Hydrogeological Assessment Conservation Meadows Subdivision, Phase 2, Waterloo, Ontario

REVISED FINAL



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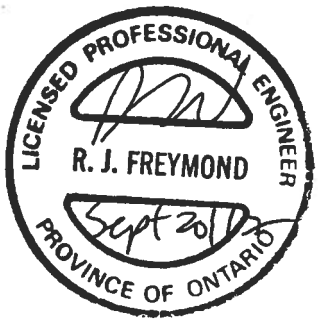
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1.0 INTRODUCTION

Stantec Consulting Limited (Stantec) was retained by Activa Holdings Inc. (Activa) to complete a hydrogeological assessment for Phase 2 of the Conservation Meadows Subdivision, located on Part Lot 28, German Company Tract, City of Waterloo. The subject property (the Site) covers 7.9 ha of land north of Conservation Drive, between Roy Schmidt Road and Rideau River Street **(Figure 1, Appendix A)**. The new subdivision will consist of townhouses, detached homes, trails/parklands, roads and walkways.

The Site is part of the North Waterloo Subwatershed area, for which a detailed environmental study was completed in 2013 (Ecoplans Ltd *et al.*, 2013). Groundwater monitoring is on-going in the area as part of environmental management initiatives (Stantec, 2016, 2017a). This hydrogeological assessment was completed in support of the Draft Plan of Subdivision and corresponding Zone Change application for the Site. The assessment was based on review of the North Waterloo Scoped Subwatershed Study (NWSSS) (Ecoplans Ltd *et al.*, 2013) and subsequent groundwater monitoring by Stantec (2016, 2017a). The objectives of the hydrogeological assessment were to:

1. Characterize the existing geological and hydrogeological conditions within the Site, including the identification of groundwater depths and flow patterns, groundwater quality conditions and potential hydraulic relationships between local aquifer systems and surface water features.

2. Assess whether residential foundations and water/sewage servicing will intercept the groundwater table and determine what mitigation measures could be employed to minimize the potential disturbances on pre-development groundwater elevations and flow patterns.

3. Assess the potential need for construction dewatering throughout the various construction phases of the development and discuss potential mitigation measures in the event that dewatering is required.

4. Review the pre- and post-development water balance to confirm that they conform to the requirements of the NWSSS, i.e., evaluate potential land use change impacts to the groundwater recharge function of the Site, including an evaluation of proposed measures to be employed under the post-development condition to mitigate these impacts.

5. Review the proposed land use activities for conformity with Source Water Protection requirements as stipulated in the *Clean Water Act*, *2006, S.O. 2006, c. 22*.

6. Recommend an on-going groundwater monitoring program that adheres to the specifications outlined in the NWSSS (Ecoplans *et al.*, 2013).

7. Suggest post development groundwater infiltration options.

Introduction
September 19, 2017

This report is arranged into seven (7) sections, including this introduction (Section 1). Section 2 presents the physical site setting. Section 3 presents the local geological and hydrogeological conditions. Section 4 presents the water balance and impact assessment for the Site. Section 5 discusses proposed monitoring to assess potential impacts and mitigation measures. Report conclusions and recommendations are listed in Section 6 with references in Section 7.

All figures and tables referenced in this report are provided in Appendices A and B, respectively. Appendix C provides available borehole data for the Site and Appendix D preliminary development plans.

2.0 PHYSICAL SETTING

2.1 PHYSIOGRAPHY, LAND USE AND TOPOGRAPHY

The Site is situated along the border of the Oxford Till Plain and Waterloo Hills physiographic regions **(Figure 2, Appendix A)**. As defined by Chapman and Putnam (1984), the Oxford Till Plain is a drumlinized till plain with undulating to gently rolling topography and soils of a calcareous nature. The Waterloo Hills in contrast is an area of sand till ridges or kame moraines, with outwash sand in intervening low lying areas.

Land cover at the Site currently consists of agricultural cropland, or areas of meadow vegetation previously disturbed by construction activity. To the north, east and southwest of the Site are residential areas, and to the west and southeast agricultural lands.

Ground surface topography slopes downward to the south/southwest, ranging from approximately 365 m above mean sea level (AMSL) along the northeast property limit to 355 m AMSL along the southwest property limit (**Figure 2, Appendix A**). Drainage at the Site is therefore to the south/southwest toward Laurel Creek and its associated water features.

2.2 SURFACE WATER AND WETLANDS

There are no surface water features or wetlands on the Site. North of the site is a surface water divide, with drainage on the north side of the divide north toward Martin Creek. Drainage at the Site, on the south side of the divide, is south / southwest toward Laurel Creek located 700 m to the south-southwest and Beaver Creek, a tributary of Laurel Creek, located 500 m to the southwest **(Figure 2, Appendix A)**. Beaver Creek and Laurel Creek flow south into the Laurel Creek Reservoir, before flowing east to the Grand River approximately 8.25 km away. The Sunfish Lake and Laurel Creek Wetland Complex is a provincially significant wetland (PSW) associated with the two creeks and reservoir **(Figure 2, Appendix A)**.

Grand River Conservation Authority (GRCA) (1993, as cited in Ecoplans et al., 2013) classified the reach of Laurel Creek south of the of the Site as a coldwater system and important source for groundwater discharge that possibly supplies baseflow to maintain aquatic habitat in the creek and PSW. This classification was confirmed as part of the NWSSS as stream flow and vertical hydraulic gradient data indicated groundwater discharge along Laurel Creek during both high and low groundwater level conditions (Ecoplans *et al.*, 2013).

Beaver Creek is a potential coldwater system, but its function as a location of groundwater discharge has been degraded over the years by intensive agricultural activity in the subwatershed. Minimal groundwater / surface water interactions were interpreted along the majority of Beaver Creek in the NWSSS, with the exception of seasonal groundwater discharge the creek's southern extent (Ecoplans *et al.*, 2013).

2.3 REGIONAL GEOLOGY AND HYDROGEOLOGY

The Site is located within the Waterloo Moraine, a kame moraine formed in an interlobate position between ice lobes extending from the Lake Ontario-Erie, Huron, and Georgian bay areas (Karrow, 1993). Numerous advances and retreats of the ice lobes during the Wisconsinan glaciation resulted in a complex deposit of ice-contact and glacial outwash sands and gravels separated by silt- and clay-rich tills. The conceptual hydrogeologic model for the Waterloo Moraine therefore comprises four main aquifers and aquitards after Terraqua Investigations Ltd (1995), or 19 different hydrostratigraphic units after Bajc and Shirota (2007). The model generally does not include more recent deposits shown on surficial geology mapping such as organics **(Unit 19, Figure 2, Appendix A)** or modern alluvium **(Unit 19, Figure 3, Appendix A)**, which are found in wetlands and creek/river valleys.

The following description of the Moraine hydrostratigraphic units is quoted from the NWSSS (Ecoplans et al., 2007). Hydrostratigraphic units are described from ground surface downward, with Bajc and Shirota (2007) unit names shown in parentheses.

Aquitard 1 (ATB1): Aquitard 1 consists of low permeability, spatially discontinuous, surficial till units found predominantly along the flanks of the Waterloo Moraine **(Unit 5d, Figure 3, Appendix A)**. Along the western flank of the moraine Aquitard 1 corresponds to the Mornington, Stratford and Tavistock Tills; whereas along the eastern flank of the Moraine this unit corresponds to the Upper Maryhill and Port Stanley Tills (Bajc and Shirota, 2007).

Aquifer 1 (AFB1/ATB2/AFB2): Aquifer 1 consists of layered silt and fine sand to coarse sand and gravel **(Unit 6 and Unit 7a, Figure 3, Appendix A)**. In some areas, Aquifer 1 is interpreted to be bisected by the middle Maryhill Till (ATB2), effectively separating Aquifer 1 into two units, AFB1 and AFB2. Along the flanks of the Moraine, Aquifer 1 generally thins as the ground surface elevation decreases and approaches Aquitard 2.

Aquitard 2 (ATB3): Aquitard 2 corresponds to the lower Maryhill Till and represents one of the primary regional hydrostratigraphic units. The Maryhill Till was broken down into Upper (ATB1), Middle (ATB2) and Lower (ATB3) units by Bajc and Shirota (2007). Along the flanks of the moraine the Maryhill Till is often found to be discontinuous, or has been re worked and re deposited as glaciofluvial sediments. ATB3 is present throughout most of the North Waterloo Subwatershed with the exception of localized areas where it has been eroded by glacial meltwater channels.

Aquifer 2 (AFB3/AFC1): Aquifer 2 corresponds to the lower Waterloo Moraine Stratified Sediments and Catfish Creek Drift as referred to by Karrow (1993), and when present is found below Aquitard 2, mainly along the eastern flank of the Moraine.

Aquitard 3 (ATC1/AFC1/ATC2): Aquitard 3 corresponds to the Catfish Creek Till. Bajc and Shirota (2007) divided this unit into an upper (ATC1) and lower aquitard (ATC2), with an aquifer (AFC1) found occasionally between the two units. This unit is nearly continuous throughout the Moraine and is characterized as a stony, silt to sand till. However, in the North Waterloo Subwatershed, is has been eroded in localized areas by glacial meltwater similar to Aquitard 2.

Aquifer 3 (AFD1): Aquifer 3 is spatially discontinuous throughout much of the core areas of the Waterloo Moraine and is found below Aquitard 3. AFD1 likely corresponds to sands and gravel re worked from Catfish Creek and Pre Catfish Creek Tills, and represents the main supply aquifer in the Cities of Kitchener and Waterloo with the nearby Waterloo North Production Well W5A **(Figure 4, Appendix A)**, located approximately 16 km to the southeast, completed in this unit.

Aquitard 4 (ATE1/ATG1): Aquitard 4 corresponds to the Pre Catfish Creek Till and Canning Drift.

Aquifer 4 (AFF1): Aquifer 4 is spatially discontinuous throughout much of the core areas of the Waterloo Moraine, and is typically found directly overlying bedrock. Aquifer 4 is interpreted to correspond to the sand and gravel units typically found beneath Aquitard 4, directly overlying bedrock. Where present, Aquifer 4 is hydraulically connected with the upper portion of the bedrock. The upper most bedrock unit beneath the North Waterloo Subwatershed is the Salina Formation, an Silurian aged assemblage of dolostone, shale and evaporites (Armstrong and Dodge, 2007).

As noted in the NWSSS (Ecoplans et al., 2013), across the core of the Moraine, regional groundwater flow is from west to east. Within the North Waterloo Subwatershed, shallow groundwater flow converges on Laurel Creek and its associated features, being to the south and southwest in the area of the Conservation Meadows Subdivision1.

2.4 SOURCE WATER PROTECTION

The Site intersects Well Head Protection Area (WHPA) - C and - D for Waterloo North Production Well W5A **(Figure 4, Appendix A)**. WHPA-C and WHPA-D represent the areas in which the time-of-travel for a potential contaminant from surface to the well is between two and ten years, and ten and twenty-five years, respectively. The Site also intersects a significant groundwater recharge area (SGRA) at its southeast corner **(Figure 5, Appendix A)**, which coincides with the area of ice-contact stratified drift i.e., Aquifer 1, at surface **(Unit 6, Figure 3, Appendix A)**.

Under the *Approved Source Protection Plan* for the Grand River Source Protection Area, significant drinking water quality threats are defined within the WHPA-C for Waterloo North Production Well W5A for activities related to handling and storage of a dense non-aqueous phase liquid (DNAPL) (Lake Erie Region (LER) Source Protection Committee (SPC), 2015).

Preliminary screening through the Regional Municipality of Waterloo (RMOW) *TAPS Source Water Protection Tool* (2017) will be required as part of the planning approval application process.

Additionally, the Site intersects a Wellhead Protection Sensitivity Area (WPSA) -8, as defined per the *Official Plan 2031* (RMOW, 2015). The WPSA-8 "delineates the area outside the ten year time of travel to the limit of the total land area contributing water to a municipal drinking water supply well" (RMOW, 2015). Within the WPSA-8, Category A or "High Risk Uses" per Schedule B of the *Official Plan 2031* are not permitted, i.e., waste treatment and disposal facilities, salvage yards and bulk storage or hazardous chemicals or substances. The proposed development will not include any Category A land uses. Development will not be impacted by Source Water Protection policies under the *Official Plan 2031*.

3.0 LOCAL HYDROGEOLOGY

3.1 HYDROSTRATIGRAPHY

The regional hydrostratigraphic sequence, as described in Section 2.3, describes conditions from ground surface to the top of bedrock, covering 70 m to 80 m of overburden deposits (Ecoplans *et al.*, 2013). The proposed development is expected to impact the upper 10 m of overburden deposits. As such, the description of local hydrostratigraphy is limited to deposits above 10 m below ground surface (BGS).

Surficial geology mapping suggests the site is covered in deposits of glaciolacustrine derived silt to clay till **(Unit 5d, Figure 3, Appendix A)**, corresponding to Aquitard 1, with a small area of ice-contact stratified deposits in the southeast corner of the Site **(Unit 6, Figure 3, Appendix A),** corresponding to Aquifer 1 (Ontario Geological Survey, 2010). Borehole data **(Appendix C)** indicate the Site is covered in up to 1 m of clayey silt fill, underlain by 1 m to 3 m of clayey silt to silt material, which in turn is underlain by fine to medium sand of variable silt content to the maximum drilling depth of 10.7 m BGS **(Figure 6, Appendix A)**.

3.2 GROUNDWATER LEVELS

Groundwater is encountered beneath the Site within the sand unit **(Figure 6, Appendix A)**, between 353 m AMSL and 354.5 m AMSL (3.5 m BGS to 5.7 m BGS), as observed at monitoring wells MW7-10 and BH105 from 2007 to 2016 **(Figure 7, Appendix A)**. Shallower, perched, groundwater conditions may also exist in the clayey silt to silt unit, as observed at Borehole 101 (Upper), which is screened north of the Site in the silt unit, where groundwater is occasionally encountered within 1.2 m to 2 m of ground surface **(Figure 7, Appendix A)**.

Seasonal groundwater level fluctuations of 0.5 m to 1.0 m are noted in the MW7-10 and BH105 groundwater hydrographs, with levels highest in the early spring, gradually declining over the spring and summer **(Figure 7, Appendix A)**. This pattern in fluctuations is common within shallow groundwater systems in southern Ontario where high water table conditions occur in the spring as a result of lower evapotranspiration losses and a melting snowpack, which provide a greater volume of water for recharge. Low water table conditions occur in the late summer to fall as more water is drawn from the subsurface over this period to meet evapotranspiration demands.

Groundwater level data from BH12 were not used in the above characterization of groundwater levels for the Site because long-term trends in the hydrograph for this well appear more erratic, suggesting data errors or well integrity concerns.

3.3 GROUNDWATER FLOW

Groundwater elevation contours from August 2016 (the period with the greatest spatial coverage of groundwater elevation data), for wells screened in the sand unit, are shown on **Figure 8 (Appendix A)**. From the contours, horizontal groundwater flow in the shallow groundwater system is interpreted to the south and south-southwest, with a horizontal hydraulic gradient of approximately 4.6 x 10^{-3} m/m, as measured along the eastern property limit between the 354 m AMSL contour and BH105.

The horizontal hydraulic conductivity of the sand unit as estimated from hydraulic conductivity testing at MW7-10 by Stantec for the NWSSS (Ecoplans *et al.*, 2013) is 8.7 x 10^{-5} m/s **(Table 1, Appendix B)**. This value is consistent with the upper limit of hydraulic conductivity, cited for a silty sand to fine sand of 10^{-7} m/s to 10^{-5} m/s, after Fetter (2001). Applying Darcy's law:

$$v = \frac{K \nabla}{\theta}$$

where: v = velocity (m/yr)
K = hydraulic conductivity (8.7 x 10^{-5} m/s)
∇ = hydraulic gradient (0 m/m to 4.6 x 10^{-3} m/m)
θ = porosity (0.3, after Fetter 2001, for a well sorted to mixed sand or gravel)

the estimated velocity of horizontal groundwater flow through the sand unit is estimated at up to 42 m per year.

Nested groundwater monitors north of the Site, in Phase 1 of the subdivision, suggest very little hydraulic separation between the upper and lower monitors at BH17 and BH20 as groundwater elevations between the upper and lower screen are quite similar. However, in the absence of borehole data for these locations, it is difficult to say if this lack of hydraulic separation is across units of similar or dissimilar composition. For example, at BH101, where the upper well is screened in a silt and the lower well is screened in a sand, the hydraulic separation is quite evident with a 4 m head difference between the upper and lower screen. At BH101 groundwater elevations suggest vertically downward flow as elevations are higher in the upper screen.

Despite the indications of vertically downward flow at the Site, the Site's groundwater recharge function is expected to be limited by the presence of low permeability clay to silt textured fill and glaciolacustrine deposits at surface. Groundwater flow from the Site, however limited, may ultimately contribute to groundwater discharge (baseflow) to Laurel Creek, Beaver Creek and the Sunfish Lake and Laurel Creek Wetland Complex.

3.4 GROUNDWATER QUALITY

Groundwater quality sampling was completed by Stantec at MW7-10, from 2010 to 2015, for general chemistry and dissolved metals analysis. Analytic results were reported in Stantec (2016) and are provided in **Table 2 (Appendix B)** for reference.

Groundwater quality data at MW7-10 were assessed against Ontario Regulation 169/03, the Ontario Drinking Water Quality Standard (ODWS). Data show no exceedances of health-related ODWS criteria, i.e., Maximum Acceptable Criteria (MAC) and Interim Maximum Acceptable Criteria (IMAC) for the tested parameters. However, the non-health related Operational Guideline (OG) for hardness (80-100 mg/L) was consistently exceeded. The presence of elevated hardness is not unexpected, given the calcareous nature of the local soils, and is quite common through the Waterloo area. Based on the anion to cation ratio of the analytical samples, groundwater at MW7-10 can be classified as calcium-bicarbonate type water.

4.0 WATER BALANCE AND IMPACT ASESSMENT

A water balance analysis was completed as part of the NWSSS for a 31.8 ha subcatchment of the North Waterloo Subwatershed that includes the Site (Ecoplans *et al.*, 2013). The analysis was based on the results of a hydrological model developed for the North Waterloo Subwatershed with the GAWSER modelling software. The analysis made use of regional inputs such as soils, land use, and topography, and local inputs such as meteorological data from the Laurel Dam weather station, and stream flow data from Beaver and Laurel creeks (Ecoplans *et al.*, 2013).

Based on the NWSSS water balance analysis, under pre-development (existing) conditions, annual precipitation is estimated 844.8 mm at the Site. After accounting for evapotranspiration at a rate of 507.2 mm/yr, the available surplus (337.6 mm/yr) is proportioned into 154.2 mm/yr of runoff and 183.4 mm/yr of infiltration. As published in Ontario Ministry of the Environment and Energy (MOEE) (1995), the pre-development infiltration rate is within the 150 mm/yr to 200 mm/yr range expected for a silty sand to sandy silt.

The NWSSS water balance analysis is considered appropriate for use in this impact assessment because development planning is still in the preliminary design phase. During detailed design the water balance analysis and impact assessment should be refined to incorporate site specific characteristics and monthly analytical calculations.

4.1 GROUNDWATER RECHARGE

The proposed development will consist of up to 292 residential units, roads, walkways, trails and parkland **(see Draft Plan of Subdivision, Appendix D)**. Portions of the Site will therefore be converted into impervious surfaces, leading to lower infiltration volumes post development.

The impact of development on the annual water balance was assessed as part of the *Functional Servicing and Stormwater Management Report* (Stantec, 2017b). Calculations were completed on the Site and contributing drainage area, which cover an area of 10.7 ha. Results are summarized in the following paragraphs and the reader should refer to Stantec (2017b) for detailed calculation sheets.

For the 10.7 ha area, pre-development infiltration at a rate of 183.4 mm/yr, will contribute an annual volume of 19,624 m^3 of water in infiltration. Post-development it is assumed that approximately 55% of the Site and contributing drainage area will become impervious, creating an infiltration deficit of 10,803 m^3/yr.

The conceptual grading plan **(Appendix D)** indicates that Low Impact Development (LID) in the form of infiltration trenches, has been proposed to augment recharge post development. Similar LID methods were used for Phase 1 of the subdivision. Assuming that 80% of the available runoff from rooftop areas on residential lots is redirected to the infiltration trenches, along with runoff from lawn areas located along the Conservation Drive multi-residential blocks, then 10,769 m^3/yr

of water will be available for recharge augmentation, effectively cancelling the infiltration deficit.

The low permeability of the clayey silt to silt soils at surface, and potential for shallow (1.2 m to 2 m deep) perched water levels, may limit the amount of recharge augmentation that can occur through LID measures. Appropriate design of infiltration facilities will be required during detailed design to overcome these limitations.

4.2 SITE SERVICING

The proposed development will be connected to underground utility infrastructure (e.g., storm and sanitary sewers). Invert levels of the site servicing are expected to be up to 3 m to 5 m BGS. Below ground site servicing could intercept groundwater in the sand unit, or if perched conditions develop in the surficial clayey silt to silt deposits.

Construction dewatering activities are expected to be completed on an as-required basis, with the rate of this dewatering dictated by the amount of construction occurring on the Site at a given time, the type of subsurface material and groundwater elevations encountered in the excavations, and the elevation to which the groundwater table must be lowered to install infrastructure. Potential dewatering efforts are expected to be limited in the surficial clayey silt to silt deposits given the interpreted horizontal hydraulic conductivity is low, however, should excavations encounter groundwater in the sand unit where horizontal hydraulic conductivity values are higher, larger dewatering volumes would be expected. If construction dewatering volumes are projected to exceed 50,000 L/day, registration of an Environmental Activity and Sector Registry (EASR) or Permit to Take Water (PTTW) will be required for dewatering to occur. A dewatering assessment can be completed during the detailed design to determine dewatering and water taking permitting requirements.

In areas where site servicing extends below the groundwater table, it is recommended that anti-seepage (cut-off) collars be installed to prevent the preferential movement of groundwater along the servicing alignments. The use of anti-seepage collars will likely be required given that the subsurface of the Site is largely characterized by deposits where groundwater movement is more restricted (e.g., silt to clay based soils). An assessment for the need, total number and exact placements of anti-seepage collars along the servicing alignments can be explored in more detail during the detailed design phase of the project.

4.3 SPILL CONTAINMENT AND RESPONSE

The Site intersects a WHPA-C, WHPA-D and SGRA. Care should be taken during construction to minimize the risk of groundwater quality impacts from potential spills, which given the type of construction is likely to be from the refuelling of major construction equipment that cannot readily leave the site (e.g., earth movers). Potential spills at the Site are expected to be localized and involve a small volume of material, as the Site will not be used for the storage and handling

of large volume of chemicals. Based on the above, the following mitigation measures are recommended as mitigation for potential contaminant spills during construction:

- Trucks or other road vehicles should be refuelled and maintained offsite, where practicable.
- Refuelling and lubrication of other construction equipment should not be allowed within 30 m of a drainage system or dewatering excavation.
- Regular inspections of the hydraulic and fuel systems on machinery should be completed, with leaks repaired immediately upon detection or the equipment being removed from Site.
- Spill kits containing absorbent materials should be kept on Site.
- An emergency spill response and reporting plan should be developed and implemented.

5.0 PROPOSED MONITORING

The NWSSS (Ecoplans *et al.*, 2013) proposes that *"In additional to typical 'during-construction' monitoring'... pre', 'during' and 'post'- construction...groundwater monitoring should be prepared as part of supporting studies for future development applications. Terms of Reference for monitoring programs should be submitted for approval by agencies having jurisdiction (e.g., GRCA, Region[al Municipality of Waterloo] and City [of Waterloo]) at least two years in advance of a development application being filed on a property."*

The intent of the various stages of proposed monitoring are as follows:

Stage 1. Pre-Construction – Groundwater monitoring within and surrounding the development site to quantitatively identify, and establish a baseline for, hydrogeological site conditions. At minimum two years of monitoring is required.

Stage 2. During-Construction – Continuation of Stage 1 monitoring, with the addition of monitoring to assess the efficacy of construction mitigation measures. Monitoring should be completed for the duration of construction.

Stage 3. Post-Construction – Monitoring, as required, to assess the efficacy of mitigation measures implemented during construction. At minimum two years of monitoring is required.

Stage 1 (pre-construction) monitoring has been ongoing at the Site since 2007 as part of the larger Conservation Meadows Subdivision and North Waterloo development plans. Results are documented annually, most recently by Stantec (2016, 2017a), and have been summarized in Section 3.

Stage 2 and Stage 3 monitoring plans would at minimum, continue the existing manual water level monitoring that is completed at monitoring wells BH12, BH104 and BH105. It is recommended that the continuous water level, and any water quality, data collected at MW7/10 as part of the North Waterloo Phase 1 development plan (Stantec, 2016), also be reviewed during these stages.

Additional monitoring data and/or changes to monitoring frequencies, may be required during Stage 2 and Stage 3, however this should be assessed as part of detailed design, once further information is available on infrastructure design, proposed construction methods and dewatering requirements.

6.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are provided based on the completed hydrogeological assessment

1. Surficial deposits are predominantly clayey silt to silt textured fill or glaciolacustrine deposits, except for a small area in the southwest where sand textured deposits are interpreted to exist based on surficial geology mapping. The clayey silt to silt textured deposits form a surficial aquitard where present. Beneath the clayey silt to silt deposits is a unit of fine to medium sand.

2. Groundwater is encountered at the Site within the sand unit between 353 m AMSL and 354.5 m AMSL or 3.5 m BGS to 5.7 m BGS. Perched groundwater may also be present in the upper clayey silt to silt textured deposits. Available (2007 to 2016) data suggest up to 0.5 m to 1 m of seasonal water level fluctuation in the area.

3. Horizontal groundwater flow in the sand unit is interpreted to be to the south and south-southwest beneath the Site. However, the horizontal hydraulic gradient is on the order of 10^{-3} m/m.

4. The estimated horizontal hydraulic conductivity for the sand unit is 8.7×10^{-5} m/s. The velocity of horizontal groundwater flow through the sand unit is expected to be up to 42 m/yr.

5. Groundwater level data suggest that vertical groundwater flow at the Site is downward; however, recharge will be limited by the low hydraulic conductivity of the surficial clayey silt to silt deposits, where present.

6. Groundwater in the shallow groundwater system is calcium-bicarbonate type water. No tested parameters were detected above their applicable health-related ODWS standard.

7. The Site intersects a SGRA and WHPA-C and WHPA-D for the Waterloo North Production Well W5A. Preliminary screening of the proposed development through the Region of Waterloo *TAPS Source Water Protection Tool* will be required as part of the planning approval application process.

8. Based on the NWSSS water balance analysis, and calculations from the *Functional Services and Stormwater Management Report,* under pre-development conditions 19,624 m^3 (183.6 mm) of infiltration is estimated to occur annually over the Site (7.94 ha) and its contributing drainage area (2.76 ha). Under post-development conditions impervious cover will increase by 55%, which will result in an annual infiltration deficit of 10,803 m^3. LID techniques such as the redirection of rooftop and lawn runoff to infiltration trenches could be used to eliminate the deficit. Designs should take into consideration limitations posed by

the low hydraulic conductivity of surficial clayey silt to silt deposits and the potential for perched, shallow water levels.

9. Construction dewatering for groundwater control may be required during installation of underground servicing, particularly if site services extend into the underlying sand unit. A dewatering assessment can be completed during the detailed design phase to determine dewatering volumes and potential water taking permitting requirements.

10. Servicing may occur below the groundwater table in some areas of the Site. Efforts may be required to minimize the disturbance that this servicing could have on pre-development groundwater flow patterns. Typically, the most common mitigation measure is the installation of anti-seepage (cut-off) collars to prevent the preferential movement of groundwater along the servicing alignments. An assessment for the need, total number and exact placements of anti-seepage collars along the servicing alignments can be explored in more detail during the detailed design phase of the project.

11. The Site is located in the North Waterloo Scoped Subwatershed Study Area, and as such a groundwater monitoring program must be established to document pre-, during- and post-construction hydrogeological conditions.

The following recommendations are offered based on the above conclusions:

1. During detailed design, it is recommended that the water balance and impact assessment be refined using site specific characteristics and monthly analytical calculations.

2. It is recommended that on-going monitoring at BH12, BH104 and BH105 continue in support of Phase 2 development to meet requirements for pre-, during- and post-construction monitoring. Continuous water level, and any water quality, data collected from monitoring well MW7-10, should also be reviewed during data analysis and assessment. During- and post-construction monitoring plans for Conservation Meadows Subdivision Phase 2 should be finalized during detailed design.

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APPENDIX A:
FIGURES

533000 533200 533400 533600

4815600 4815400 4815200 4815000

BH 21
BH 101
BH 17
BH 20
BH 102
BH 103
BH 104
BH 105
MW7-10
BH 12
A
A'

Rideau River Pl
Rideau River St
Springwater Pl
Springwater Dr
Kelso Dr
Kelso Pl
Tidewater Pl
Pinery Trail
Wasaga Cres
Cranberry St
Conservation Dr
Roy Schmidt Rd
Beaver Creek Rd
Green Acre Park Lane

N

Legend
- Property Limit
- Borehole Location
- Monitoring Well
- Road
- Railway
- Cross-Section Location
- Watercourse
- Waterbody

0 100 200 metres

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Notes
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Project Location
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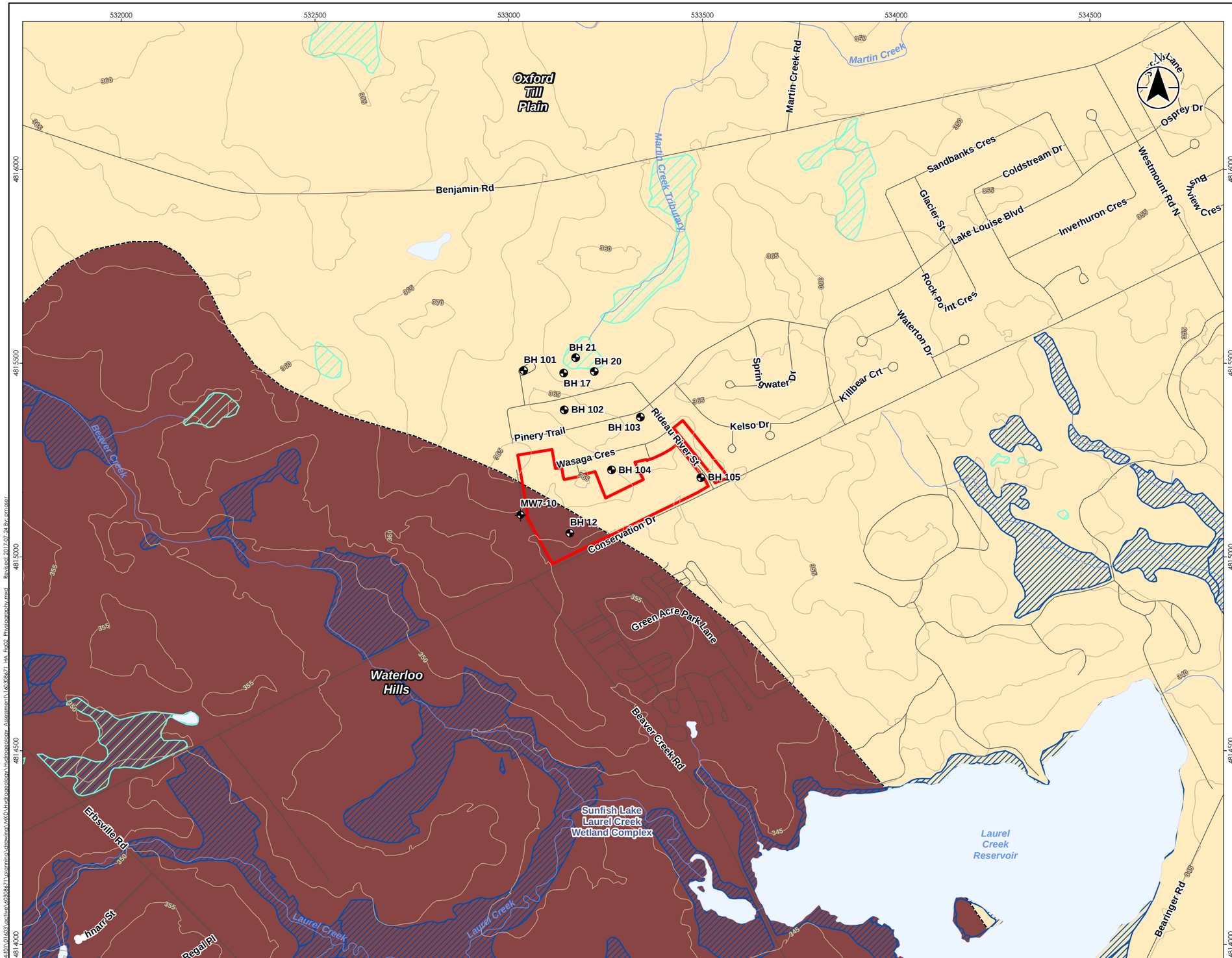
Client/Project
ACTIVA HOLDINGS INC.
CONSERVATION MEADOWS SUBDIVISON, PHASE 2
HYDROGEOLOGICAL ASSESSMENT

Figure No.
1

Title
Site Plan

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Stantec

Legend

- Property Limit
- Borehole Location
- Monitoring Well
- Contour (5m Interval)
- Road
- Railway
- Watercourse
- Waterbody
- Wetland - Evaluated (Provincial)
- Wetland - Not evaluated per OWES
- Physiographic Region Boundary

Physiography

- 6: Till Plains (Drumlinized)
- 4: Kame Moraines

0 250 500 metres

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Notes

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3. Chapman, L.J. and Putnam, D.F. 2007. Physiography of southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 228.



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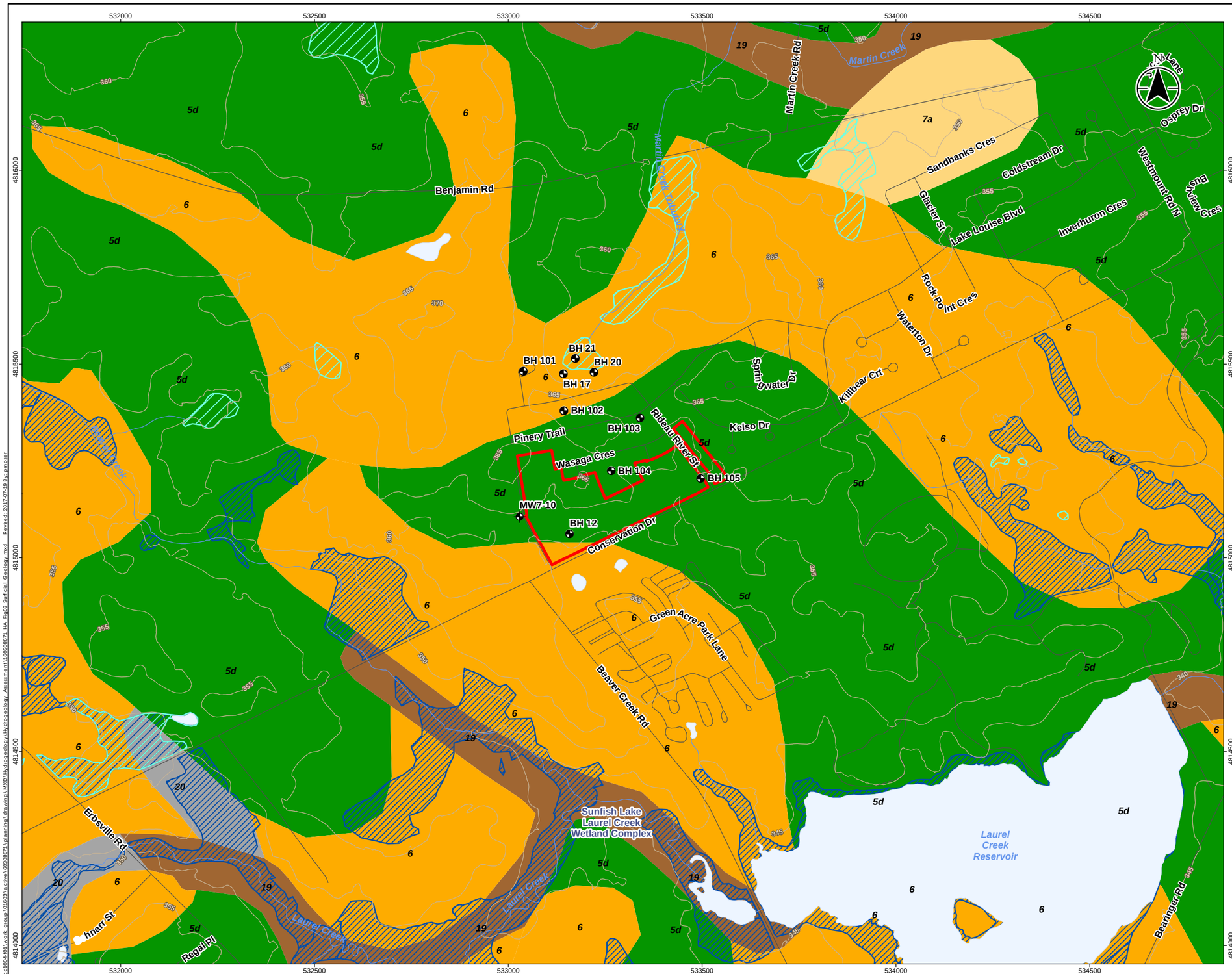
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CONSERVATION MEADOWS SUBDIVISON, PHASE 2
HYDROGEOLOGICAL ASSESSMENT

Figure No.
2

Title
Physiography

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Stantec

Legend

- Property Limit
- Borehole Location
- Monitoring Well
- Contour (5m Interval)
- Road
- Railway
- Watercourse
- Waterbody
- Wetland - Evaluated (Provincial)
- Wetland - Not evaluated per OWES
- 20: Organic deposits
- 19: Modern alluvial deposits
- 7a: Glaciofluvial deposits (Sandy deposits)
- 6: Ice-contact stratified deposits
- 5d: Glaciolacustrine-derived silty to clayey till

0 250 500 metres

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Notes

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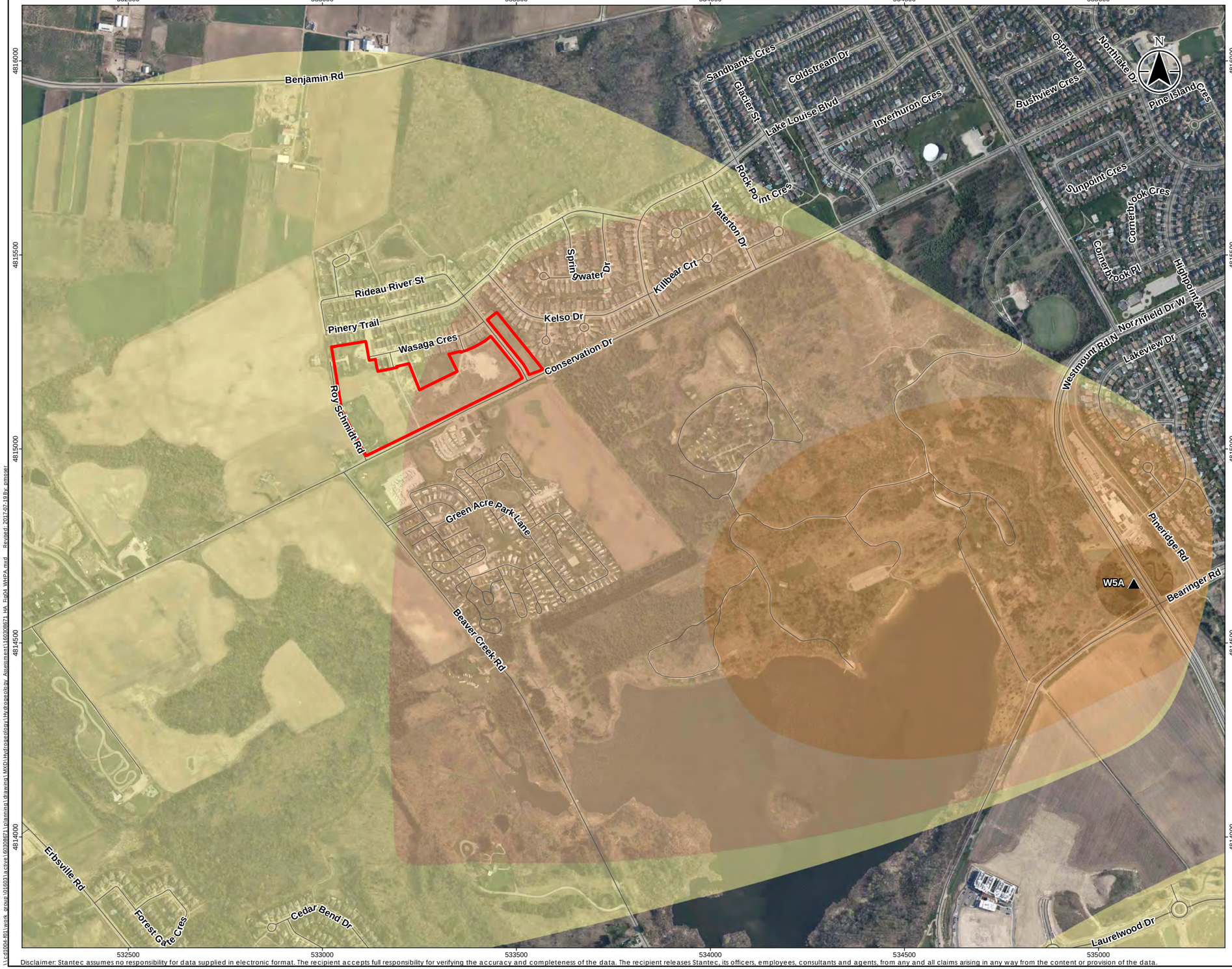
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CONSERVATION MEADOWS SUBDIVISON, PHASE 2
HYDROGEOLOGICAL ASSESSMENT

Figure No.
3

Title
Surficial Geology

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Stantec

Legend

- Property Limit
- Production Well
- Road
- Railway

Well Head Protection Area

- WHPA A
- WHPA B
- WHPA C
- WHPA D

0 250 500 metres

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Notes

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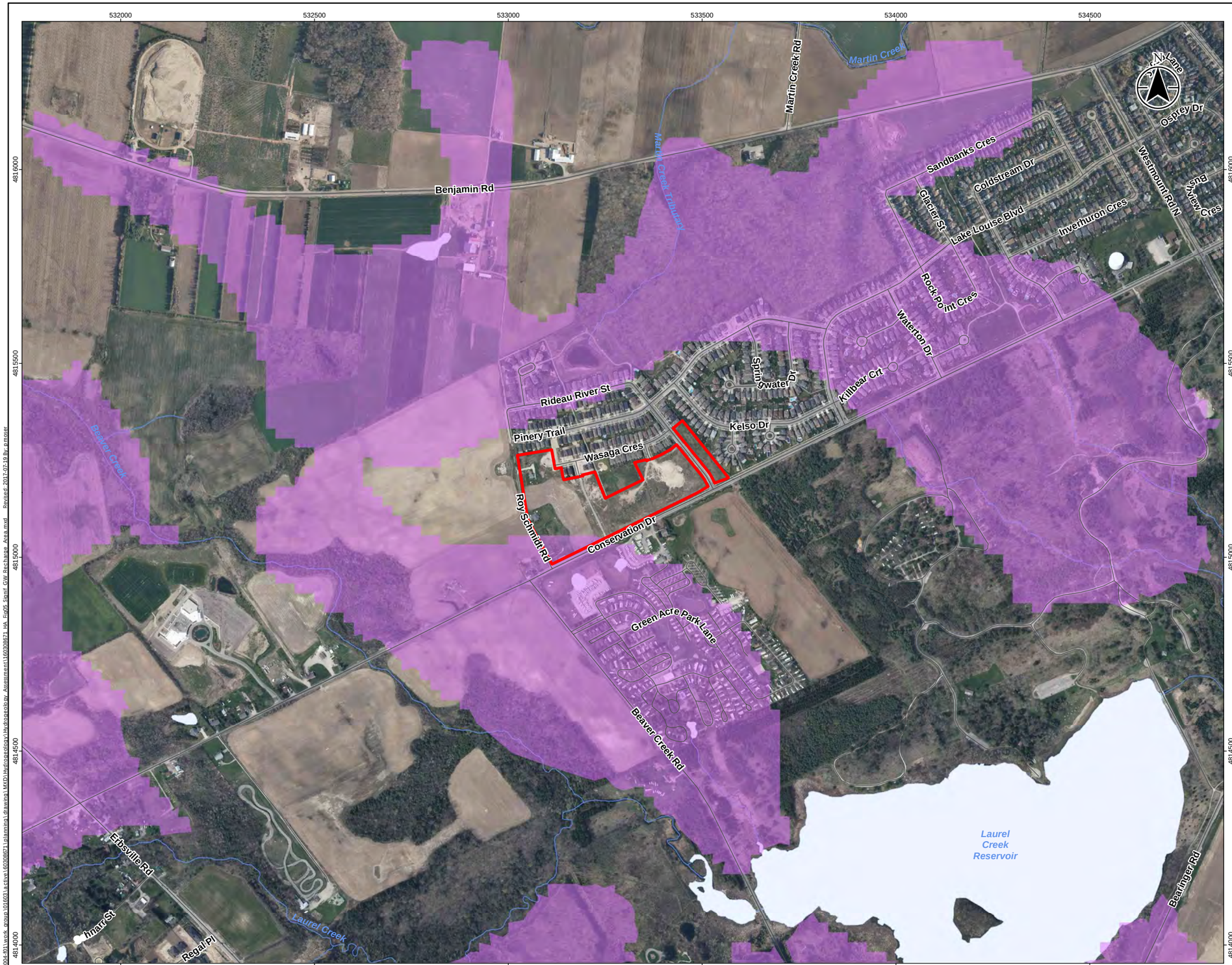
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CONSERVATION MEADOWS SUBDIVISON, PHASE 2
HYDROGEOLOGICAL ASSESSMENT

Figure No.
4

Title
Well Head Protection Areas

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Stantec

Legend

- Property Limit
- Road
- Railway
- Watercourse
- Waterbody
- Significant Groundwater Recharge Area

0 250 500 metres

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Notes

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ACTIVA HOLDINGS INC.
CONSERVATION MEADOWS SUBDIVISON, PHASE 2
HYDROGEOLOGICAL ASSESSMENT

Figure No.
5

Title
Significant Groundwater Recharge Areas

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A
EAST

A'
WEST

MW7-10(OS - 0m)
Roy Schmidt Road

BH 104(OS - 0m)

BH 105(OS - 0m)
Rideau River Street

Property Limit

Property Limit

Elevation (mAMSL)

371 370 369 368 367 366 365 364 363 362 361 360 359 358 357 356 355 354 353 352 351 350 349 348 347 346 345

TOPSOIL
CLAYEY SILT, trace gravel
SAND, fine to medium grained, trace silt, trace gravel
SILT, trace fine to coarse sand, trace gravel
SAND, fine to medium grained

FILL (topsoil)
SILT TILL, trace sand
SAND, fine to medium grained, trace silt

FILL (clayey silt)
SILT, fine sandy silt
SAND, silty fine to medium sand



MW7-10 (OS m)

Well ID (Offset)

Sand

Stratigraphy

Water Level (August 2016)

Well Screen

Fill / Topsoil
Silt
Sand

10x Vertical Exaggeration

0 25 50 metres

1:1,500 (At original document size of 11x17)

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Project Location
Waterloo,
Ontario

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CONSERVATION MEADOWS SUBDIVISON, PHASE 2
HYDROGEOLOGICAL ASSESSMENT

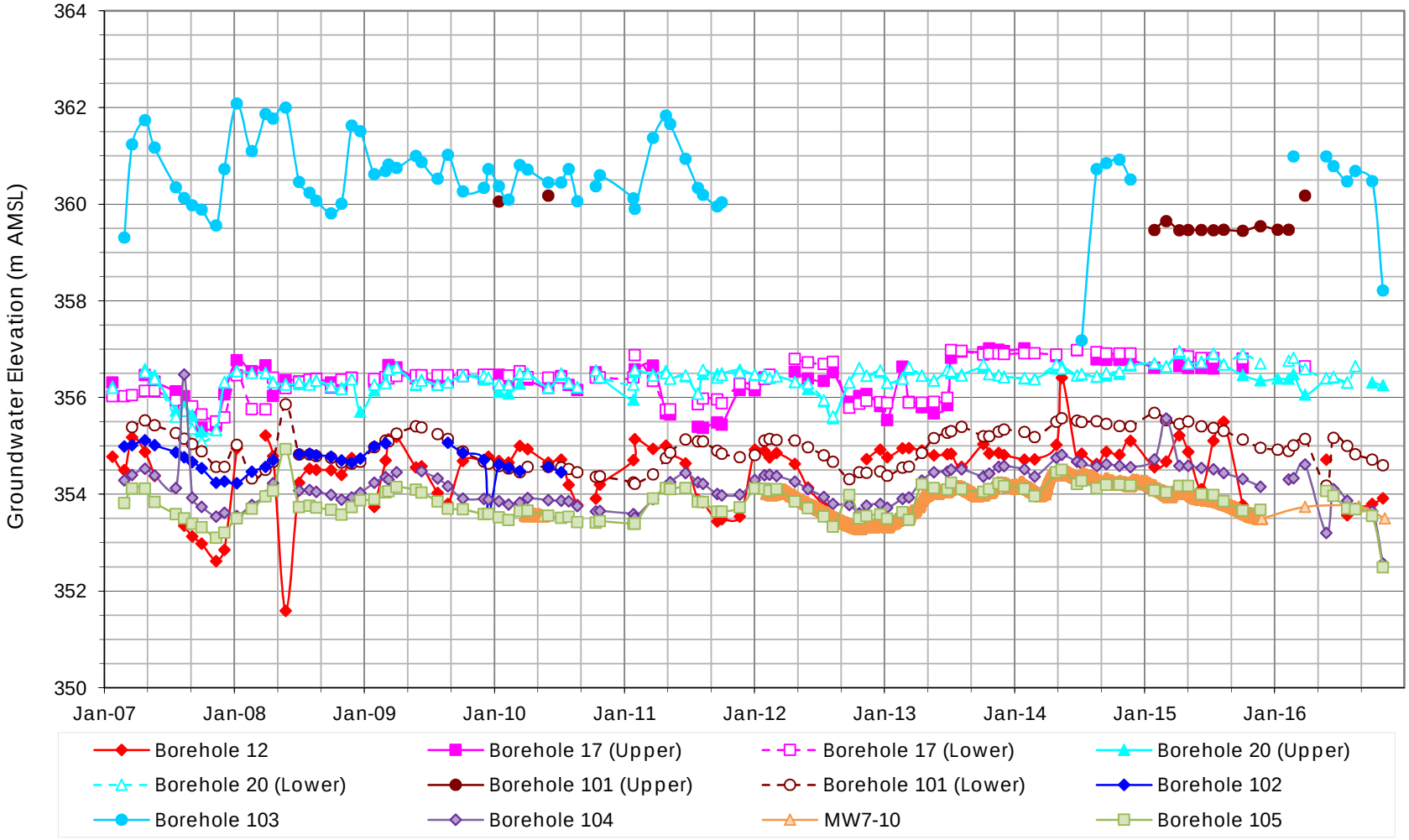
Figure No.
6

Title
Cross-Section A-A'

Figure X-X.X

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Note: Data not show for dry monitoring wells, e.g., BH101 (Upper).

Client/Project

Conservations Meadows Subdivision, Phase 2
Hydrogeological Assessment
Activa Holdings Inc

Figure No.

7

Title

Hydrograph - Groundwater Elevation

Stantec



Stantec

Legend

- Property Limit
- 353.54 Groundwater Elevation (August 2016)
- (--) Data not available
- Borehole Location
- Monitoring Well
- Road
- Railway
- Inferred Groundwater Flow Direction
- Groundwater Contour
- Watercourse
- Waterbody

0 100 200 metres

1:3,000 (At original document size of 11x17)

Notes

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Client/Project
ACTIVA HOLDINGS INC.
CONSERVATION MEADOWS SUBDIVISON, PHASE 2
HYDROGEOLOGICAL ASSESSMENT

Figure No.
8

Title
Groundwater Flow

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APPENDIX B:
TABLES

TABLE 1
WELL CONSTRUCTION DETAILS
CONSERVATION MEADOWS SUBDIVISION PHASE II
ACTIVA HOLDINGS INC

Well ID	Installed By	UTM Coordinates (NAD 83 Zn 17 N)		Elevations		Well Stick-up (m)	Borehole Depth		Screened Interval				Screened Material Description	Hydraulic Conductivity (m/s)
		Northing	Easting	Top of Casing (m AMSL)	Ground Surface (m AMSL)		(m BGS)	(m AMSL)	Top Elevation (m BGS)	Top Elevation (m AMSL)	Bottom Elevation (m BGS)	Bottom Elevation (m AMSL)		
BH12	Naylor	533159	4815063	356.47	355.56	0.91	--	--	--	--	--	--	--	--
BH17 (Upper)	Naylor	533143	4815475	357.98	356.98	1.00	--	--	--	--	--	--	--	--
BH17 (Lower)	Naylor	533143	4815475	357.96	356.98	0.98	--	--	--	--	--	--	--	--
BH20 (Upper)	Naylor	533222	4815479	357.41	356.76	0.65	--	--	--	--	--	--	--	--
BH20 (Lower)	Naylor	533222	4815479	357.42	356.76	0.66	--	--	--	--	--	--	--	--
BH21	Naylor	533174	4815515	--	355.45	--	--	--	--	--	--	--	--	--
BH101 (Upper)	Naylor (2007)	533040	4815482	361.94	361.42	0.52	7.62	353.80	1.20	360.22	2.11	359.31	--	--
BH101 (Lower)	Naylor (2007)	533040	4815482	361.87	361.42	0.45	7.62	353.80	4.57	356.85	7.62	353.80	--	--
BH102	Naylor (2007)	533145	4815380	363.42	362.72	0.70	10.36	352.36	7.03	355.69	10.08	352.64	SAND	--
BH103	Naylor (2007)	533341	4815360	364.10	363.43	0.67	8.08	355.35	5.03	358.40	8.08	355.35	SILT TILL	--
BH104	Naylor (2007)	533266	4815224	363.39	362.72	0.67	10.67	352.05	7.60	355.12	10.65	352.07	SAND	--
BH105	Naylor (2007)	533497	4815206	358.83	358.03	0.80	6.55	351.48	3.05	354.98	6.10	351.93	SAND	--
MW7-10	Stantec (2010)	533031	4815108	359.67	358.74	0.93	8.23	350.51	5.79	352.95	7.32	351.42	SAND	8.7E-05

Notes:
m AMSL = meters above mean sea level
m BGS = meters below ground surface
m BTOC = meters below top of well casing
- = data not available

Table 2
Groundwater Analytical Results - MW7/10
As Summarized from the Waterloo North Hydrogeological Assessment (Stantec, 2016)

Sample Location			MW7-10							
Sample Date			17-May-10	17-May-10	17-May-10	26-Oct-10	26-Oct-10	22-Aug-14	28-Sep-15	28-Sep-15
Sample ID			WG-160340875-20100517-AV02	WG-160340875-20100517-AV03	WG-160340875-20100517-AV03LR	WG-160340875-20101026-JK11	WG-160340875-20101026-JK11LR	WG-160310875-20140822-AV12	WG-160310875-20150928-AV02	WG-160310875-20150928-AV02LR
Sampling Company			STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC	STANTEC
Laboratory			MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX	MAXX
Laboratory Work Order			B062483	B062483	B062483	B0F2316	B0F2316	B4F3646	B5J8856	B5J8856
Laboratory Sample ID			FX4442	FX4443	FX4443	HQ0827	HQ0827	XG4195	BBU087	BBU087
Sample Type	Units	ODWS		Field Duplicate	Lab Replicate		Lab Replicate			Lab Replicate
Field Parameters										
Dissolved oxygen, Field	mg/L	n/v	6.9	-	-	1.2	-	-	-	-
Specific Conductivity	mS/cm	n/v	-	-	-	-	-	-	0.372	-
Oxidation Reduction Potential, field	mV	n/v	-	-	-	-	-	-	-	-
pH, Field	S.U.	6.5-8.5[D]	7.6	-	-	-	-	7.38	7.44	-
Specific Conductance, Field	µS/cm	n/v	645	-	-	-	-	544	-	-
Temperature, Field	deg C	15[C]	9.4	-	-	-	-	9.1	10.1	-
General Chemistry										
Alkalinity, Bicarbonate (as CaCO3)	mg/L	n/v	267	283	-	313	-	250	280	-
Alkalinity, Carbonate (as CaCO3)	mg/L	n/v	2	2	-	3	-	2.1	1.9	-
Alkalinity, Total (as CaCO3)	mg/L	30-500[D]	269	286	-	316	-	260	280	-
Ammonia (as N)	mg/L	n/v	0.06	0.06	-	0.09	-	<0.050	<0.050	-
Anion Sum	meq/L	n/v	6.23	6.54	-	7.18	-	5.55	6.24	-
Cation Sum	meq/L	n/v	7.31	6.97	-	7.23	-	5.79	6.24	-
Chloride	mg/L	250[C]	10	10	-	10	9	6	8.7	-
Dissolved Organic Carbon (DOC)	mg/L	5[C]	0.9	0.8	-	1.2	-	0.48	0.69	-
Electrical Conductivity, Lab	µmhos/cm	n/v	571	599	-	654	-	510	570	-
Hardness (as CaCO3)	mg/L	80-100[D]	**350[D]**	**340[D]**	-	**350[D]**	-	**280[D]**	**300[D]**	-
Ion Balance	%	n/v	8.00	3.24	-	0.350	-	2.05	0.0100	-
Langelier Index (at 20 C)	none	n/v	0.936	0.932	-	1.02	-	0.846	0.808	-
Langelier Index (at 4 C)	none	n/v	0.687	0.684	-	0.769	-	0.597	0.559	-
Nitrate (as N)	mg/L	10.0_d[A]	2.6	2.6	-	3.0	-	1.87	2.56	-
Nitrate + Nitrite (as N)	mg/L	10.0_d[A]	2.6	2.6	-	3.0	-	1.87	2.56	-
Nitrite (as N)	mg/L	1.0_d[A]	<0.01	<0.01	-	<0.01	-	<0.010	<0.010	-
Orthophosphate(as P)	mg/L	n/v	<0.01	<0.01	-	<0.01	<0.01	<0.010	<0.010	-
pH	S.U.	6.5-8.5[D]	7.9	7.9	-	7.96	-	7.95	7.85	-
Saturation pH (at 20 C)	none	n/v	7.01	7.00	-	6.94	-	7.11	7.04	-
Saturation pH (at 4 C)	none	n/v	7.25	7.25	-	7.19	-	7.36	7.29	-
Sulfate	mg/L	500_h[C]	18	18	-	18	18	7	9.9	-
Total Dissolved Solids (Calculated)	mg/L	500[C]	344	347	-	373	-	290	320	-
Metals										
Aluminum	mg/L	0.1[D]	<0.005	<0.005	<0.005	<0.005	-	<0.0050	<0.0050	<0.0050
Antimony	mg/L	0.006[B]	<0.0005	<0.0005	<0.0005	<0.0005	-	<0.00050	<0.00050	<0.00050
Arsenic	mg/L	0.025[B]	<0.001	<0.001	<0.001	<0.001	-	<0.0010	<0.0010	<0.0010
Barium	mg/L	1[A]	0.025	0.023	0.024	0.021	-	0.015	0.015	0.014
Beryllium	mg/L	n/v	<0.0005	<0.0005	<0.0005	<0.0005	-	<0.00050	<0.00050	<0.00050
Boron	mg/L	5[B]	<0.01	0.01	0.01	<0.01	-	<0.010	<0.010	<0.010
Cadmium	mg/L	0.005[A]	<0.0001	<0.0001	<0.0001	0.0001	-	<0.00010	<0.00010	<0.00010
Calcium	mg/L	n/v	99	95	95	100	-	80	86	86
Chromium	mg/L	0.05[A]	<0.005	<0.005	<0.005	<0.005	-	<0.0050	<0.0050	<0.0050
Cobalt	mg/L	n/v	<0.0005	<0.0005	<0.0005	<0.0005	-	<0.00050	<0.00050	<0.00050
Copper	mg/L	1[C]	0.002	<0.001	<0.001	0.001	-	0.0010	<0.0010	<0.0010
Iron	mg/L	0.3[C]	<0.1	<0.1	<0.1	<0.1	-	<0.10	<0.10	<0.10
Lead	mg/L	0.01_c[A]	0.0012	<0.0005	<0.0005	<0.0005	-	<0.00050	<0.00050	<0.00050
Magnesium	mg/L	n/v	26	24	25	24	-	20	21	22
Manganese	mg/L	0.05[C]	0.012	0.011	0.011	<0.002	-	<0.0020	<0.0020	<0.0020
Molybdenum	mg/L	n/v	<0.001	<0.001	<0.001	<0.001	-	<0.00050	<0.00050	<0.00050
Nickel	mg/L	n/v	0.001	<0.001	<0.001	<0.001	-	0.0010	<0.0010	<0.0010
Phosphorus	mg/L	n/v	<0.1	<0.1	<0.1	<0.1	-	<0.10	<0.10	<0.10
Potassium	mg/L	n/v	0.8	0.7	0.7	0.8	-	0.68	0.72	0.71
Selenium	mg/L	0.01[A]	<0.002	<0.002	<0.002	<0.002	-	<0.0020	<0.0020	<0.0020
Silicon	mg/L	n/v	5.8	5.5	5.6	5.8	-	5.3	5.3	5.3
Silver	mg/L	n/v	<0.0001	<0.0001	<0.0001	<0.0001	-	<0.00010	<0.00010	<0.00010
Sodium	mg/L	200_g[C] 20_g[E]	5.1	4.8	4.8	5.3	-	3.5	3.6	3.7
Strontium	mg/L	n/v	0.11	0.11	0.11	0.12	-	0.086	0.10	0.10
Thallium	mg/L	n/v	<0.00005	<0.00005	<0.00005	<0.00005	-	<0.000050	<0.000050	<0.000050
Titanium	mg/L	n/v	<0.005	<0.005	<0.005	<0.005	-	<0.0050	<0.0050	<0.0050
Uranium	mg/L	0.02[A]	0.0002	0.0002	0.0002	0.0002	-	<0.00010	0.00019	0.00021
Vanadium	mg/L	n/v	<0.001	<0.001	<0.001	<0.001	-	<0.00050	<0.00050	<0.00050
Zinc	mg/L	5[C]	0.014	0.009	0.007	0.006	-	0.0080	<0.0050	<0.0050

Notes:

O. Reg 169/03 (January 2017) and Technical Support Document for Ontario Drinking Water Standards, Objectives and Guidelines (MOE, 2006)
ODWS Table 2 - Chemical Standards, Maximum Acceptable Concentration
ODWS Table 2 - Chemical Standards, Interim Maximum Acceptable Concentration
ODWS Table 4 - Chemical/Physical Objectives and Guidelines, Aesthetic Objectives
ODWS Table 4 - Chemical/Physical Objectives and Guidelines, Operational Guidelines
ODWS Table 4 - Medical Officer of Health Reporting Limit
Concentration exceeds the indicated standard.
Measured concentration was less than the applicable standard.
Laboratory reporting limit was greater than the applicable standard.
Analyte was not detected at a concentration greater than the laboratory reporting limit.
No standard/guideline value.
Parameter not analyzed / not available.
This standard applies to water at the point of consumption. Since lead is a component in some plumbing systems, first flush water may contain higher concentrations of lead than water that has been flushed for five minutes.
Where both nitrate and nitrite are present, the total of the two should not exceed 10 mg/L (as nitrogen).
The aesthetic objective for sodium in drinking water is 200 mg/L. The local Medical Officer of Health should be notified when the sodium concentration exceeds 20 mg/L so that this information may be communicated to local physicians for their use with patients on sodium restricted diets.
When sulfate levels exceed 500 mg/L, water may have a laxative effect on some people.

APPENDIX C:
BOREHOLE LOGS

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 101

Ground Elevation: ***361.42 m***

Project: ***Groundwater Level Monitoring, Construction Phase***

Job No.: ***4500H1***

Location: ***Activa Conservation Lands, Waterloo, Ontario***

Drill Date: ***January 30, 2007***

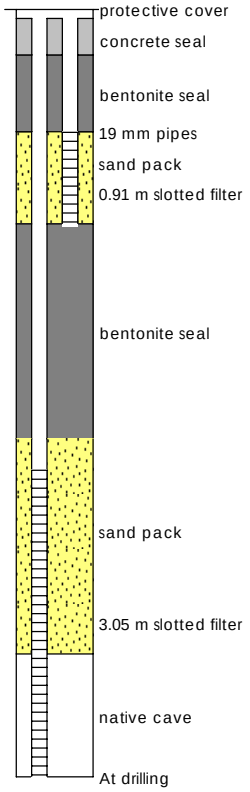
Depth (m)	Description	Symbol	Elevation (m)	Sample Number	Sample Type	N-Value
0.00	Ground Elevation		361.42			
	SILT: compact brown silt, moist; some brown clayey silt layers, APL					
1.00			360.00	1	SS	12
2.00						
3.00	compact brown silt, some fine sand, moist		359.00	2	SS	29
4.00	***SAND:*** dense brown fine to medium sand, trace silt, damp		358.00			
5.00			357.00	3	SS	23\150mm
6.00	saturated		356.00			
7.00			355.00	4	SS	39
8.00	Borehole terminated at 7.62 m		354.00	5	AS	
9.00			353.00			
10.00			352.00			
11.00			351.00			
12.00			350.00			

Dynamic Cone / Standard Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200

Water Content (%): WP WL; 10 20 30

Groundwater Observations and Standpipe Details



Reviewed by: ***CF***

Drill Method: ***Solid Stem Auger***

Notes:

Field Tech.: ***RM***

Sheet: ***1 of 1***

Drafted by: ***DC(01a)***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 102

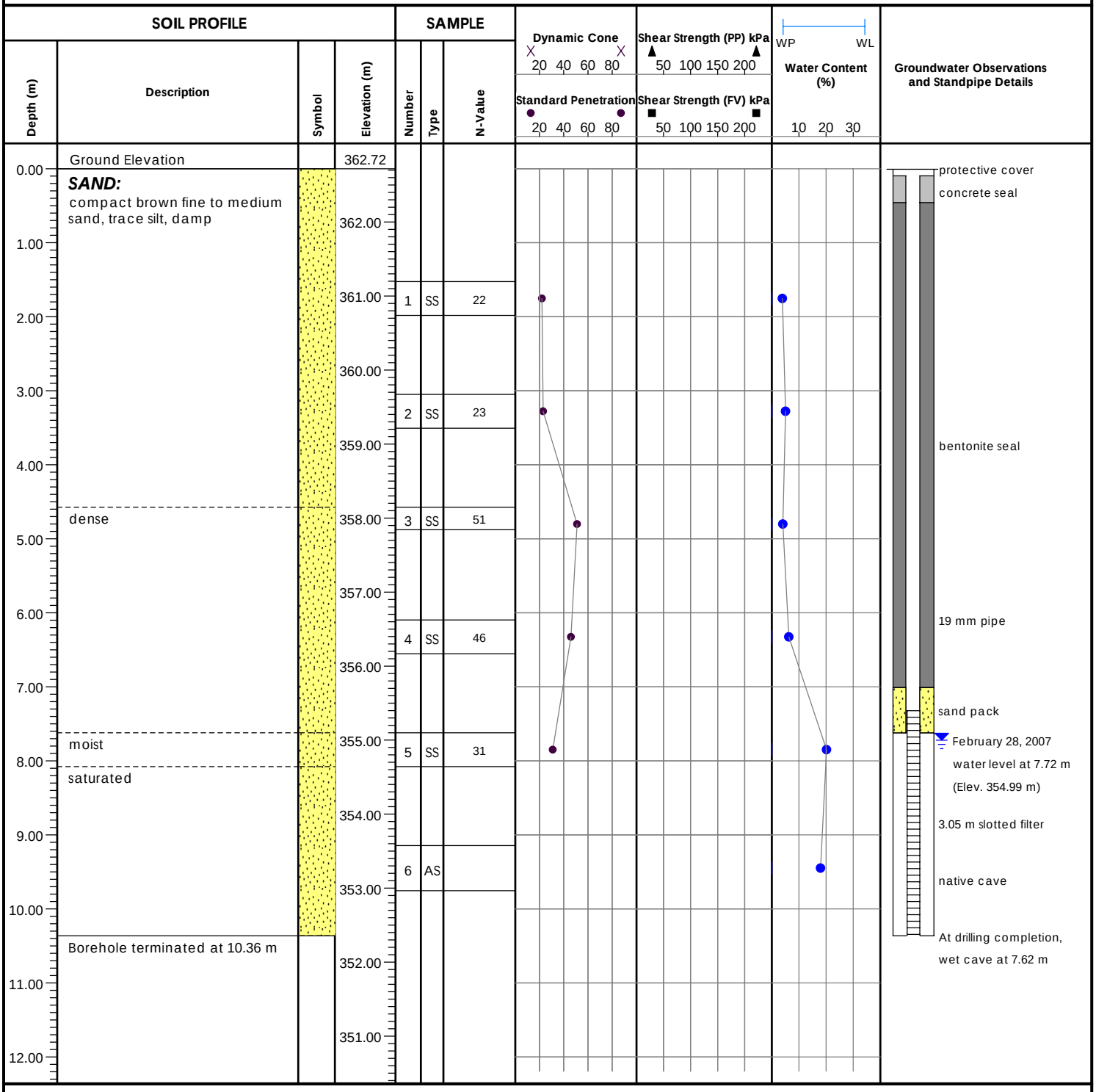
Ground Elevation: ***362.72 m***

Project: ***Groundwater Level Monitoring, Construction Phase***

Job No.: ***4500H1***

Location: ***Activa Conservation Lands, Waterloo, Ontario***

Drill Date: ***January 30, 2007***



Reviewed by: ***CF***

Drill Method: ***Solid Stem Auger***

Notes:

Field Tech.: ***RM***

Sheet: ***1 of 1***

Drafted by: ***DC(01a)***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 103

Ground Elevation: ***363.43 m***

Project: ***Groundwater Level Monitoring, Construction Phase***

Job No.: ***4500H1***

Location: ***Activa Conservation Lands, Waterloo, Ontario***

Drill Date: ***January 30, 2007***

Depth (m)	Description	Symbol	Elevation (m)	Sample Number	Sample Type	N-Value
0.00	Ground Elevation		363.43			
0.00	***SILT TILL:*** hard brown clayey silt, trace sand, DTPL					
1.00			362.00	1	SS	20
2.00						
3.00			361.00	2	SS	25
4.00			360.00			
5.00	greyish		359.00	3	SS	21
6.00	grey		358.00			
7.00			357.00	4	SS	16
8.00	Borehole terminated at 8.08 m		356.00			
9.00			355.00	5	SS	18
10.00			354.00			
11.00			353.00			
12.00			352.00			

Dynamic Cone / Standard Penetration: 20 40 60 80

Shear Strength (PP) kPa / Shear Strength (FV) kPa: 50 100 150 200

Water Content (%): WP WL; 10 20 30

Groundwater Observations and Standpipe Details:
- protective cover
- concrete seal
- bentonite seal
- February 28, 2007 water level at 4.21 m (Elev. 359.31 m)
- sand pack
- 3.05 m slotted filter
- 19 mm pipe
- At drilling completion, dry cave at 8.08 m

Reviewed by: ***CF***

Drill Method: ***Solid Stem Auger***

Notes:

Field Tech.: ***RM***

Sheet: ***1 of 1***

Drafted by: ***DC(01a)***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 104

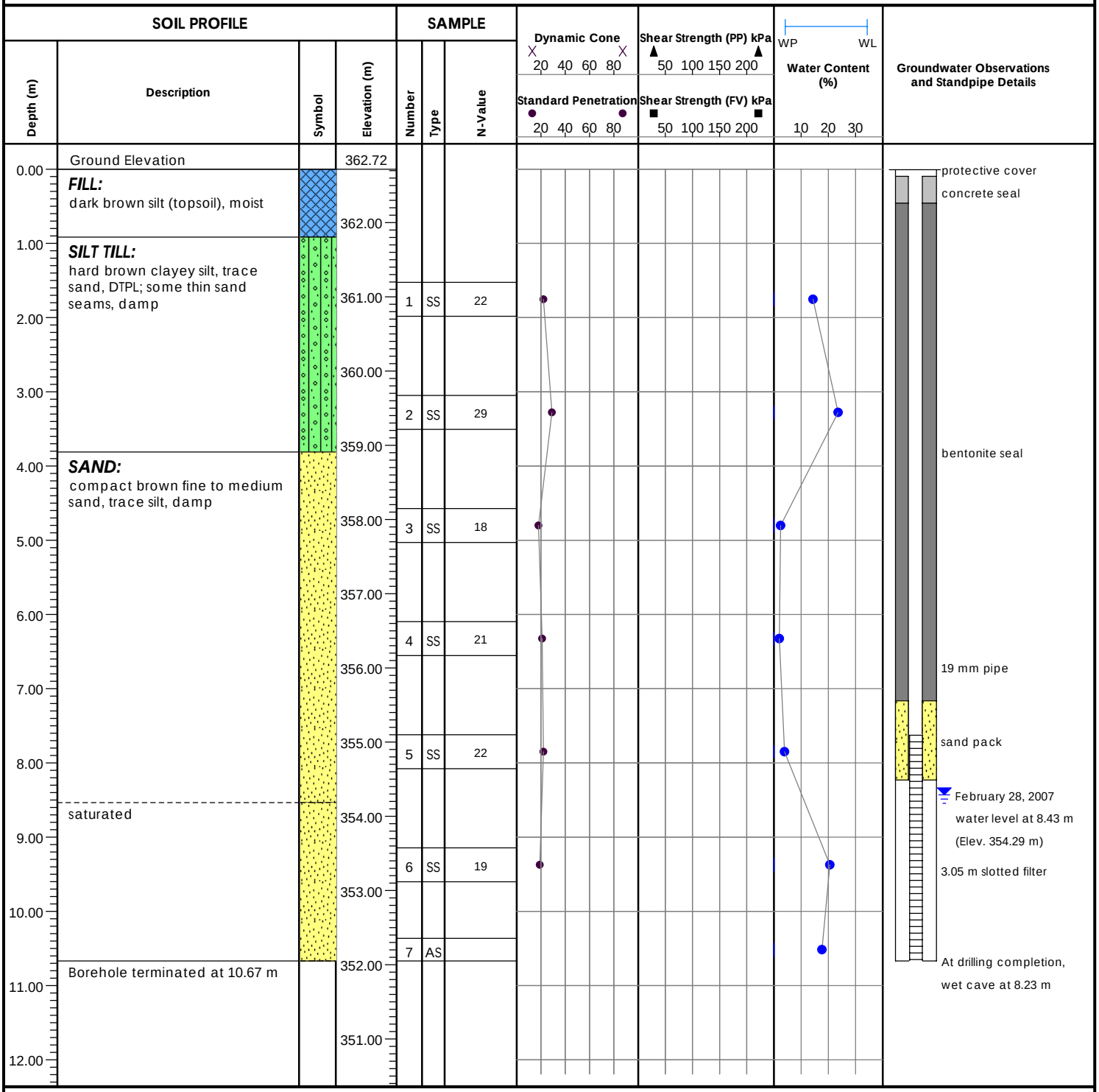
Ground Elevation: ***362.72 m***

Project: ***Groundwater Level Monitoring, Construction Phase***

Job No.: ***4500H1***

Location: ***Activa Conservation Lands, Waterloo, Ontario***

Drill Date: ***February 1, 2007***



Reviewed by: ***CF***

Drill Method: ***Solid Stem Auger***

Notes:

Field Tech.: ***RM***

Sheet: ***1 of 1***

Drafted by: ***DC(01a)***

Naylor Engineering Associates Ltd.
CONSULTING ENGINEERS

Borehole Number: 105

Ground Elevation: *362.70 m**

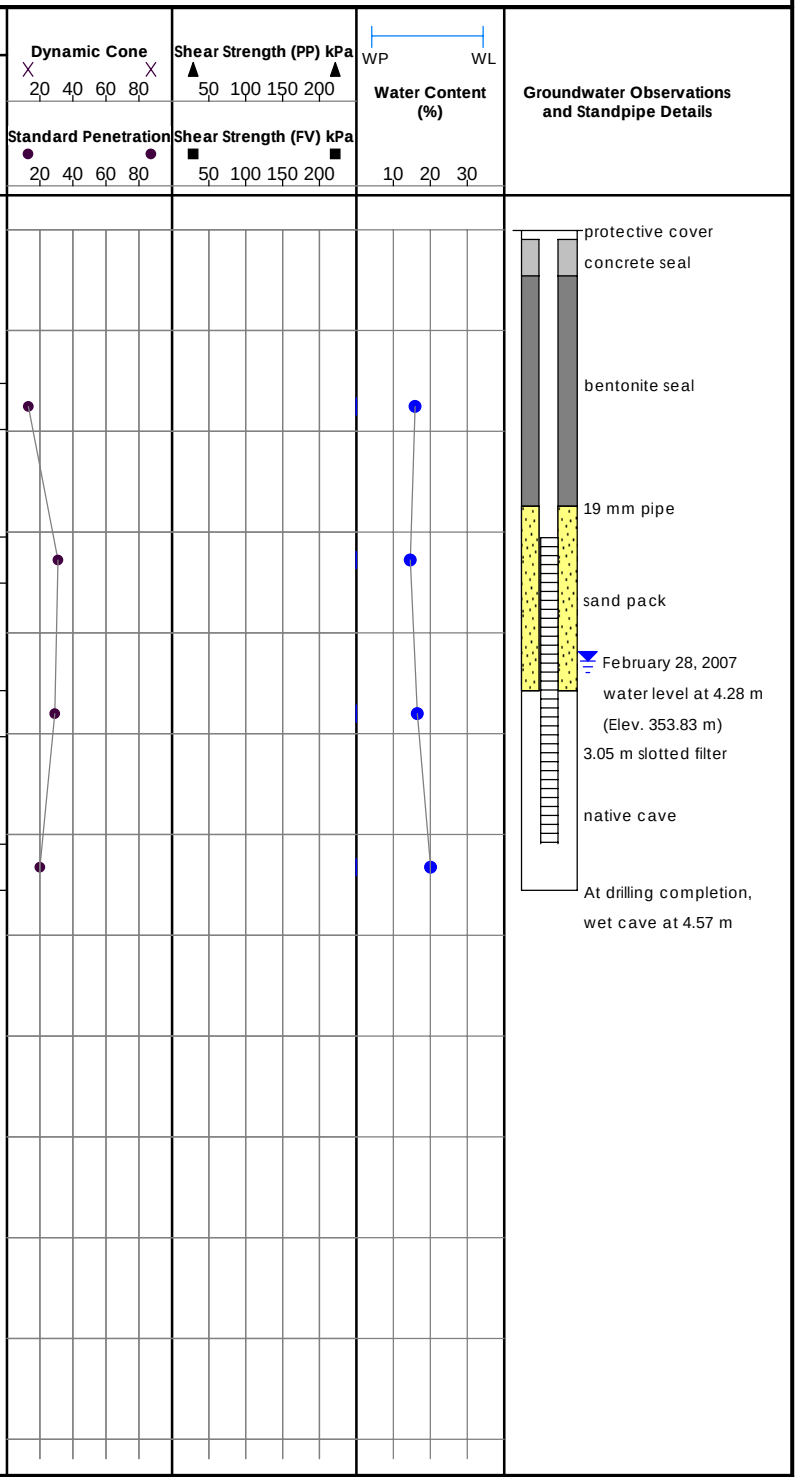
Project: *Groundwater Level Monitoring, Construction Phase*

Job No.: *4500H1*

Location: *Activa Conservation Lands, Waterloo, Ontario*

Drill Date: *February 1, 2007*

Depth (m)	Description	Symbol	Elevation (m)	Number	Type	N-Value
0.00	Ground Elevation		362.70			
	FILL: brown clayey silt, APL					
1.00			362.00			
	SILT: compact brown fine sandy silt, moist			1	SS	13
2.00			361.00			
	SAND: dense brown silty fine to medium sand, damp					
3.00			360.00	2	SS	31
4.00			359.00			
	saturated			3	SS	29
5.00			358.00			
6.00			357.00	4	SS	20
	Borehole terminated at 6.55 m		356.00			
7.00						
8.00			355.00			
9.00			354.00			
10.00			353.00			
11.00			352.00			
12.00			351.00			



Reviewed by: *CF*

Drill Method: *Solid Stem Auger*

Notes:

Field Tech.: *RM*

Sheet: *1 of 1*

Drafted by: *DC(01a)*

*Ground Elevation was resurveyed by Stantec in July 2017 as 358.03 m AMSL

Monitoring Well: MW7-10

Project:	North Waterloo Subwatershed Study	**Drilling method:**	Track Mount, CME75, Hollow Stem Auger
Client:		**Date started/completed:**	18-Mar-2010
Location:	North Waterloo, ON	**Ground surface elevation:**	n/a
Number:	160330875	**Top of casing elevation:**	n/a
Field investigator:	A.Vandenhoff	**Easting:**	n/a
Contractor:	ProCore	**Northing:**	n/a

SUBSURFACE PROFILE				SAMPLE DETAILS				WELL DETAILS	
Depth (ft)	Depth (m)	Graphic Log	Lithologic Description	Depth (m BGS)	Sample Number	Sample Type	N Value	Recovery	Well Diagram / Description
			Ground Surface						
			TOPSOIL dark brown	0.00					Concrete
			CLAYEY SILT trace gravel, light brown, firm to stiff, moist	0.25	1	SS	1-1-2-3 (3)	19" 79%	
					2	SS	2-3-5-5 (8)	13" 54%	52 mm Schedule 40 PVC casing
5	2		SAND fine to medium grained sand, trace silt, trace gravel, light reddish brown, loose, moist	1.22	3	SS	6-1-4-5 (5)	11" 46%	
			SILT trace fine to coarse sand, trace gravel, stiff, light brown, moist	2.44	4	SS	1-5-7-12 (12)	15" 63%	Holeplug
10	4		becoming clayey at 3.1 m BGS		5	SS	2-5-6-10 (11)	24" 100%	
15			SAND fine to medium grained, light brown, compact, moist	4.57	6	SS	4-14-20-24 (34)	18" 75%	Top of sand (5.2 m BGS)
			becoming wet at 5.2 to 6.1 m BGS						Top of screen (5.8 m BGS)
20	6				7	SS	8-20-22->50 (>42)	24" 100%	No.2 Silica Sand No.10 Slot PVC screen 50 mm diameter Bottom of screen (7.3 m BGS) Natural Cave
25	8		End of Monitoring Well	8.23	8	SS	9-20-32-39 (52)	24" 100%	

Screen Interval: 5.79 - 7.32 m BGS
Sand Pack Interval: 5.18 - 7.32 m BGS
Well Seal Interval: 0.30 - 5.18 m BGS

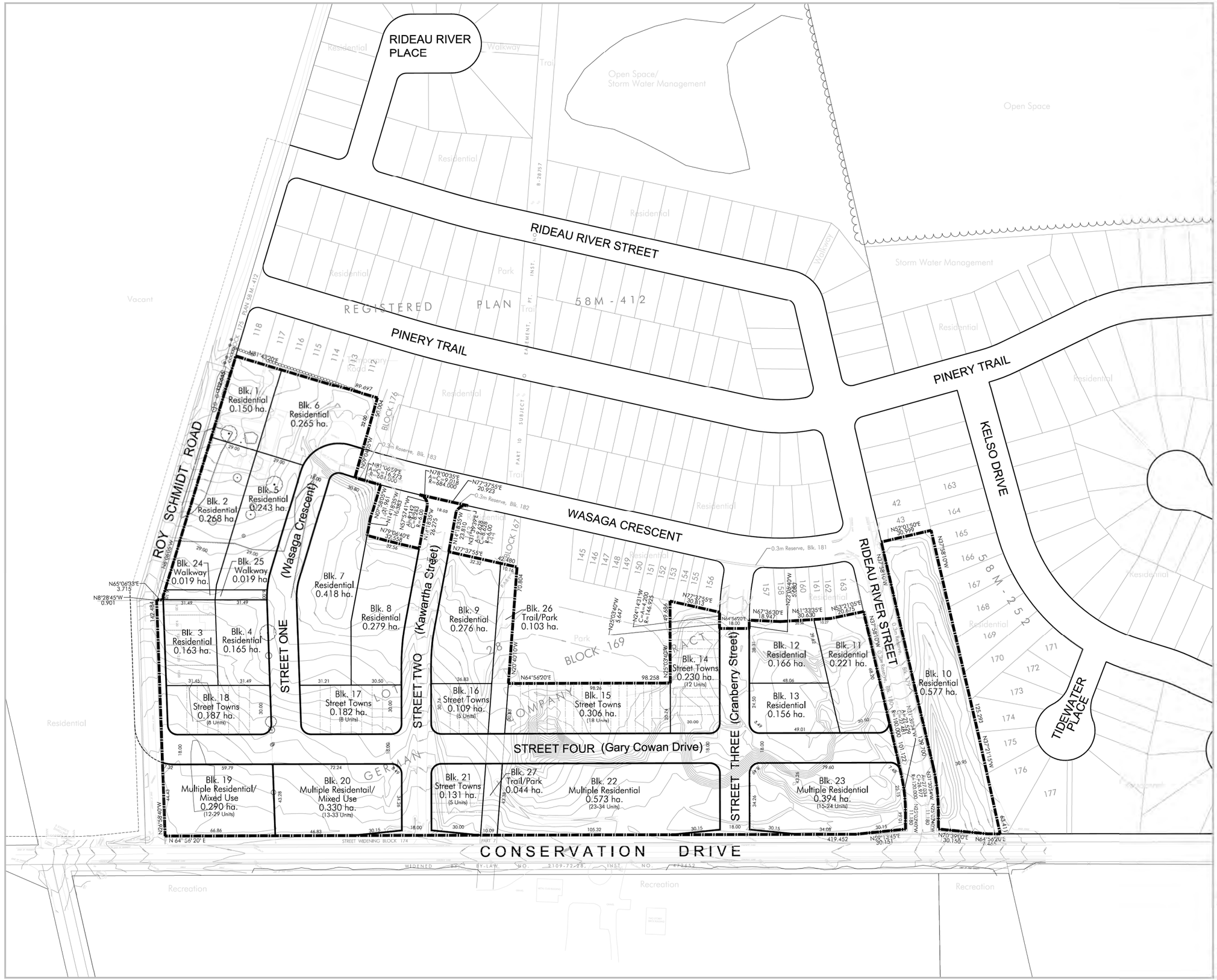
Notes:
m AMSL - metres above mean sea level
m BGS - metres below ground surface
m BTOC - metres below top of casing
SS - split-spoon sample
n/a - not available

Drawn By/Checked By: OR/LV

Stantec

STANTEC BOREHOLE AND WELL 160330875 - DPS.GPJ EQUIS DATA TEMPLATE.GDT 11/17/10

APPENDIX D:
PRELIMINARY DEVELOPMENT PLANS



Legal Description

PART OF LOT 28, GERMAN COMPANY TRACT,
(GEOGRAPHIC TOWNSHIP OF WATERLOO),
CITY OF WATERLOO,
REGIONAL MUNICIPALITY OF WATERLOO

Owner's Certificate

I AUTHORIZE MACNAUGHTON HERMSEN BRITTON CLARKSON PLANNING LIMITED TO SUBMIT THIS PLAN FOR APPROVAL.

DATE: June 27/17

Lanyl Masseo - Vice President
Planning and Development
Activa Management Corporation

Surveyor's Certificate

I HEREBY CERTIFY THAT THE BOUNDARIES OF THE LAND TO BE SUBDIVIDED ON THIS PLAN AND THEIR RELATIONSHIP TO THE ADJACENT LANDS ARE ACCURATELY AND CORRECTLY SHOWN.

DATE: JUNE 27/17

Brian Campbell - OLS,
Stantec Geomatics Ltd.

Key Plan



Subject Lands

north

Not to Scale

Additional Information Required Under Section 51(17) of the Planning Act R.S.O. 1990, c.P.13 as Amended

A. As Shown	B. As Shown	C. As Shown
D. Residential, Trail, Stormwater Management		
E. As Shown	F. As Shown	
G. As Shown	H. Municipal Water Supply	I. Sandy Loam
J. As Shown	K. All Services As Required	L. As Shown

Area Schedule 30T - _____

Description	STAGE 1					TOTAL		
	Lots/Blks	Area	Singles (min./max.)	Multiple Residential: Street Towns (min.)	Multiple Residential: Low Rise Aparts (max.)	Lots/Blks	Area	Total Units (min./max.)
Residential (1)	1-13	3.347	63-103			13	3.347	63-103
Street Towns (2)	14-18,21	1.148		56		6	1.148	56-56
Multiple Residential (2,3)	22,23	0.967		38	58	2		38-58
Multiple Residential / Mixed Use (2,4)	19,20	0.620		25	62	2	0.620	25-62
Walkways	24,25	0.038				2	0.038	
Trail / Park	26,27	0.147				2	0.147	
Roads		1.739					1.739	
TOTAL	27	8.003	63-103	119	120	27	8.003	182-279

Notes:
(1) Residential Unit Yield based on 13.7m Lots (min) and 9.0m Lots (max).
(2) Street Towns = minimum lot width 5.0m.
(3) Low Rise Apartments calculated at 60 Units per Hectare.
(4) Low Rise Apartments calculated at 100 Units per Hectare

No.	Date	Issued / Revision	By
1	September 11,2017	Edits to Area Schedule and Units Yields	LHB

MHBC PLANNING URBAN DESIGN & LANDSCAPE ARCHITECTURE
200-540 BINGEMANS CENTRE DR, KITCHENER, ON, N2B 3X9 | P 519.576.3650 F 519.576.0121 | WWW.MHBCPLAN.COM

Approval Stamp

Date	September 11,2017
File No.	8784Y
Plan Scale	1:1,000
Drawn By	L.H.B.
Checked By	P.B. / D.A.

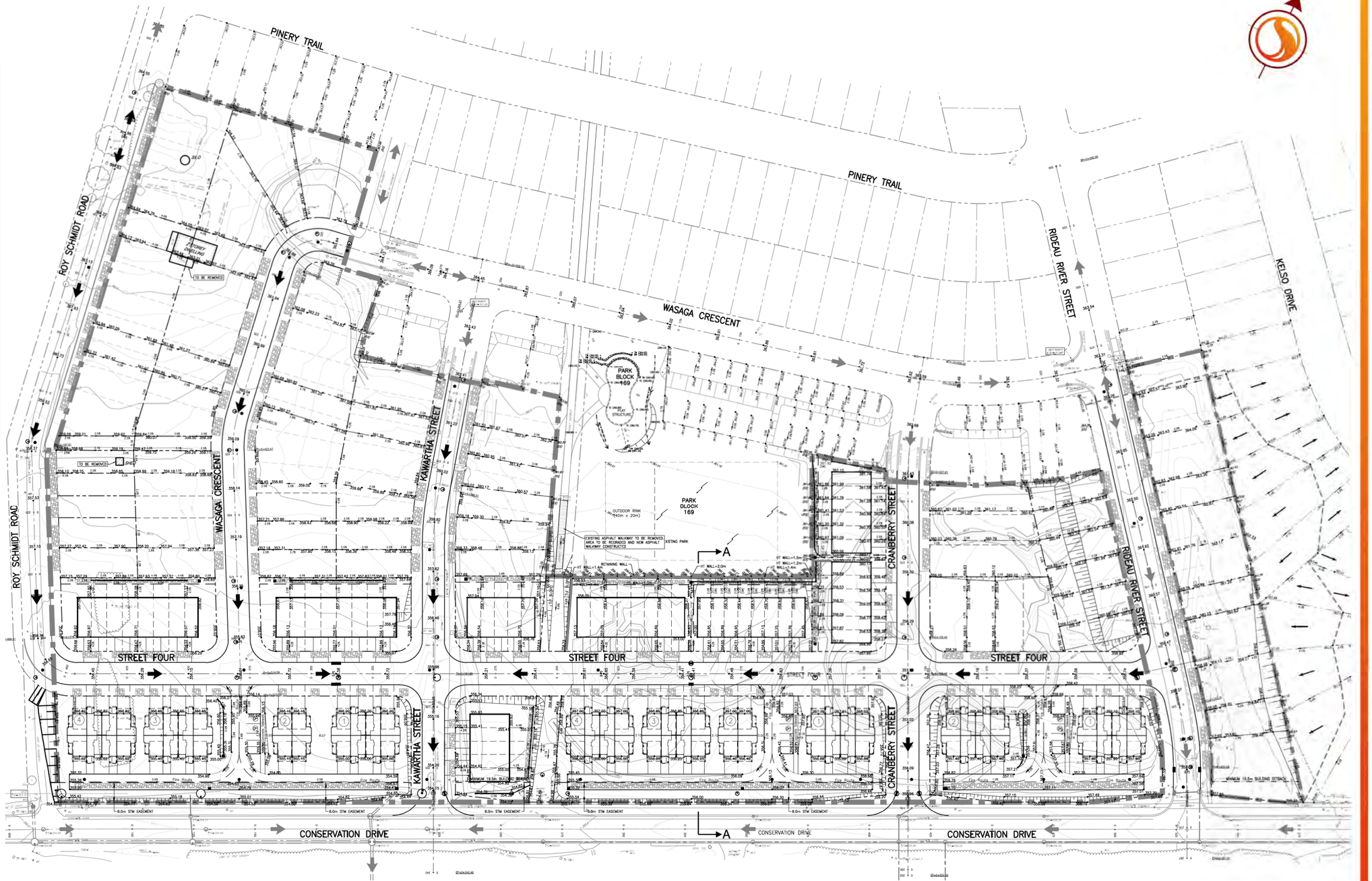
Client

Activa Holdings Inc.
55 Columbia Street East,
Waterloo, Ontario
N2J 4N7
519 886 9400
www.activagroup.ca

north

File Name DRAFT PLAN OF SUBDIVISION

K:\8784Y_ACTIVA_CONSERVATIONDR\DP\DP SEPTEMBER 11 2017.DWG



Stantec

300 Hagey Blvd. Suite 100
Waterloo, ON. N2L 0A4
Tel. 519.579.4410
www.stantec.com

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Notes

1. BENCHMARK:
   CUT CROSS IN CONCRETE CURB, NORTH EAST CORNER OF RIDEAU RIVER STREET AND WASAGA CRESCENT, CITY OF WATERLOO.
   ELEVATION = 363.82m
2. TOPOGRAPHIC SURVEY BY STANTEC CONSULTING LTD. DATED APRIL 2016. ELEVATIONS ARE REFFERRED TO THE CANADIAN GEODETIC VERTICAL DATUM (CGVD-1929:1978)
3. DRAFT PLAN FOR LANDS PROVIDED BY MHBC DATED APRIL 7, 2017.

Legend

- PROPERTY LINE
- EXISTING ELEVATION
- PROPOSED ELEVATION
- FLOW DIRECTION AND GRADE
- EXISTING CONTOUR (SURVEYED)
- EXISTING CONTOUR (CITY OF CAMBRIDGE)
- PROPOSED STORM MANHOLE
- PROPOSED SANITARY MANHOLE
- PROPOSED HYDRANT
- EXISTING STORM MANHOLE
- EXISTING SANITARY MANHOLE
- EXISTING HYDRANT
- PROPOSED SLOPE (3:1 UNLESS NOTED OTHERWISE)
- OVERLAND FLOW DIRECTION
- EXISTING OVERLAND FLOW DIRECTION
- BOREHOLE
- TEST PIT
- MONITORING WELL
- EXISTING TREE
- EXISTING DRIP LINE
- RETAINING WALL (BY OTHERS)
- INFILTRATION TRENCH

Revision	By	Appd.	YY.MM.DD
File Name: 60308671_C-400DP.dwg	M.A.R. Dwn.	J.L.C. Chkd.	M.A.R. Dsgn.	17.01.09 YY.MM.DD

Permit-Seal

Client/Project
ACTIVA HOLDINGS INC.

CONSERVATION MEADOWS SUBDIVISION PHASE 2
Waterloo, ON.

Title
CONCEPTUAL GRADING PLAN

Project No.	Scale	
60308671	0 7.5 22.5 37.5m (1:750)	
Drawing No.	Sheet	Revision
C-400	of	0

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2017/07/04 1:40 PM By: Rose, Martin

ORIGINAL SHEET - ARCH D