Geotechnical Engineering

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Hydrogeological Study

Richardson Ridge - Phase 4
467 Terry Fox Drive
Ottawa, Ontario

Prepared For

Richardson Ridge Incorporated c/o The Regional Group of Companies Incorporated

July 21, 2016

Report: PG3823-1

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EXECUTIVE SUMMARY

Assessment

Further to the request and authorization of Richardson Ridge Incorporated, on behalf of The Regional Group of Companies, Paterson Group (Paterson) completed a Hydrogeological Study for Phase 4 of the Richardson Ridge Residential Development, as per the scope set out by the Terms of Reference. The purpose of this study is to:

- characterize the existing geological and hydrogeological conditions at the subject site
- determine the pre and post-development flow contributions provided to the nearby Kizell Provincially Significant Wetland (PSW) by way of water budget analyses
- provide specific recommendations with respect to existing water wells, construction practices and the potential for environmental contamination.

This report incorporates the findings of a previous geotechnical investigation by Paterson, as well as an Environmental Impact Statement and Tree Conservation Report completed by McKinley Environmental at the subject site in 2016.

The subject site is located on the east side of Terry Fox Drive, north of Huntsville Drive, in the City of Ottawa, Ontario. The site currently consists of a mixture of open areas (previously cleared for agricultural purposes), bedrock outcrops, deciduous forest (sugar maple/ironwood), cultural meadow and woodlot areas. The property is surrounded to the north by wooded areas that form part of a future development by Richcraft Homes, to the east by a roadway allowance, wooded areas and the Kanata Lakes residential development, to the south by the Kizell Drain Wetland Complex and earlier phases of the Richardson Ridge residential development and to the west by Terry Fox Drive, agricultural land and the Carp River.

Site topography is highly variable, with large elevation changes occurring over short distances. Site elevation is lowest in the southwest corner of the site at approximately 93 m above sea level (asl). Shifting northwards, several localised nodes exist with elevations reaching as much as 104 m asl, while the average elevation at the north end of the site is closer to 100 m asl. The elevation of the site increases further heading in the eastern direction, with elevations climbing from 98 m asl at the southeastern end to 113 m asl at the top of a ridge on the northeastern side. Approaching the eastern boundary of the site, the elevation drops again, with several depressions below 100 m asl. While there are no named water bodies located on the subject site, several of the

depressions located along the eastern boundary of the site were noted to contain vernal pools, with select pools anticipated to retain some volume of water year-round.

Bedrock at the subject site consists primarily of Precambrian metasedimentary rock, with a small portion of the site at the southwestern boundary containing interbedded limestone and shale from the Middle Ordovician Verulam formation. No karst features were observed in the site bedrock. Overburden soils at the subject site range from 0 to 24 m in thickness, with greater depths of overburden materials present at the western portion of the site, becoming quickly shallower moving northeastward. Overburden generally consists of topsoil overlying silty clay, which is further underlain in certain areas by glacial till.

Based on hydraulic conductivity estimates obtained from previous studies and published literature, the bedrock unit is considered to have a higher hydraulic conductivity than the silty clay overburden soil, which is generally considered to act as a confining layer. It is our interpretation that groundwater will generally flow laterally through the upper layer of fractured/weathered bedrock, as opposed to vertically upwards or downwards through the overburden soils of lower hydraulic conductivity. However, given the composition of the bedrock on site (Precambrian high grade metamorphic rock), the volume of recharge occurring within the site boundaries is expected to be minimal.

With regards to discharge zones, neither the topographical or geological conditions are suitable for discharge to be occurring at the subject site. While the PSW located south of the site could theoretically be considered a discharge zone, the volume is anticipated to be minimal given the intermittent hydroperiod of the wetland and limited recharge potential of the surrounding areas.

The pre-development water budget analysis conducted at the subject site determined that an estimated 8,201 m^3/year of surplus water currently infiltrates the surface soils and either recharges local bedrock aquifer systems or travels laterally as interflow at the overburden/bedrock interface. The remaining estimated 21,300 m^3/year of surplus leaves the site as runoff, a large portion of which is anticipated to flow towards the Kizell PSW adjacent to the site. The post-development water budget analysis alternatively determined that an estimated 10,485 m^3/year of surplus water will infiltrate the surface soils and 23,136 m^3/year will leave the site as runoff. These values equate to approximate increases in both infiltration and runoff of 28% and 9% respectively. While this may result in an increase in water levels within the PSW, it is expected to be negligible given the increase in runoff volume relative to the area of the wetland.

A review of the Ontario water well record database indicated that the well located nearest to the site that may currently remain in use is located 1.2 km northeast of the site at 560 Goulbourn Forced Road. However, the well was noted to be drawing water from a bedrock aquifer approximately 15 m bgs, well below the expected maximum depth of excavation at the site. Additionally, dewatering activities at the site are anticipated to be short term in duration and require only low levels of pumping due to the nature of the materials on site. Furthermore, there are no known buildings within the steady state radius of influence for the subject site. As such, the impacts of the proposed development on both the surrounding infrastructure and existing well users is expected to be negligible.

A review of the MOECC's Brownfield Environmental Site Registry did not identify any environmental concerns in the immediate vicinity of the study area. Based on observations of Paterson staff during field work, no potential groundwater contamination concerns were identified with respect to the site. Additionally, no visual or olfactory evidence of contamination was observed in the soil, groundwater, or bedrock.

The EIS prepared by McKinley Environmental indicates that a slight increase in water level would have minimal potential to impact the overall vegetative composition or functionality of the wetland. The anticipated increase in flow contributions under post-development conditions is expected to be much smaller in scale when compared to the potential annual fluctuations that occur naturally. The EIS notes that from a biological perspective, impacts from changes in water level of the magnitude anticipated under post-development conditions are negligible, as they are likely to fall within the range of existing natural variability.

In terms of biological activity in the Kizell PSW, the most significant feature is the presence of a population of Blanding's turtles. The EIS prepared by McKinley Environmental notes that the currently existing habitat for the Blanding's turtle is poor quality due to the hydroperiod that exists at the subject site. As such, the anticipated neutral or minimal increase in water levels and/or hydroperiod under post-development conditions will either have no substantial effect on the turtle population, or will represent a marginal improvement to habitat quality.

Recommendations

A brief summary of the recommendations of the hydrogeological study is provided as follows:

- Prior to and during site development, it is recommended that construction best management practices with respect to fuels and chemical handling, spill prevention, and erosion and sediment control be followed.
- It is recommended that construction best management practices be employed during blasting activities to minimize sediment accumulation in water runoff from the site to the Kizell PSW adjacent to the site.
- Should potential dewatering volumes during construction activities be anticipated to exceed 50,000 L/day, it is recommended that either an EASR or PTTW (dependant on pumping requirements) be obtained prior to construction commencing at the site.
- This report has been completed as per the agreed-upon scope of work for this project. It is recommended that the sufficiency of these conclusions be re-evaluated at the detail design phase and that any data gaps be addressed accordingly.

1.0 INTRODUCTION

1.1 Background

Paterson Group (Paterson) was retained by Richardson Ridge Incorporated (c/o The Regional Group of Companies Incorporated (Regional)) to complete both a hydrogeological study and groundwater impact assessment for Phase 4 of the Richardson Ridge residential development. The site is located at 467 Terry Fox Drive, north of Huntsville Drive, in the City of Ottawa (hereinafter referred to as the "subject site"). This report incorporates the findings of the previous Geotechnical Investigation Report (PG3695-1 dated April 4, 2016) prepared by Paterson.

1.2 Scope of Work

Paterson has completed this report in accordance with Section 7 of the finalized Terms of Reference (TOR) for Richardson Ridge - Phase 4, prepared by Regional and included in Appendix 1 of this report. As per the TOR, the purpose of the study was to:

- Characterize the hydrogeological setting of the subject site. Consideration was given to bedrock and surficial geology, aquifers, aquitards, horizontal and vertical flow patterns, existing groundwater use and aquifer vulnerability.

Additionally, as per the TOR, the study was to include the following:

- A groundwater impact assessment outlining potential impacts to nearby structures/environment/existing well users and flow contributions to the adjacent provincially significant wetland (PSW);
- Pre and post-development water budget analyses to determine the hydrogeological function of the subject site on the adjacent PSW.

2.0 PREVIOUS REPORTS

In addition to a review of the general literature summarized in the following sections and in the 'References' section of this report (MOECC water well database, available geological and physiographic mapping), Paterson reviewed the following site-specific reports:

- "Geotechnical Investigation - Richardson Ridge - Phase 4" - prepared by Paterson Group – April 4, 2016.
- "Richardson Ridge Phase 4 Development, Tree Conservation Report", prepared by McKinley Environmental Solutions, February 2016.
- "Richardson Ridge Phase 4 Development, Environmental Impact Statement", prepared by McKinley Environmental Solutions, February 2016.
- "Characterization of Ottawa's Watersheds", Prepared for the City of Ottawa, Dated March 2011.

3.0 METHOD OF INVESTIGATION

3.1 Records Review

A review of available physiographic, geological, and hydrogeological data was completed as a part of this assessment. However, the literature review and previous reports did not provide site-specific data regarding overburden and bedrock aquifers, recharge and discharge conditions or flow contributions to the nearby PSW. Further detail is provided in the following sections.

3.2 Field Program

A field program was developed to assess geology, groundwater conditions, and hydraulic gradients in the overburden at the subject site. The test holes were advanced to various depths across the site to assess hydrogeological and geotechnical conditions at the approximate depth of the proposed construction activities.

A total of 3 boreholes, 2 hand auger holes and 12 test pits were advanced to depths ranging from 0.4 to 24 m below ground surface (bgs). The test holes were distributed in a manner to provide general coverage of the silty clay deposit located within the western portion of the site, with the boreholes being completed in areas where the clay deposit was noted to be deepest. All boreholes completed on site were instrumented with flexible standpipe piezometers. The location of the test holes is shown on Drawing PG3695-1 - Test Hole Location Plan, located in Appendix 2.

The field program was conducted on December 7, 14 and 15, 2015. The boreholes were advanced using a track-mounted auger drill rig while the test pits were completed using a rubber tired backhoe. Both the drilling and excavating occurred under full-time supervision of Paterson personnel.

Soil samples were obtained from the test holes by means of split spoon sampling, thin walled shelby tube sampling and the sampling of shallow soils directly from auger flights (or from the excavation in the case of the test pits). Split-spoon samples were taken at approximate 0.76 m intervals. The depth at which grab, split-spoon, auger flight and shelby tube samples were obtained from the test holes are shown as "**G**", "**SS**", "**AU**" and "**TW**" respectively on the Soil Profile and Test Data sheets, appended to this report.

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. The "N" value is the number of blows required to drive the split-spoon sampler 300 mm into the ground after an initial penetration of 150 mm using a 63.5 kg hammer falling from a height of 760 mm. This test was done in accordance with ASTM D1586-11 - Standard Method for Penetration Test and Split-Barrel Sampling of Soils.

All samples were classified on site, placed in sealed plastic bags and were transported to our laboratory for further review and testing. Transportation of the samples was completed in accordance with ASTM D4220-95 (2007) - Standard Practice for Preserving and Transporting Soils.

Subsurface conditions observed in the test holes were recorded in detail in the field. Reference should be made to the Soil Profile and Test Data sheets presented in Appendix 2 for specific details of the soil profiles encountered at the test hole locations.

Further to the initial field program, a site inspection was conducted in June 2016 to assess the hydroperiod characteristics of the PSW located south of the subject site. As part of the inspection, surface soils were examined for general composition and moisture levels. Visual observations were made of tree staining to gain a better understanding of the high water level within the wetland. Further detail regarding characteristics of the PSW are discussed further in subsequent sections of this report.

3.3 Laboratory Testing

All soil samples were retained for laboratory review following the field portion of the subsurface investigation. The soils were classified in general accordance with ASTM D2488-09a, Standard Practice for Description and Identification of Soils (Visual-Manual Procedure). A total of two Shelby tube samples were submitted for unidimensional consolidation testing and one sample was submitted for Atterberg Limits testing from the boreholes completed during the field program. Based on the soil descriptions across the subject site during the geotechnical investigation, these samples are considered to be sufficiently representative of the site.

3.4 Piezometer Installation

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

3.5 Groundwater Level Measurement

Following the 2015 geotechnical field program, groundwater levels were measured at the piezometer installations using an electronic water level meter. Groundwater levels were measured relative to the ground surface elevation at each location. Groundwater levels at each location are noted on the Soil Profile and Test Data sheets, appended to this report. Groundwater level measurements were completed on January 6, 2016. Groundwater levels in the piezometers varied between 0.8 m and 7.0 m bgs.

3.6 Surveying

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

3.7 Water Budget

The site specific water budget analyses conducted at the subject site employed the method derived by Thornthwaite and Mather (1957). This method utilizes soil water holding capacity along with the mean monthly air temperature and precipitation values to estimate the evapotranspiration (ET) at a specific location over the same time period (referred to as the water balance of the site). By subtracting the average annual ET from the average annual precipitation, it was possible to determine the average annual water surplus available for either infiltration or runoff. The water holding capacities used in the water balance calculations at the subject site were obtained from the MOE Stormwater Management Planning and Design Manual (2003). The water balance information was then provided by Environment Canada's Engineering Climate Services division. The water balance information is presented in Appendix 3 of this report.

The average annual water surplus obtained from the water balance calculations were separated into infiltration and runoff using the approach taken from MOEE (1995). This method multiplies the sum of three factors (topography, soil type and land cover) by the annual water surplus to provide an estimated annual infiltration potential. The topography factor was derived from the field surveys conducted by the City of Ottawa and AOV as part of the geotechnical work completed at the subject site. The soil factor was based on the average composition of the overburden materials found at the subject site during the geotechnical field program conducted in December 2015. The vegetation factor was based on the vegetation mapping provided by McKinley Environmental (2016). Both the water balance and water budget calculations are discussed in greater detail within Section 5.0 of this report.

4.0 REVIEW AND EVALUATION

4.1 Physical Setting

The subject site is located on the east side of Terry Fox Drive, north of Huntsville Drive, in the City of Ottawa, Ontario. The location of the subject site is shown on Drawing PG3823-1 - Site Plan appended to this report.

The subject site currently consists of a mixture of open areas (previously cleared for agricultural purposes), bedrock outcrops, cultural meadow and woodlot areas and deciduous forest (sugar maple/ironwood). The property is surrounded to the north by wooded areas that form part of a future development by Richcraft Homes, to the east by a roadway allowance, wooded areas and the Kanata Lakes residential development, to the south by the Kizell Drain Wetland Complex and earlier phases of the Richardson Ridge residential development and to the west by Terry Fox Drive, agricultural land and the Carp River.

Site topography is highly variable, with large elevation changes occurring over short distances. Site elevation is lowest in the southwest corner of the site at approximately 93 m above sea level (asl). Shifting northwards, several localised nodes exist with elevations reaching as much as 104 m asl, while the average elevation at the north end of the site is closer to 100 m asl. The elevation of the site increases further heading in the eastern direction, with elevations climbing from 98 m asl at the southeastern end to 113 m asl at the top of a ridge on the northeastern side. Approaching the eastern boundary of the site, the elevation drops again, with several depressions below 100 m asl elevation.

While there are no named water bodies located on the subject site, several of the depressions located along the eastern boundary of the site were noted to contain vernal pools, with select pools retaining some volume of water year-round.

According to available mapping, the subject site is located in the Ottawa valley Clay Plains physiographic region (Chapman and Putnam, 1984). The region is characterized by relatively flat clay plains interrupted by rock ridges, which is generally consistent with field observations at the subject site.

4.2 Geology

Surficial Geology

Overburden mapping provided by the Ontario Geological Survey online mapping tool was reviewed as a part of this assessment. Available mapping indicates that overburden soils at the western portion of the subject site consist primarily of offshore marine deposits (silt and clay) associated with the Champlain Sea, with exposed Precambrian bedrock dominating the eastern portion. Overburden soils mapping is shown on Drawing PG3823-3 - Surficial Geology Mapping.

Overburden soils identified in the previous geotechnical investigation by Paterson were generally consistent with the available mapping. Bedrock outcropping was observed by Paterson at multiple locations throughout the subject site. Overburden thickness varied from 0 to approximately 24 m across the subject site, with greater depths of overburden materials present at the western portion of the site, becoming quickly shallower moving northeastward. Soils generally consisted of topsoil over silty clay, which was underlain by glacial till in select areas. Within the PSW located south of the site, the soils were observed to consist of 0.2 to 0.3 m of organics underlain by silty clay, with select locations along the northern portion of the PSW containing glacial till consisting of silty sand with silt, clay and gravel underlying the organic layer.

Specific details are provided on the Soil Profile and Test Data Sheets attached within Appendix 2 of this report.

Bedrock Geology

Bedrock mapping, provided by Natural Resources Canada Urban Geology of the National Capital Region mapping, was reviewed as a part of this assessment. Available mapping indicates that bedrock at the subject site consists primarily of Precambrian metasedimentary rock (paragneiss). A small portion of the site at the southwestern boundary contains interbedded limestone and shale bedrock from the Middle Ordovician Verulam formation. Bedrock geology mapping is shown on Drawing PG3823-4 - Bedrock Geology Mapping.

While no coring was completed as part of the geotechnical investigation at the subject site, several test pits intercepted, and were able to remove, small amounts of weathered cap rock containing gneissic material, which is consistent with the mapping reviewed for the area.

Karst Features

The term 'karst' refers to a geologic formation characterized by the dissolution of carbonate bedrock, such as limestone or dolostone. Based on the bedrock characteristics of the site noted above in Subsection 4.2, only one of the geological formations present at the subject site has any potential for karstification to occur (the interbedded limestone and shale of the Verulam formation). However, this possibility only exists if precipitation is allowed to infiltrate the top of the bedrock to dissolutionally enlarge previously existing joints and bedding planes. Given the depth of surficial soils overlying the limestone bedrock in the area that are non-conducive to groundwater infiltration, it is highly unlikely that karstification is occurring.

4.3 Hydrogeological Setting

Existing Aquifer Systems

Aquifer systems may be defined as geological media, either overburden soils or fractured bedrock, which permit the movement of groundwater under hydraulic gradients. In general, aquifer systems may be present in overburden soils or bedrock. Although groundwater has been observed within overburden soils at the subject site, the relatively thin overburden does not allow for the development of significant water supply wells. Water supply wells in the vicinity are instead likely found in bedrock aquifers.

Bedrock aquifer mapping, provided by Natural Resources Canada Urban Geology of the National Capital Region mapping, was reviewed as a part of this assessment. Using this tool, two water supply aquifer systems have been identified in the vicinity of the study area - the Verulam formation aquifer system and the Precambrian bedrock aquifer system.

The Verulam Formation aquifer system is located west of the site and extends out further west beyond the boundary of the study area. As there are no reliable MOECC well records available for review in the area, it was inferred that the aquifer was present at a minimum depth of 25 m bgs (overburden thickness in the area was found to reach approximately 24 m during the geotechnical field program).

The Precambrian bedrock aquifer system is encountered throughout the subject site. While there were no water wells located in the vicinity of the site, wells completed within this formation outside the study area reported encountering water-bearing fractures at depths of over 14 m below existing grade. Bedrock aquifer mapping is shown on Drawing PG3823-5 - Bedrock Aquifer Mapping.

Groundwater Levels

Groundwater was observed both in the piezometers installed at the borehole locations as well as in open holes during the test pitting program. Based on a review of water well records, groundwater is also present in the bedrock at greater depths.

Groundwater levels in the overburden were observed to vary between 0.8 and 7.0 m bgs during the field program. During the subsurface investigation, overburden soils were generally observed to be moist, becoming wet with depth, with saturated conditions observed in the silty clay layer at TP 1 to TP 4, TP 10 to TP 12 and in BH 1 to BH 3. Saturated conditions were also observed in the lower glacial till at TP 1 and TP 4. During site visits conducted by Paterson, several vernal pools were noted within the eastern portion of the property and are discussed in detail in the environmental impact statement completed for the project by McKinley Environmental (2016). Based on the colour and consistency of the recovered soil samples, the long term groundwater level within the overburden is expected to be between 3 and 6 m bgs.

Horizontal Hydraulic Gradients

Due to the nature of the water levels obtained from field work conducted at the subject site (open hole water levels and piezometers), the absolute direction of horizontal hydraulic gradients in the vicinity of the subject site was not determined. However, using the available data, an approximate horizontal hydraulic gradient in the overburden material was observed with a north-to-south orientation and a magnitude of approximately 0.0002 to 0.03 m/m. Shallow groundwater flow in the vicinity of the subject site is considered to reflect local topography. Regional groundwater flow is considered to be in a southwesterly direction, towards the Carp River.

Vertical Hydraulic Gradients

Vertical hydraulic gradients were not measured within the study area as the previous studies completed at the site did not warrant the installation of monitoring well nests. If the vertical hydraulic gradient were to be measured, it is inferred that the direction would be slightly downward as is typically observed in areas of recharge (bedrock outcrops within the eastern portion of the site). Lower lying areas in downgradient zones (clay deposits within western portion of the site) may exhibit upward vertical hydraulic gradients and provide discharge to local area water features.

Hydraulic Conductivity

The hydraulic conductivity values were conservatively estimated based upon previous experience at similar sites in the area and typical published values for similar stratigraphy obtained from Freeze and Cherry (1979). The values are interpreted to be in the order of:

- 1×10^{-7} to 1×10^{-9} m/sec for stiff brown silty clay
- 1×10^{-9} to 1×10^{-12} m/sec for grey silty clay
- 1×10^{-5} to 1×10^{-7} m/sec for glacial till
- 1.0×10^{-6} to 1×10^{-8} m/sec for weathered bedrock outcrops

Groundwater Recharge and Discharge

In general, groundwater will follow the path of least resistance from areas of higher hydraulic head to areas of lower hydraulic head. While upward and downward hydraulic gradients may be indicative of areas of discharge and recharge respectively, other factors must be considered.

Based on hydraulic conductivity estimates obtained from previous studies and published literature, the bedrock unit is considered to have a higher hydraulic conductivity than the silty clay overburden soil, which is generally considered to act as a confining layer. It is our interpretation that groundwater will generally flow laterally through the upper layer of fractured/weathered bedrock, as opposed to vertically upwards or downwards through the overburden soils of lower hydraulic conductivity. However, given the composition of the bedrock on site (Precambrian high grade metamorphic rock), the volume of recharge occurring within the site boundaries is expected to be minimal.

With regards to discharge zones, neither the topographical or geological conditions are suitable for discharge to be occurring at the subject site. While the PSW located south of the site could theoretically be considered a discharge zone, the volume is anticipated to be minimal given the intermittent hydroperiod of the wetland and limited recharge potential of the surrounding areas.

Kizell PSW Hydroperiod

The hydroperiod of a wetland is characterized by the seasonal fluctuations in water level resulting from groundwater and surface water contributions coupled with the storage capacity of the soils within the wetland.

During the site inspection conducted as part of the field program, the soils generally consisted of organics underlain by either silty clay or glacial till comprised of silty sand/clay with gravel, which is consistent with the soils typically present in a hardwood swamp. Due to the limited permeability of the soils present on site, as well as the relative absence of water found throughout the wetland at the time of the site visit (only isolated depressions containing standing water were found), contributions from groundwater are expected to be minimal. With the topographic variations present both north and south of the PSW (steep slopes both trending towards the wetland), it is likely that the main contributions come from surface water runoff.

The hydroperiod for the Kizell PSW was estimated based on the tree staining observed at the site and the composition of soils present. The staining found on the trees illustrated that the high water level in the area reaches a maximum elevation of approximately of 0.3 m above ground surface (ags), with an average elevation closer to 0.15 m ags. The curve depicted on Figure 1 in Appendix 3 illustrates both the annual spring and fall highs as well as the lows that follow both (where surface water is limited to isolated pools within depressions in the ground surface).

Catchment Areas

As previously stated, the soils at the subject site generally consist of either topsoil or silty clay underlain by bedrock, with several bedrock outcrops present. The silty clay deposit located at the western portion of the site tends to direct surface water in a southwest direction towards Terry Fox Drive, while the area to the east tends to direct surface water in a southerly direction towards the Kizell PSW. Despite the variations in flow direction, as all surface water eventually

reaches the PSW, there is one catchment area considered to exist within the boundaries of the subject site.

Post-development, the portion of the catchment area that drains to the west/southwest will be slightly larger as a result of the topography being altered to accommodate servicing installations. Additionally, large portions of the site are expected to be covered by either urban areas (lawns, parks) or impervious surfaces (roadways, rooftops). However, despite changes made to both the topography and drainage characteristics of the site, the overall direction of flow is expected to remain towards the PSW to the south of the site. Therefore, there is not expected to be any change to the number of catchment areas at the site under post-development conditions.

5.0 SITE SPECIFIC WATER BUDGET ASSESSMENT

The site specific water budget assessment (SSWB) was conducted in an effort to determine the pre and post-development flow contributions to the PSW located south of the site. The site comprises a total area of approximately 9 hectares and currently consists of a mixture of open areas, bedrock outcrops, deciduous forest, cultural meadow and woodlot areas. Post-development, approximately 4.1 hectares will become hard surfaces (rooftops, roadways, driveways) and can be considered impervious. The remaining portions of the site are considered to remain pervious and able to accept infiltration (although infiltration rates may change depending on surface alterations such as landscaped areas and parks as opposed to currently existing bedrock outcrops). Pre and post-development terrain compositions are illustrated on Drawings PG3823-6 - Pre-Development Terrain Composition and PG3823-7 - Post-Development Terrain Composition, both appended to this report.

5.1 Calculations

Thornthwaite and Mather Water Balance Calculations

When falling precipitation intercepts the ground, three possible outcomes arise. The water can either evaporate back into the atmosphere (evapotranspiration), infiltrate into the surface soils (infiltration) or leave the area as runoff.

As mentioned earlier in this report, the method employed by Thornthwaite and Mather (1957) was used along with modelling software to determine the partitioning of water throughout various portions of the hydrologic cycle. Inputs into the modelling program included monthly temperature, precipitation, water holding capacities and site latitude. Using the long term averages of these variables, it was possible to calculate annual potential and actual evapotranspiration, change in soil moisture storage and the water surplus. The formula employed by Thornthwaite and Mather is as follows:

$$S = R + I = P - ET$$

Where: S = surplus (mm/year)
R = annual runoff (mm/year)
I = annual infiltration (mm/year)
P = annual precipitation (mm/year)
ET = annual evapotranspiration (mm/year).

The soils at the subject site generally consist of topsoil overlying a silty clay deposit, with several bedrock outcrops present within the central and eastern regions. Therefore, the above noted calculations were carried out for the soil moisture holding capacities of each material found on site. Based on the location of the site within the Ottawa area, climatic data was obtained from climate stations located at both the McDonald-Cartier International Airport and the Township of Appleton covering the period of January 1945 to December 2015. Table 1, below, displays the soil types present on site and their associated water holding capacities as well as the evapotranspiration and surplus data. The monthly/annual water balance and water budget data is presented in Appendix 3 of the report.

Table 1: Site Specific Water Surplus Information

Soil Type	Water Holding Capacity (mm)	Evapotranspiration (mm/year)	Surplus Water (mm/year)
Anthropogenic Sources (buildings and roadways)	5	467	422
Precambrian Metamorphic Bedrock	10	474	416
Clay Loam (urban lawns)	100	559	333
Clay (pasture and shrubs)	200	599	291
Clay Loam (pasture and shrubs)	250	609	282
Clay (mature forest)	350	615	275
Clay Loam (mature forest)	400	617	272

Table reproduced using water holding capacity values from MOE (2003) - Stormwater Management Planning and Design Manual and modelling data from Environment Canada.

Infiltration Factors

In order to break down the surplus water values for the various materials into infiltration and runoff, various factors must be considered. The MOEE Technical Guidelines for the Preparation of Hydrogeological Studies for Land Development Applications (1995) lists three main factors that contribute to surface water infiltration rates.

The first factor is topography, which is broken down further into three sections: flat and average slope, rolling land and hilly land. Flat and average slope provides the greatest potential for infiltration and has the largest factor applied to it (0.3), while the other two have progressively lower factors (rolling land is 0.2 and hilly land is 0.1).

The second factor is soil, which is also broken down further into three sections: tight impervious clay, medium combinations of clay and loam and open sandy loam. Open sandy loam provides the greatest potential for infiltration (factor of 0.4) while the other two have progressively less potential for infiltration to occur (factors for medium combinations of clay and loam is 0.2 and tight impervious clay is 0.1).

The final factor the MOEE manual uses to partition infiltration from runoff is land cover. It is broken down into two sections: open fields/cultivated lands and woodlands. Woodlands have greater infiltration potential and a factor of 0.2. Open fields and cultivated lands have lower potential and with a factor of 0.1.

A summary of the MOEE manual's descriptors and their associated infiltration factors is shown below in Table 2.

Table 2: MOEE (1995) Infiltration Factors

Description of Area/Development Site	Value of Infiltration Factor
Topography	
Flat and average slope (<0.6 m/km)	0.30
Rolling land (slope of 2.8-3.8 m/km)	0.20
Hilly land (slope of 28-47 m/km)	0.10
Soil	
Tight impervious clay	0.10
Medium combinations of clay and loam	0.20
Open sandy loam	0.40
Cover	
Open fields/cultivated lands	0.10
Woodlands	0.20

Table reproduced from MOEE (1995) - Technical Guidelines for the Preparation of Hydrogeological Studies for Land Development Applications.

The topography throughout the subject site consists primarily of hilly land, with the maximum slope approaching 90m/km at the steepest areas (the west side of the site has less slope). Therefore, a pre-development topography factor of 0.05 was given for all materials found on site. In order for the site to be developed, it is expected that alterations will be made to the topography of the site. In general, it is expected that the overall slope of the site will be reduced in order to accommodate houses and roadways. Therefore, the post-development topography factor for select materials (topsoil, anthropogenic sources) was elevated to between 0.15 and 0.2.

As previously discussed, soils at the subject site generally consist of topsoil overlying stiff silty clay with several bedrock outcrops present. Therefore, the pre-development soils factors ranged from 0.10 for stiff silty clay to 0.20 for the clay loam topsoil. Under post-development conditions, the majority of the site will consist of either landscaped areas or impervious surfaces, with soil factors ranging from 0.20 for clay loam to 0.02 for anthropogenic sources.

The majority of the site was historically cleared for agricultural purposes, with only the eastern portion of the site remaining covered by woodlot and deciduous forest. The pre-development vegetation factors therefore ranged from 0.05 to 0.20. Post-development, it is expected a large percentage of the trees present on site will be removed to accommodate roadways and housing, with the majority of the trees remaining being located either in blocks designated for conservation or in landscaped areas (lawns, parks). As such, post-development vegetation factors generally decreased to values closer to 0.1, with the exception of anthropogenic sources, which was given a factor of 0 due to its negligible potential to benefit from vegetation cover.

The pre and post-development infiltration factors for all materials considered are included in the water budget calculations provided in Table C8 and C9 included in Appendix 3 of this report.

5.2 Pre and Post-Development Water Budget

The pre-development water budget analysis conducted at the subject site determined that an estimated 8,180 m^3/year of surplus water currently infiltrates the surface soils and either recharges local bedrock aquifer systems or travels laterally as interflow at the overburden/bedrock interface. The remaining estimated 21,205 m^3/year of surplus leaves the site as runoff, a large portion of which is anticipated to flow towards the Kizell PSW adjacent to the site.

The post-development water budget analysis alternatively determined that an estimated 10,375 m^3/year of surplus water will infiltrate the surface soils and 22,993 m^3/year will leave the site as runoff. These values equate to approximate increases in both infiltration and runoff of 27% and 8% respectively.

One of the variables that changed is the addition of over 40,000 m^2 of anthropogenic sources. This addition will reduce the overall percentages of silty clay and bedrock outcrop located at the site to approximately 18% and 13% of their original values respectively, while at the same time increase the overall water surplus available for partitioning between infiltration and runoff. Alterations to the topography of the site (reduction in slope) to accommodate housing and roadway construction caused an increase in the average topography factor, which also increased the infiltration potential of the area.

Additional water budget analyses were conducted for the expected high and low points of the hydroperiod for the PSW (April and August respectively) under both pre and post-development conditions. The results of the analyses indicated that, during the dry months, there would be an expected 21.7% increase in runoff under post-development conditions adding an approximate 29.6 m^3 of runoff over the span of August. As this amounts to an approximate dispersion of 0.2 mm of water over the area of the PSW, this increase in runoff is not expected to result in any measurable effects to the wetland.

Details of both the pre and post-development water budget analyses are presented in Tables C8 to C13 included in Appendix 3 of this report.

6.0 GROUNDWATER IMPACT ASSESSMENT

6.1 Impact of Proposed Development on Surrounding Infrastructure

As previously stated, soils at the subject site generally consist of topsoil overlying a silty clay deposit that becomes progressively deeper moving westward, with several bedrock outcrops present moving eastward and a small section noted to contain a sandy glacial till layer between the silty clay and bedrock units. There are no known buildings within the projected steady state radius of influence calculated in the following section of this report. Additionally, dewatering activities are expected to be short term in duration and require only low levels of pumping due to the nature of the materials on site. Any large quantities of water removed from the site will be in relation to precipitation events or if discontinuous areas of either perched groundwater or shallow water bearing fractures are encountered in the bedrock. As such, the impacts of the proposed development on the surrounding infrastructure are expected to be negligible.

6.2 Impact of Proposed Development on Existing Well Users

A search of the Ontario Water Well Records database and the Ontario Groundwater Information Network (GIN) indicated that there are 2 wells within a 500 m radius of the proposed development. Upon investigation, it was determined that the wells were improperly located on the mapping system and are actually located several kilometers away, well outside the theoretical radius of influence for the site. The well located nearest to the site that may currently remain in use is located 1.2 km northeast of the site at 560 Goulbourn Forced Road. However, this well was noted to be drawing water from a bedrock aquifer located approximately 15 m bgs, well below the expected maximum depth of servicing excavations at the site.

The steady-state radius of influence calculations were based upon the Sichardt equation as shown below:

$$R = r_e + 3000 * \Delta h(K^{0.5})$$

Where: R = radius of influence (m)
r_e = equivalent radius of influence (m)
Δh = expected groundwater drawdown (m)
K = hydraulic conductivity (m/sec).

For the purposes of completing the calculations, the following values were used in the analysis:

- r_e = 7.96 m, based on the typical dimensions of the servicing excavations at the subject site
- Δh = 3 m, based on the expected maximum drawdown occurring during servicing excavations.
- K = 1 x 10^{-6} m/sec, based upon experience with similar materials and published values.

Using the above equation and assumptions, a radius of influence of approximately 17 m will develop as a steady state condition in the area of the servicing excavations.

The only buildings located within the vicinity of the proposed development are south of the subject site, within earlier phases of the Richardson Ridge residential development. As these homes are serviced by municipal supplies, and there are no active domestic wells located within the theoretical radius of influence for the site, it is not expected that the proposed development will negatively affect the water quantity and/or quality of nearby well users.

6.3 Impact of Proposed Development on the Environment

A review of the MOECC's Brownfield Environmental Site Registry did not identify any environmental concerns in the immediate vicinity of the study area. Based on observations of Paterson staff during field work, no potential groundwater contamination concerns were identified with respect to the site. Additionally, no visual or olfactory evidence of contamination was observed in the soil, groundwater, or bedrock. Considerations relevant to the water budget analyses are discussed below. Additional details of the potential environmental impacts with regards to terrestrial habitat, wildlife and species at risk are provided in the EIS completed by McKinley Environmental (2016) for the subject site.

Pre and post-development water budget analyses were completed at the subject site to assess the changes in flow contributions to the Kizell PSW located south of the site. The results of the analyses indicated that the flow contributions to the wetland would increase minimally under post-development conditions. It is therefore expected that water levels in the wetland will, at a minimum, remain the same, but could also have the potential to increase under post-development

conditions, which would extend its hydroperiod. While significant increases in water levels within a wetland have the potential to be detrimental to its health, it is important to note that the increase in runoff volumes at the subject site is minimal, with subsequently minimal increases in water levels expected as a result.

The EIS prepared by McKinley Environmental indicates that a slight increase in water level would have minimal potential to impact the overall vegetative composition or functionality of the wetland. Water levels vary naturally and considerably within wetlands annually due to many factors such as weather, seasonal patterns, fluctuations in rainfall and even beaver activity (McKinley Environmental, 2016). As previously discussed, tree staining witnessed during site inspections suggest that annual water level highs reach between 0.15 and 0.30 m ags, with extensive dry periods throughout the summer months, where only standing water within isolated depressions are visible. The anticipated increase in flow contributions under post-development conditions is expected to be much smaller in scale when compared to the potential annual fluctuations that occur naturally. The EIS notes that from a biological perspective, impacts from changes in water level of the magnitude anticipated under post-development conditions are negligible, as they are likely to fall within the range of existing natural variability (McKinley Environmental, 2016). The EIS concludes that the scale of change which may occur in the wetland is negligible compared to existing natural variability, and therefore that the development is not likely to substantially impact the wetland, vegetative composition, or the wetland habitat functionality (McKinley Environmental 2016).

In terms of biological activity in the Kizell PSW, the most significant feature is the presence of a population of Blanding's turtles. The EIS includes a discussion of potential impacts, mitigation and compensation requirements for the turtles, which are summarized from the Overall Benefit Permit submission to the Ontario Ministry of Natural Resources and Forestry (OMNRF). The EIS also notes that the currently existing Blanding's turtle habitat is generally poor quality due to the lack of open water areas and the short hydroperiod of the wetland. As part of the Blanding's Turtle Habitat Compensation project, a new permanent pond adjacent to Terry Fox Drive is to be constructed to enhance the functionality of the wetland as a habitat for the turtles (McKinley Environmental, 2016). The EIS concludes that any alterations to the wetland that increase the extent or duration of standing water are likely to improve the functionality of habitat for the Blanding's turtle population. As such, the anticipated neutral or minimal increase in water levels and/or hydroperiod under post-development conditions will either have no

substantial effect on the turtle population, or will represent a marginal improvement to habitat quality (McKinley Environmental 2016).

Notwithstanding the results of the water budget analyses, several potential impacts remain to the Kizell PSW as a result of the development, which are discussed in detail within the EIS completed by McKinley Environmental (2016).

7.0 ASSESSMENT AND RECOMMENDATIONS

Existing Wells

No wells were found to exist within the theoretical radius of influence at the subject site. Furthermore, the well located closest to the subject site (approximately 1.2 km to the northeast) is completed at significant depth within the bedrock aquifer system, well below the anticipated maximum depth of excavation required to install services. As such, the well is considered to have negligible potential to be impacted by construction dewatering activities at the subject site. There is therefore no need to implement monitoring programs for existing well users in the area.

Sources of Contamination

No concerns were identified with respect to actual or potential sources of contamination at the time of completion of this study.

Prior to and during site development, it is recommended that construction best management practices with respect to fuels and chemical handling, spill prevention, and erosion and sediment control be followed. This will minimize the potential for the introduction of contaminants to the soil, surface water, or groundwater at the subject site.

Blasting

Bedrock removal by means of blasting within the shallow bedrock will be required as part of construction activities at the subject site. While the lack of existing well users in the area minimizes risk to drinking water quality, there is potential to impact the water quality of the nearby Kizell PSW. It is therefore recommended that construction best management practices be employed during blasting activities to minimize sediment accumulation in water runoff from the site to the PSW. At the time of report preparation, it was understood that both silt fencing and vegetative setbacks will be in place during construction, which are expected to adequately slow overland stormwater flows and decrease sediment accumulation in the PSW.

Services

It is our understanding that the subject site is to be developed with municipal sewer and water services. General recommendations regarding site servicing are provided under separate cover in our geotechnical investigation report. Specific hydrogeological and geotechnical recommendations will be provided during the detail design phase. Although specific details regarding site servicing are not currently available, it is our expectation that site servicing depths will not exceed 9 m bgs. It is also expected that a secondary storm outlet to the PSW south of the site will be installed within the eastern portion of the site to aid in maintaining baseflow at the upstream portion of the wetland. The vegetated setback from the wetland and limited potential diameter of the outlet are anticipated to limit the velocity of water entering the wetland and avoid sedimentation and erosional issues.

Permit To Take Water

For any water taking of greater than 50,000 L/day, either an Environmental Activity and Sector Registration (EASR) or a Permit To Take Water (PTTW) is required from the MOECC, dependant on dewatering requirements. At the subject site, an EASR or PTTW may be required for construction dewatering or works below the water table. The requirement for either will be determined during the detail design phase. The information contained in this report may be used as supporting documentation for an EASR or PTTW application for the subject site. Depending on the nature of the proposed water taking, an additional hydrogeological investigation may be required.

Areas of Recharge Potential

Based on geological and hydrogeological conditions at the subject site, as discussed in previous sections, the potential for significant groundwater recharge through overburden soils and bedrock outcrops to the underlying bedrock aquifer is considered to be limited over a large portion of the subject site. The majority of recharge to bedrock aquifers is interpreted to occur outside the boundaries of the study area, where overburden materials are more conducive to infiltration and bedrock outcrops are less competent.

8.0 CLOSURE

The client should be aware that any information pertaining to soils and all test hole logs are furnished as a matter of general information only, and test hole descriptions or logs are not to be interpreted as descriptive of conditions at locations other than those of the test holes.

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 Richardson Ridge Incorporated, The Regional Group of Companies Incorporated, or their agent(s) is not authorized without review by Paterson Group for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

Michael Laflamme, GIT

Carlos P. Da Silva. P.Eng., ing., QP_{ESA}

Report Distribution:

- Regional Group
- Paterson Group Inc.
- Rideau Valley Conservation Authority

9.0 REFERENCES

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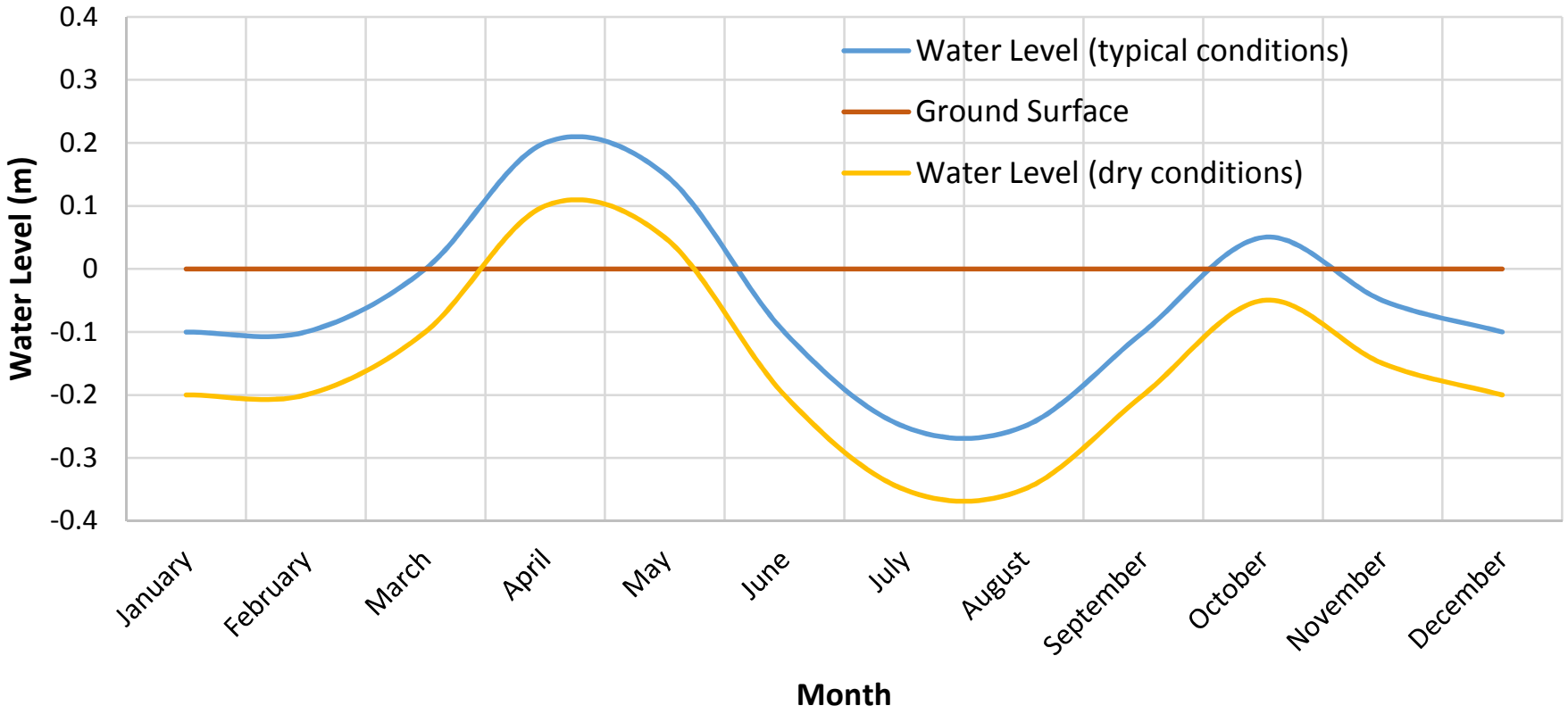
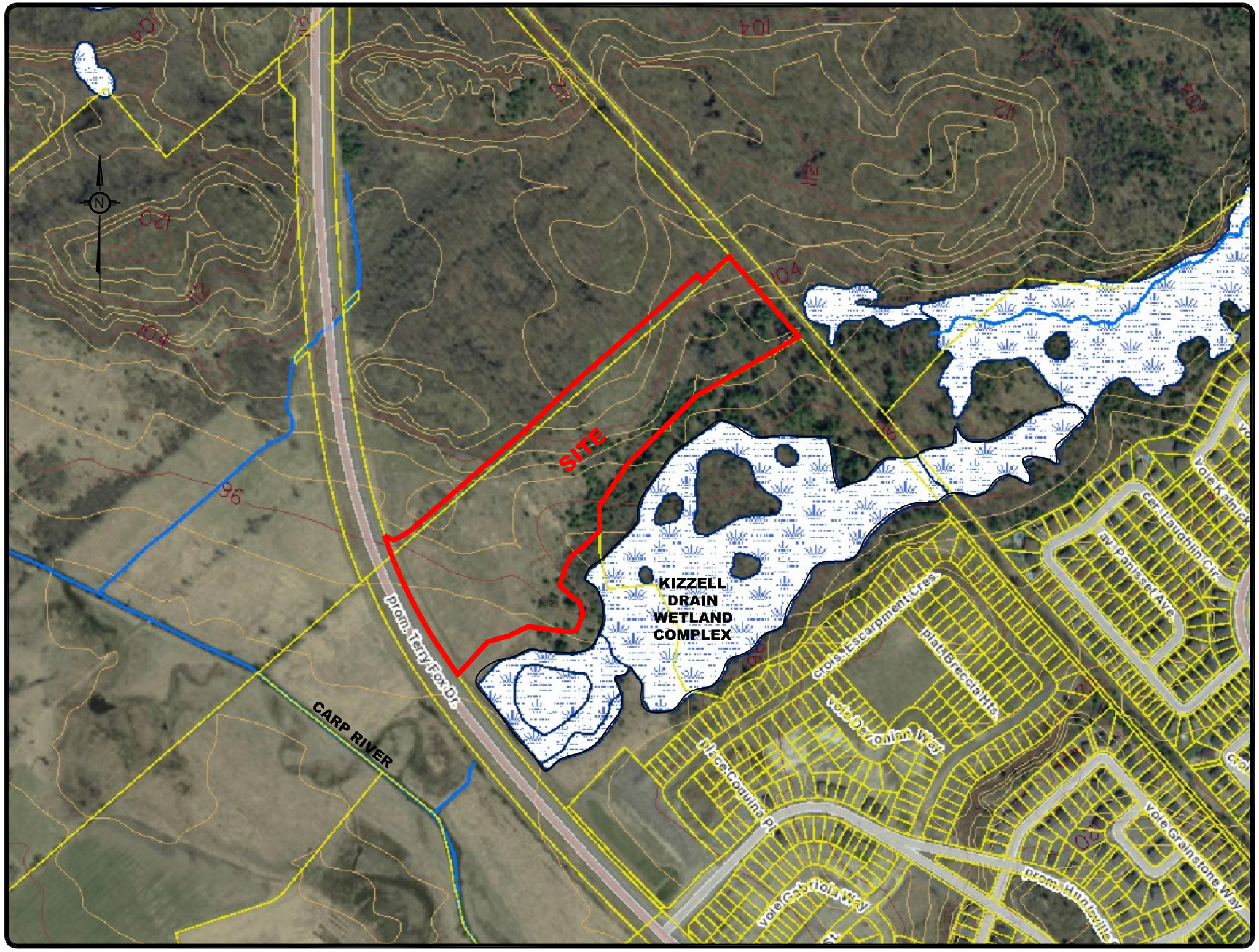
McKinley Environmental Solutions. "Richardson Ridge Phase 4 Development - Environmental Impact Statement", February, 2016.

FIGURES

Figure 1 - Approximate Kizell PSW Hydroperiod
Drawing PG3823-1 - Site Plan
Drawing PG3823-2 - MOECC Water Well Plan
Drawing PG3823-3 - Surficial Geology Mapping
Drawing PG3823-4 - Bedrock Geology Mapping
Drawing PG3823-5 - Bedrock Aquifer Mapping
Drawing PG3823-6 - Pre-Development Terrain Composition
Drawing PG3823-7 - Post-Development Terrain Composition

Figure 1 - Approximate Kizell PSW Hydroperiod





Date	Description	Rev.

Client:

RICHARDSON RIDGE INC.
c/o THE REGIONAL GROUP OF COMPANIES

Consultant:

paterson group
consulting engineers

Project:

HYDROGEOLOGICAL STUDY
467 TERRY FOX DRIVE
OTTAWA, ONTARIO

Drawing:

SITE PLAN

Scale: N.T.S.	Seal:
Date: 06/2016	
Drawn by: MPG	
Checked by: CDS	
File: PG3823	

Drawing No.: **PG3823-1**

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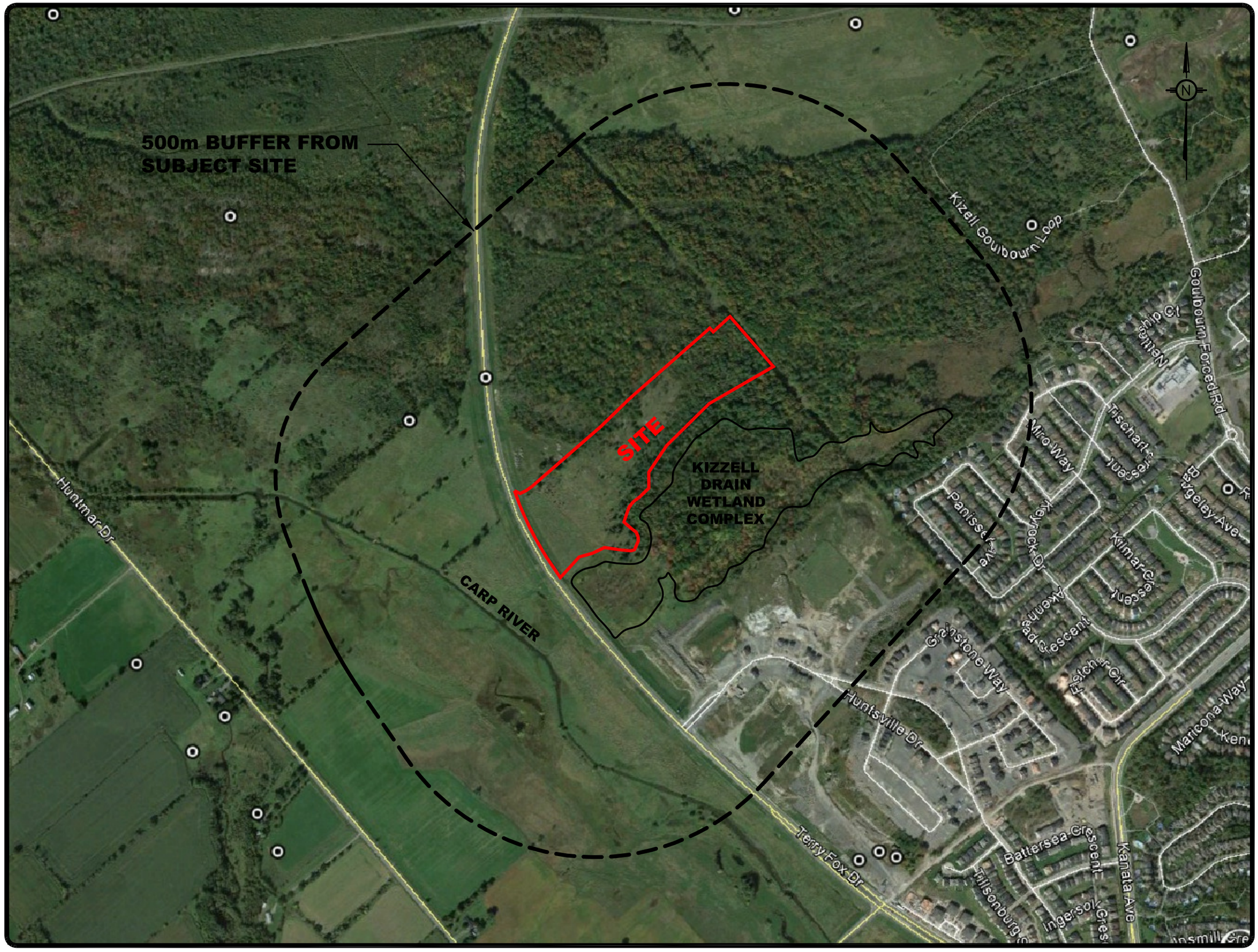

Date	Description	Rev.

Client:

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Consultant:

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consulting engineers

Project:

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467 TERRY FOX DRIVE
OTTAWA, ONTARIO

Drawing:

MOECC WATER WELL PLAN

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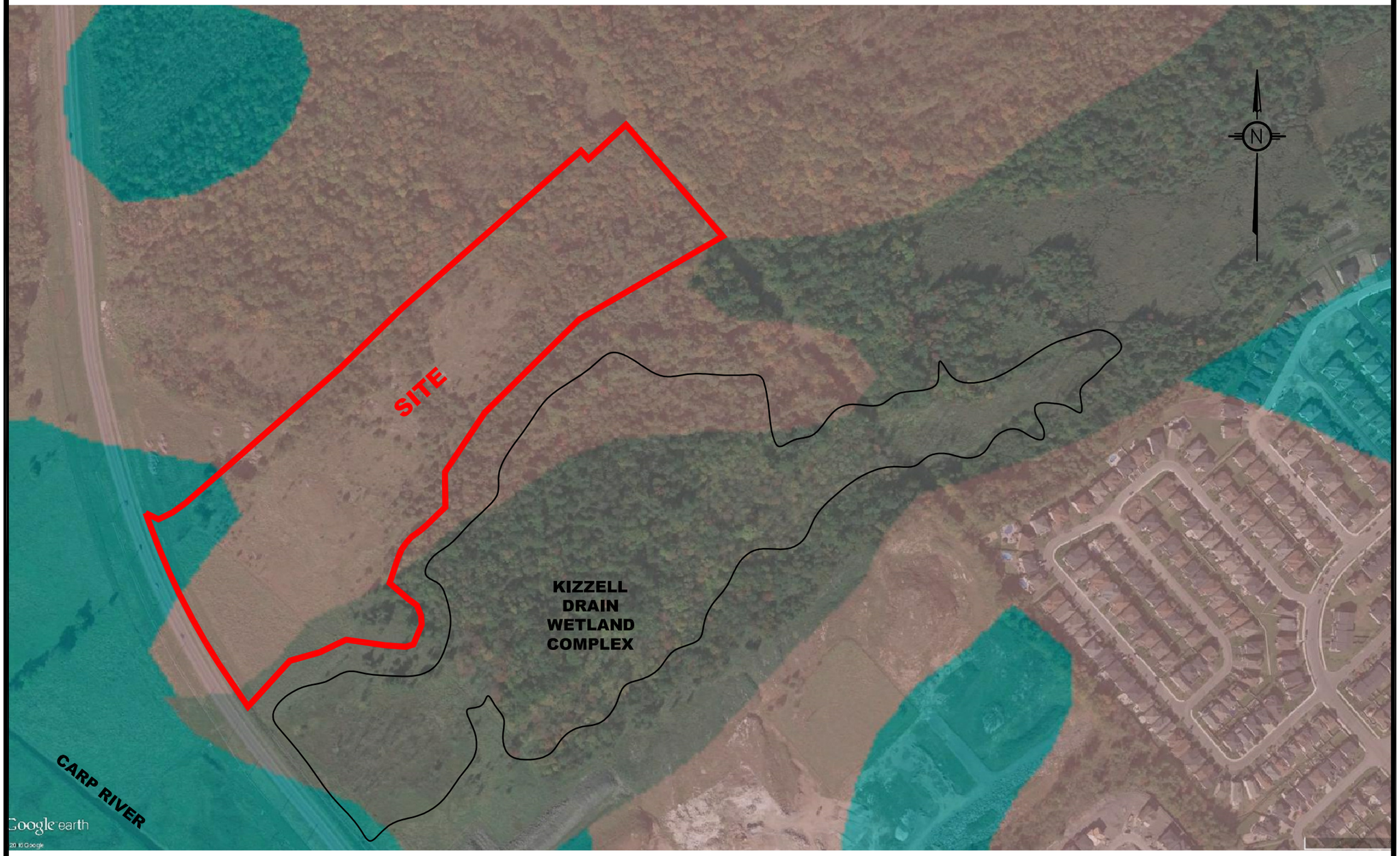

FINE-TEXTURED GLACIOMARINE DEPOSITS (SILT, CLAY)

PRECAMBRIAN ROCK

ORGANIC DEPOSITS (PEAT, MUCK, MARL)

Date	Description	Rev.

Client:

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c/o THE REGIONAL GROUP OF COMPANIES

Consultant:

paterson group
consulting engineers

Project:

HYDROGEOLOGICAL STUDY
467 TERRY FOX DRIVE
OTTAWA, ONTARIO

Drawing:

SURFICIAL GEOLOGY MAPPING

Scale: N.T.S.	Seal:
Date: 06/2016	
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Drawing No.: **PG3823-3**

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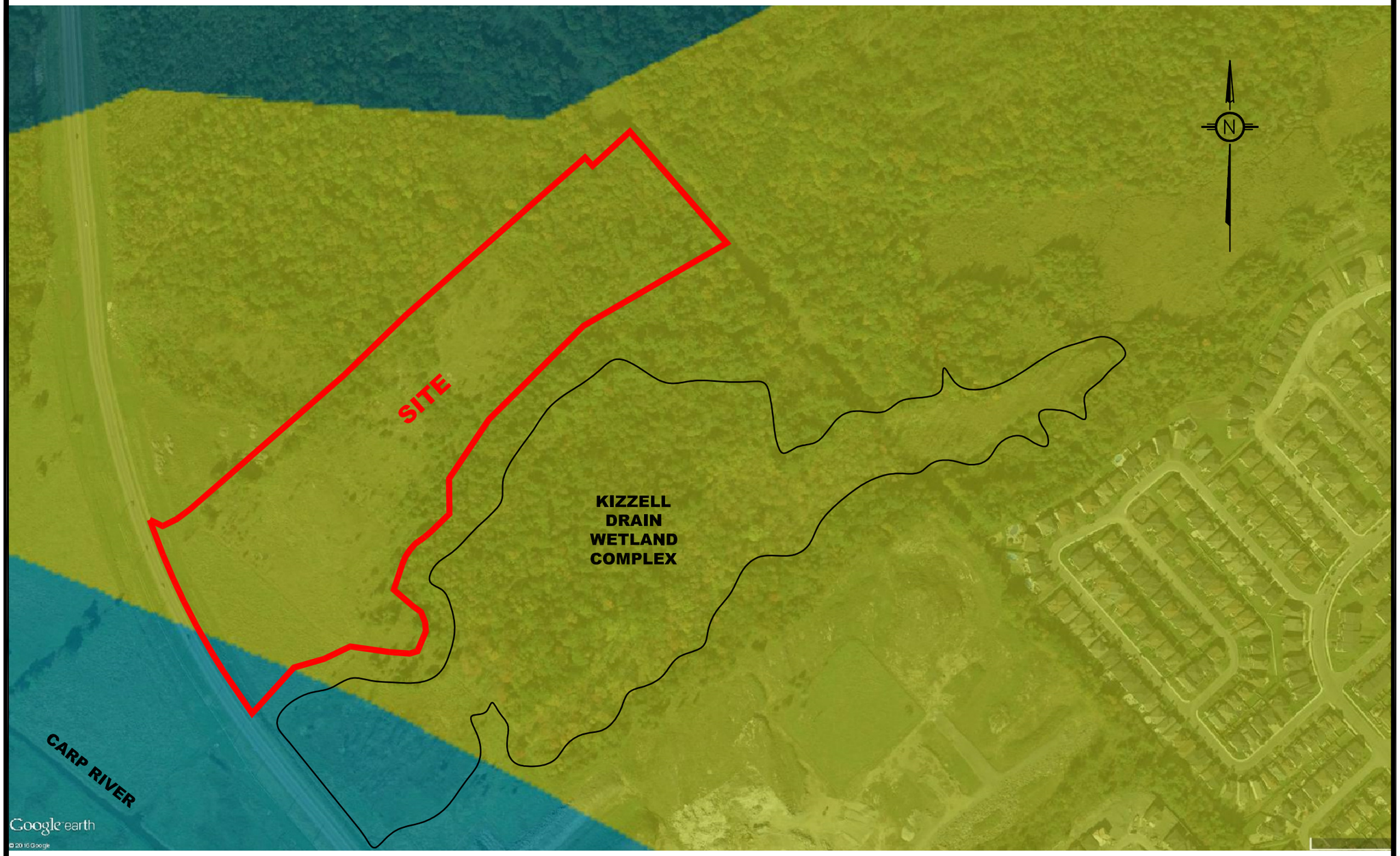

GRENVILLE SUPERGROUP AND FLINTON GROUP (CLASTIC META SEDIMENTARY ROCKS)

MID-ORDOVICIAN LIMESTONE, DOLOSTONE, SHALE, ARKOSE, SANDSTONE

Date	Description	Rev.

Client:

RICHARDSON RIDGE INC.
c/o THE REGIONAL GROUP OF COMPANIES

Consultant:

paterson group
consulting engineers

Project:

HYDROGEOLOGICAL STUDY
467 TERRY FOX DRIVE
OTTAWA, ONTARIO

Drawing:

BEDROCK GEOLOGY MAPPING

Scale: N.T.S.	Seal:
Date: 06/2016	
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Drawing No.: **PG3823-4**

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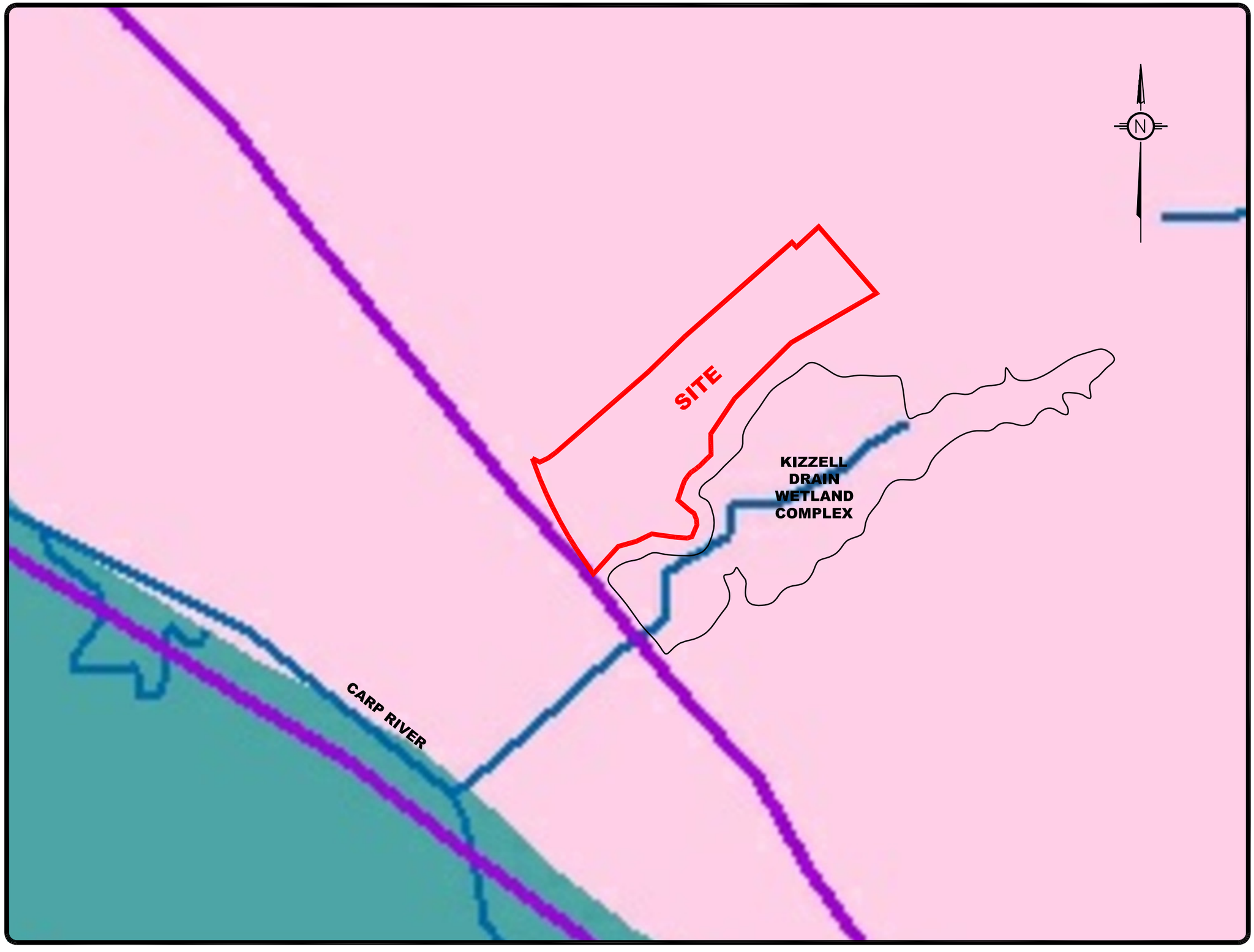

PRECAMBRIAN ROCKS (VARIABLE YIELD/QUALITY)

ROCKCLIFFE, GULL RIVER, BOBCAYGEON, VERULAM AND LINDSAY FORMATIONS (SUFFICIENT SUPPLY FOR DOMESTIC USE, VARIABLE QUALITY)

Date	Description	Rev.

Client:

RICHARDSON RIDGE INC.
c/o THE REGIONAL GROUP OF COMPANIES

Consultant:

paterson group
consulting engineers

Project:

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467 TERRY FOX DRIVE
OTTAWA, ONTARIO

Drawing:

BEDROCK AQUIFER MAPPING

Scale: N.T.S.	Seal:
Date: 06/2016	
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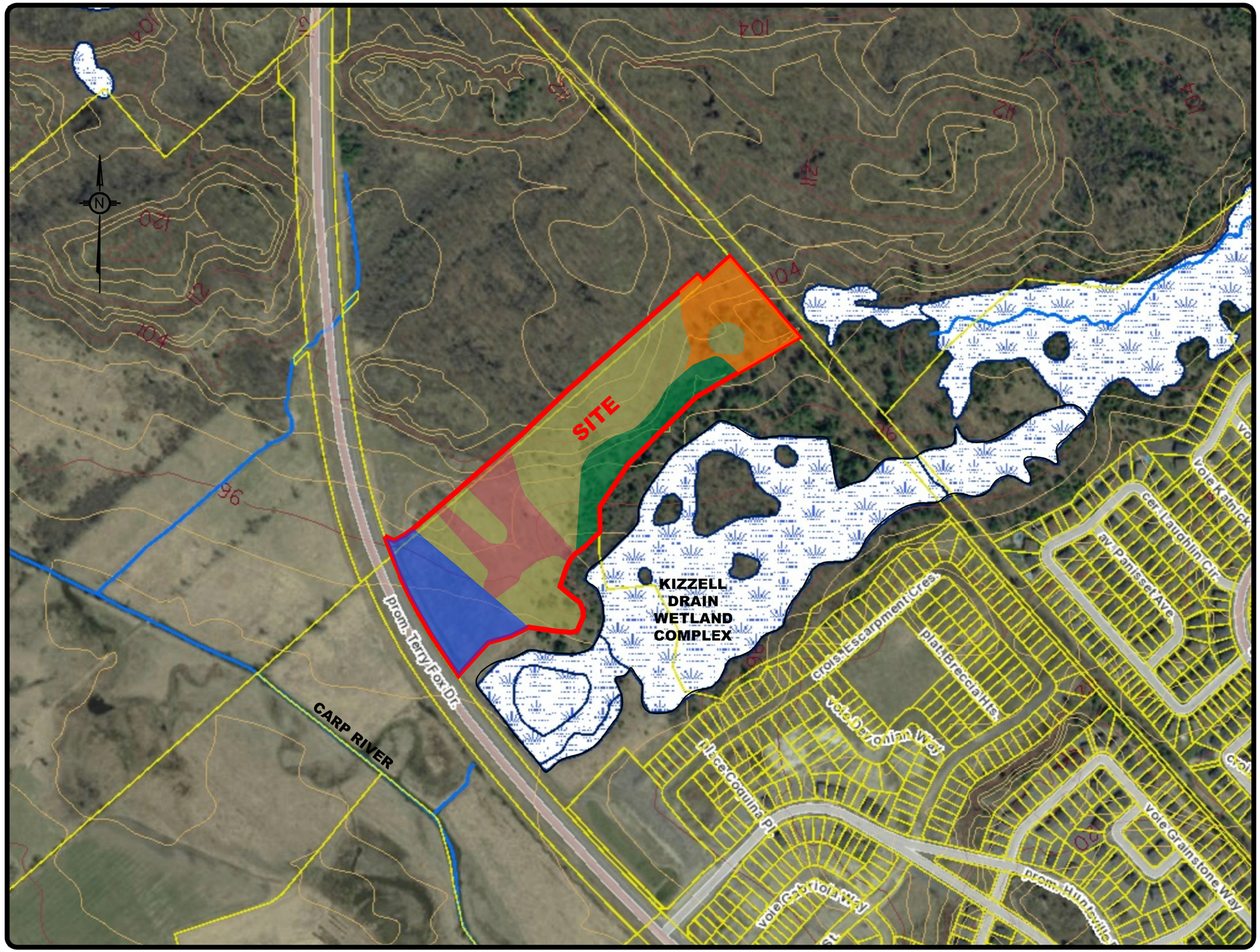

- STIFF SILTY CLAY (PASTURE AND SHRUBS)
- PRECAMBRIAN METAMORPHIC BEDROCK
- CLAY LOAM (PASTURE AND SHRUBS)
- CLAY LOAM (MATURE FOREST)
- STIFF SILTY CLAY (MATURE FOREST)

Date	Description	Rev.

Client:

RICHARDSON RIDGE INC.
c/o THE REGIONAL GROUP OF COMPANIES

Consultant:

paterson group
consulting engineers

Project:

HYDROGEOLOGICAL STUDY
467 TERRY FOX DRIVE
OTTAWA, ONTARIO

Drawing:

PRE-DEVELOPMENT TERRAIN COMPOSITION

Scale: N.T.S.	Seal:
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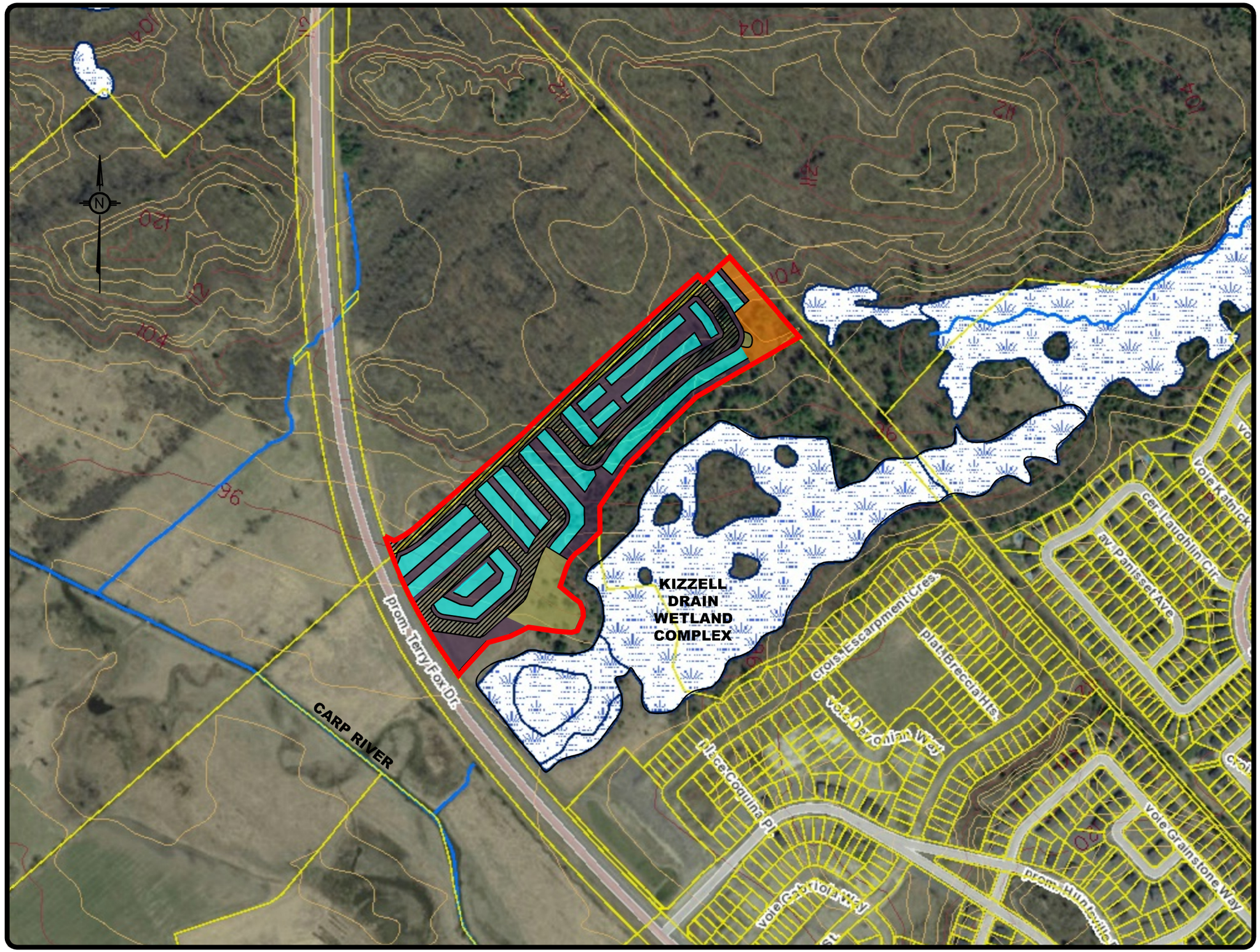

ROADWAYS

PRECAMBRIAN METAMORPHIC BEDROCK

ROOFTOPS

CLAY LOAM (URBAN LAWNS)

STIFF SILTY CLAY (MATURE FOREST)

Date	Description	Rev.

Client:

RICHARDSON RIDGE INC.
c/o THE REGIONAL GROUP OF COMPANIES

Consultant:

paterson group
consulting engineers

Project:

HYDROGEOLOGICAL STUDY
467 TERRY FOX DRIVE
OTTAWA, ONTARIO

Drawing:

POST-DEVELOPMENT TERRAIN COMPOSITION

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APPENDIX 1

Terms of Reference - Richardson Ridge Phase 4 (Prepared May 10, 2016 - Revised June 2, 2016)

Water Balance - Impact on PSW –Terms of Reference
Richardson Ridge Phase 4 (May 10 2016)

Paterson Group will coordinate study and undertake hydrogeological and water balance calculations.
Novatech will provide planning policy , subdivision context and background**.**
MES (McKinley Environmental) will be responsible for description of the PSW and environmental analysis and possible impacts of the development on the PSW.
IBI will describe historical and continuing changes to the storm drainage patterns in the area and the subdivision engineering works that may be considered to lessen the impact of the subdivision on the PSW.

1) Reason for Study – Why is it necessary – next to PSW within 120 metres, now want to construct a subdivision and have to describe the impacts on PSW **(Paterson help from Novatech).**
2) Description of MNR, MVCA and City OP Policy **(Novatech).**
3) Existing Conditions – Description of the biological community including the adjacent upland vegetative community, tree species, and presence of Species at Risk **(MES)**. Existing topography, overburden and bedrock geology, and hydrological/hydrogeological conditions will also be discussed. Topography will be analysed using mapping provided by Annis O'Sullivan Vollebekk Ltd. while the various geological, hydrological and hydrogeological components will be discussed using recent mapping from the Ontario Geological Survey **(Paterson)**.
4) Description of the PSW – summary of location, flora and fauna, existing mapping of wetland limits, PSW evaluation and key characteristics that make it a PSW (based on the wetland evaluation completed by Nick Stow of the City of Ottawa). Presence of Species at Risk and management priorities will be discussed, including the management direction set by OMNRF, which emphasizes Species at Risk habitat **(MES)**.
5) Description of the subdivision – # units, type and size , tree removal requirements, filling, grading, stormwater, services, park overlooking the PSW, paths etc. **(Novatech)**.
6) EIS and OMNRF Permit – Summary – What does the EIS say about the development: Significant issues, mitigation, and integration of Species at Risk and wetland management priorities into the subdivision design. Blanding's Turtle permit and management plan including the new turtle compensation pond, fencing, and transfer of retained blocks of the PSW (as negotiated with OMNRF) **(MES)**.
7) A hydrogeological study with water balance and groundwater impact assessment components included. Study will consider aquifer systems, groundwater levels/gradients, recharge/discharge zones, catchment areas, recommended monitoring programs and impacts to nearby structures/environment/existing well users/PSW. Water balance data will be processed using modelling software at Environment Canada to determine both pre and post-development flow contributions to adjacent PSW **(Paterson).**
8) Discussion of existing drainage patterns for the site and general area including description of what works have been completed in Kizell pond, Phase 3 Richardson, Terry Fox Dr. culverts, and the impact on flows/drainage patterns over time. **(IBI).**
9) Discussion of the anticipated impact of the subdivision on the PSW. Anticipated impacts on habitat structure, flora, and fauna including Species at Risk habitat. Potential impacts of bedrock blasting and suggested mitigation measures will be discussed. If the water balance study demonstrates that existing hydrology and hydroperiod are likely to be significantly impacted, anticipated effects on wetland flora and fauna will be discussed and compared to existing values (based on the wetland evaluation completed by Nick Stow of the City of Ottawa) **(MES)**
10) Discussion of what things we can do to lessen impact – rear yard drainage, dikes in trenches, routing of various storm events, dam to maintain water levels, etc. (**IBI)** as well as proposed biological mitigation measures, including turtle pond **(MES)**

11) Recommendations – (**Paterson, IBI, MES)**

APPENDIX 2

Soil Profile and Test Data Sheets
Symbols and Terms
Drawing PG3695-1 - Test Hole Location Plan

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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.

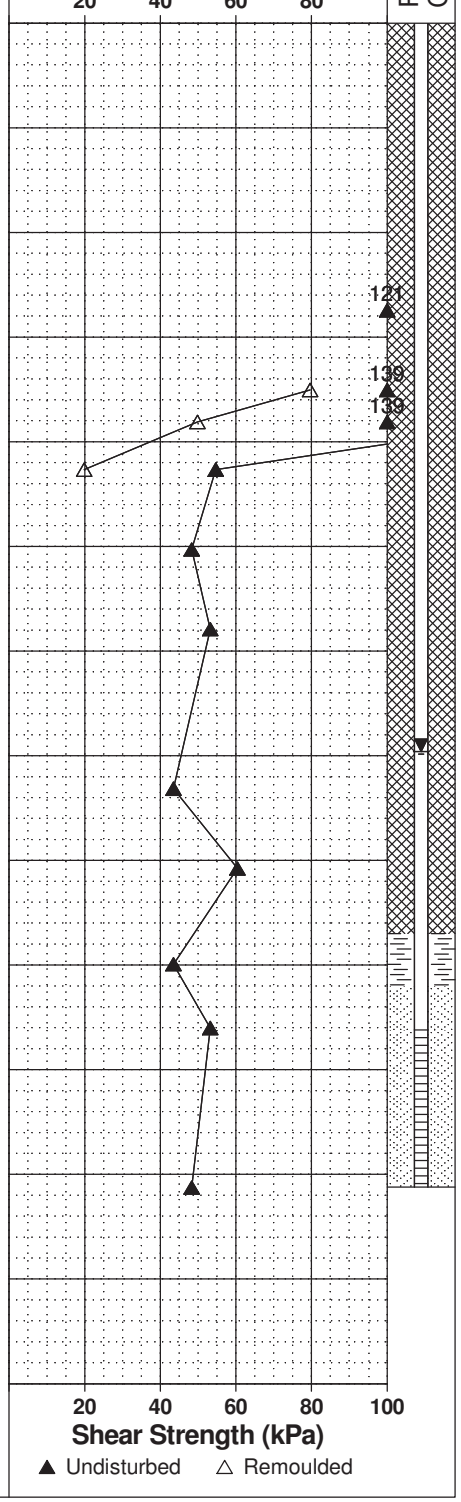
FILE NO. PG3695

REMARKS

HOLE NO. 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)
GROUND SURFACE						0	94.69
TOPSOIL 0.30		AU	1				
		SS	2	100	3	1	93.69
		SS	3	100	3	2	92.69
Very stiff to stiff, brown **SILTY CLAY**						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



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SOIL PROFILE AND TEST DATA

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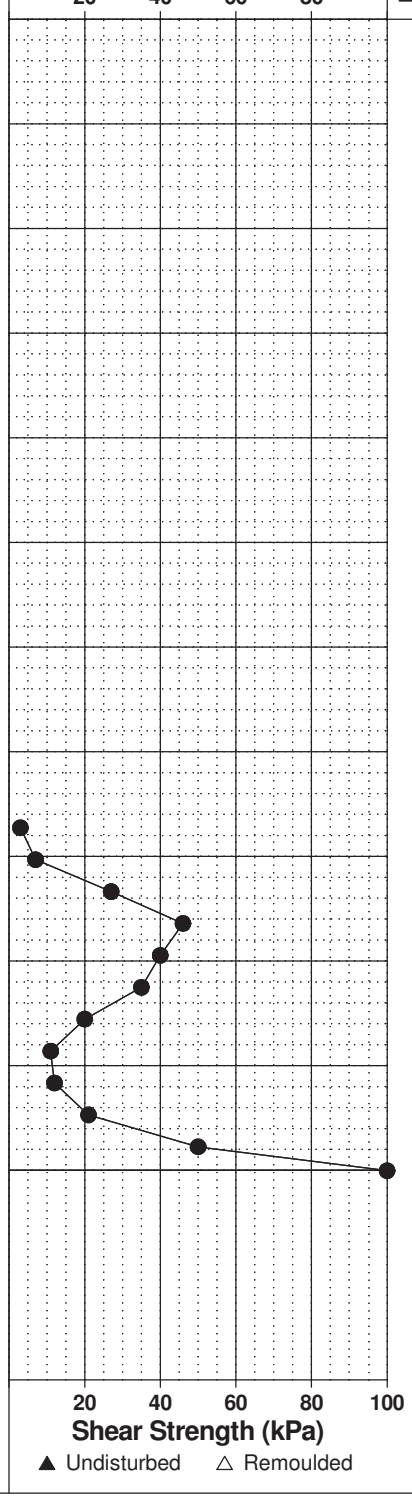
FILE NO. PG3695

REMARKS

HOLE NO. BH 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 %	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)									



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SOIL PROFILE AND TEST DATA

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

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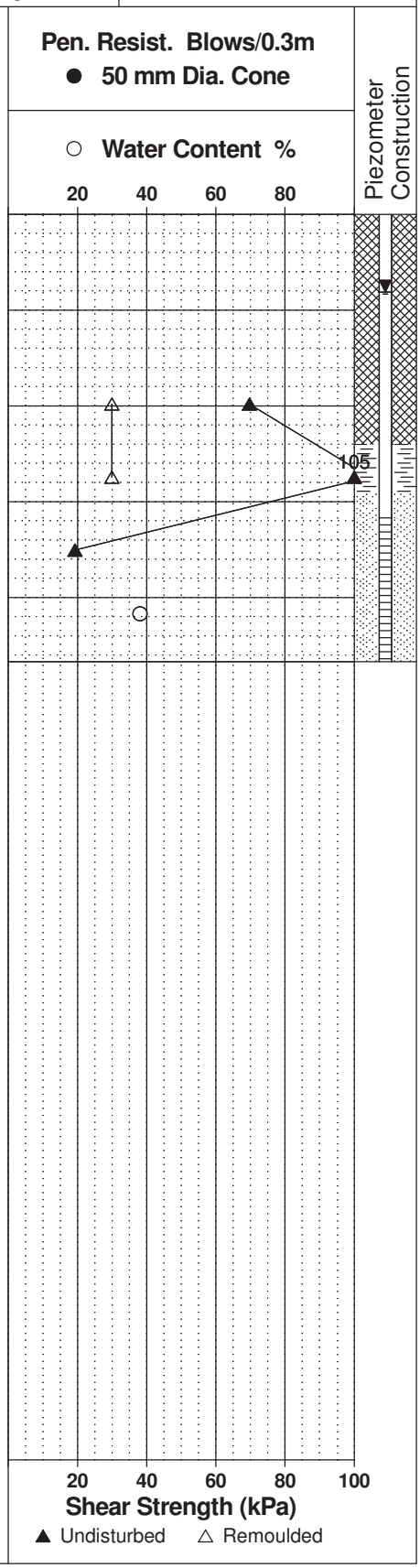
FILE NO. PG3695

REMARKS

HOLE NO. BH 2

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

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

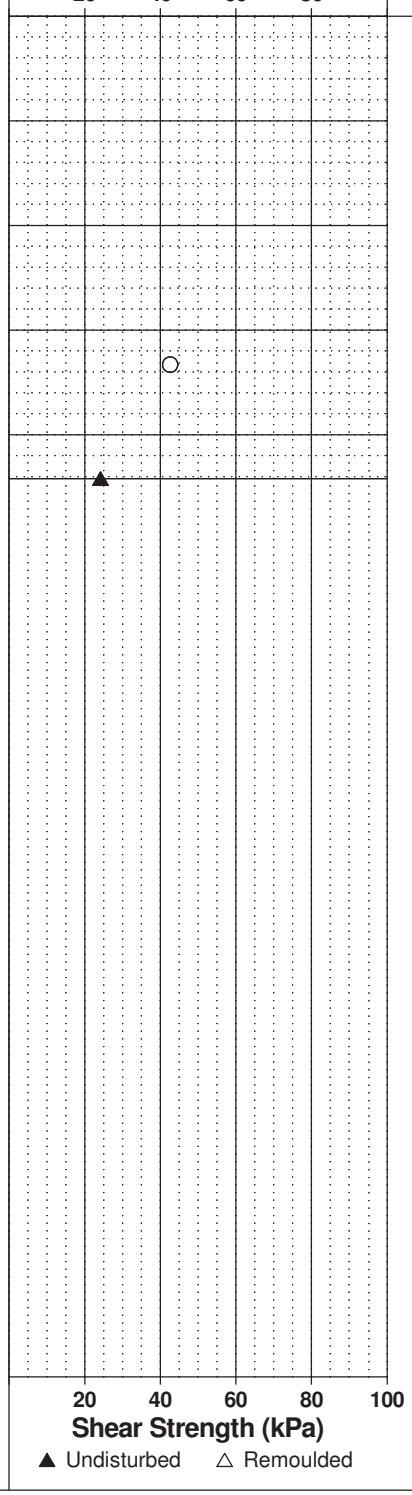
FILE NO. PG3695

REMARKS

HOLE NO. BH 2A

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

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	93.53		
Inferred **SILTY CLAY**						1	92.53		
						2	91.53		
3.05						3	90.53		
Firm, brown **SILTY CLAY**		TW	1						
4.42						4	89.53		
End of Borehole									



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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.

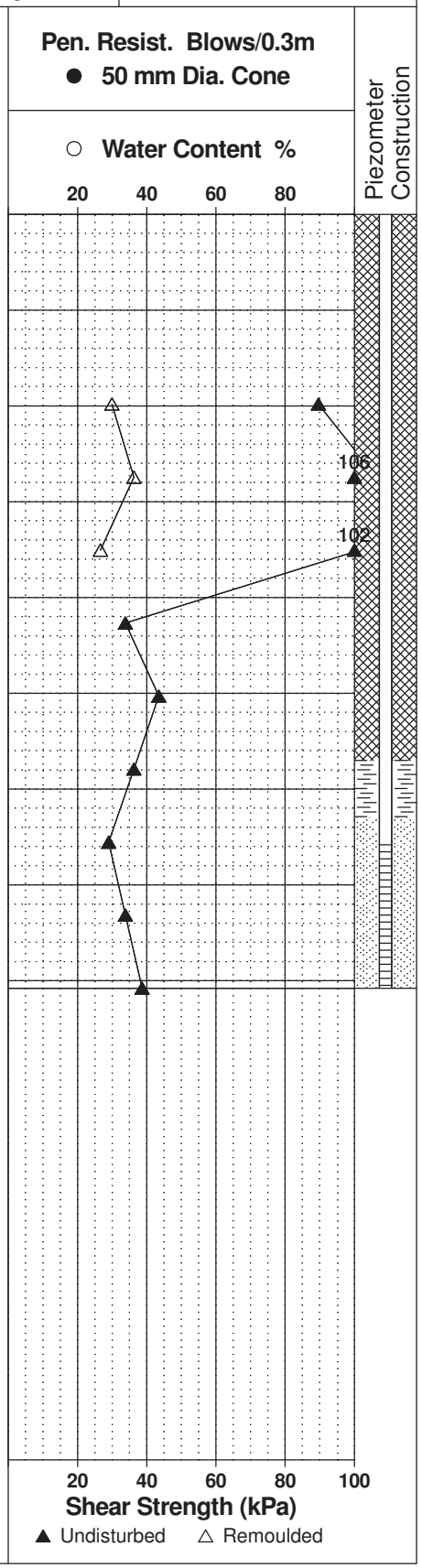
FILE NO. PG3695

REMARKS

HOLE NO. BH 3

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)
GROUND SURFACE						0	93.90
TOPSOIL 0.30							
		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)							



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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. 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 %	Piezometer Construction
GROUND SURFACE									
TOPSOIL 0.10						0	99.56		
Brown, **SILTY CLAY**									
1.10						1	98.56		
End of Auger Hole Practical refusal to hand augering at 1.10m depth									

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

20 40 60 80

20 40 60 80 100

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.

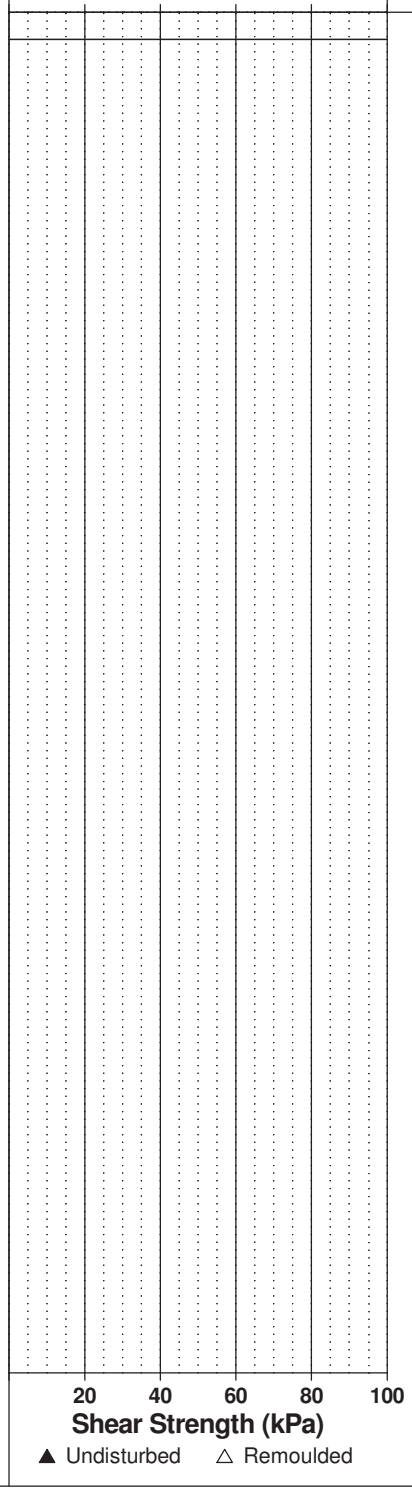
FILE NO. PG3695

REMARKS

HOLE NO. HA 2

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 %	Piezometer Construction
GROUND SURFACE						0	99.57		
TOPSOIL									
0.40									
End of Auger Hole									
Practical refusal to hand augering at 0.40m depth									



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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.

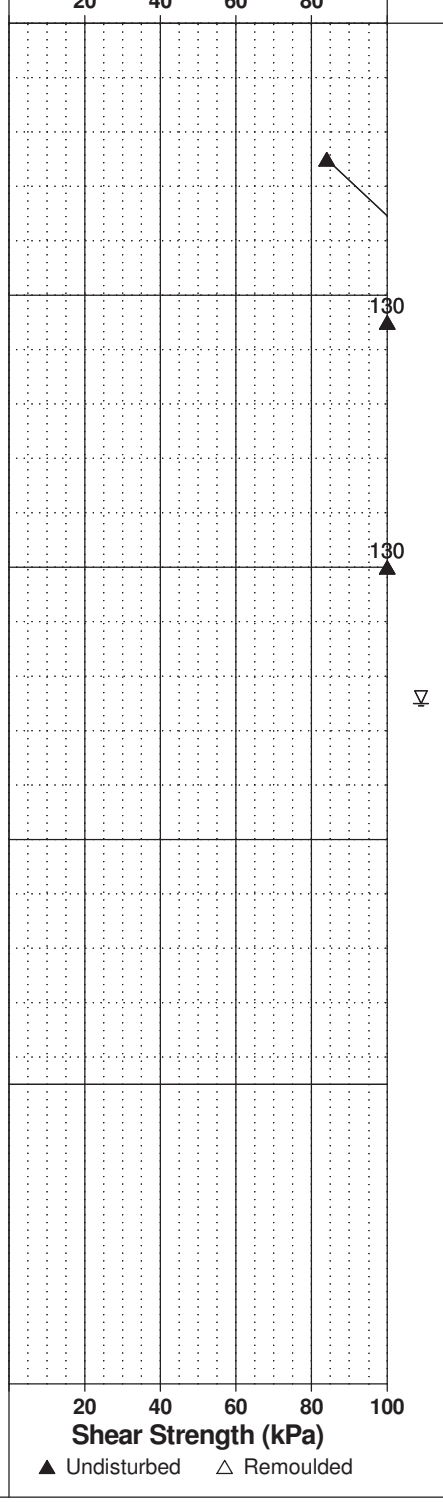
FILE NO. PG3695

REMARKS

HOLE NO. TP 1

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									
TOPSOIL 0.12		G	1			0	99.61		
		G	2			1	98.61		
Very stiff, brown **SILTY CLAY**		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)									



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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 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	
		G	2			2	95.82	130	▽
						3	94.82	130	
3.30									
End of Test Pit									
(Open hole GWL @ 2.0m depth)									

Water Content % scale: 20, 40, 60, 80

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
Ottawa, Ontario

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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	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE									
TOPSOIL 0.25						0	95.46		
Very stiff, brown **SILTY CLAY**		G	1			1	94.46	130	
		G	2			2	93.46	130	
3.20						3	92.46		
End of Test Pit									
(Open hole GWL @ 1.3m depth)									

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

20 40 60 80

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.

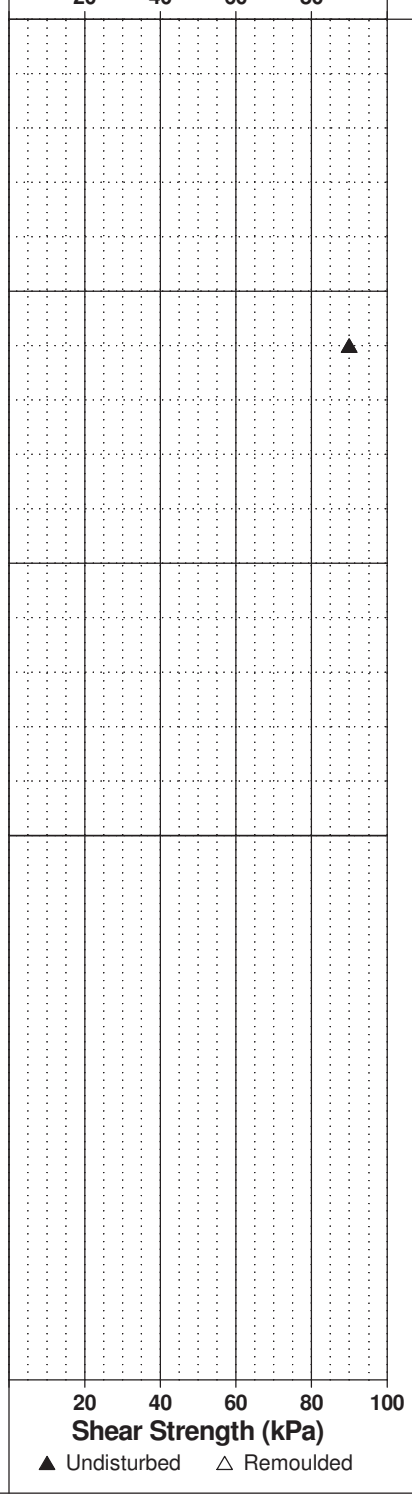
FILE NO. PG3695

REMARKS

HOLE NO. TP 4

BORINGS BY Backhoe **DATE** December 14, 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 %	Piezometer Construction
GROUND SURFACE						0	95.26		
TOPSOIL 0.25		G	1						
Very stiff, brown **SILTY CLAY**		G	2			1	94.26		▽
1.70									
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders		G	3			2	93.26		
3.00		G	4			3	92.26		
End of Test Pit									
(Open hole GWL @ 1.1m depth)									



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

Pen. Resist. Blows/0.3m: 20 40 60 80

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
Ottawa, Ontario

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FILE NO. PG3695

REMARKS

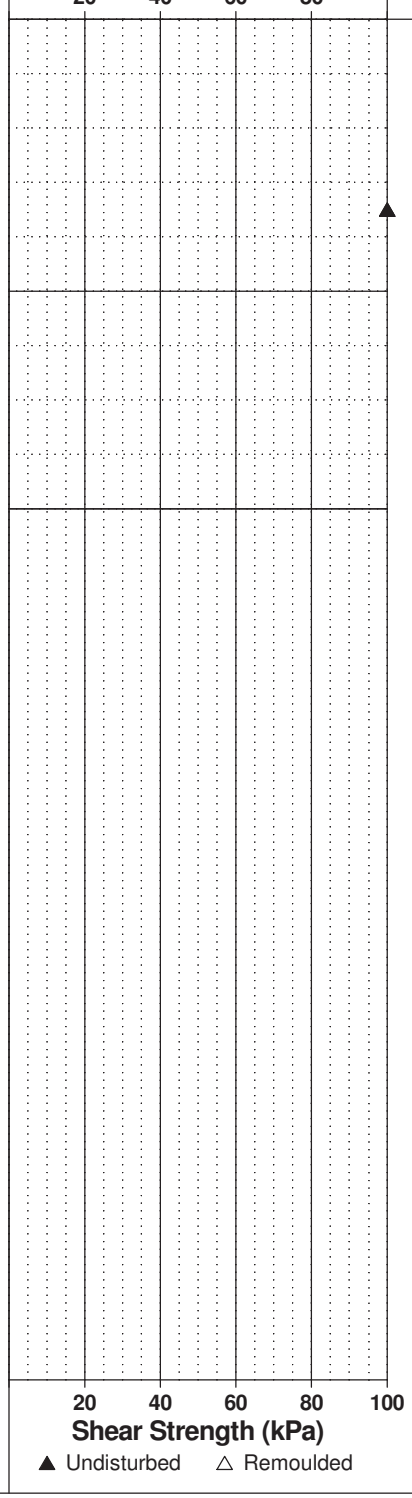
HOLE NO. TP 6

BORINGS BY Backhoe **DATE** December 14, 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 %	Piezometer Construction
GROUND SURFACE						0	99.03		
TOPSOIL 0.30		G	1						
Very stiff, brown **SILTY CLAY**		G	2			1	98.03		
1.10									
BEDROCK									
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)



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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 7

BORINGS BY Backhoe **DATE** December 14, 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 %	Piezometer Construction
GROUND SURFACE									
TOPSOIL 0.20						0	100.33		
Very stiff, brown **SILTY CLAY**		G	1			1	99.33	130	
		G	2			2	98.33	130	
3.00 End of Test Pit (TP dry upon completion)						3	97.33		

Pen. Resist. Blows/0.3m: 20 40 60 80

Water Content %: 20 40 60 80

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	SAMPLE % RECOVERY	SAMPLE 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	20 40 60 80	
TOPSOIL 0.30		G	1						
Very stiff, brown **SILTY CLAY**		G	2			1	95.77	130	
1.80									
BEDROCK 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)

20 40 60 80 100
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. TP 9

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

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	97.19
TOPSOIL							
0.20							
Very stiff, brown **SILTY CLAY**		G	1			1	96.19
1.70							
Very stiff, brown **SILTY CLAY** with sea shells, trace sand		G	2			2	95.19
3.00						3	94.19
End of Test Pit							
(TP dry upon completion)							

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

○ Water Content %

20 40 60 80

130

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

Piezometer Construction

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SOIL PROFILE AND TEST DATA

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Prop. Residential Development - Terry Fox Drive
Ottawa, Ontario

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

FILE NO. PG3695

REMARKS

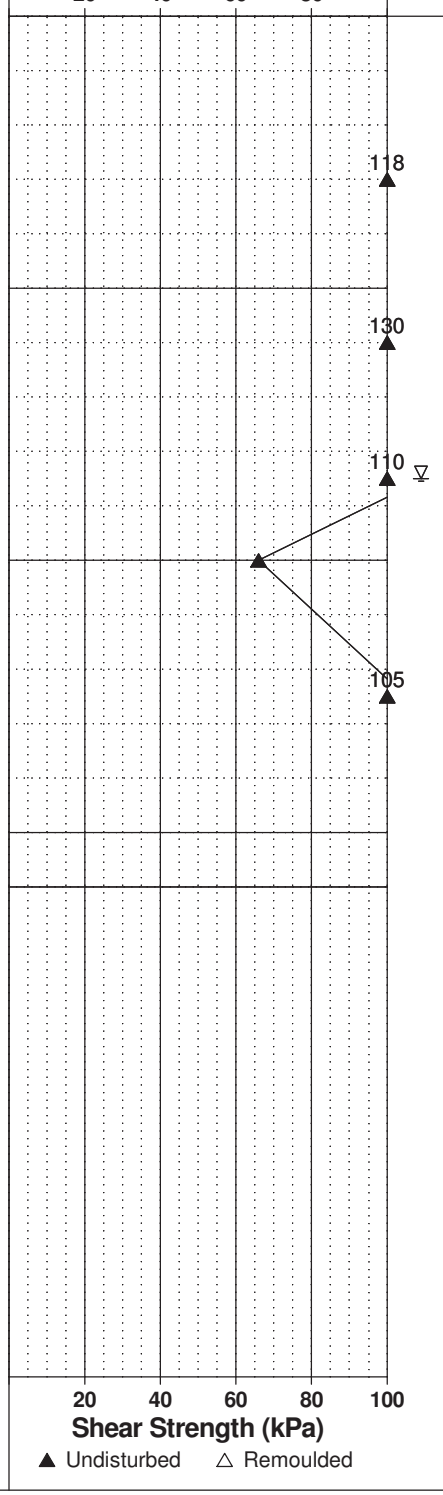
HOLE NO. TP10

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

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

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

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. TP11

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

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.90
TOPSOIL 0.15							
Very stiff, brown **SILTY CLAY**		G	1			1	92.90
1.30							
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)							

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

20 40 60 80

130

Piezometer Construction

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

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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.

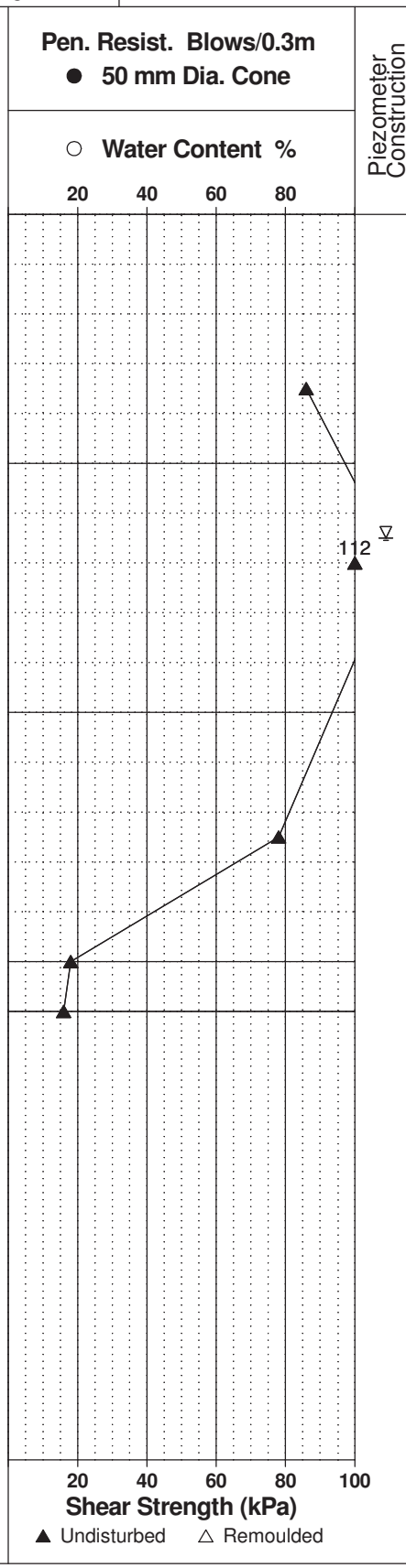
FILE NO. PG3695

REMARKS

HOLE NO. TP12

BORINGS BY Backhoe **DATE** December 14, 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 %	Piezometer Construction
GROUND SURFACE						0	93.29		
TOPSOIL		G	1						
0.35									
Very stiff to stiff, brown **SILTY CLAY**		G	2			1	92.29		
- stiff to firm and grey by 2.4m depth		G	3			2	91.29		
						3	90.29		
3.20									
End of Test Pit									
(Open hole GWL @ 1.3m depth)									



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 x 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

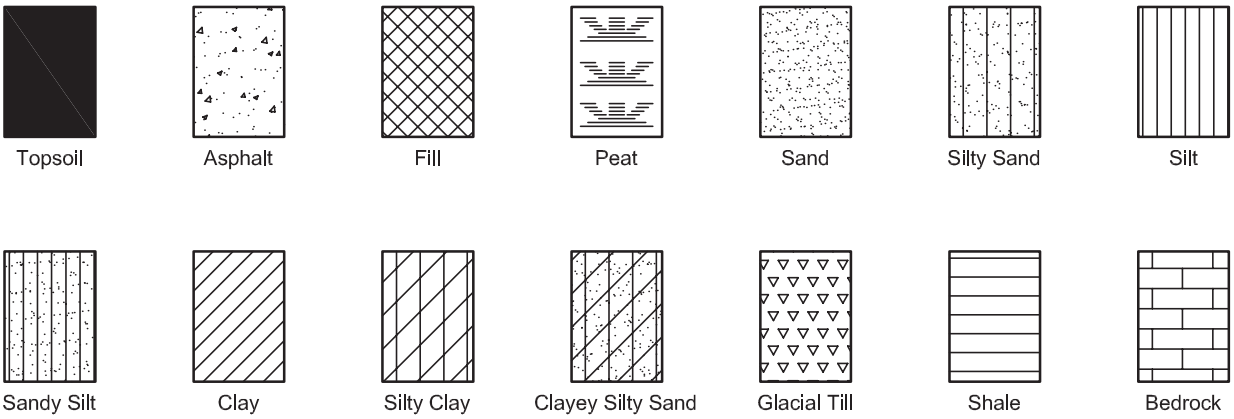
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void 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.

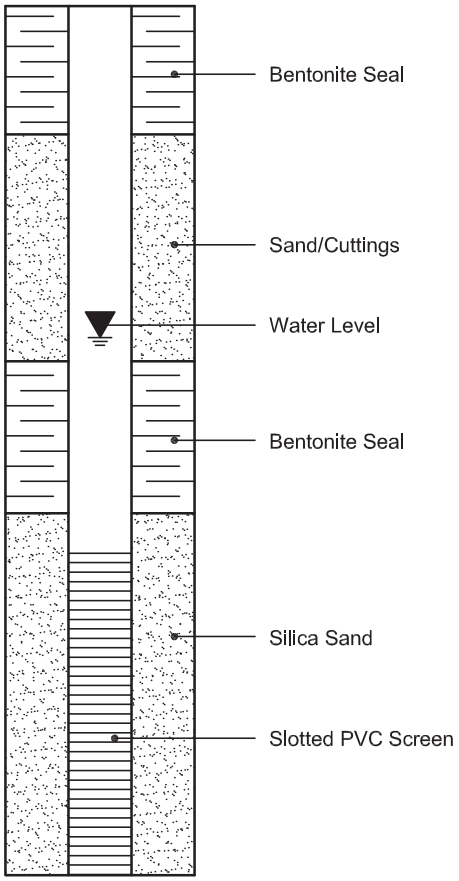
SYMBOLS AND TERMS (continued)

STRATA PLOT

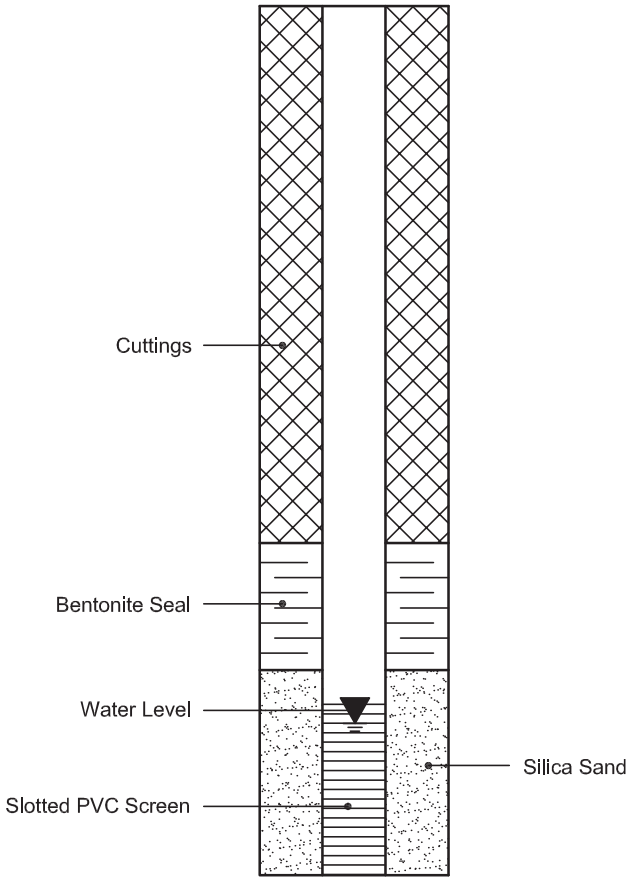


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



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NO.	REVISIONS	DATE	INITIAL
0			

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.:	0

p:\autocad drawings\geotechnical\pg36xx\pg3695-1r.dwg

APPENDIX 3

Table C1 - Monthly Water Balance for Soil With 5 mm Water Holding Capacity at Richardson Ridge
Table C2 - Monthly Water Balance for Soil With 10 mm Water Holding Capacity at Richardson Ridge
Table C3 - Monthly Water Balance for Soil With 100 mm Water Holding Capacity at Richardson Ridge
Table C4 - Monthly Water Balance for Soil With 200 mm Water Holding Capacity at Richardson Ridge
Table C5 - Monthly Water Balance for Soil With 250 mm Water Holding Capacity at Richardson Ridge
Table C6 - Monthly Water Balance for Soil With 350 mm Water Holding Capacity at Richardson Ridge
Table C7 - Monthly Water Balance for Soil With 400 mm Water Holding Capacity at Richardson Ridge
Table C8 - Pre-Development Annual Water Budget Calculations for Richardson Ridge
Table C9 - Post-Development Annual Water Budget Calculations for Richardson Ridge
Table C10 - Pre-Development Monthly Water Budget Calculations for Richardson Ridge - April
Table C11 - Post-Development Monthly Water Budget Calculations for Richardson Ridge - April
Table C12 - Pre-Development Monthly Water Budget Calculations for Richardson Ridge - August
Table C13 - Post-Development Monthly Water Budget Calculations for Richardson Ridge - August

Table C1 - Monthly Water Balance for Soil With 5 mm Water Holding Capacity at Richardson Ridge				
Month	**Temperature (°C)**	**Total Precipitation (mm)**	**Evapotranspiration (mm)**	**Water Surplus (mm)**
January	-10.4	59	0	25
February	-8.9	51	1	28
March	-2.5	61	6	99
April	6.1	71	32	90
May	13.1	77	66	14
June	18.4	87	84	5
July	20.9	86	83	3
August	19.7	86	81	4
September	15.1	86	66	18
October	8.6	76	36	38
November	1.8	76	11	59
December	-6.4	73	1	39
Annual	**6.3**	**889**	**467**	**422**

Table C2 - Monthly Water Balance for Soil With 10 mm Water Holding Capacity at Richardson Ridge				
Month	**Temperature (°C)**	**Total Precipitation (mm)**	**Evapotranspiration (mm)**	**Water Surplus (mm)**
January	-10.4	59	0	25
February	-8.9	51	1	28
March	-2.5	61	6	99
April	6.1	71	33	90
May	13.1	77	68	14
June	18.4	87	85	5
July	20.9	86	84	3
August	19.7	86	81	4
September	15.1	86	67	15
October	8.6	76	37	37
November	1.8	76	11	57
December	-6.4	73	1	39
Annual	**6.3**	**889**	**474**	**416**

Table C3 - Monthly Water Balance for Soil With 100 mm Water Holding Capacity at Richardson Ridge				
Month	**Temperature (°C)**	**Total Precipitation (mm)**	**Evapotranspiration (mm)**	**Water Surplus (mm)**
January	-10.4	59	0	24
February	-8.9	51	1	28
March	-2.5	61	6	98
April	6.1	71	33	90
May	13.1	77	81	14
June	18.4	87	114	4
July	20.9	86	116	1
August	19.7	86	89	1
September	15.1	86	70	2
October	8.6	76	37	9
November	1.8	76	11	30
December	-6.4	73	1	32
Annual	**6.3**	**889**	**559**	**333**

Table C4 - Monthly Water Balance for Soil With 200 mm Water Holding Capacity at Richardson Ridge				
Month	**Temperature (°C)**	**Total Precipitation (mm)**	**Evapotranspiration (mm)**	**Water Surplus (mm)**
January	-10.4	59	0	18
February	-8.9	51	1	24
March	-2.5	61	6	93
April	6.1	71	33	89
May	13.1	77	80	14
June	18.4	87	117	4
July	20.9	86	133	1
August	19.7	86	107	1
September	15.1	86	72	2
October	8.6	76	38	7
November	1.8	76	11	17
December	-6.4	73	1	21
Annual	**6.3**	**889**	**599**	**291**

Table C5 - Monthly Water Balance for Soil With 250 mm Water Holding Capacity at Richardson Ridge				
Month	**Temperature (°C)**	**Total Precipitation (mm)**	**Evapotranspiration (mm)**	**Water Surplus (mm)**
January	-10.4	59	0	16
February	-8.9	51	1	23
March	-2.5	61	6	90
April	6.1	71	33	89
May	13.1	77	81	14
June	18.4	87	117	4
July	20.9	86	135	1
August	19.7	86	112	1
September	15.1	86	74	2
October	8.6	76	38	7
November	1.8	76	11	16
December	-6.4	73	1	19
Annual	**6.3**	**889**	**609**	**282**

Table C6 - Monthly Water Balance for Soil With 350 mm Water Holding Capacity at Richardson Ridge				
Month	**Temperature (°C)**	**Total Precipitation (mm)**	**Evapotranspiration (mm)**	**Water Surplus (mm)**
January	-10.4	59	0	16
February	-8.9	51	1	21
March	-2.5	61	6	87
April	6.1	71	33	88
May	13.1	77	81	14
June	18.4	87	117	4
July	20.9	86	136	1
August	19.7	86	116	1
September	15.1	86	75	2
October	8.6	76	38	7
November	1.8	76	11	16
December	-6.4	73	1	18
Annual	**6.3**	**889**	**615**	**275**

Table C7 - Monthly Water Balance for Soil With 400 mm Water Holding Capacity at Richardson Ridge				
Month	**Temperature (°C)**	**Total Precipitation (mm)**	**Evapotranspiration (mm)**	**Water Surplus (mm)**
January	-10.4	59	0	16
February	-8.9	51	1	20
March	-2.5	61	6	86
April	6.1	71	33	87
May	13.1	77	81	14
June	18.4	87	117	4
July	20.9	86	136	1
August	19.7	86	117	1
September	15.1	86	76	2
October	8.6	76	38	7
November	1.8	76	11	16
December	-6.4	73	1	18
Annual	**6.3**	**889**	**617**	**272**

Table C8 - Pre-Development Annual Water Budget Calculations for Richardson Ridge

Geologic Unit	Area (m^2)	Water Surplus (mm)	Topography Factor	Soil Factor	Vegetation Factor	Infiltration Factor	Runoff Factor	Total Infiltration (mm/year)	Total Infiltration (L/year)	Total Runoff (mm/year)	Total Runoff (L/year)
Precambrian Metamorphic Bedrock	31,000	416	0.05	0.12	0.05	0.22	0.78	91.52	2,837,120	324.48	10,058,880
Clay Loam (Pasture and Shrubs)	16,900	282	0.05	0.15	0.1	0.3	0.7	84.6	1,429,740	197.4	3,336,060
Clay Loam (Mature Forest)	12,300	272	0.05	0.2	0.2	0.45	0.55	122.4	1,505,520	149.6	1,840,080
Stiff Silty Clay (Pasture and Shrubs)	18,700	291	0.05	0.1	0.1	0.25	0.75	72.75	1,360,425	218.25	4,081,275
Stiff Silty Clay (Mature Forest)	11,100	275	0.05	0.1	0.2	0.35	0.65	96.25	1,068,375	178.75	1,984,125
Totals	**90,000**	-	-	-	-	-	-	-	**8,201,180**	-	**21,300,420**

Table C9 - Post-Development Annual Water Budget Calculations for Richardson Ridge

Geologic Unit	Area (m^2)	Water Surplus (mm)	Topography Factor	Soil Factor	Vegetation Factor	Infiltration Factor	Runoff Factor	Total Infiltration (mm/year)	Total Infiltration (L/year)	Total Runoff (mm/year)	Total Runoff (L/year)
Precambrian Metamorphic Bedrock	4,000	416	0.05	0.12	0.05	0.22	0.78	91.52	366,080	324.48	1,297,920
Clay Loam (Urban Lawns)	39,300	333	0.15	0.2	0.1	0.45	0.55	149.85	5,889,105	183.15	7,197,795
Stiff Silty Clay (Mature Forest)	5,700	275	0.05	0.1	0.12	0.27	0.73	74.25	423,225	200.75	1,144,275
Anthropogenic Sources	41,000	422	0.2	0.02	0	0.22	0.78	92.84	3,806,440	329.16	13,495,560
Totals	**90,000**	-	-	-	-	-	-	-	**10,484,850**	-	**23,135,550**
Difference (L/year)	-	-	-	-	-	-	-	-	**2,283,670.00**	-	**1,835,130.00**
Percentage Variation	-	-	-	-	-	-	-	-	**27.84%**	-	**8.62%**

Table C10 - Pre-Development Monthly Water Budget Calculations for Richardson Ridge - April

Geologic Unit	Area (m^2)	Water Surplus (mm)	Topography Factor	Soil Factor	Vegetation Factor	Infiltration Factor	Runoff Factor	Total Infiltration (mm/year)	Total Infiltration (L/year)	Total Runoff (mm/year)	Total Runoff (L/year)
Precambrian Metamorphic Bedrock	31,000	90	0.05	0.12	0.05	0.22	0.78	19.8	613,800	70.2	2,176,200
Clay Loam (Pasture and Shrubs)	16,900	90	0.05	0.15	0.1	0.3	0.7	27	456,300	63	1,064,700
Clay Loam (Mature Forest)	12,300	87	0.05	0.2	0.2	0.45	0.55	39.15	481,545	47.85	588,555
Stiff Silty Clay (Pasture and Shrubs)	18,700	89	0.05	0.1	0.1	0.25	0.75	22.25	416,075	66.75	1,248,225
Stiff Silty Clay (Mature Forest)	11,100	88	0.05	0.1	0.2	0.35	0.65	30.8	341,880	57.2	634,920
Totals	**90,000**	-	-	-	-	-	-	-	**2,309,600**	-	**5,712,600**

Table C11 - Post-Development Monthly Water Budget Calculations for Richardson Ridge - April

Geologic Unit	Area (m^2)	Water Surplus (mm)	Topography Factor	Soil Factor	Vegetation Factor	Infiltration Factor	Runoff Factor	Total Infiltration (mm/year)	Total Infiltration (L/year)	Total Runoff (mm/year)	Total Runoff (L/year)
Precambrian Metamorphic Bedrock	4,000	90	0.05	0.12	0.05	0.22	0.78	19.8	79,200	70.2	280,800
Clay Loam (Urban Lawns)	39,300	89	0.15	0.2	0.1	0.45	0.55	40.05	1,573,965	48.95	1,923,735
Stiff Silty Clay (Mature Forest)	5,700	88	0.05	0.1	0.12	0.27	0.73	23.76	135,432	64.24	366,168
Anthropogenic Sources	41,000	90	0.2	0.02	0	0.22	0.78	19.8	811,800	70.2	2,878,200
Totals	**90,000**	-	-	-	-	-	-	-	**2,600,397**	-	**5,448,903**
Difference (L/month)	-	-	-	-	-	-	-	-	**290,797.00**	-	**-263,697.00**
Percentage Variation	-	-	-	-	-	-	-	-	**12.59%**	-	**-4.62%**

Table C12 - Pre-Development Monthly Water Budget Calculations for Richardson Ridge - August

Geologic Unit	Area (m^2)	Water Surplus (mm)	Topography Factor	Soil Factor	Vegetation Factor	Infiltration Factor	Runoff Factor	Total Infiltration (mm/year)	Total Infiltration (L/year)	Total Runoff (mm/year)	Total Runoff (L/year)
Precambrian Metamorphic Bedrock	31,000	4	0.05	0.12	0.05	0.22	0.78	0.88	27,280	3.12	96,720
Clay Loam (Pasture and Shrubs)	16,900	1	0.05	0.15	0.1	0.3	0.7	0.3	5,070	0.7	11,830
Clay Loam (Mature Forest)	12,300	1	0.05	0.2	0.2	0.45	0.55	0.45	5,535	0.55	6,765
Stiff Silty Clay (Pasture and Shrubs)	18,700	1	0.05	0.1	0.1	0.25	0.75	0.25	4,675	0.75	14,025
Stiff Silty Clay (Mature Forest)	11,100	1	0.05	0.1	0.2	0.35	0.65	0.35	3,885	0.65	7,215
Totals	**90,000**	-	-	-	-	-	-	-	**46,445**	-	**136,555**

Table C13 - Post-Development Monthly Water Budget Calculations for Richardson Ridge - August

Geologic Unit	Area (m^2)	Water Surplus (mm)	Topography Factor	Soil Factor	Vegetation Factor	Infiltration Factor	Runoff Factor	Total Infiltration (mm/year)	Total Infiltration (L/year)	Total Runoff (mm/year)	Total Runoff (L/year)
Precambrian Metamorphic Bedrock	4,000	4	0.05	0.12	0.05	0.22	0.78	0.88	3,520	3.12	12,480
Clay Loam (Urban Lawns)	39,300	1	0.15	0.2	0.1	0.45	0.55	0.45	17,685	0.55	21,615
Stiff Silty Clay (Mature Forest)	5,700	1	0.05	0.1	0.12	0.27	0.73	0.27	1,539	0.73	4,161
Anthropogenic Sources	41,000	4	0.2	0.02	0	0.22	0.78	0.88	36,080	3.12	127,920
Totals	**90,000**	-	-	-	-	-	-	-	**58,824**	-	**166,176**
Difference (L/month)	-	-	-	-	-	-	-	-	**12,379.00**	-	**29,621.00**
Percentage Variation	-	-	-	-	-	-	-	-	**26.65%**	-	**21.69%**

APPENDIX 4

Client Drawing - 16364-15 Regional Pt Lts 7 8 C1 MA ph4 SUB D7-4M 36X48

APPROVED UNDER SECTION 51 OF THE PLANNING ACT
BY THE CITY OF OTTAWA.

THIS _____ DAY OF _____, _____

MICHAEL MIZZI, MCIP RPP, ACTING GENERAL MANAGER
PLANNING AND GROWTH MANAGEMENT DEPARTMENT
PLANNING AND INFRASTRUCTURE PORTFOLIO
CITY OF OTTAWA

PLAN 4M-

I CERTIFY THAT THIS PLAN
IS REGISTERED IN THE LAND REGISTRY OFFICE
FOR THE LAND TITLES DIVISION OF OTTAWA-CARLETON NO. 4
AT _____ O'CLOCK ON THE _____ DAY OF _____, _____
AND ENTERED IN THE PARCEL REGISTER FOR
PROPERTY IDENTIFIERS _____
_____
AND THE REQUIRED CONSENTS ARE REGISTERED AS
PLAN DOCUMENT NO._____

_____
LAND REGISTRAR

This plan comprises all of the land identified by PIN .

PLAN OF SUBDIVISION OF

PART OF LOTS 7 And 8
CONCESSION 1

Geographic Township of March

CITY OF OTTAWA

Surveyed by Annis , O'Sullivan , Vollebekk Ltd.

Scale 1 : 750

30 22.5 15 7.5 0 15 30 Metres

Metric

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

SURVEYOR'S CERTIFICATE

I CERTIFY THAT :

1. This survey and plan are correct and in accordance with the Surveys Act, the Surveyors Act and the Land Titles Act and the regulations made under them.
2. The Survey was completed on the ___ day of _____,2016.

_____ _____
Date Edward M. Lancaster
Ontario Land Surveyor

OWNER'S CERTIFICATE

THIS IS TO CERTIFY THAT :

1. Lots 1 to 41, both inclusive, Blocks 42 to 63, both inclusive, Blocks 65 and 66, the Streets, namely Streets 1 to 4 and the Reserve, namely, Block 64 have been laid out in accordance with our instructions.
2. The Streets are dedicated as public highways.

Dated the ____ day
of _____,2016 _____
XXX, President
XXXXXX.
I have authority to bind the corporation.

NOTES AND LEGEND

-○-	denotes	Survey Monument Planted.
-■-	"	Survey Monument Found
SIB	-	Standard Iron Bar.
SSIB	-	Short Standard Iron Bar.
CC	-	Cut Cross.
IB	-	Iron Bar.
CLF	-	Chain Link Fence
BF	-	Board Fence
(AOG)	-	Annis, O'Sullivan, Vollebekk Ltd.
(P1)	-	Plan
(P2)	-	Plan

All planted survey monuments are IB's unless otherwise noted.

Distances shown on curved limits are Arc distances unless otherwise noted.

Distances shown on this plan are ground distances and can be converted to grid distances by multiplying by the combined scale factor of 0.9999xx.

Bearings are grid, derived from Can-Net 3.0 Real Time Network GPS observations on reference points A and B, shown hereon, having a bearing of Nxx°xx'xx"W and are referenced to Specified Control Points 01919791338 and 01919871649, MTM Zone 9 (76°30' West Longitude) NAD-83 (original).

Coordinates are derived from Can-Net 3.0 Real Time Network GPS observations referenced to Specified Control Points 01919791338 and 01919871649, MTM Zone 9 (76°30' West Longitude) NAD-83 (original).

Coordinate values are to urban accuracy in accordance with O. Reg. 216/10.

. 01919791338	Northing	5006055.96	Easting	346140.91
. 01919871649	Northing	5007189.87	Easting	372435.05
. Point A	Northing		Easting	
. Point B	Northing		Easting	

Caution: Coordinates cannot, in themselves, be used to re-establish corners or boundaries shown on this plan.

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