470	7			24				0.10		0.10	0.24		0.24	0.53		0.53	10,000
RR-475	9			31				0.12		0.12	0.31		0.31	0.68		0.68	10,000
TOTAL PHASE 1	41	156		561						2.27			5.68			12.49	
EXISTING																	
RR-01	7			24				0.10		0.10	0.24		0.24	0.53		0.53	10,000
RR-02	7			24				0.10		0.10	0.24		0.24	0.53		0.53	10,000
RR-210	11			37				0.15		0.15	0.38		0.38	0.83		0.83	10,000
RR-215	6	4		31				0.13		0.13	0.32		0.32	0.70		0.70	10,000

POPULATION DENSITY

Single Family 3.4 persons/unit
Semi Detached & Townhouse 2.7 persons/unit
Medium Density 1.8 persons/unit

WATER DEMAND RATES

Residential 350 l/cap/day

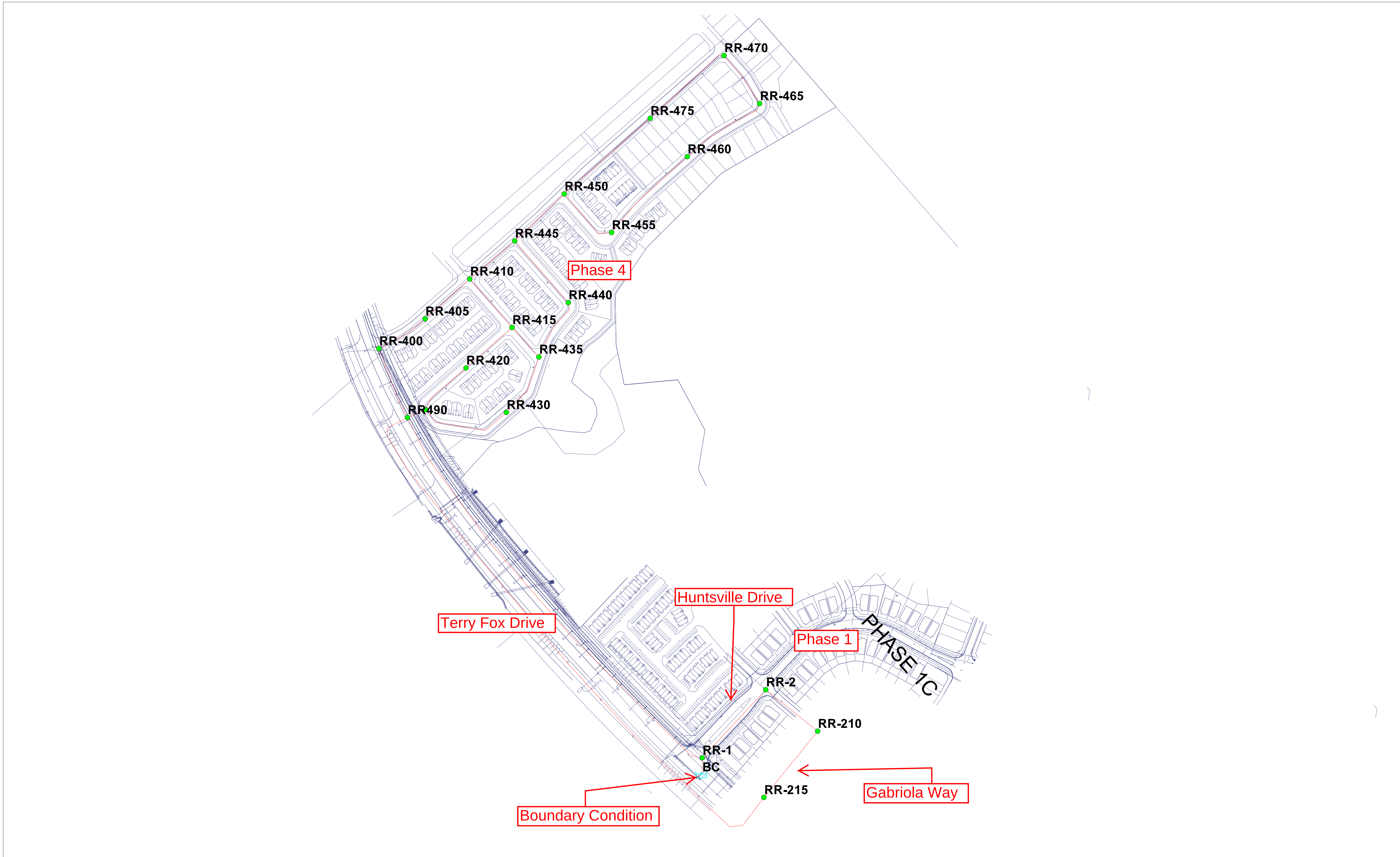
PEAKING FACTORS

Maximum Daily Residential 2.5 x avg. day
Maximum Hourly Residential 2.2 x max. day

FIRE DEMANDS

Single Family 10,000 l/min (166.7 l/s)
Semi Detached & Townhouse 10,000 l/min (166.7 l/s)
Medium Density 15,000 l/min (250 l/s)

RR Phase 4 - Node ID's

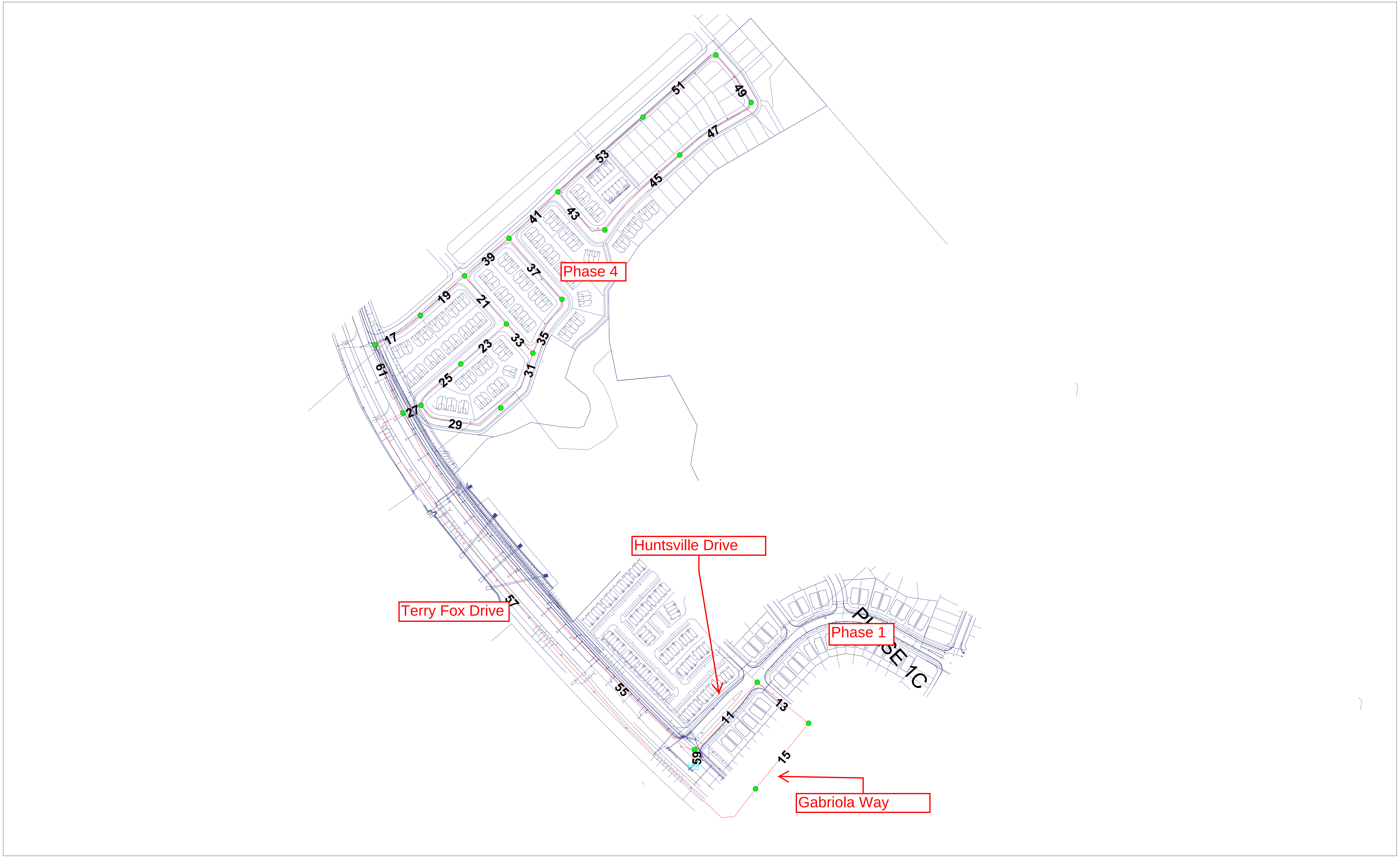


Date: Sunday, July 17, 2016

RR Phase 4 - Pipe Sizes

Date: Sunday, July 17, 2016

RR Phase 4 - Pipe ID's



Date: Sunday, July 17, 2016

RR Phase 4 - Max HGL Pressures (kPa)

Date: Sunday, July 17, 2016

RR Phase 4 - Max Day Fireflow (l/s)

Date: Sunday, July 17, 2016

RR Phase 4 - Peak Hour Pressures (kPa)

Date: Sunday, July 17, 2016

RR Phase 4 - Basic Day (Max HGL) HGL 162.2 m - Junction Report

		ID	Demand (L/s)	Elevation (m)	Head (m)	Pressure (kPa)
1		RR-1	0.10	96.00	162.20	648.71
2		RR-2	0.10	98.50	162.20	624.21
3		RR-210	0.15	98.25	162.20	626.66
4		RR-215	0.13	96.90	162.20	639.88
5		RR-400	0.04	97.50	162.20	633.97
6		RR-405	0.09	101.50	162.20	594.78
7		RR-410	0.10	101.00	162.20	599.67
8		RR-415	0.22	99.85	162.20	610.94
9		RR-420	0.18	99.20	162.20	617.31
10		RR-425	0.12	97.20	162.20	636.91
11		RR-430	0.10	97.25	162.20	636.42
12		RR-435	0.07	97.50	162.20	633.97
13		RR-440	0.24	98.75	162.20	621.72
14		RR-445	0.09	102.00	162.20	589.87
15		RR-450	0.15	105.00	162.20	560.47
16		RR-455	0.32	105.50	162.20	555.57
17		RR-460	0.21	105.00	162.20	560.47
18		RR-465	0.14	104.00	162.20	570.27
19		RR-470	0.10	106.00	162.20	550.67
20		RR-475	0.12	107.00	162.20	540.87
21		RR490	0.00	97.20	162.20	636.92

RR Phase 4 Peak Hour HGL 155.2m - Junction Report

		ID	Demand (L/s)	Elevation (m)	Head (m)	Pressure (kPa)
1		RR-1	0.53	96.00	155.20	580.11
2		RR-2	0.53	98.50	155.20	555.60
3		RR-210	0.83	98.25	155.19	557.98
4		RR-215	0.70	96.90	155.19	571.17
5		RR-400	0.24	97.50	155.12	564.62
6		RR-405	0.48	101.50	155.11	525.38
7		RR-410	0.54	101.00	155.11	530.25
8		RR-415	1.20	99.85	155.11	541.51
9		RR-420	0.96	99.20	155.11	547.90
10		RR-425	0.66	97.20	155.12	567.55
11		RR-430	0.54	97.25	155.11	567.01
12		RR-435	0.36	97.50	155.11	564.54
13		RR-440	1.32	98.75	155.11	552.25
14		RR-445	0.48	102.00	155.11	520.39
15		RR-450	0.84	105.00	155.10	490.90
16		RR-455	1.74	105.50	155.09	485.98
17		RR-460	1.14	105.00	155.09	490.87
18		RR-465	0.76	104.00	155.09	500.67
19		RR-470	0.53	106.00	155.09	481.07
20		RR-475	0.68	107.00	155.09	471.28
21		RR490	0.00	97.20	155.12	567.61

RR Phase 4 Max Day + Fireflow HGL 143.9m - Fireflow Design Report

		ID	Total Demand (L/s)	Critical Node 1 ID	Critical Node 1 Pressure (kPa)	Critical Node 1 Head (m)	Adjusted Fire-Flow (L/s)	Available Flow @Hydrant (L/s)	Critical Node 2 ID	Critical Node 2 Pressure (kPa)	Critcal Node 2 Head (m)	Adjusted Available Flow (L/s)	Design Flow (L/s)
1		RR-1	166.91	RR-475	361.14	132.85	7,380.09	9,135.52	RR-475	32.76	99.34	7,380.03	7,380.03
2		RR-2	166.91	RR-475	360.18	135.26	3,860.10	709.09	RR-2	139.97	112.78	709.09	709.09
3		RR-210	167.05	RR-210	335.92	132.53	289.31	289.31	RR-210	139.96	112.53	289.31	289.31
4		RR-215	166.99	RR-215	254.76	122.90	212.24	212.24	RR-215	139.96	111.18	212.24	212.24
5		RR-400	166.78	RR-475	256.49	123.67	252.43	303.10	RR-475	52.79	102.89	252.44	252.43
6		RR-405	166.89	RR-475	250.76	127.09	245.18	273.81	RR-475	90.86	110.77	245.19	245.18
7		RR-410	166.92	RR-475	245.03	126.01	238.41	270.47	RR-475	83.02	109.47	238.42	238.41
8		RR-415	167.22	RR-475	250.59	125.42	245.37	263.66	RR-475	109.11	110.98	245.38	245.37
9		RR-420	167.11	RR-475	255.99	125.32	252.17	251.41	RR-420	139.96	113.48	251.41	251.41
10		RR-425	166.97	RR-475	259.79	123.71	257.24	294.58	RR-475	78.26	105.19	257.25	257.24
11		RR-430	166.92	RR-475	254.34	123.20	249.83	248.58	RR-430	139.96	111.53	248.58	248.58
12		RR-435	166.83	RR-475	248.90	122.90	242.95	267.28	RR-475	98.18	107.52	242.96	242.95
13		RR-440	167.27	RR-475	238.90	123.13	232.12	238.89	RR-475	128.12	111.82	232.12	232.12
14		RR-445	166.89	RR-475	223.94	124.85	217.29	242.62	RR-475	90.94	111.28	217.29	217.29
15		RR-450	167.05	RR-475	177.38	123.10	185.02	193.88	RR-475	120.36	117.28	185.02	185.02
16		RR-455	167.46	RR-455	166.72	122.51	178.91	178.91	RR-455	139.96	119.78	178.91	178.91
17		RR-460	167.19	RR-460	152.70	120.58	172.26	172.26	RR-460	139.96	119.28	172.26	172.26
18		RR-465	167.01	RR-470	149.29	119.23	170.84	174.14	RR-470	131.79	117.45	170.84	170.84
19		RR-470	166.91	RR-470	139.96	120.28	166.91	166.91	RR-470	139.96	120.28	166.91	166.91
20		RR-475	166.98	RR-475	141.34	121.42	167.55	167.56	RR-475	139.96	121.28	167.56	167.55

RR Phase 4 Peak Hour HGL 155.2m - Pipe Report

		ID	From Node	To Node	Length (m)	Diameter (mm)	Roughness	Flow (L/s)	Velocity (m/s)	Headloss (m)	HL/1000 (m/km)
1		11	RR-1	RR-2	114.88	297.00	120.00	3.37	0.05	0.00	0.01
2		13	RR-2	RR-210	81.97	204.00	110.00	2.84	0.09	0.01	0.08
3		15	RR-210	RR-215	105.32	204.00	110.00	2.01	0.06	0.00	0.04
4		17	RR-400	RR-405	68.18	297.00	120.00	6.86	0.10	0.00	0.05
5		19	RR-405	RR-410	73.92	297.00	120.00	6.38	0.09	0.00	0.05
6		21	RR-410	RR-415	79.45	204.00	110.00	0.66	0.02	0.000	0.01
7		23	RR-415	RR-420	75.79	204.00	110.00	-1.62	0.05	0.00	0.03
8		25	RR-420	RR-425	72.52	204.00	110.00	-2.58	0.08	0.00	0.07
9		27	RR-425	RR490	24.48	204.00	110.00	-5.37	0.16	0.01	0.25
10		29	RR-425	RR-430	115.88	204.00	110.00	2.13	0.07	0.01	0.05
11		31	RR-430	RR-435	81.26	204.00	110.00	1.59	0.05	0.00	0.03
12		33	RR-435	RR-415	49.17	204.00	110.00	-1.08	0.03	0.000	0.01
13		35	RR-435	RR-440	79.33	204.00	110.00	2.31	0.07	0.00	0.05
14		37	RR-440	RR-445	100.62	204.00	110.00	0.99	0.03	0.00	0.01
15		39	RR-445	RR-410	72.60	250.00	110.00	-5.18	0.11	0.01	0.09
16		41	RR-445	RR-450	84.29	250.00	110.00	5.69	0.12	0.01	0.11
17		43	RR-450	RR-455	81.05	250.00	110.00	2.87	0.06	0.00	0.03
18		45	RR-455	RR-460	132.50	250.00	110.00	1.13	0.02	0.000	0.01
19		47	RR-460	RR-465	110.00	250.00	120.00	-0.01	0.000	0.00	0.00
20		49	RR-465	RR-470	73.97	250.00	110.00	-0.77	0.02	0.000	0.00
21		51	RR-470	RR-475	121.42	250.00	110.00	-1.30	0.03	0.000	0.01
22		53	RR-475	RR-450	141.21	250.00	110.00	-1.98	0.04	0.00	0.01
23		55	RR-1	RR490	561.43	297.00	120.00	11.16	0.16	0.08	0.13
24		57	RR-215	RR490	740.25	155.00	100.00	1.31	0.07	0.06	0.09
25		59	RR-1	BC	1.00	297.00	120.00	-15.06	0.22	0.000	0.23
26		61	RR490	RR-400	92.17	297.00	120.00	7.10	0.10	0.01	0.06

[B]

Project Title

RICHARDSON RIDGE PHASE 4
SERVICEABILITY STUDY

Drawing Title

CONCEPTUAL
SERVICING PLAN

Sheet No.

110
2016-08-16

APPENDIX B

[B]

Project Title

RICHARDSON RIDGE PHASE 4
SERVICEABILITY STUDY

Drawing Title

CONCEPTUAL SANITARY
DRAINAGE AREA PLAN

Sheet No.

511
2016-08-16

IBI GROUP
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SANITARY SEWER DESIGN SHEET

RICHARDSON RIDGE PHASE 4
CITY OF OTTAWA
Richardson Ridge Inc.

LOCATION				RESIDENTIAL										ICI AREAS							INFILTRATION ALLOWANCE			FIXED	TOTAL	PROPOSED SEWER DESIGN						
				AREA w/ Units (Ha)	UNIT TYPES				AREA w/o Units (Ha)	POPULATION		PEAK FACTOR	PEAK FLOW (L/s)	AREA (Ha)						PEAK FLOW (L/s)	AREA (Ha)		FLOW (L/s)	FLOW (L/s)	FLOW (L/s)	CAPACITY (L/s)	LENGTH (m)	DIA (mm)	SLOPE (%)	VELOCITY (full) (m/s)	AVAILABLE CAPACITY	
														INSTITUTIONAL		COMMERCIAL		INDUSTRIAL														
STREET	AREA ID	FROM MH	TO MH		SF	SD	TH	APT		IND	CUM			IND	CUM	IND	CUM	IND	CUM		IND	CUM									L/s	(%)
SOUTHERN OUTLET TO TERRY FOX DRIVE																																
		MH109A	MH110A	0.82			28			75.6	75.6	4.00	1.23		0.00		0.00		0.00	0.00	0.82	0.82	0.23		1.45	48.39	92.45	200	2.00	1.492	46.93	96.99%
		MH110A	MH111A	0.10			2			5.4	81.0	4.00	1.31		0.00		0.00		0.00	0.00	0.10	0.92	0.26		1.57	20.24	9.82	200	0.35	0.624	18.67	92.24%
		MH111A	MH112A	0.22			6			16.2	97.2	4.00	1.58		0.00		0.00		0.00	0.00	0.22	1.14	0.32		1.89	20.24	31.69	200	0.35	0.624	18.35	90.64%
		MH112A	MH113A	0.04						0.0	97.2	4.00	1.58		0.00		0.00		0.00	0.00	0.04	1.18	0.33		1.91	20.24	25.55	200	0.35	0.624	18.34	90.59%
		MH113A	MH114A	0.03						0.0	97.2	4.00	1.58		0.00		0.00		0.00	0.00	0.03	1.21	0.34		1.91	20.24	18.72	200	0.35	0.624	18.33	90.55%
		MH118A	MH119A	0.34			9			24.3	24.3	4.00	0.39		0.00		0.00		0.00	0.00	0.34	0.34	0.10		0.49	48.39	64.00	200	2.00	1.492	47.90	98.99%
		MH119A	MH114A	0.30			9			24.3	48.6	4.00	0.79		0.00		0.00		0.00	0.00	0.30	0.64	0.18		0.97	48.39	57.87	200	2.00	1.492	47.42	98.00%
		MH114A	MH115A	0.84			2			5.4	151.2	4.00	2.45		0.00		0.00		0.00	0.00	0.84	2.69	0.75		3.20	20.24	39.96	200	0.35	0.624	17.04	84.18%
		MH115A	MH116A	0.30			7			18.9	170.1	4.00	2.76		0.00		0.00		0.00	0.00	0.30	2.99	0.84		3.59	20.24	73.42	200	0.35	0.624	16.65	82.25%
		MH116A	MH107A	0.07			1			2.7	172.8	4.00	2.80		0.00		0.00		0.00	0.00	0.07	3.06	0.86		3.66	20.24	23.99	200	0.35	0.624	16.59	81.94%
		MH101A	MH102A	0.39			13			35.1	35.1	4.00	0.57		0.00		0.00		0.00	0.00	0.39	0.39	0.11		0.68	34.22	58.38	200	1.00	1.055	33.54	98.02%
		MH102A	MH103A	0.45			14			37.8	72.9	4.00	1.18		0.00		0.00		0.00	0.00	0.45	0.84	0.24		1.42	34.22	68.78	200	1.00	1.055	32.80	95.86%
		MH103A	MH104A	0.02						0.0	72.9	4.00	1.18		0.00		0.00		0.00	0.00	0.02	0.86	0.24		1.42	20.24	10.01	200	0.35	0.624	18.82	92.98%
		MH104A	MH105A	0.03						0.0	72.9	4.00	1.18		0.00		0.00		0.00	0.00	0.03	0.89	0.25		1.43	20.24	21.25	200	0.35	0.624	18.81	92.93%
		MH105A	MH106A	0.07			1			2.7	75.6	4.00	1.23		0.00		0.00		0.00	0.00	0.07	0.96	0.27		1.49	20.24	13.53	200	0.35	0.624	18.75	92.62%
		MH106A	MH107A	0.14			4			10.8	86.4	4.00	1.40		0.00		0.00		0.00	0.00	0.14	1.10	0.31		1.71	20.24	27.63	200	0.35	0.624	18.53	91.56%
		MH107A	MH108A							0.0	259.2	4.00	4.20		0.00		0.00		0.00	0.00	0.00	4.16	1.16		5.36	20.24	10.59	200	0.35	0.624	14.88	73.50%
		MH108A	EX. MH1002A							0.0	259.2	4.00	4.20		0.00		0.00		0.00	0.00	0.00	4.16	1.16		5.36	20.24	36.22	200	0.35	0.624	14.88	73.50%
				4.16	0	0	96	0	0.00	259.2	TRUE			0.00	TRUE	0.00	TRUE	0.00	TRUE		4.16	TRUE										
NORTHERN OUTLET TO TERRY FOX DRIVE																																
		MH120A	MH121A	0.46	6			10		38.4	38.4	4.00	0.62		0.00		0.00		0.00	0.00	0.46	0.46	0.13		0.75	29.63	76.69	200	0.75	0.914	28.88	97.47%
		MH121A	MH122A	0.39	4			11		33.4	71.8	4.00	1.16		0.00		0.00		0.00	0.00	0.39	0.85	0.24		1.40	29.63	82.72	200	0.75	0.914	28.23	95.27%
		MH122A	MH123A	0.03						0.0	71.8	4.00	1.16		0.00		0.00		0.00	0.00	0.03	0.88	0.25		1.41	29.63	11.02	200	0.75	0.914	28.22	95.24%
		MH123A	MH124A	0.30	5					17.0	88.8	4.00	1.44		0.00		0.00		0.00	0.00	0.30	1.18	0.33		1.77	45.26	37.82	200	1.75	1.396	43.49	96.09%
		MH124A	MH125A	0.22	3					10.2	99.0	4.00	1.60		0.00		0.00		0.00	0.00	0.22	1.40	0.39		2.00	45.26	36.24	200	1.75	1.396	43.27	95.59%
		MH125A	MH126A	0.11	1					3.4	102.4	4.00	1.66		0.00		0.00		0.00	0.00	0.11	1.51	0.42		2.08	20.24	10.98	200	0.35	0.624	18.16	89.71%
		MH126A	MH127A	0.45	7					23.8	126.2	4.00	2.04		0.00		0.00		0.00	0.00	0.45	1.96	0.55		2.59	20.24	67.55	200	0.35	0.624	17.65	87.19%
		MH127A	MH128A	0.86	14		1			50.3	176.5	4.00	2.86		0.00		0.00		0.00	0.00	0.86	2.82	0.79		3.65	20.24	105.85	200	0.35	0.624	16.59	81.97%
		MH128A	MH129A	0.32			11			29.7	206.2	4.00	3.34		0.00		0.00		0.00	0.00	0.32	3.14	0.88		4.22	20.24	41.21	200	0.35	0.624	16.02	79.15%
		MH129A	MH130A	0.22			5			13.5	219.7	4.00	3.56		0.00		0.00		0.00	0.00	0.22	3.36	0.94		4.50	20.24	24.14	200	0.35	0.624	15.74	77.77%
		MH130A	MH131A				4			10.8	230.5	4.00	3.73		0.00		0.00		0.00	0.00	0.00	3.36	0.94		4.68	20.24	20.44	200	0.35	0.624	15.57	76.90%
		MH131A	MH134A				16			43.2	273.7	4.00	4.43		0.00		0.00		0.00	0.00	0.00	3.36	0.94		5.38	20.24	67.90	200	0.35	0.624	14.87	73.44%
		MH132A	MH133A		1		6	7		32.2	32.2	4.00	0.52		0.00		0.00		0.00	0.00	0.00	0.00	0.00		0.52	48.39	55.89	200	2.00	1.492	47.87	98.92%
		MH133A	MH134A					6		10.8	43.0	4.00	0.70		0.00		0.00		0.00	0.00	0.00	0.00	0.00		0.70	48.39	43.35	200	2.00	1.492	47.69	98.56%
		MH134A	MH135A					6		10.8	327.5	4.00	5.31		0.00		0.00		0.00	0.00	0.00	3.36	0.94		6.25	20.24	39.27	200	0.35	0.624	14.00	69.14%
		MH135A	MH136A					5		9.0	336.5	4.00	5.45		0.00		0.00		0.00	0.00	0.00	3.36	0.94		6.39	20.24	38.78	200	0.35	0.624	13.85	68.42%
		MH136A	MH137A					10		18.0	354.5	4.00	5.74		0.00		0.00		0.00	0.00	0.00	3.36	0.94		6.69	59.26	78.00	200	3.00	1.828	52.58	88.72%
		MH137A	MH138A				10			27.0	381.5	4.00	6.18		0.00		0.00		0.00	0.00	0.00	3.36	0.94		7.12	59.26	84.42	200	3.00	1.828	52.14	87.98%
		MH138A	EX. MH1000A				7			18.9	400.4	4.00	6.49		0.00		0.00		0.00	0.00	0.00	3.36	0.94		7.43	24.19	53.84	200	0.50	0.746	16.77	69.30%
				3.36	41	0	60	55	0.00	400.4	TRUE			0.00	TRUE	0.00	TRUE	0.00	TRUE		3.36	TRUE										
					41	0	156	55																								

Design Parameters:

Residential			ICI Areas			Peak Factor
SF	3.4	p/p/u	INST	50,000	L/Ha/day	1.5
TH/SD	2.7	p/p/u	COM	50,000	L/Ha/day	1.5
APT	1.8	p/p/u	IND	35,000	L/Ha/day	MOE Chart
Other	60	p/p/Ha		17000	L/Ha/day	

Notes:
1. Mannings coefficient (n) = 0.013
2. Demand (per capita): 350 L/day 300 L/day
3. Infiltration allowance: 0.28 L/s/Ha
4. Residential Peaking Factor:
Harmon Formula = 1+(14/(4+P^0.5))
where P = population in thousands

Designed: RM

Checked: DY

Dwg. Reference: 39606-511

No.	Revision	Date
1.	Serviceability Report - Submission #1	8/12/2016

File Reference:	Date:	Sheet No:
39606-5.7	8/12/2016	1 of 1

APPENDIX C

Project Title

RICHARDSON RIDGE PHASE 4 SERVICEABILITY STUDY

Drawing Title

CONCEPTUAL STORM DRAINAGE AREA PLAN

Sheet No.

510

2016-08-16

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STORM SEWER DESIGN SHEET

RICHARDSON RIDGE PHASE 4
City of Ottawa
Richardson Ridge Inc.

LOCATION				AREA (Ha)										RATIONAL DESIGN FLOW													SEWER DATA								
STREET	AREA ID	FROM	TO	C= 0.20	C= 0.25	C= 0.40	C= 0.50	C= 0.57	C= 0.65	C= 0.69	C= 0.70	C= 0.76	C= 0.80	IND 2.78AC	CUM 2.78AC	INLET (min)	TIME IN PIPE	TOTAL (min)	i (5) (mm/hr)	i (10) (mm/hr)	i (100) (mm/hr)	5yr PEAK FLOW (L/s)	10yr PEAK FLOW (L/s)	100yr PEAK FLOW (L/s)	FIXED FLOW (L/s)	DESIGN FLOW (L/s)	CAPACITY (L/s)	LENGTH (m)	PIPE SIZE (mm) DIA	W	H	SLOPE (%)	VELOCITY (m/s)	AVAIL CAP (5yr) (L/s)	(%)
WESTERN OUTLET																																			
Street No. 1		MH132	MH133									0.26		0.55	0.55	10.00	0.54	10.54	104.19	122.14	178.56	57.24				57.24	87.74	55.89	250			2.00	1.731	30.50	34.76%
Street No. 1		MH133	MH134									0.14		0.30	0.85	10.54	0.37	10.91	101.43	118.89	173.79	85.72				85.72	142.67	43.35	300			2.00	1.955	56.94	39.91%
Street No. 4		MH128	MH129								0.17			0.33	0.33	10.00	0.62	10.62	104.19	122.14	178.56	34.47				34.47	53.73	39.45	250			0.75	1.060	19.26	35.84%
Street No. 4		MH129	MH130				0.22				0.08			0.46	0.79	10.62	0.30	10.92	101.03	118.41	173.08	80.04				80.04	158.41	25.09	375			0.75	1.389	78.36	49.47%
Street No. 4		MH130	MH131								0.14			0.27	1.06	10.92	0.26	11.18	99.57	116.69	170.56	106.01				106.01	158.41	21.54	375			0.75	1.389	52.39	33.07%
Street No. 4		MH131	MH134								0.27			0.53	1.59	11.18	0.75	11.93	98.35	115.26	168.45	156.39				156.39	257.58	70.69	450			0.75	1.569	101.19	39.28%
Street No. 1		MH134	MH135									0.13		0.27	2.71	11.93	0.20	12.13	94.99	111.31	162.65	257.43				257.43	488.73	36.31	450			2.70	2.977	231.30	47.33%
Street No. 1		MH135	MH136									0.14		0.30	3.01	12.13	0.22	12.35	94.13	110.29	161.15	282.93				282.93	488.73	38.73	450			2.70	2.977	205.81	42.11%
Street No. 1		MH136	MH137									0.28		0.59	3.60	12.35	0.45	12.80	93.23	109.23	159.59	335.36				335.36	488.73	81.01	450			2.70	2.977	153.37	31.38%
Street No. 1		MH139	MH138									0.16		0.34	0.34	10.00	0.72	10.72	104.19	122.14	178.56	35.22				35.22	59.68	35.31	300			0.35	0.818	24.46	40.98%
Street No. 1		MH138	MH137									0.26		0.55	0.89	10.72	1.67	12.39	100.54	117.84	172.24	89.22				89.22	133.02	81.42	450			0.20	0.810	43.80	32.93%
Street No. 2		MH137	MH119				0.20					0.24	0.08	0.96	5.45	12.80	0.88	13.68	91.40	107.07	156.43	497.90				497.90	687.10	79.50	750			0.35	1.507	189.20	27.54%
Street No. 2		MH119	MH114									0.18		0.38	5.83	13.68	0.69	14.37	88.07	103.16	150.68	513.25				513.25	687.10	61.95	750			0.35	1.507	173.85	25.30%
Street No. 3		MH109	MH110									0.44		0.93	0.93	10.00	0.81	10.81	104.19	122.14	178.56	96.86				96.86	142.67	95.28	300			2.00	1.955	45.81	32.11%
Street No. 3		MH110	MH111									0.06		0.13	1.06	10.81	0.09	10.90	100.09	117.31	171.46	105.74				105.74	142.67	10.53	300			2.00	1.955	36.93	25.89%
Street No. 3		MH111	MH112									0.11		0.23	1.29	10.90	0.65	11.55	99.66	116.80	170.71	128.44				128.44	184.99	32.23	525			0.17	0.828	56.55	30.57%
Street No. 3		MH112	MH113				0.09					0.08		0.29	1.58	11.55	0.57	12.12	96.66	113.27	165.53	153.00				153.00	184.99	28.22	525			0.17	0.828	31.98	17.29%
Street No. 3		MH113	MH114									0.03		0.06	1.65	12.12	0.37	12.48	94.19	110.36	161.26	155.07				155.07	184.99	18.14	525			0.17	0.828	29.92	16.17%
Street No. 3		MH114	MH115									0.13		0.27	7.75	14.37	0.60	14.96	85.65	100.32	146.51	663.73				663.73	944.84	37.77	1050			0.11	1.057	281.11	29.75%
Street No. 3		MH115	MH108				0.21					0.23		0.78	8.53	14.96	1.41	16.37	83.67	97.99	143.09	713.46				713.46	944.84	89.35	1050			0.11	1.057	231.38	24.49%
Street No. 3		MH101	MH102									0.23		0.49	0.49	10.00	0.43	10.43	104.19	122.14	178.56	50.63				50.63	258.68	58.38	375			2.00	2.269	208.04	80.43%
Street No. 3		MH102	MH103				0.44					0.28		1.20	1.69	10.43	0.53	10.95	101.98	119.54	174.73	172.26				172.26	258.68	71.60	375			2.00	2.269	86.42	33.41%
Street No. 3		MH103	MH104									0.05		0.11	1.79	10.95	0.21	11.17	99.41	116.50	170.28	178.41				178.41	248.09	10.75	600			0.15	0.850	69.68	28.09%
Street No. 3		MH104	MH105									0.04		0.08	1.88	11.17	0.45	11.61	98.41	115.34	168.56	184.95				184.95	248.09	22.77	600			0.15	0.850	63.14	25.45%
Street No. 3		MH105	MH106									0.03		0.06	1.94	11.61	0.22	11.83	96.38	112.95	165.05	187.24				187.24	248.09	10.98	600			0.15	0.850	60.85	24.53%
Street No. 3		MH106	MH107									0.10		0.21	2.15	11.83	0.64	12.47	95.44	111.83	163.42	205.57				205.57	248.09	32.89	600			0.15	0.850	42.52	17.14%
Street No. 3		MH107	MH108									0.04		0.08	2.24	12.47	0.34	12.81	92.72	108.64	158.73	207.56				207.56	248.09	17.46	600			0.15	0.850	40.53	16.34%
Block 55		MH108	MH116											0.00	10.77	16.37	0.09	16.46	79.37	92.93	135.67	854.43				854.43	1,348.97	6.00	1200			0.11	1.155	494.55	36.66%
Block 55		MH116	HW2											0.00	10.77	16.46	0.09	16.55	79.12	92.63	135.24	851.75				851.75	1,348.97	6.00	1200			0.11	1.155	497.22	36.86%
				0.00	0.00	0.00	1.16	0.00	0.00	0.00	0.66	3.64	0.08	10.77	TRUE																				
EASTERN OUTLET																																			
Street No. 1		MH120	MH121									0.36		0.76	0.76	10.00	0.99	10.99	104.19	122.14	178.56	79.25				79.25	141.68	73.69	375			0.60	1.243	62.43	44.06%
Street No. 1		MH121	MH122									0.34		0.72	1.48	10.99	1.02	12.00	99.25	116.32	170.00	146.78				146.78	230.39	85.54	450			0.60	1.403	83.61	36.29%
Street No. 1		MH122	MH123									0.15		0.32	1.80	12.00	0.07	12.08	94.68	110.94	162.10	170.03				170.03	420.63	11.27	450			2.00	2.562	250.60	59.58%
Street No. 4		MH123	MH124								0.17			0.33	2.13	12.08	0.23	12.31	94.37	110.57	161.56	200.69				200.69	470.28	39.29	450			2.50	2.865	269.60	57.33%
Street No. 4		MH124	MH125								0.15			0.29	2.42	12.31	0.23	12.53	93.41	109.44	159.91	225.92				225.92	470.28	39.00	450			2.50	2.865	244.37	51.96%
Street No. 4		MH140	MH127				0.29				0.53			1.43	1.43	10.00	0.99	10.99	104.19	122.14	178.56	149.46				149.46	200.37	104.10	375			1.20	1.757	50.91	25.41%
Street No. 4		MH127	MH126				0.22				0.30			0.89	2.32	10.99	0.58	11.56	99.25	116.32	170.01	230.67				230.67	325.82	68.69	450			1.20	1.985	95.15	29.20%
Street No. 4		MH126	MH125								0.05			0.10	2.42	11.56	0.09	11.65	96.60	113.20	165.42	233.90				233.90	325.82	10.33	450			1.20	1.985	91.92	28.21%
Block 42		MH125	MH141											0.00	4.84	12.53	0.10	12.63	92.48	108.35	158.30	447.59				447.59	640.56	12.93	600			1.00	2.195	192.97	30.12%
Block 42		MH141	MH142											0.00	4.84	12.63	0.30	12.93	92.08	107.88	157.62	445.68				445.68	640.56	39.69	600			1.00	2.195	194.88	30.42%
Block 42		MH142	HW1											0.00	4.84	12.93	0.11	13.05	90.89	106.48	155.56	439.91				439.91	640.56	15.00	600			1.00	2.195	200.65	31.32%
				0.00	0.00	0.00	0.51	0.00	0.00	0.00	1.20	0.85	0.00	4.84	TRUE																				

Definitions:
Q = 2.78CiA, where:
Q = Peak Flow in Litres per Second (L/s)
A = Area in Hectares (Ha)
i = Rainfall intensity in millimeters per hour (mm/hr)
[i = 998.071 / (TC+6.053)^0.814] 5 YEAR
[i = 1174.184 / (TC+6.014)^0.816] 10 YEAR
[i = 1735.688 / (TC+6.014)^0.820] 100 YEAR

Notes:
1. Mannings coefficient (n) = 0.013

Designed: RM
Checked: DY
Dwg. Reference: 39606-510

No.	Revision	Date
1.	Serviceability Report - Submission #1	8/12/2016

File Reference:	Date:	Sheet No:
39606.5.7.1	8/12/2016	1 of 1

APPENDIX D

Project Title

RICHARDSON PHASE 4
SERVICEABILITY STUDY

Drawing Title

MACRO GRADING
PLAN

Sheet No.

210
2016-08-16

Geotechnical Engineering

Environmental Engineering

Hydrogeology

Geological Engineering

Materials Testing

Building Science

Archaeological Services

patersongroup

Geotechnical Investigation

Proposed Residential Development
Richardson Ridge - Phase 4
Terry Fox Drive - Ottawa

Prepared For

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July 14, 2016

Report: PG3695-1 Revision 1

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Drawing PG3695-2 - Permissible Grade Raise Plan

1.0 Introduction

Paterson Group (Paterson) was commissioned by Regional Group of Companies to conduct a geotechnical investigation for Phase 4 of the proposed residential development Richardson Ridge to be located along Terry Fox Drive, in the City of Ottawa (refer to Figure 1 - Key Plan presented in Appendix 2).

The objective of the current investigation was to:

❏ determine the subsurface conditions by means of test pits, hand augers, boreholes and review of existing information.

❏ provide geotechnical recommendations for the design of the proposed building including construction considerations which may affect its design.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. The report contains the geotechnical findings and includes recommendations pertaining to the design and construction of the subject development as understood at the time of writing this report.

Investigating the presence or potential presence of contamination on the subject property was not part of the scope of work of this present investigation.

2.0 Proposed Project

It is understood that the proposed development will consist of residential single home and townhouse units with a basement level. Asphalt roadways, driveways and landscaped areas will occupy the remainder of the subject site. It is further understood that the subject site will be serviced by municipal water and sewer.

3.0 Method of Investigation

3.1 Field Investigation

The field program was conducted on December 7, 14 and 15, 2015, and June 13, 2016. On December 7, 2015, the ground surface across the site was reviewed by Paterson personnel along with a surveyor from Annis, O'Sullivan Vollebekk to confirm the presence of bedrock outcrops. Where observed, bedrock outcrop elevations were surveyed, the survey results are presented in Drawing PG3695-1 - Test Hole Location Plan in Appendix 2. On December 14, 2015, test pits were completed within the west portion of the subject site to identify the presence of a silty clay deposit. On December 15, 2015, three (3) boreholes were completed within the portion of the site where the silty clay deposit was noted to be deep. On June 13, 2016, sixteen (16) hand auger holes were completed within the east portion of the site.

The test hole locations were determined in the field by Paterson personnel with consideration to site features and underground services. All test hole locations were surveyed by Annis O'Sullivan Vollebekk Ltd and are referenced to a geodetic datum. The hand auger hole locations were surveyed by Paterson personnel using a hand held GPS unit. The test hole locations are presented in Drawing PG3695-1 - Test Hole Location Plan presented in Appendix 2.

The test pits were completed using a rubber-tired backhoe. The boreholes were drilled using a track-mounted auger drill rig operated by a two person crew. All fieldwork was conducted under the full-time supervision of personnel from Paterson's geotechnical division under the direction of a senior engineer. The testing procedure consisted of excavating or augering to the required depths and sampling the overburden.

Sampling and In Situ Testing

Soil samples were collected from the side walls of the test pits or from boreholes using a 50 mm diameter split-spoon (SS) sample or the auger flights. All soil samples were visually inspected and initially classified on site. The grab, split-spoon and auger samples were placed in sealed plastic bags. All samples were transported to the laboratory for further examination and classification. The depths at which the grab, split-spoon and auger samples were recovered from the test holes are presented as G, SS and AU, respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

The Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split-spoon samples. The SPT results are recorded as “N” values on the Soil Profile and Test Data sheets as number of blows required to drive the split-spoon sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm.

Undrained shear strength testing was conducted in cohesive soils using a field vane apparatus. This testing was done in general accordance with ASTM D2573-08 - Standard Test Method for Field Vane Shear Test in Cohesive Soil.

The subsurface conditions observed in the test holes were recorded in detail in the field. The soil profiles are presented on the Soil Profile and Test Data sheets in Appendix 1.

Flexible standpipes were installed in all the boreholes to permit monitoring of the groundwater levels subsequent to the completion of the sampling program.

All samples will be stored in the laboratory for a period of one month after issuance of this report and be discarded unless otherwise directed.

3.2 Field Survey

The test hole locations and ground surface elevations were surveyed by Annis O’Sullivan Vollebekk Ltd. The locations and ground surface elevations for each test hole location are presented on Drawing PG3695-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

The soil samples recovered from our field investigation were examined in our laboratory. The subsurface soils were classified in general accordance with ASTM D2488-09a, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). Two (2) Shelby tube samples were submitted for unidimensional consolidation and one (1) sample was selected for Atterberg limit testing from the boreholes completed for our investigation. The results of the consolidation and Atterberg testing are presented on the Unidimensional Consolidation Test Results and Atterberg Limits sheets presented in Appendix 1 and are further discussed in Sections 4 and 5.

3.4 Analytical Testing

One soil sample was submitted for analytical testing to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The results are presented in Appendix 1 and are discussed further in Subsection 6.7.

4.0 Observations

4.1 Surface Conditions

Currently, the ground surface across the subject site consists of grassed and treed areas. Bedrock outcrops were noted throughout the central and east portions of the subject site. The ground surface across the central portion of the site undulates significantly and slopes downward within the west portion of the site.

4.2 Subsurface Profile

Generally, the subsurface profile encountered at the test hole locations consists of topsoil over a silty clay deposit and glacial till and/or bedrock. Based on undrained shear strength values, the silty clay varied between a firm to very stiff consistency.

Refer to the Soil Profile and Test Data sheets in Appendix 1 for specific details of the soil profiles encountered at each test hole location.

Based on available geological mapping, the subject site is located in an area where the bedrock consists of either diorite, gabbro or paragneiss. The overburden drift thickness is estimated to be 0 to 5 m depth.

A series of hand auger holes were excavated within the east portion of the site to provide a preliminary delineation of the soils along the toe of the exposed bedrock face. The hand auger hole locations are presented in Drawing PG3695-1 - Test Hole Location Plan in Appendix 2. The soil profile encountered at the hand auger hole locations are presented in Table 1 below.

Table 1 - Soil Profile at Hand Auger Hole Locations

Test Hole Number	Soil Description	Groundwater Observation
HA 1	0 m - 0.10 m Topsoil 0.10 m - 1.10 m Brown silty clay, trace sand	Dry upon completion
HA 2	0 m - 0.40 m Topsoil	Dry upon completion
HA 3	0 m - 0.10 m Topsoil 0.10 m - 1.00 m Brown silty clay, trace sand	Dry upon completion
HA 4	0 m - 0.20 m Brown silty sand 0.20 m - 0.81 m Brown silty clay, trace sand Hand Auger refusal at 0.81 m	Dry upon completion

Table 1 - Soil Profile at Hand Auger Hole Locations(Continued)

Test Hole Number	Soil Description	Groundwater Observation
HA 5	0.0 m - 0.10 m Topsoil 0.10 m - 1.47 m Brown silty clay, trace sand	Wet at 0.4 m depth
HA 6	0.0 m - 0.20 m Topsoil 0.20 m - 1.35 m Brown silty clay, trace sand	Dry upon completion
HA 7	0.0 m - 0.18 m Topsoil, trace gravel 0.18 m - 1.37 m Brown silty clay, trace sand	Wet at 1.2 m depth
HA 8	0.0 m - 0.15 m Topsoil 0.15 m - 0.61 m Brown silty clay, trace sand Hand auger refusal at 0.61 m	Wet at 0.4 m depth
HA 9	0.0 m - 0.23 m Topsoil 0.23 m - 0.69 m Brown silty clay, trace sand Hand auger refusal at 0.69 m	Dry upon completion
HA 10	0.0 m - 0.23 m Topsoil 0.23 m - 0.67 m Brown silty clay, trace sand Hand auger refusal at 0.67 m	Dry upon completion
HA 11	0.0 m - 0.15 m Topsoil 0.15 m - 0.29 m Brown silty clay, trace sand and gravel Hand Auger refusal at 0.29 m	Dry upon completion
HA 12	0.0 m - 0.13 m Topsoil 0.13 m - 1.35 m Brown silty clay, trace sand	Dry upon completion
HA 13	0.0 m - 0.15 m Topsoil 0.15 m - 1.35 m Brown silty clay, trace sand	Wet at 0.3 m depth
HA 14	0.0 m - 0.13 m Topsoil 0.13 m - 0.79 m Brown silty clay, trace sand	Dry upon completion
HA 15	0.0 m - 0.13 m - Topsoil 0.13 m - 1.35 m Brown silty clay, trace sand	Wet at 1.3 m depth
HA 16	0.0 m - 0.18 m Topsoil 0.18 m - 1.35 m Brown silty clay, trace sand	Wet at 1.3 m depth

4.3 Groundwater

On January 6, 2015, groundwater levels were measured in piezometers installed at the borehole locations. The measured groundwater levels are presented on the Soil Profile and Test Data sheets in Appendix 1. The long-term groundwater level can also be estimated based on field observations of the recovered soil samples, such as moisture levels, colouring and consistency. Based on these observations, the long-term groundwater level can be expected between 3 to 6 m depth. Groundwater levels are subject to seasonal fluctuations and could vary at the time of construction.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is adequate for the proposed residential development. However, due to the presence of the sensitive silty clay layer within the southwest portion of the current phase, areas of the site will be subjected to grade raise restrictions.

Permissible grade raise recommendations are discussed in Subsection 5.3 and recommended permissible grade raise areas are presented in Drawing PG3695-2 - Permissible Grade Raise Plan in Appendix 2. If higher than permissible grade raises are required, preloading with or without a surcharge, lightweight fill and/or other measures should be investigated to reduce the risks of unacceptable long-term post construction total and differential settlements. It should be noted that our permissible grade raise restrictions will be waived if a settlement surcharge program is designed by Paterson and given sufficient time to be successfully completed.

It should be further noted that bedrock outcrops and shallow bedrock were observed across the central and east portions of Phase 4. It is understood that a bedrock blasting program is to be completed within these areas. As part of the blasting program, crushing of the blasted material is to be completed to enable reuse of the material on site. Construction recommendations for use of the crushed material and footing placement over blasted areas are provided in the following subsections.

It should be noted that the existing slopes within the site are considered stable and no setbacks are required from a slope stability perspective. Bedrock was noted to be encountered at shallow depths in the areas where slopes are present, which provides a high factor of safety for slope stability (ie.- greater than 1.5) under static and seismic conditions.

The above and other considerations are further discussed in the following sections.

5.2 Site Grading and Preparation

Stripping Depth

Topsoil and deleterious fill, such as those containing organic materials, should be stripped from under any buildings, paved areas, pipe bedding and other settlement sensitive structures.

Fill Placement

Fill placed for grading beneath the building areas should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. The backfill material should be tested and approved prior to delivery to the site. The fill should be placed in maximum 300 mm thick lifts and compacted to 98% of the standard Proctor maximum dry density (SPMDD).

Where over-blasting has occurred below proposed underside of footing level, it is suitable for a site crushed rock material, consisting of 150 mm minus material which is adequately compacted to be placed below underside of footing. Where required for grading purposes, the 150 mm minus material should be topped with a Granular B Type II or Granular A crushed stone material.

If site excavated blast rock is to be used as fill to build up the bearing medium, it should be suitably fragmented to produce a well-graded material with a maximum particle size of 400 mm placed in maximum 600 mm loose lifts and compacted by an adequately sized bulldozer making several passes and approved by the geotechnical consultant at the time of placement. Any blast rock greater than 400 mm in diameter should be segregated and hoe rammed into acceptable fragments. The site excavated blast rock fill with maximum particle size of 400 mm should be capped with a minimum of 300 mm of of Granular B Type II or Granular A crushed stone material and should be compacted to at least 98% of its standard Proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be placed as general landscaping fill where settlement of the ground surface is of minor concern. The existing fill materials should be spread in thin lifts and at a minimum compacted by the tracks of the spreading equipment to minimize voids. If the material is to be placed to increase the subgrade level for areas to be paved, the fill should be compacted in maximum 300 mm lifts and compacted to 95% of the SPMDD. Non-specified existing fill and site-excavated soils are not suitable for placement as backfill against foundation walls unless a composite drainage blanket connected to a perimeter drainage system is provided.

Fill used for grading beneath the base and subbase layers of paved areas should consist, unless otherwise specified, of clean imported granular fill, such as OPSS Granular B Type II or select subgrade material. This material should be tested and approved prior to delivery to the site. The fill should be placed in lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the paved areas should be compacted to at least 95% of its SPMDD.

If excavated rock is to be used as fill to build up the subgrade for roadways, it should be suitably fragmented to produce a well-graded material with a maximum particle size of 300 mm. Where the fill is open-graded, a blinding layer of finer granular fill or a geotextile may be required to prevent adjacent finer materials from migrating into the voids, with associated loss of ground and settlements.

5.3 Foundation Design

Bearing Resistance Values

Footings for the proposed buildings can be designed using the bearing resistance values presented in Table 1. It should be noted that where foundations are placed over engineered fill over bedrock or directly over bedrock, Part 9 of the current OBC 2012 standard should be used for design purposes. Also, where foundations are placed over a silty clay deposit, Part 4 of the current OBC 2012 standard should be used for design purposes. The area requiring permissible grade raise restrictions outlined in Drawing PG3695-2 - Permissible Grade Raise Areas in Appendix 2 should be used to delineate the houses where silty clay is anticipated below footing level.

Table 2 - Bearing Resistance Values

Bearing Surface	Bearing Resistance Value at SLS (kPa)	Factored Bearing Resistance Value at ULS (kPa)
Firm Silty Clay	60	125
Stiff Silty Clay	100	150
Clean, Bedrock	500	1000
Engineered Fill	150	250

Note: Strip footings, up to 2 m wide, and pad footings, up to 4 m wide, placed over a silty clay bearing surface can be designed using the abovenoted bearing resistance values.

The bearing resistance values are provided on the assumption that the footings will be placed on undisturbed soil bearing surfaces. An undisturbed soil bearing surface consists of one from which all topsoil and deleterious materials, such as loose, frozen or disturbed soil, whether in situ or not, have been removed, in the dry, prior to the placement of concrete for footings.

A clean, surface-sounded bedrock bearing surface should be free of loose materials, and have no near surface seams, voids, fissures or open joints which can be detected from surface sounding with a rock hammer.

A geotechnical resistance factor of 0.5 was applied to the reported bearing resistance values at ULS.

Where a building is founded partly on bedrock and partly on soil, it is recommended to decrease the soil bearing resistance value by 25% for the footings placed on soil bearing media to reduce the potential long term total and differential settlements. Also, at the soil/bedrock and bedrock/soil transitions, it is recommended that the upper 0.5 m of the bedrock be removed for a minimum length of 2 m (on the bedrock side) and replaced with nominally compacted OPSS Granular A or Granular B Type II material. The width of the subexcavation should be at least the proposed footing width plus 0.5 m. Steel reinforcement, extending at least 3 m on both sides of the 2 m long transition, should be placed in the top part of the footings and foundation walls.

Bearing resistance values for footing design should be determined on a per lot basis at the time of construction.

Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to an engineered fill, firm to stiff silty clay above the groundwater table when a plane extending horizontally and vertically from the underside of the footing at a minimum of 1.5H:1V passing through in situ soil of the same or higher bearing capacity as the bearing medium soil.

Settlement/Grade Raise

Consideration must be given to potential settlements which could occur due to the presence of the silty clay deposit and the combined loads from the proposed footings, any groundwater lowering effects, and grade raise fill. The foundation loads to be considered for the settlement case are the continuously applied loads which consist of the unfactored dead loads and the portion of the unfactored live load that is considered to be continuously applied. For dwellings, a minimum value of 50% of the live load is recommended by Paterson.

Generally, the potential long term settlement is evaluated based on the compressibility characteristics of the silty clay. These characteristics are estimated in the laboratory by conducting unidimensional consolidation tests on undisturbed soil samples collected using Shelby tubes in conjunction with a piston sampler. Two (2) site specific consolidation tests were conducted. The results of the consolidation tests from our testing are presented in Table 2 and in Appendix 1.

The value for p'_c is the preconsolidation pressure and p'_o is the effective overburden pressure of the test sample. The difference between these values is the available preconsolidation. The increase in stress on the soil due to the cumulative effects of the fill surcharge, the footing pressures, the slab loadings and the lowering of the groundwater should not exceed the available preconsolidation if unacceptable settlements are to be avoided.

The values for C_{cr} and C_c are the recompression and compression indices, respectively. These soil parameters are a measure of the compressibility due to stress increases below and above the preconsolidation pressures. The higher values for the C_c, as compared to the C_{cr}, illustrate the increased settlement potential above, as compared to below, the preconsolidation pressure.

Table 3 - Summary of Consolidation Test Results

Borehole	Sample	Depth (m)	p'_c (kPa)	p'_o (kPa)	C_{cr}	C_c	Q
BH 2	TW 5	4.17	62	55	0.014	0.482	G
BH 2A	TW 1	3.33	53.8	49	0.01	0.385	P

* - Q - Quality assessment of sample - G: Good A: Acceptable P: Likely disturbed

The values of p'_c, p'_o, C_{cr} and C_c are determined using standard engineering testing procedures and are estimates only. Natural variations within the soil deposit will affect the results. The p'_o parameter is directly influenced by the groundwater level. Groundwater levels were measured during the site investigation. Groundwater levels vary seasonally which has an impact on the available preconsolidation. Lowering the groundwater level increases the p'_o and therefore reduces the available preconsolidation. Unacceptable settlements could be induced by a significant lowering of the groundwater level. The p'_o values for the consolidation tests carried out for the present investigation are based on the long term groundwater level observed at each borehole location. The long-term groundwater level is based on the colour and undrained shear strength profile of the silty clay.

The total and differential settlements will be dependent on characteristics of the proposed buildings. For design purposes, the total and differential settlements are estimated to be 25 and 20 mm, respectively. A post-development groundwater lowering of 0.5 m was assumed.

The potential post construction total and differential settlements are dependent on the position of the long term groundwater level when building are situated over deposits of compressible silty clay. Efforts can be made to reduce the impacts of the proposed development on the long term groundwater level by placing clay dykes in the service trenches, reducing the sizes of paved areas, leaving green spaces to allow for groundwater recharge or limiting planting of trees to areas away from the buildings. However, it is not economically possible to control the groundwater level.

To reduce potential long term liabilities, consideration should be given to accounting for a larger groundwater lowering and to provide means to reduce long term groundwater lowering (e.g. clay dykes, restriction on planting around the dwellings, etc). Buildings on silty clay deposits increases the likelihood of movements and therefore of cracking. The use of steel reinforcement in foundations placed at key structural locations will tend to reduce foundation cracking compared to unreinforced foundations.

Based on the undrained shear strength values and consolidation testing results, permissible grade raise areas have been defined for Phase 4 of the proposed development. The recommended permissible grade raise areas are presented in Drawing PG3695-2 - Permissible Grade Raise Plan in Appendix 2.

Based on the above discussion, several options could be considered to accommodate proposed grade raises with respect to our permissible grade raise recommendations, such as, the use of lightweight fill, which allow for raising the grade without adding a significant load to the underlying soils. Alternatively, it is possible to preload or surcharge the subject site in localized areas provided sufficient time is available to achieve the desired settlements. It should be noted that a settlement surcharge program is currently under consideration for lots/blocks within the south portion of the site where a significant proposed grade raise is required.

Underground Utilities

The underground services may be subjected to unacceptable total or differential settlements. In particular, the joints at the interface building/soil may be subjected to excessive stress if the differential settlements between the building and the services are excessive. This should be considered in the design of the underground services.

Once the required grade raises are established, the above options could be further discussed along with further recommendations on specific requirements.

Preloading and Surcharging Alternative

Provided sufficient time is available to induce the required settlements, consideration could be given to preloading and surcharging the subject site where sensitive silty clay is encountered below underside of footing. For preliminary design purposes, it is suggested that the site be preloaded to finished grade and surcharged with an additional 1.5 to 2.5 m of fill. Settlement plates to monitor long term settlement should be installed at selected locations. Once the desired settlements have taken place, the surcharged portion can be removed and the site is considered acceptable for development.

5.4 Design for Earthquakes

It should be noted that where foundations are placed over glacial till or bedrock, Part 9 of the current OBC 2012 standard should be used for design purposes. Also, where foundations are placed over a silty clay deposit, Part 4 of the current OBC 2012 standard should be used for design purposes. The area requiring permissible grade raise restrictions outlined in Drawing PG3695-2 - Permissible Grade Raise Areas in Appendix 2 should be used to delineate the houses where silty clay is anticipated below footing level.

The site class for seismic site response can be taken as **Class E** for footings placed over the sensitive silty clay deposit within the west portion of the site (where a permissible grade raise of 2.5 m or less is delineated in Drawing PG3695-2). A seismic site **Class D** is recommended for the remainder of the area where footings will be founded over a silty clay deposit. Reference should be made to the latest version of the Ontario Building Code (2012) for a full discussion of the earthquake design requirements. The soils underlying the subject site are not susceptible to liquefaction.

5.5 Basement Slab

With the removal of all topsoil and deleterious fill, containing organic matter, within the footprints of the proposed buildings, undisturbed native soil surface or approved granular fill will be considered acceptable subgrade on which to commence backfilling for floor slab construction. Any soft areas should be removed and backfilled with appropriate backfill material. OPSS Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab. It is recommended that the upper 200 mm of sub-slab fill consist of 19 mm clear crushed stone.

It is recommended that a minimum 300 mm thick layer (native soil plus crushed stone layer) be present between the floor slabs and the bedrock surface to reduce the risks of bending stresses in the concrete slab. The bending stress could lead to cracking of the concrete slabs. This requirement could be waived if the bedrock surface is relatively flat within the footprint of the building. This recommendation does not refer to potential concrete shrinkage cracking which should be controlled in the usual manner.

5.6 Pavement Structure

For design purposes, the pavement structure presented in the following tables could be used for the design of driveways and local residential streets. It should be noted that for residential driveways and car only parking areas, an Ontario Traffic Category A is applicable. For local roadways or roadways with bus traffic, an Ontario Traffic Category B should be used for design purposes.

Table 4 - Recommended Pavement Structure - Driveways

Thickness (mm)	Material Description
50	**Wear Course** - HL 3 or Superpave 12.5 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
300	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil or OPSS Granular B Type I or II material placed over in situ soil or fill	

Table 5 - Recommended Pavement Structure - Local Residential Roadways

Thickness (mm)	Material Description
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete
50	**Binder Course -** Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
450	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil or OPSS Granular B Type I or II material placed over in situ soil	

Table 6 - Recommended Pavement Structure - Roadways with Bus Traffic	
Thickness mm	**Material Description**
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete
50	**Upper Binder Course** - Superpave 19.0 Asphaltic Concrete
50	**Lower Binder Course** - Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
600	**SUBBASE** - OPSS Granular B Type II
	SUBGRADE - Either in situ soil or OPSS Granular B Type II material placed over in situ soil

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project.

If soft spots develop in the subgrade during compaction or due to construction traffic, the affected areas should be excavated and replaced with OPSS Granular B Type I or II material. Weak subgrade conditions may be experienced over service trench fill materials. This may require the use of a geotextile, thicker subbase or other measures that can be recommended at the time of construction as part of the field observation program.

The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 100% of the material's SPMDD using suitable vibratory equipment. It is recommended that a compaction level between 91% and 96.5% be provided for Superpave 19.0. A compaction level between 92% to 97.5% be provided for Superpave 12.5.

Pavement Structure Drainage

Satisfactory performance of the pavement structure is largely dependent on the contact zone between the subgrade material and the base stone in a dry condition. Failure to provide adequate drainage under conditions of heavy wheel loading can result in the fine subgrade soil being pumped into the voids in the stone subbase, thereby reducing load carrying capacity.

Due to the low permeability of the subgrade materials (where silty clay is encountered at subgrade level) consideration should be given to installing subdrains during the pavement construction as per City of Ottawa standards. The sub-drain inverts should be approximately 300 mm below subgrade level. The subgrade surface should be crowned to promote water flow to the drainage lines.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

A perimeter foundation drainage system is recommended to be provided for the proposed structures. The system should consist of a 150 mm diameter perforated corrugated plastic pipe, surrounded on all sides by 150 mm of 19 mm clear crushed stone, placed at the footing level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for placement as backfill against the foundation walls unless used in conjunction with a composite drainage system, such as Delta Drain 6000 or Miradrain G100N. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should be placed for this purpose.

6.2 Protection Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effect of frost action. A minimum 1.5 m thick soil cover (or equivalent) should be provided in this regard.

A minimum of 2.1 m thick soil cover (or equivalent) should be provided for other exterior unheated footings.

For footings founded directly on sound bedrock where insufficient soil cover is available, the suggested soil cover is not required.

6.3 Excavation Side Slopes

The subsurface soil are considered to be mainly a Type 2 and Type 3 soils according to the Occupational Health and Safety Act and Regulations for Construction Projects. The excavation side slopes should be stable in the short term at 1H:1V. Shallower slopes should be provided for deeper excavations or for excavation below the groundwater level. Where such side slopes are not permissible or practical, temporary shoring should be installed.

The slope cross-sections recommended above are for temporary slopes. Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should be maintain safe working distance from the excavation sides.

Slopes in excess of 3 m in height should be periodically inspected by the geotechnical consultant in order to detect if the slopes are exhibiting signs of distress.

A trench box is recommended to be installed at all times to protect personnel working in trenches with steep or vertical sides. The services are expected be installed by “cut and cover” methods and excavations should not remain open for extended periods of time.

6.4 Pipe Bedding and Backfill

Bedding and backfill materials should be in accordance with City of Ottawa standards and specifications.

The pipe bedding for sewer and water pipes should consist of at least 150 mm of OPSS Granular A material over a stiff silty clay subgrade. However, the bedding thickness should be increased to 300 mm for areas over a bedrock or grey, firm silty clay subgrade. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of the SPMDD. The bedding material should extend at a minimum to the spring line of the pipe.

The cover material, which should consist of OPSS Granular A, should extend from the spring line of the pipe to a minimum of 300 mm above the obvert of the pipe. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of the SPMDD.

Generally, the dry brown silty clay could be place above the cover material if the excavation and backfilling operations are completed in dry weather conditions. The wet silty clay materials could be difficult to place and compact, due to the high water content.

Where hard surface areas are considered above the trench backfill, the trench backfill material within the frost zone (about 1.8 m below finished grade) should consist of the soils exposed at the trench walls to minimize differential frost heaving. The trench backfill should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 95% of the SPMDD.

To reduce long-term lowering of the groundwater level, clay seals should be provided in the service trenches. The seals should be a minimum of 1.5 m long (in the trench direction) and should extend from trench wall to trench wall. Generally, the seals should extend from the frost line and fully penetrate the bedding, subbedding and cover material. The barriers should consist of relatively dry and compactable brown silty clay placed in maximum 225 mm thick loose layers and compacted to a minimum of 95% of the SPMDD. The clay seals should be placed at the site boundaries, roadway intersections and at a maximum distance of every 50 m in the service trenches.

6.5 Groundwater Control

Due to the relatively impervious nature of the silty clay materials, groundwater infiltration into the excavations should be low and controllable by open sumps. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations.

A temporary MOE permit to take water (PTTW) will be required for this project if more than 50,000 L/day are to be pumped during the construction phase. At least 4 to 5 months should be allowed for completion of the application and issuance of the permit by the MOE.

The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the founding medium

6.6 Winter Construction

Precautions should be provided if winter construction is considered for this project. The subsurface soil conditions mostly consist of frost susceptible materials. In presence of water and freezing conditions, ice could form within the soil mass. Heaving and settlement upon thawing could occur.

In the event of construction during below zero temperatures, the founding stratum should be protected from freezing temperatures by the installation of straw, propane heaters and tarpaulins or other suitable means. The excavation base should be insulated from sub-zero temperatures immediately upon exposure and until such time as heat is adequately supplied to the building and the footings are protected with sufficient soil cover to prevent freezing at founding level.

The trench excavations should be constructed to avoid the introduction of frozen materials, snow or ice into the trenches. As well, pavement construction is difficult during winter. The subgrade consists of frost susceptible soils, which will experience total and differential frost heaving during construction. Also, the introduction of frost, snow or ice into the pavement materials, which is difficult to avoid, could adversely affect the performance of the pavement structure.

6.7 Landscaping Considerations

Tree Planting Restrictions

The proposed residential dwellings are located in a moderate sensitivity area with respect to tree plantings over a silty clay deposit. It is recommended that trees placed within 4.5 m of the foundation wall consist of low water demanding trees with shallow roots systems that extend less than 1.5 m below ground surface. Trees placed greater than 4.5 m from the foundation wall may consist of typical street trees, which are typically moderate water demand species with roots extending to a maximum 2 m depth.

It is well documented in the literature, and is our experience, that fast-growing trees located near buildings founded on cohesive soils that shrink on drying can result in long-term differential settlements of the structures. Tree varieties that have the most pronounced effect on foundations are seen to consist of poplars, willows and some maples (i.e. Manitoba Maples) and, as such, they should not be considered in the landscaping design.

Swimming Pools

The in-situ soils are considered to be acceptable for swimming pools. In areas where sensitive silty clay is observed, above ground swimming pools must be placed at least 5 m away from the residence foundation and neighbouring foundations. Otherwise, pool construction is considered routine, and can be constructed in accordance with the manufacturer`s requirements.

Aboveground Hot Tubs

Additional grading around the hot tub should not exceed permissible grade raises. Otherwise, hot tub construction is considered routine, and can be constructed in accordance with the manufacturer’s specifications.

Installation of Decks or Additions

Additional grading around proposed deck or addition should not exceed permissible grade raises. Otherwise, standard construction practices are considered acceptable.

6.8 Corrosion Potential and Sulphate

The analytical test results are presented in Table 7 along with industry standards for the applicable threshold values. The results are indicative that Type 10 Portland cement (Type GU) is acceptable.

Table 7 - Corrosion Potential

Parameter	Laboratory Results TP 6 G3 PG1845	Threshold	Commentary
Chloride	24 µg/g	Chloride content less than 400 mg/g	Negligible concern
pH	7.58	pH value less than 5.0	Neutral Soil
Resistivity	35.6 ohm.m	Resistivity greater than 1,500 ohm.cm	Slightly to Moderately Agressive
Sulphate	47 µg/g	Sulphate value greater than 1 mg/g	Negligible Concern

7.0 Recommendations

It is recommended that the following be completed once the master plan and site development are determined:

❏ Review detailed grading plan(s) from a geotechnical perspective.

❏ Observation of all bearing surfaces prior to the placement of concrete.

❏ Periodic observation of the condition of unsupported excavation side slopes in excess of 3 m in height, if applicable.

❏ Observation of all subgrades prior to placing backfilling materials.

❏ Field density tests to ensure that the specified level of compaction has been achieved.

❏ Sampling and testing of the bituminous concrete including mix design reviews.

A report confirming that these works have been conducted in general accordance with Paterson's recommendations could be issued upon request, following the completion of a satisfactory material testing and observation program by the geotechnical consultant.

8.0 Statement of Limitations

The recommendations made in this report are for review and design purposes. Paterson requests permission to review the recommendations when the drawings and specifications are completed.

A soils investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the test locations, we request immediate notification to permit reassessment of our recommendations.

The recommendations provided herein should only be used by the design professionals associated with this project. They are not intended for contractors bidding on or undertaking the work. The latter should evaluate the factual information provided in this report and determine its suitability and completeness for their intended construction schedule and methods. Additional testing may be required for their purposes.

A geotechnical investigation is a limited sampling of a site. The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Regional Group of Companies and their agent(s) is not authorized without review by this firm for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
July 14, 2014
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

Stephanie A. Boisvenue, P.Eng.

David J. Gilbert, P.Eng.

Report Distribution:

- ❑ Regional Group of Companies (3 copies)
- ❑ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

UNIDIMENSIONAL CONSOLIDATION TESTING SHEETS

ATTERBERG LIMITS' TESTING RESULTS

ANALYTICAL TEST RESULTS

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. BH 1

BORINGS BY CME 75 Power Auger

DATE December 15, 2015

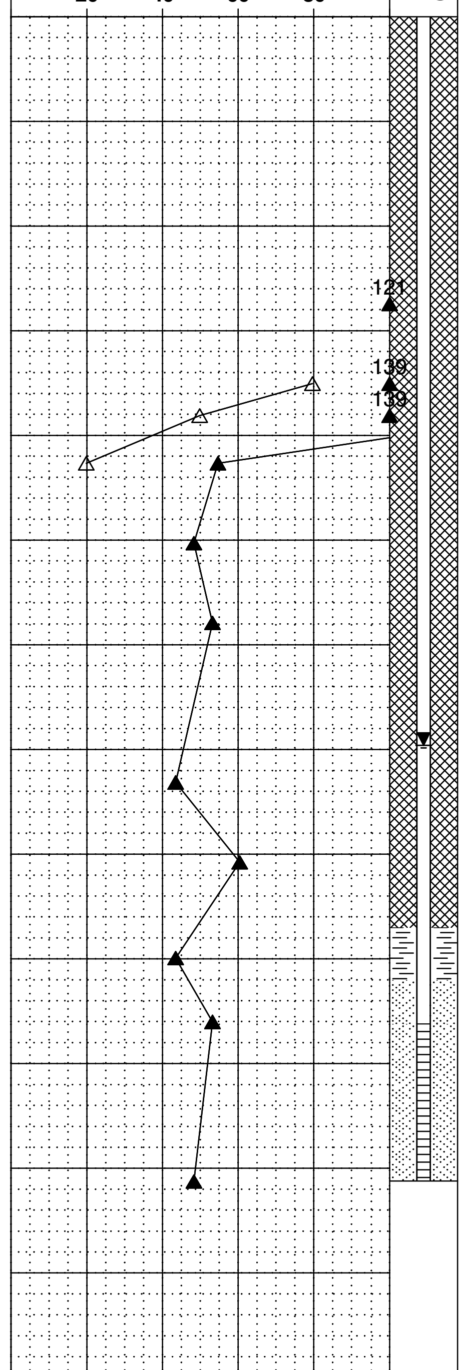
SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	94.69
TOPSOIL 0.30		AU	1				
Very stiff to stiff, brown **SILTY CLAY**		SS	2	100	3	1	93.69
		SS	3	100	3	2	92.69
						3	91.69
						4	90.69
						5	89.69
-firm and grey by 5.9m depth						6	88.69
						7	87.69
						8	86.69
						9	85.69
						10	84.69
11.12						11	83.69
Dynamic Cone Penetration Test commenced at 11.12m depth. Cone pushed to 20.6m depth.						12	82.69
						13	81.69

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

Piezometer Construction



20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

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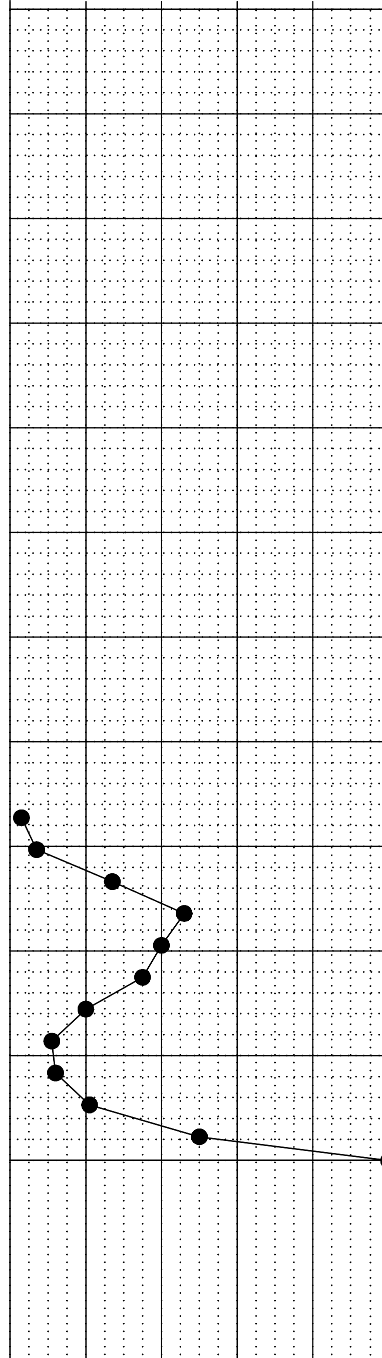
REMARKS

HOLE NO. BH 1

BORINGS BY CME 75 Power Auger **DATE** December 15, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20, 40, 60, 80)	Piezometer Construction
GROUND SURFACE						13	81.69		
						14	80.69		
						15	79.69		
						16	78.69		
						17	77.69		
						18	76.69		
						19	75.69		
						20	74.69		
						21	73.69		
						22	72.69		
						23	71.69		
24.00						24	70.69		
End of Borehole Practical DCPT refusal at 24.00m depth (GWL @ 6.96m-Jan. 6, 2016)									



Shear Strength (kPa): 20, 40, 60, 80, 100

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
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FILE NO. PG3695

REMARKS

HOLE NO. BH 2

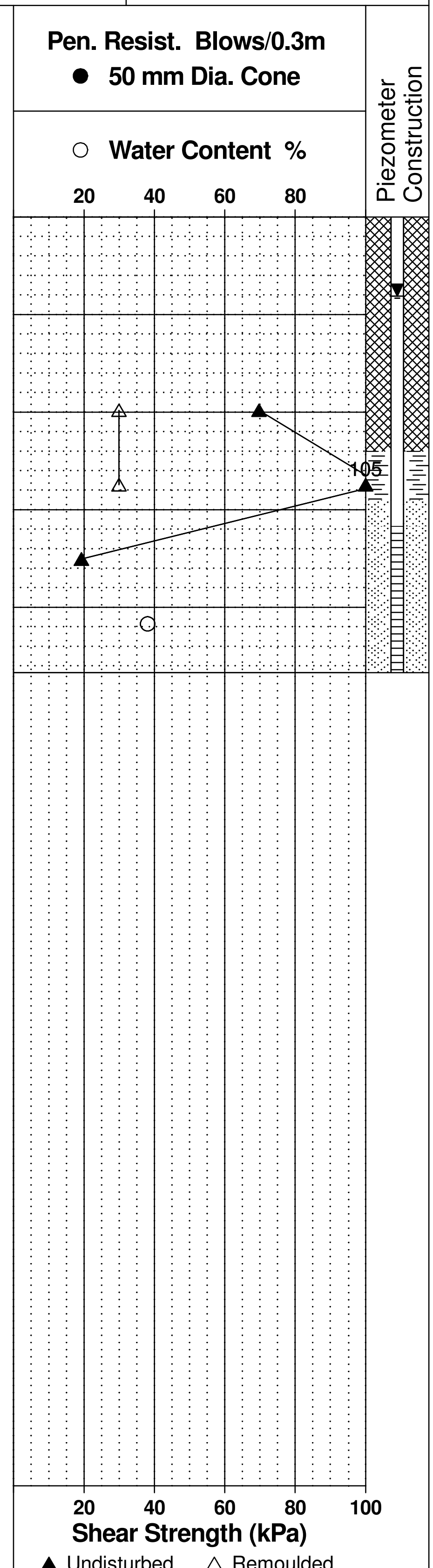
BORINGS BY CME 75 Power Auger **DATE** December 15, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.53
TOPSOIL 0.30							
		SS	1	100	6	1	92.53
Stiff to firm brown **SILTY CLAY**, some sand						2	91.53
						3	90.53
- soft to firm and grey by 3.7m depth						4	89.53
		TW	2	75			
4.67		SS	3	100	50+		

End of Borehole

Practical refusal to augering at 4.67m depth

(GWL @ 0.81m-Jan. 6, 2016)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

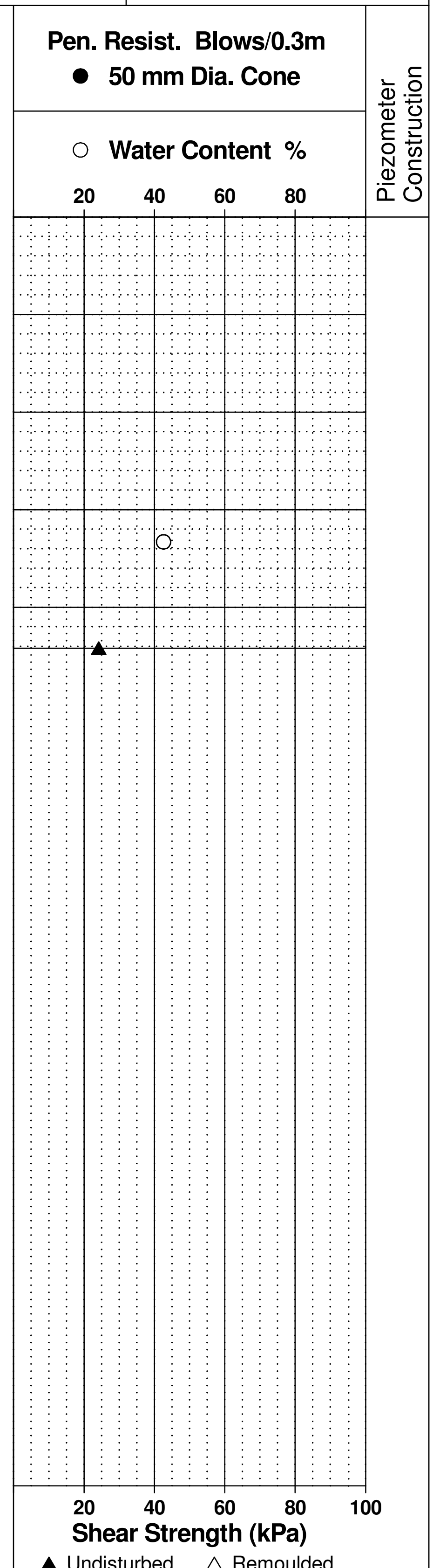
FILE NO. **PG3695**

REMARKS

HOLE NO. **BH 2A**

BORINGS BY CME 75 Power Auger **DATE** December 15, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.53
Inferred **SILTY CLAY**						1	92.53
						2	91.53
3.05						3	90.53
Firm, brown **SILTY CLAY**		TW	1			4	89.53
4.42							
End of Borehole							



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Prop. Residential Development - Terry Fox Drive
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FILE NO. **PG3695**

REMARKS

HOLE NO. **BH 3**

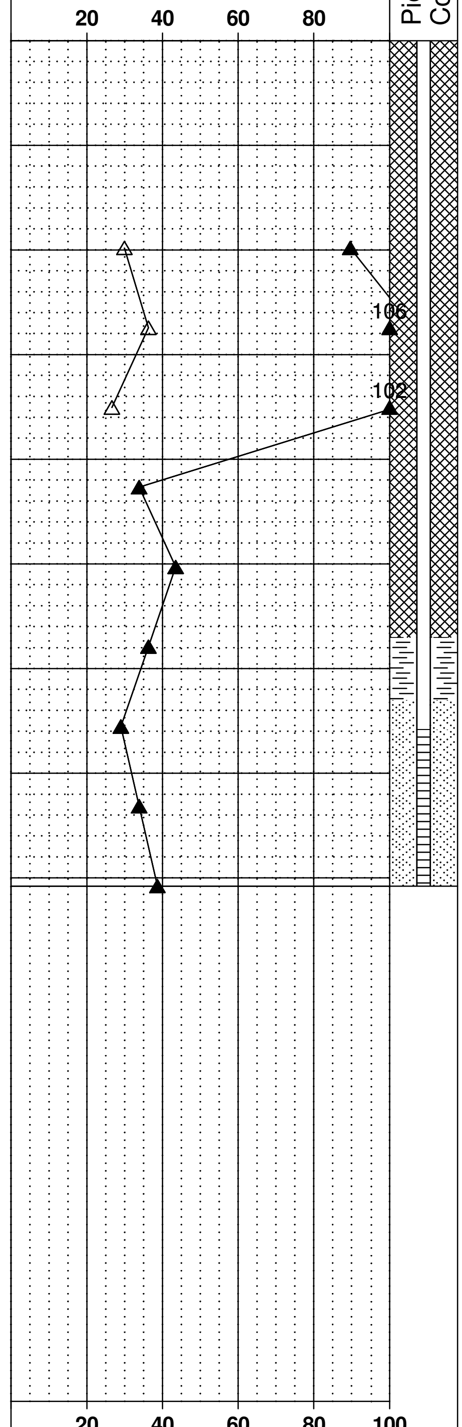
BORINGS BY CME 75 Power Auger **DATE** December 15, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.30						0	93.90
		SS	1	100	5	1	92.90
						2	91.90
Stiff to firm, brown **SILTY CLAY**						3	90.90
- grey by 4.2m depth						4	89.90
						5	88.90
						6	87.90
						7	86.90
8.08						8	85.90
End of Borehole							
(Piezometer blocked-Jan. 6, 2016)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

Piezometer Construction



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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Ottawa, Ontario

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FILE NO. PG3695

REMARKS

HOLE NO. HA 1

BORINGS BY Hand Auger **DATE** December 7, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20 40 60 80)	Piezometer Construction
GROUND SURFACE						0	99.56		
TOPSOIL 0.10									
Brown, **SILTY CLAY** 1.10						1	98.56		
End of Auger Hole Practical refusal to hand augering at 1.10m depth									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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FILE NO. PG3695

REMARKS

HOLE NO. HA 2

BORINGS BY Hand Auger

DATE December 7, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20 40 60 80)	Piezometer Construction
GROUND SURFACE						0	99.57		
TOPSOIL (to 0.40)									
End of Auger Hole Practical refusal to hand augering at 0.40m depth									

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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FILE NO. PG3695

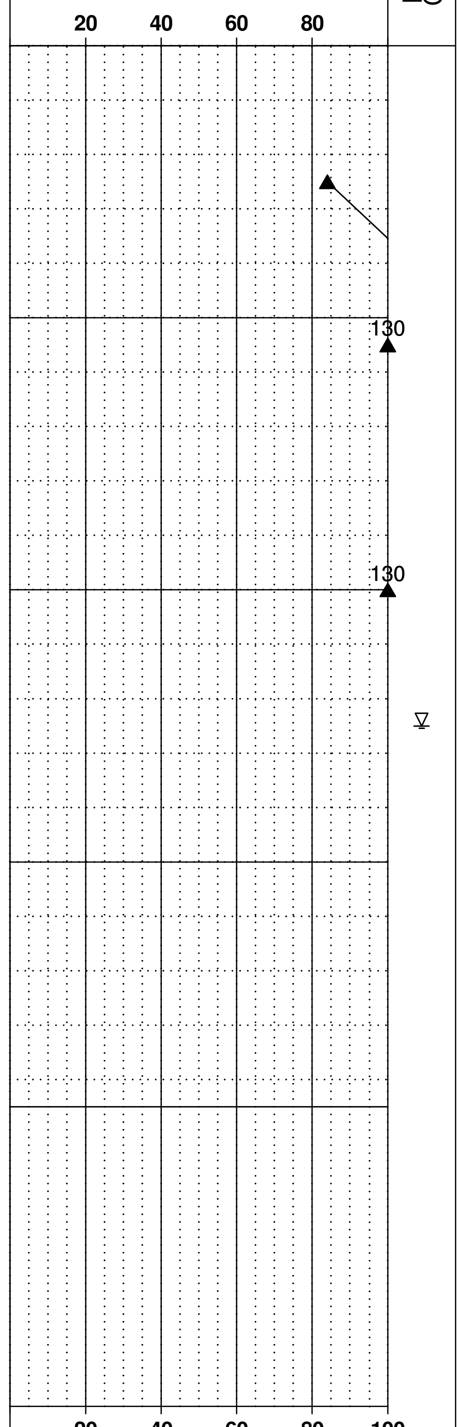
REMARKS

HOLE NO. TP 1

BORINGS BY Backhoe **DATE** December 14, 2015

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	99.61
TOPSOIL 0.12	G	1				
Very stiff, brown **SILTY CLAY**	G	2			1	98.61
	G	3			2	97.61
	G	4			3	96.61
3.70 **GLACIAL TILL:** Grey silty sand with clay 3.90	G	5				
End of Test Pit						
(Open hole GWL @ 2.5m depth)						

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone
○ Water Content %



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

Piezometer Construction

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SOIL PROFILE AND TEST DATA

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FILE NO. PG3695

REMARKS

HOLE NO. TP 2

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	97.82		
TOPSOIL 0.15									
Very stiff, brown SILTY CLAY		G	1			1	96.82	130 ▲	
						2	95.82	130 ▲	∇
		G	2						
3.30						3	94.82	130 ▲	
End of Test Pit									
(Open hole GWL @ 2.0m depth)									

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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FILE NO. PG3695

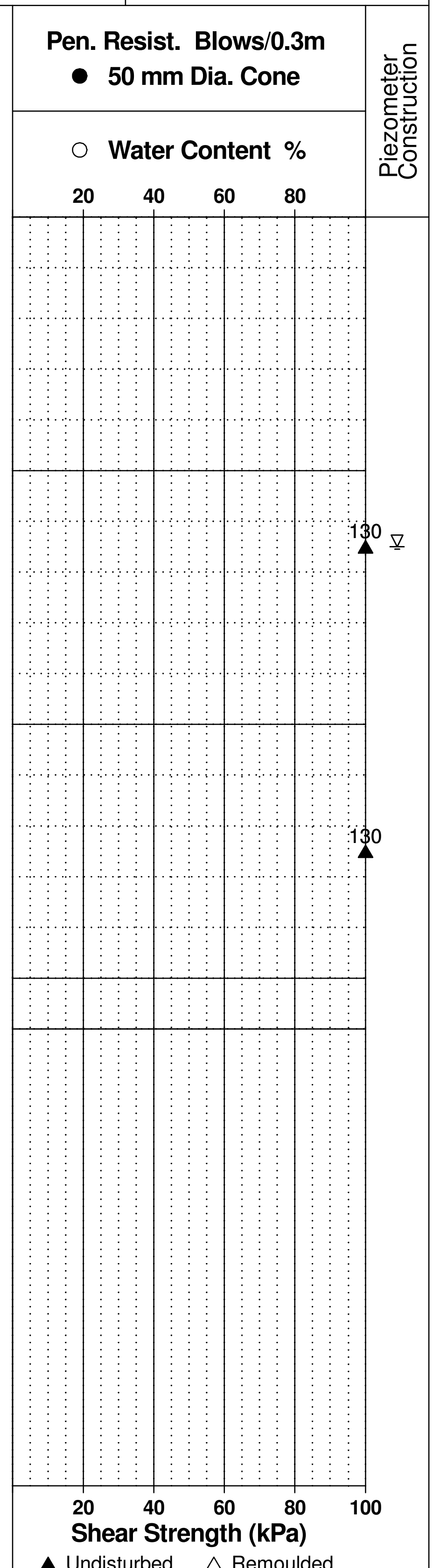
REMARKS

HOLE NO. TP 3

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	95.46
TOPSOIL — 0.25							
Very stiff, brown **SILTY CLAY**						1	94.46
		G	1				
						2	93.46
		G	2				
— 3.20						3	92.46
End of Test Pit							
(Open hole GWL @ 1.3m depth)							



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SOIL PROFILE AND TEST DATA

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Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. TP 4

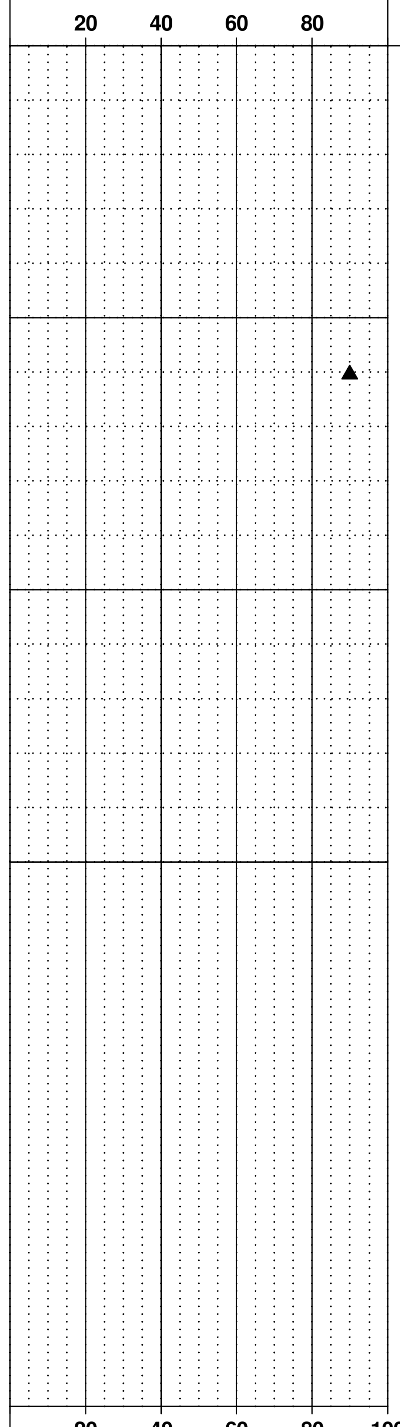
BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	95.26
TOPSOIL (to 0.25)		G	1				
Very stiff, brown **SILTY CLAY** (0.25 – 1.70)						1	94.26
		G	2				
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders (1.70 – 3.00)		G	3			2	93.26
		G	4			3	92.26
End of Test Pit							
(Open hole GWL @ 1.1m depth)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. TP 5

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20 40 60 80)	Piezometer Construction
GROUND SURFACE						0	97.28		
TOPSOIL 0.10									
BEDROCK: weathered bedrock with silty sand 0.90		G	1						
End of Test Pit TP terminated on bedrock surface @ 0.90m depth (TP dry upon completion)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

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Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. TP 6

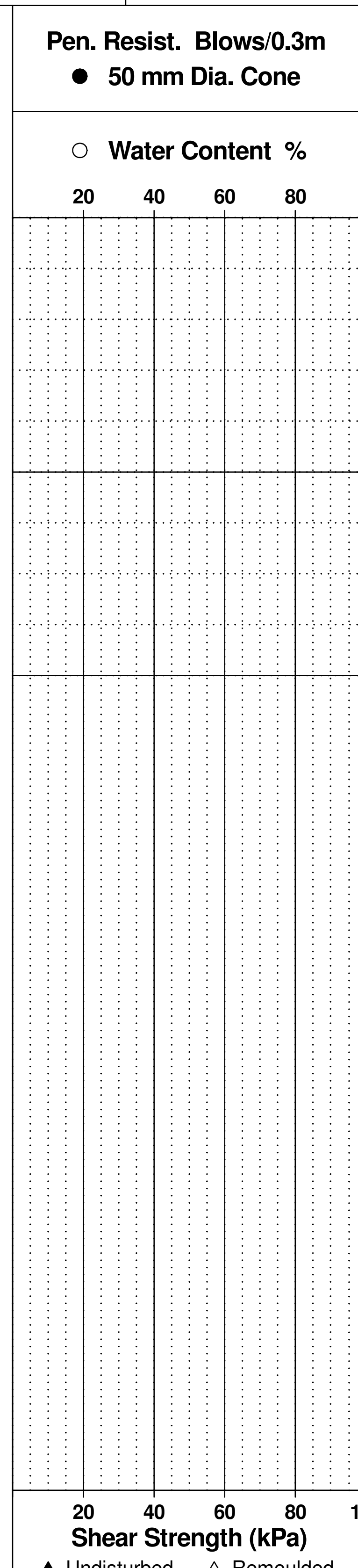
BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	99.03
TOPSOIL (to 0.30)		G	1				
Very stiff, brown **SILTY CLAY** (0.30 to 1.10)		G	2			1	98.03
BEDROCK (1.10 to 1.75)							
End of Test Pit							

TP terminated on bedrock surface at 1.1m depth on north portion and at 1.75m depth on south portion.

(TP dry upon completion)



Piezometer Construction

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

BORINGS BY Backhoe

DATE December 14, 2015

FILE NO. PG3695

HOLE NO. TP 7

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	100.33		
TOPSOIL 0.20									
Very stiff, brown **SILTY CLAY**		G	1			1	99.33	▲ 130	
		G	2			2	98.33	▲ 130	
3.00						3	97.33		
End of Test Pit									
(TP dry upon completion)									

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. TP 8

BORINGS BY Backhoe

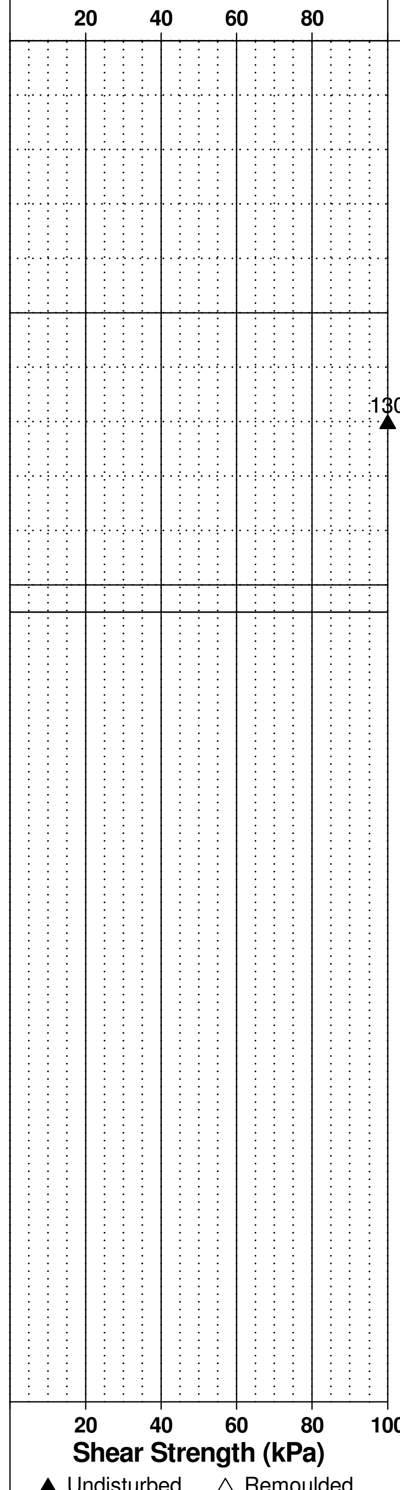
DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	96.77		
TOPSOIL (to 0.30)		G	1						
Very stiff, brown **SILTY CLAY** (0.30 to 1.80)		G	2			1	95.77	130 ▲	
BEDROCK (1.80 to 2.10)						2	94.77		

End of Test Pit

Practical refusal to excavation at 1.80m depth in northern portion of test pit and 2.10m depth in the southern portion.

(TP dry upon completion)



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. TP 9

BORINGS BY Backhoe **DATE** December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	97.19		
TOPSOIL 0.20									
Very stiff, brown **SILTY CLAY** 1.70		G	1			1	96.19	▲ 130	
Very stiff, brown **SILTY CLAY** with sea shells, trace sand 3.00		G	2			2	95.19		
End of Test Pit						3	94.19		
(TP dry upon completion)									

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. TP10

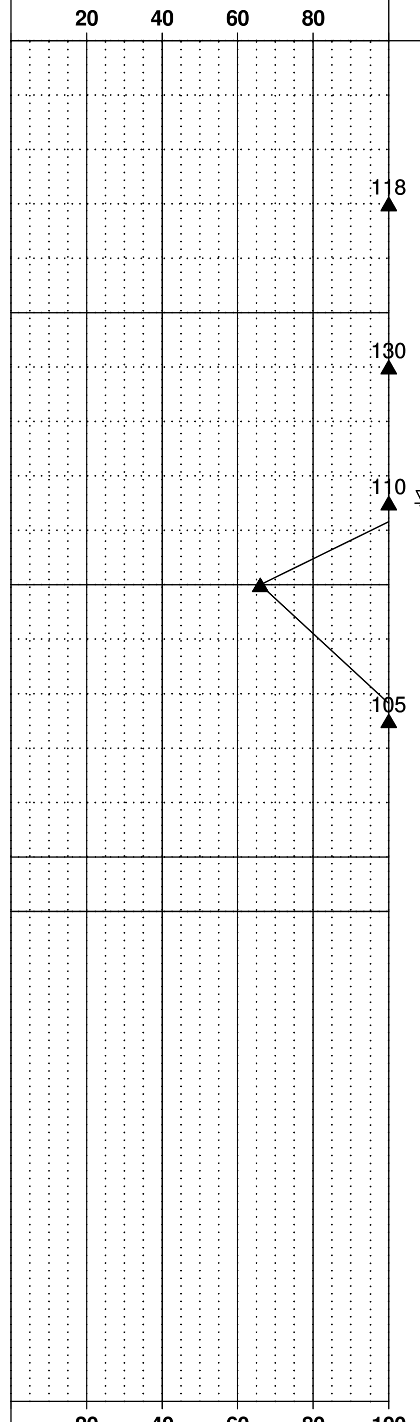
BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.54
TOPSOIL 0.25							
		G	1			1	92.54
Very stiff, brown **SILTY CLAY**							
		G	2			2	91.54
3.20		G	3			3	90.54
End of Test Pit							
(Open hole GWL @ 1.7m depth)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone
○ Water Content %

Piezometer Construction



Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. PG3695

REMARKS

HOLE NO. TP11

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	93.90		
TOPSOIL 0.15									
Very stiff, brown **SILTY CLAY** 1.30		G	1			1	92.90	▲ 130	∇
Brown **SILTY SAND** with gravel and cobbles		G	2			2	91.90		
		G	3						
2.90 End of Test Pit									
(Open hole GWL @ 1m depth)									

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Limited.

FILE NO. **PG3695**

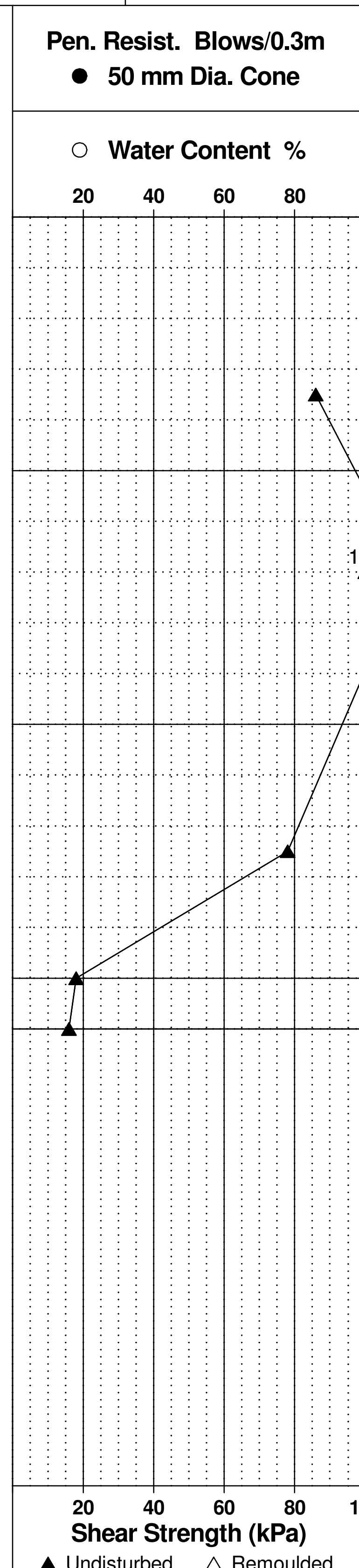
REMARKS

HOLE NO. **TP12**

BORINGS BY Backhoe

DATE December 14, 2015

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.29
TOPSOIL		G	1				
0.35							
						1	92.29
Very stiff to stiff, brown **SILTY CLAY**		G	2				
						2	91.29
- stiff to firm and grey by 2.4m depth		G	3				
						3	90.29
3.20							
End of Test Pit							
(Open hole GWL @ 1.3m depth)							



Piezometer Construction

SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) 'N' value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	'N' Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

Consistency	Undrained Shear Strength (kPa)	'N' Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called “mechanical breaks”) are easily distinguishable from the normal in situ fractures.

RQD %	**ROCK QUALITY**
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS	-	Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))
TW	-	Thin wall tube or Shelby tube
PS	-	Piston sample
AU	-	Auger sample or bulk sample
WS	-	Wash sample
RC	-	Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC%	-	Natural moisture content or water content of sample, %
LL	-	Liquid Limit, % (water content above which soil behaves as a liquid)
PL	-	Plastic limit, % (water content above which soil behaves plastically)
PI	-	Plasticity index, % (difference between LL and PL)
Dxx	-	Grain size which xx% of the soil, by weight, is of finer grain sizes These grain size descriptions are not used below 0.075 mm grain size
D10	-	Grain size at which 10% of the soil is finer (effective grain size)
D60	-	Grain size at which 60% of the soil is finer
Cc	-	Concavity coefficient = $(D30)^2 / (D10 \times D60)$
Cu	-	Uniformity coefficient = D60 / D10

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: $1 < Cc < 3$ and $Cu > 4$
Well-graded sands have: $1 < Cc < 3$ and $Cu > 6$
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay (more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

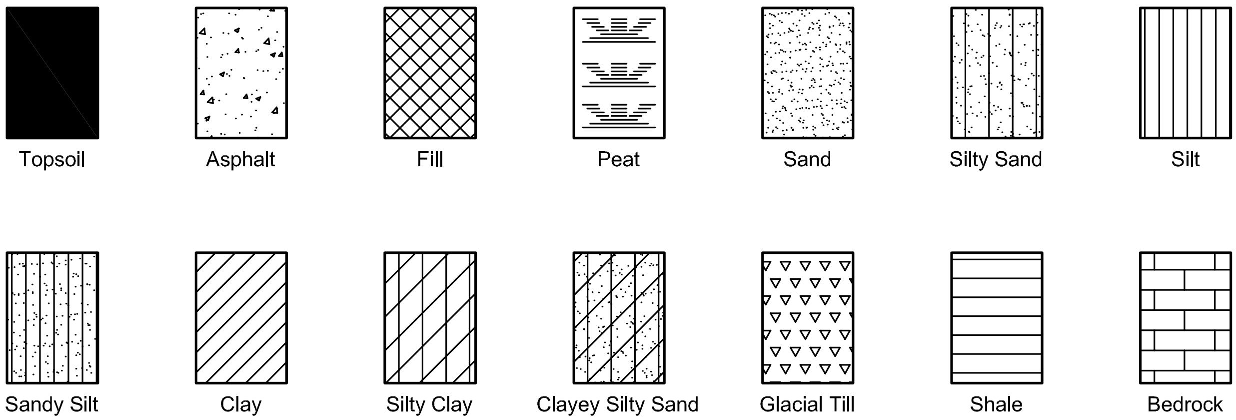
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void Ratio		Initial sample void ratio = volume of voids / volume of solids
Wo	-	Initial water content (at start of consolidation test)

PERMEABILITY TEST

k	-	Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

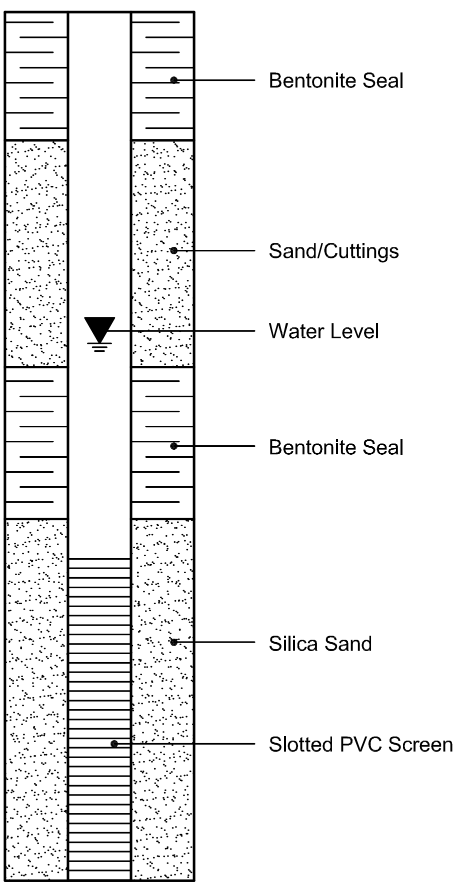
SYMBOLS AND TERMS (continued)

STRATA PLOT

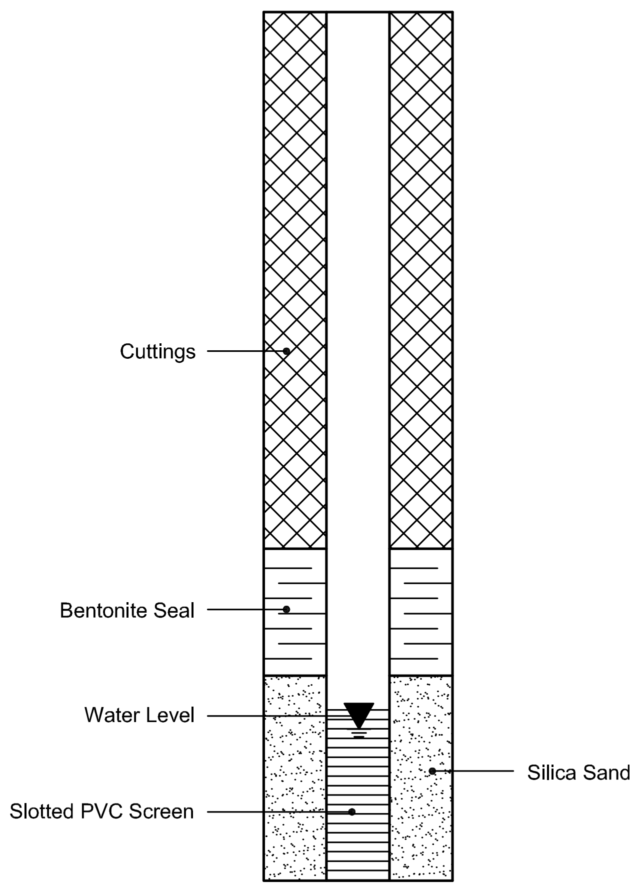


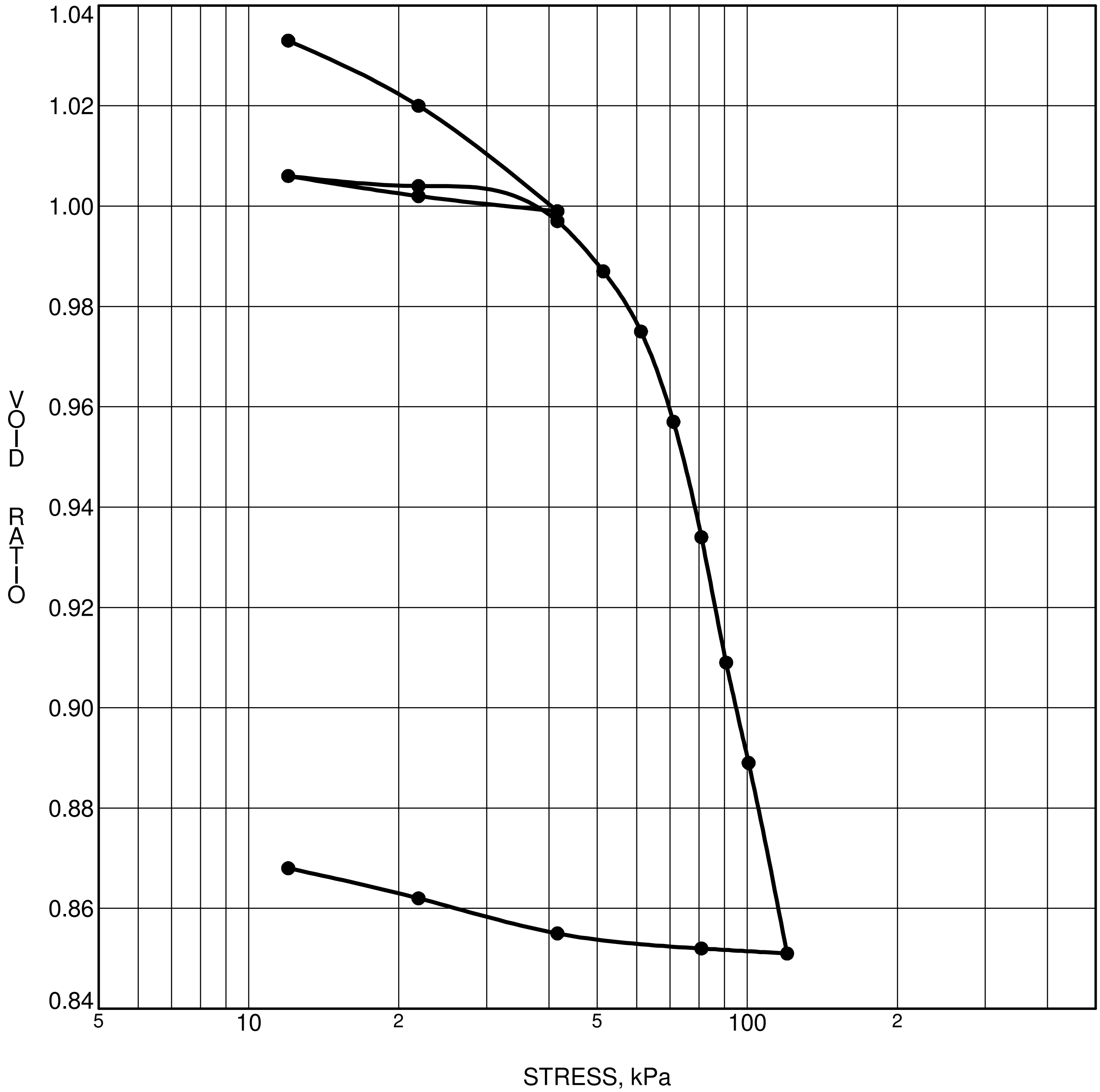
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 2**	p'_o	**55** kPa	Ccr	**0.014**
Sample No.	**TW 5**	p'_c	**62** kPa	Cc	**0.482**
Sample Depth	**4.17** m	OC Ratio	**1.1**	Wo	**38.1** %
Sample Elev.	**89.36** m	Void Ratio	**0.868**	Unit Wt.	**18.2** kN/m^3

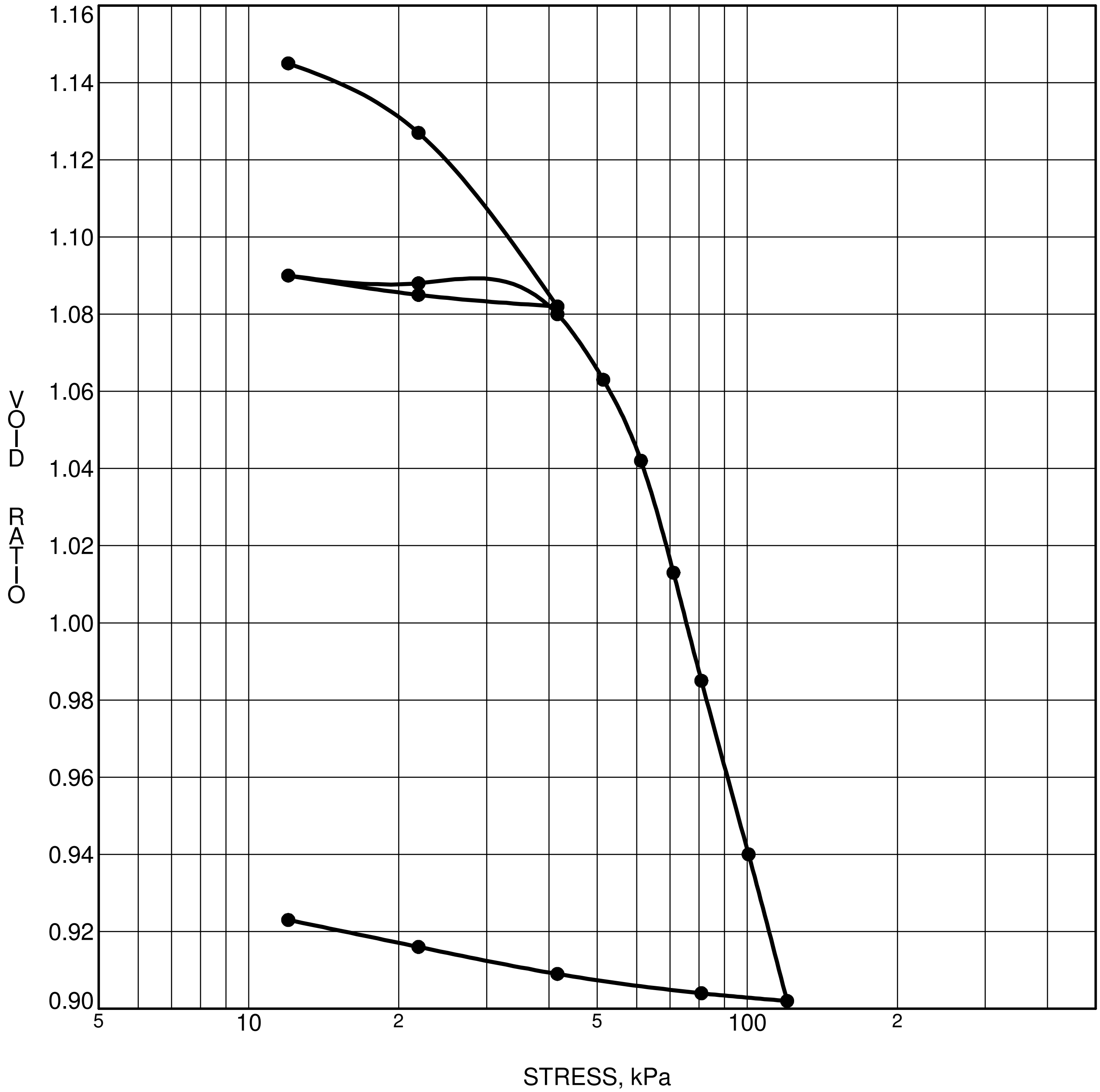
CLIENT **Regional Group of Companies** FILE NO. **PG3695**

PROJECT **Geotechnical Investigation - Prop. Residential Development - Terry Fox Drive** DATE **January 5, 2016**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 2A**	p'o	**49** kPa	Ccr	**0.008**
Sample No.	**TW 1**	p'c	**53.8** kPa	Cc	**0.385**
Sample Depth	**3.33** m	OC Ratio	**1.1**	Wo	**42.6** %
Sample Elev.	**90.20** m	Void Ratio	**0.923**	Unit Wt.	**17.7** kN/m^3

CLIENT **Regional Group of Companies**
FILE NO. **PG3695**
PROJECT **Geotechnical Investigation - Prop. Residential Development - Terry Fox Drive**
DATE **January 8, 2016**

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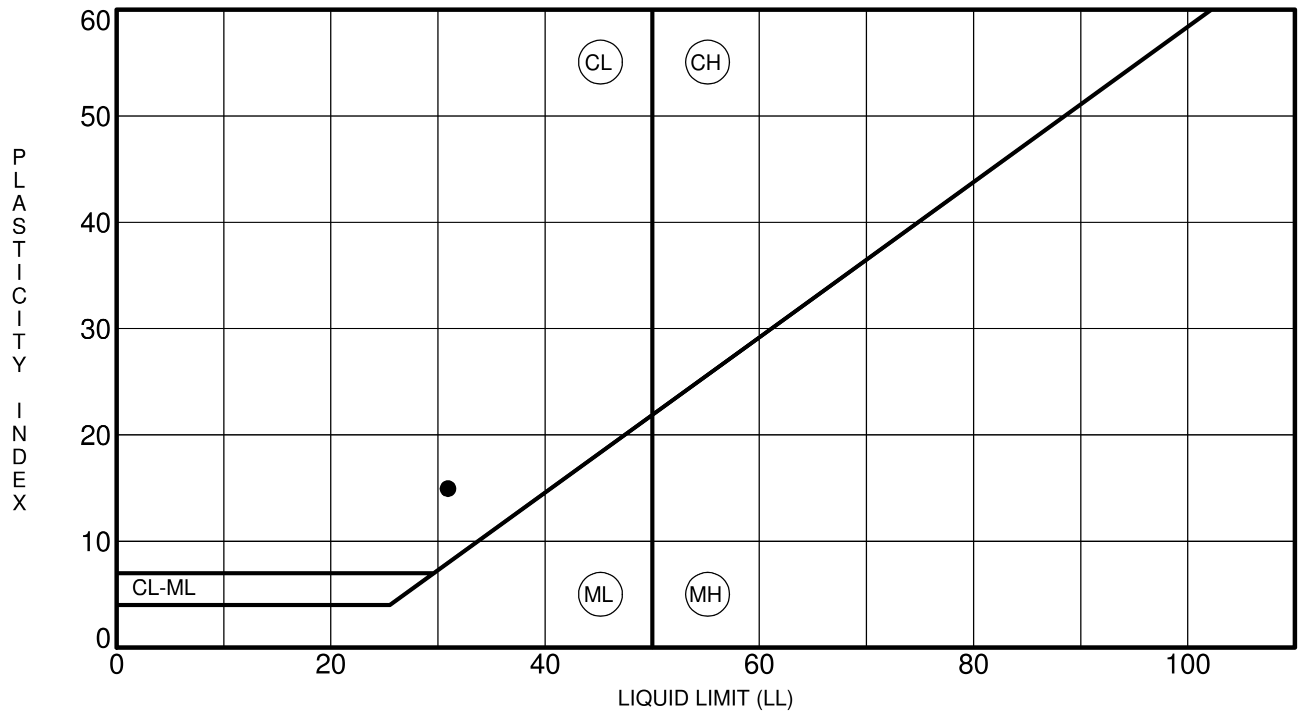
154 Colonnade Road South, Ottawa, Ontario K2E 7J5

CONSOLIDATION TEST



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH 2**	**TW 5**	**31**	**16**	**15**		**CL - Inorganic clays of low plasticity**

CLIENT	**Regional Group of Companies**	FILE NO.	**PG3695**
PROJECT	**Geotechnical Investigation - Prop. Residential Development - Terry Fox Drive**	DATE	**15 Dec 15**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

ATTERBERG LIMITS' RESULTS

PARACEL
LABORATORIES LTD.

Order #: 0931126

Certificate of Analysis

Report Date: 05-Aug-2009
Order Date:28-Jul-2009

Client: **Paterson Group Consulting Engineers**
Client PO: 7904 Project Description: PG1845

	Client ID:	TP6 G3	-	-	-
	Sample Date:	27-Jul-09	-	-	-
	Sample ID:	0931126-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	69.9	-	-	-
General Inorganics					
pH	0.05 pH Units	7.58	-	-	-
Resistivity	0.10 Ohm.m	35.6	-	-	-
Anions					
Chloride	5 ug/g dry	24	-	-	-
Sulphate	5 ug/g dry	47	-	-	-

APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG3695-1 - TEST HOLE LOCATION PLAN

DRAWING PG3695-2 - PERMISSIBLE GRADE RAISE PLAN

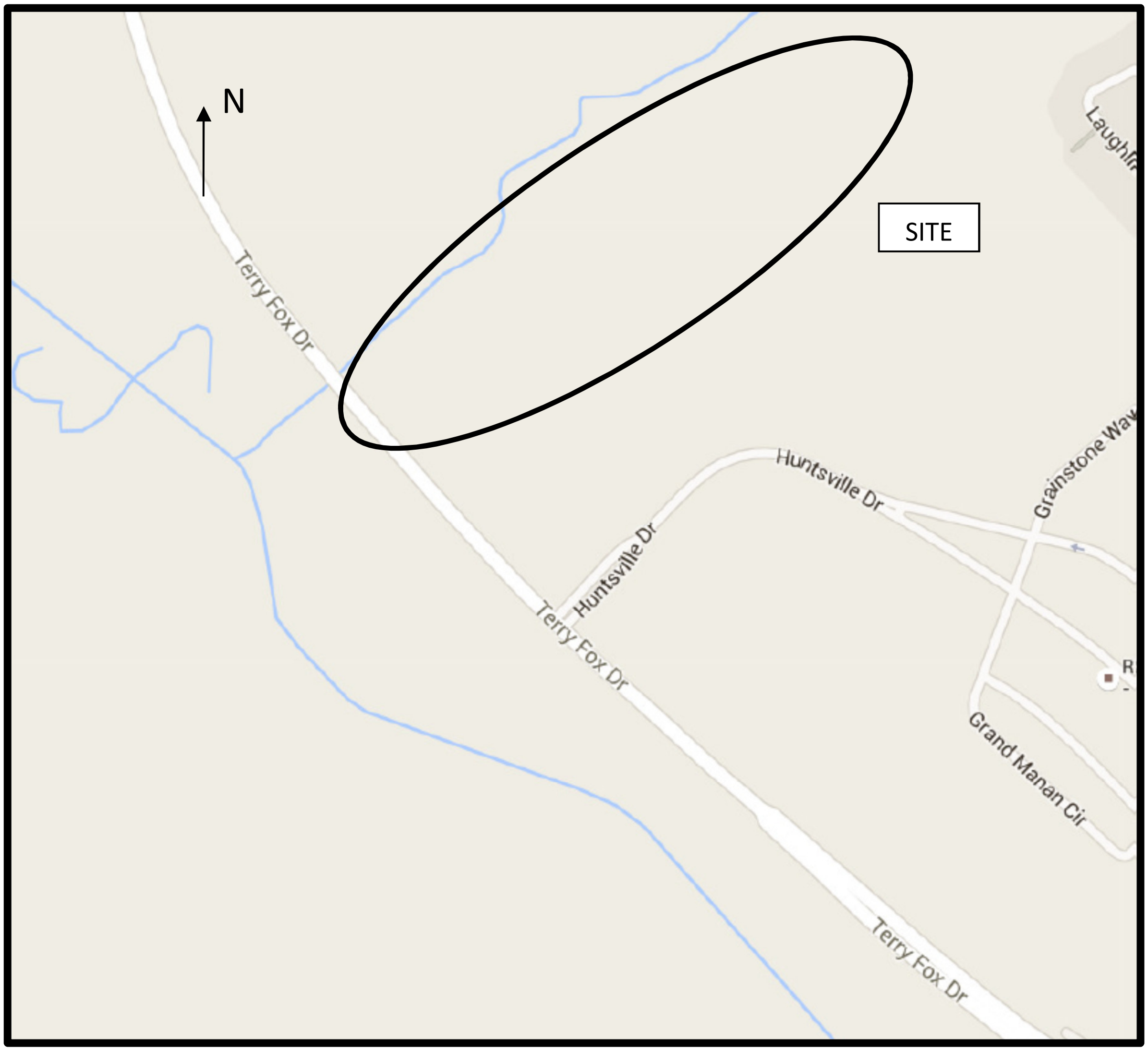


FIGURE 1

KEY PLAN

patersongroup
consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL
1	BASE PLAN UPDATED AND HAND AUGER HOLES ADDED	21/06/2016	DJG

REGIONAL GROUP

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT - RICHARDSON RIDGE PHASE 4
OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Stamp:

Scale:	1:1000
Drawn by:	MPG
Checked by:	SB
Approved by:	DJG
Date:	01/2016
Report No.:	PG3695-1
Drawing No.:	PG3695-1
Revision No.:	1

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154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL
1	PERMISSIBLE GRADE RAISE AREAS UPDATED	12/07/2016	RCG

REGIONAL GROUP

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT - RICHARDSON RIDGE PHASE 4
OTTAWA, ONTARIO

Title:

PERMISSIBLE GRADE RAISE PLAN

Stamp:

Scale: 1:1000	Report No.: PG3695
Drawn by: MPG	Drawing No.: PG3695-2
Checked by: RG	
Approved by: DJG	
Date: 07/2016	Revision No.: 1