JLR No.: 29803-003
Revision: 2

April 22, 2024

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Hydrologic Impact Study

Wildpine Trails

J.L.Richards
ENGINEERS · ARCHITECTS · PLANNERS

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1.0 Introduction

1.1 Purpose

J.L. Richards & Associates Ltd (JLR) has been retained by Latitude Homes Inc (LHI) to prepare this Hydrological Impact Study (HIS) in support of the site plan application for the development known as Wildpine Trails at 37 Wildpine Court in Ottawa.

The need for an HIS is triggered by the location of the development being within a 30 metres setback from a wetland. The setback was jointly agreed upon between the biologists from the Mississippi Valley Conservation Authority (MVC) and Kilgour & Associates Limited (KAL). The Hydrological Impact Study is, therefore, a requirement of application approval by the MVC and City of Ottawa. The HIS is required to identify the impact, if any, to the wetland and identify, if required, any proposed mitigation measures necessary to minimize the impacts to the wetland.

This HIS should be read in conjunction with the Environmental Impact Statement (EIS) and Tree Conservation Report (TCR) for the site prepared by KAL.

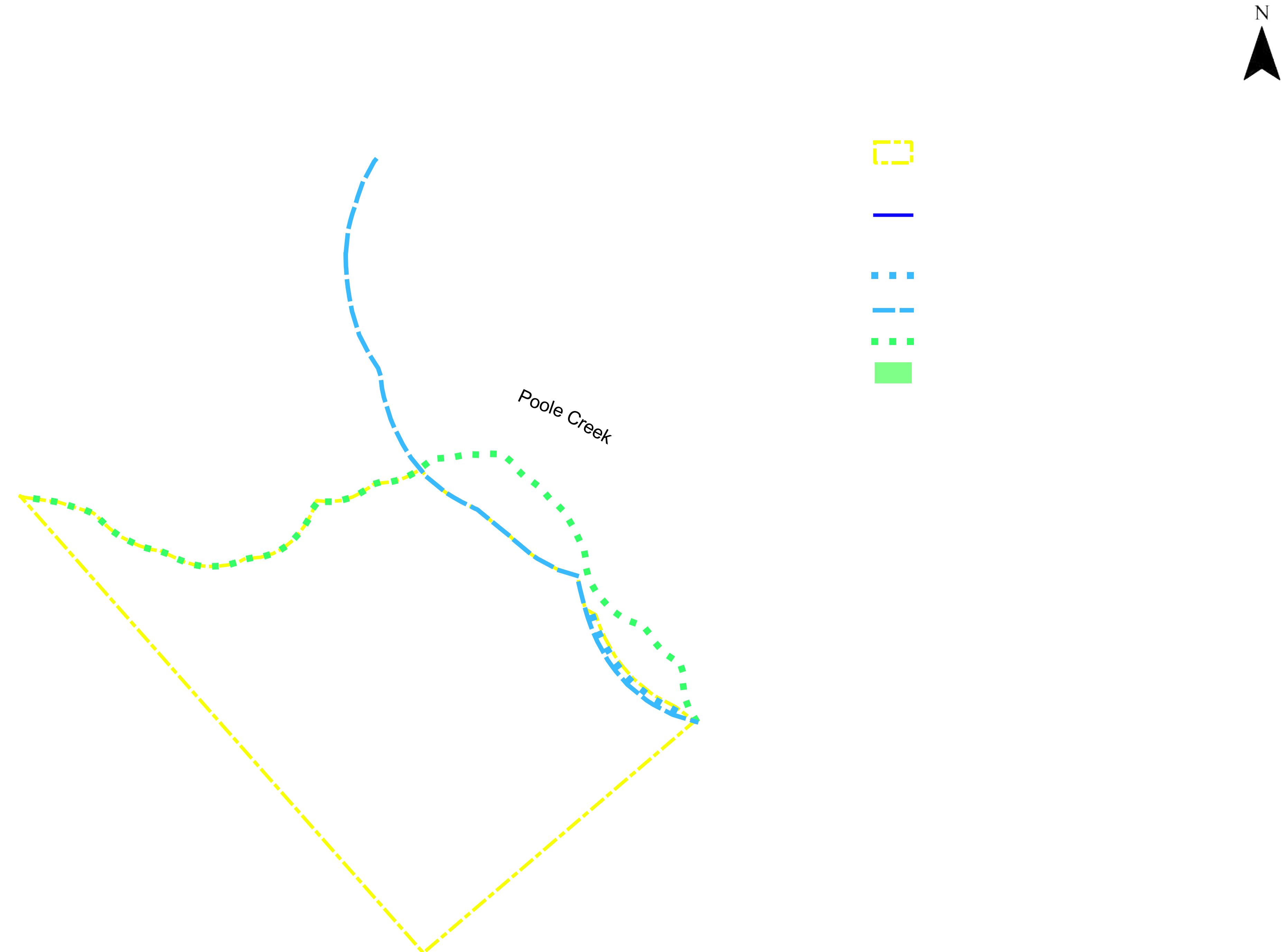
1.2 Site Description

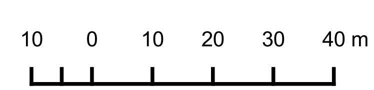
The Wildpine Trails development is located on a ≈2.1 ha parcel of land that is bounded by existing residential parcels to the west on Ravenscroft Court and south on Wildpine Court, a strip mall to the north and Poole Creek to the east.

Located on the site is a gravelled cul-de-sac turning area connected along the southern boundary to Wildpine Court, a single detached residential property with separate garage and shed buildings. Around the residential property and turning area is an open lawn area but the majority of the site is forested.

Part of the site is within the regulated floodplain of Poole Creek and/or the regulated limits of the non-evaluated wetland. The HIS will focus on the water balance on the extent of the site which can potentially be subject to development and that will potentially impact the operation of the wetland.

The proposed site development (per the May 2, 2023, Site Plan provided by Latitude Homes) will include a four-storey apartment building with 94 rental units. The development site as a whole and study extents, referred to as 'the site' for this report, are shown in Figure 1-1.





PROJECT:

Hydrological Impact Study
Wildpine Trails, Ottawa ON

DRAWING:

Site Location and Study Extents

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DESIGN:	BP	JLR NO:	29803-000
DRAWN:	BP	DRAWING NO:	**Figure 1-1**
CHECKED:	GF		

2.0 Existing Conditions

2.1 Land Cover

The current site is divided into two (2) distinct land cover areas. The northern portion of the site is predominately forested with deciduous trees while the southern portion has open lawn space, a gravelled turning area and a single storey residential building with separate garage and shed. Given that the site has been in this condition since at least 1991, according to available aerial photography, then the current site land cover will be considered as existing condition.

2.2 Soil Conditions

EXP Geotechnical Engineers visited the site to undertake geotechnical investigations. Between visits in December 2020 and May 2021, 18, test holes have been dug across the site including 4 boreholes and 12 test pits. Groundwater levels were recorded when observed during each of the visits and infiltration testing was undertaken at five (5) locations during the visit in May 2021. The testing was consistent with the recommendations of the CVC/TRCA's publication entitled "Low Impact Development – Stormwater Management Planning and Design Guide, 2010". A report was prepared by EXP detailing the soil conditions and infiltration testing of the site.

A 100mm to 300mm deep topsoil was encountered at ground surface across the majority of the site. Fill was found across all the site, beneath the topsoil or at the surface, in a layer 1 to 3 metres thick. The fill was generally organic with cobbles, boulders, topsoil and tree roots found in all test holes with some construction debris found in some of the test pits.

Parts of the site, mainly to the north and east, had an organic silty sand to sandy silt layer composed of decayed wood and topsoil. The organics layer had depths ranging from 2 to 4 metres below the existing grade. This material was classed as organic silty sand to sandy silt (SM to ML) under the Unified Soil Classification System (USCS).

To the north and the east of the site, the material underlying the organics layer is a sandy silt (ML) with trace to some gravel extending to depths of 5 to 6 metres. The organics layer is not present in the south and west of the site which has glacial till underlying the fill. The glacial till layer extends to depths of 4 to 6 metres or deeper. The glacial till can be classified as silty sand with gravel (SM).

A summary of the soil parameters and values used for the water budget analysis is provided in Table 2-1. The approximate extent of each soil type for the purposes of the water budget assessment is based on Voronoi polygons around each test hole location is shown on Figure 2-1.

The infiltration rates listed in Table 2-1 are as per the measurements taken by EXP in May 2021 and are selected based on representation of the soil type and location within the site.

Table 2-1: Soils Summary

Soil Type	Moisture Content (%)	Organic Content (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Infiltration Rate (mm/hr)
Organics	89.4	14.4	0	59	34	7	131
Sandy Silt	-	-	0	36	59	5	14

Soil Type	Moisture Content (%)	Organic Content (%)	Gravel (%)	Sand (%)	Silt (%)	Clay (%)	Infiltration Rate (mm/hr)
Glacial Till	-	-	39	48	13		300

2.3 Topography and Drainage

The site has two (2) topography zones. The area to the south and west is a shelf gently sloping towards the northeast. Along the south and east, there is a steeper sloped section going towards either Poole Creek at the eastern edge and the Stittsville Wetland Complex to the northeast and east. The highest point of the site is at the connection point with Ravenscroft Court to the west.

The topography is shown in Figure 2-2 with the drainage divide between Poole Creek and the Wetland Complex to the north-east.

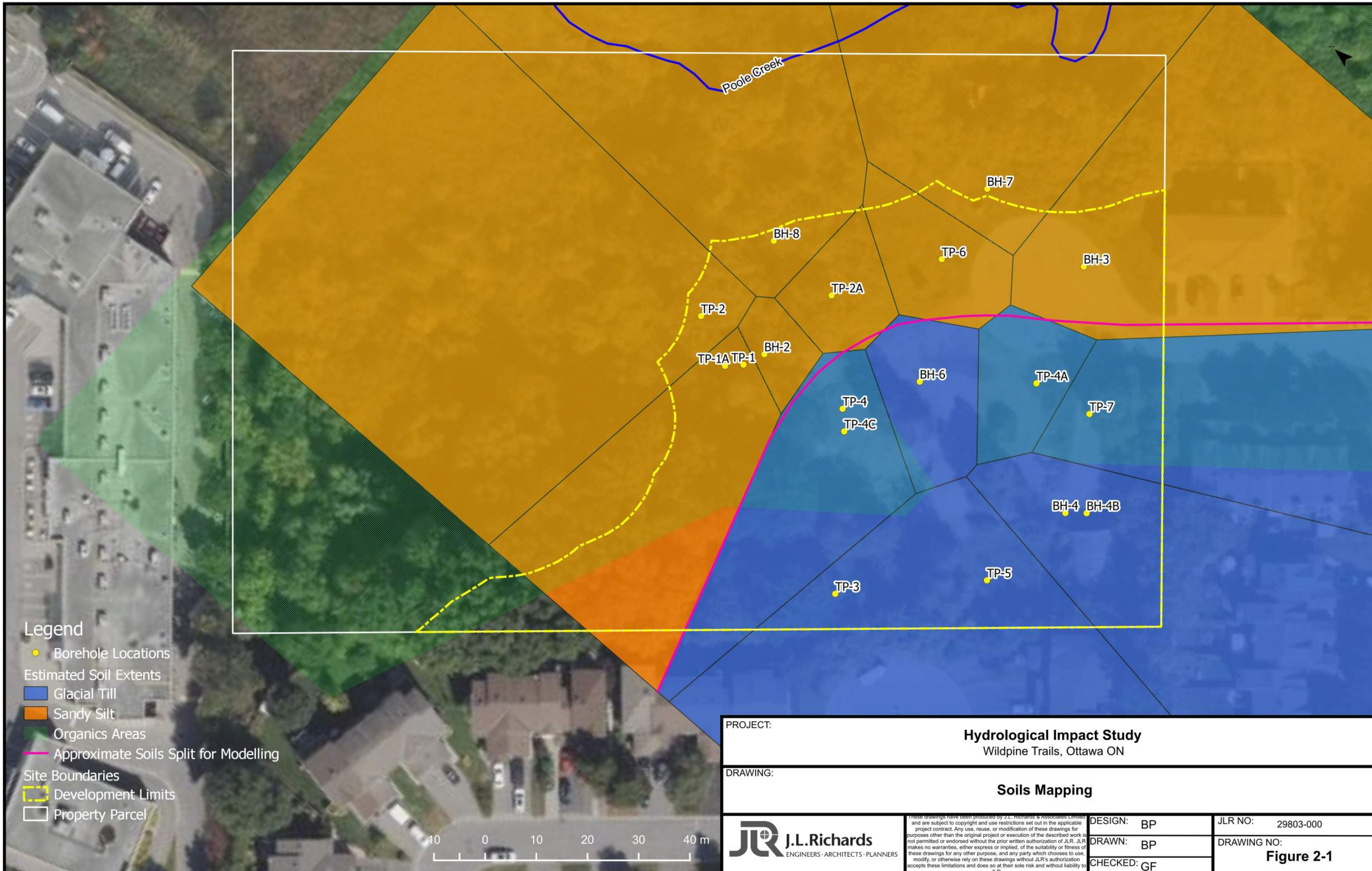
2.4 Groundwater

Groundwater measurements were recorded when observed by EXP in each of the test holes during both visits in December 2020, recorded 25 days later in January 2021, in May 2021, in March 2022 and every two weeks between January and May 2023. Figure 2-3 shows the highest recorded groundwater measurements at each of the test holes as well as the approximate divide in groundwater gradient to Poole Creek and the Wetland Complex.

2.5 Poole Creek

In May 2020, Marshall Macklin Monaghan submitted the Upper Poole Creek Subwatershed Study to the Township of Goulbourn. Although the extents of the study are to the north of the site (i.e., upstream each), the report provides some characterization of the watercourse. It is one of the few cold or cool water streams in the region; however, temperature impacts have been felt from increased stormwater management ponds in the subwatershed. The headwaters of the stream originate from wetlands while along the stream urban runoff from Stittsville contributes to the flow.

The development guidelines in the Subwatershed Study recommends for enhanced water quality protection which is equivalent to an 80% TSS removal and no quantity control is required for flooding or erosion is required except to meet sewer capacities.



PROJECT:

Hydrological Impact Study
Wildpine Trails, Ottawa ON

DRAWING:

Soils Mapping

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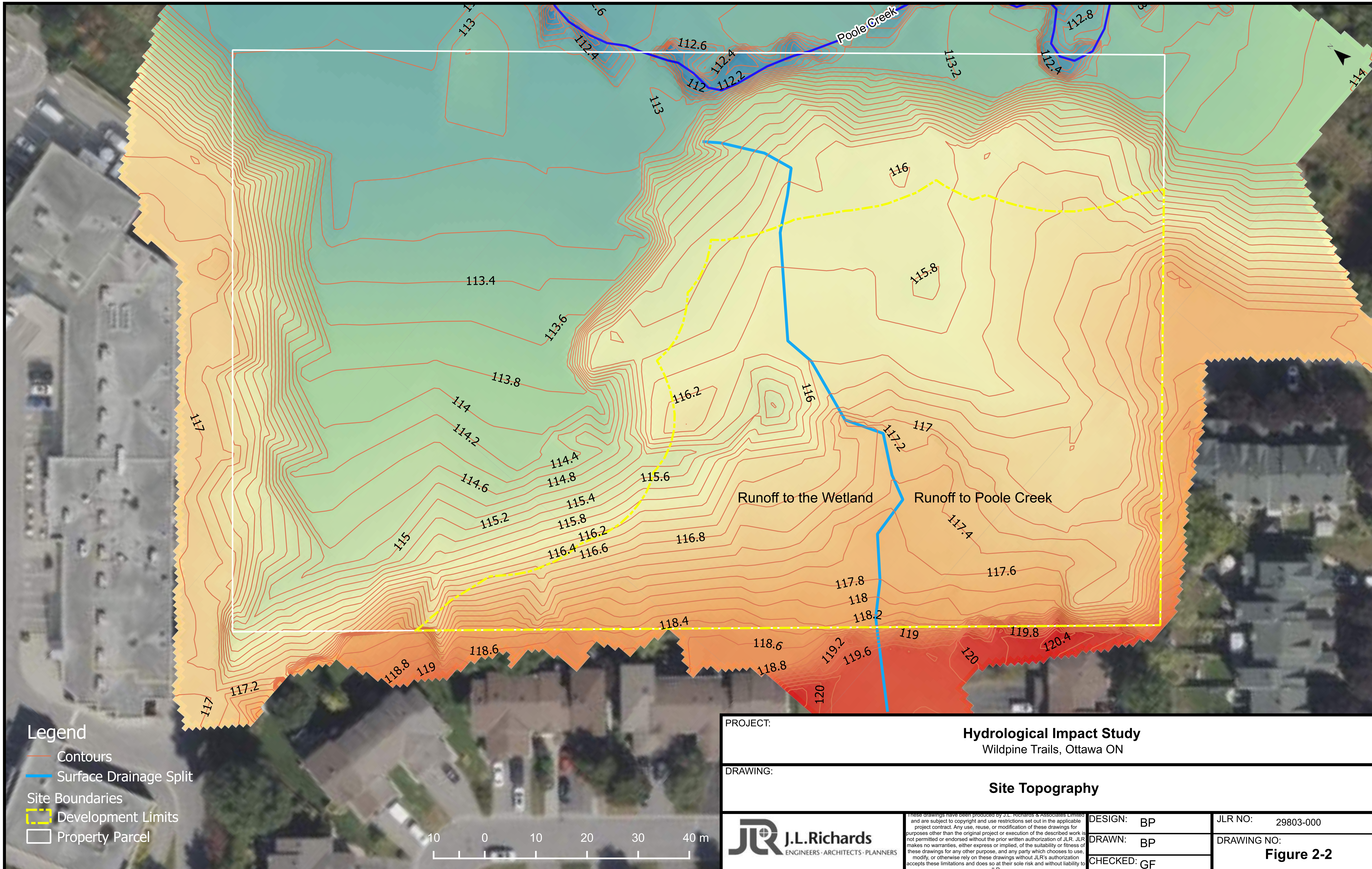
DESIGN: BP
DRAWN: BP
CHECKED: GF

JLR NO: 29803-000
DRAWING NO: **Figure 2-1**



PROJECT:

Hydrological Impact Study

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DRAWING:

Site Topography

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DESIGN:	BP
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JLR NO:	29803-000
DRAWING NO:	**Figure 2-2**

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DRAWING:

Groundwater Elevations

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DESIGN:	BP	JLR NO:	29803-000
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3.0 Proposed Conditions

The Wildpine Trails site development is for a 4-storey, 49-unit apartment building accessed off a new public right-of-way which will connect the cul-de-sacs at the end of Ravenscroft Court and Wildpine Court. In the corner lot created by the road connection it is proposed to include two semi-detached residential properties. The apartment unit is in an ‘L’ shape with the backs facing the wetland and Poole Creek. The underground parking garage will extend beyond the footprint of the apartment block to follow parallel to the lot boundary with the public right of way. Access to the underground garage will be via an access ramp to the east of the building.

As per the MVCA requirements, agreed with the developer, development may extend up to a 15-metre setback from the wetland delineation or up to 28 to 30 metres of the Top of Bank of the channel of Poole Creek. These setbacks were agreed between the MVCA, the developer and the biologist.

The layout of the future development is shown in Figure 3-1.

3.1 Grading and Drainage

The site is intended to be graded to an approximate elevation of 118 metres to match the existing grading at the connections with Wildpine Court and Ravenscroft Court. A single sag will be created in the public right-of-way with catchbasins connected to the minor system. Major overland flow on the public right-of-way will drain towards Wildpine Court while the drainage on the residential lot will drain towards the right-of-way and drainage on the apartment lot will be split between the wetland and Poole Creek. Grading will slope down to meet the existing ground at the 15-metre setback to the wetland.

3.2 Stormwater Management

3.2.1 Apartment Collection System

The lands at the front of the apartment building lot will be captured by the drainage system for the garage roof structure and conveyed through the building as part of the building mechanical system. The garage roof structure drainage will, together with the drainage system for the roof of the apartment building, will be discharged at ground level to the northwest of the building.

Runoff from the ramp and upstream grassed areas will be collected by the trench drain at the bottom of the ramp and be conveyed via the building mechanical system to discharge on the east side of the building.

3.2.2 Apartment Lot Site Drainage

The rear yard of the apartment complex will be graded towards the east and west. Flow from the grassed area will be conveyed via channels to two bioretention cells, one to the east alongside Poole Creek and one to the west along the boundary with the wetland. The stormwater from the building will also be discharged via the building outlets to the ditch drainage system to be conveyed to the bioretention cells.

The bioretention cells will consist of a 450mm ponding area controlled by a berm, which will act as a level spreader for large storm events to discharge to the downstream receiver. A 300mm deep filter media layer will facilitate plant growth and water quality treatment. Below the soil layer a 400mm deep storage layer of clearstone will hold stormwater prior to infiltration to the groundwater. The west bioretention cell which is along the wetland side of the site has a surface area of 105m² and the east bioretention cell, fronting Poole Creek, has a surface area of 90m². The bioretention cells are located within the setback limits of the site.

The east bioretention cell includes an underdrain and a liner for separation to the groundwater and will provide filtration. The west bioretention cell does not include an underdrain or liner and will exfiltrate into the underlying native soils.

3.2.3 Semi-Detached Residential and Wilpine Court

Drainage from the right of way and the semi-detached units will be conveyed via a minor system to connect to the existing minor system on Wildpine Court. ICDs will be placed at the catchbasins on the public right of way to control flows to the minor system design event. Rear yard flow from the residential units will be directed to a rear-yard superpipe with downstream control to limit the release rate from the units to around 6 L/s. Major system flow will utilise the right-of-way and existing major system overland flow paths to the outlet to Poole Creek at the bend in the existing section of Wildpine Court.

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Hydrological Impact Study

Wildpine Trails, Ottawa ON

DRAWING:

Future Development Configuration

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4.0 Water Balance

4.1 Approach and Methodology

An understanding of the water budget within the study area can be gained through the use of a continuous hydrological model, as recommended by the Toronto and Region Conservation Authority (TRCA). Based on their publication entitled "Stormwater Management Criteria, TRCA, August 2012", the use of a continuous model such as Qualhymo or PCSWMM is recommended (refer to Table 2-1 of the aforementioned publication).

PCSWMM will be used for this study and the model includes simplified groundwater and snowmelt modules which allow the continuous simulation of the water budget including the elements of evapotranspiration, the water table and snowfall and snowmelt.

A parameter-by-parameter description of the hydrological inputs to the model is contained in Appendix A. Model input mapping is shown in Figure 4-1.

The purpose of the model is to assess the water balance of the site and therefore drainage areas for the model have been restricted to include only the site limits, to determine differences between pre and post, and delineated to account for surface and groundwater runoff. It should be noted that this is different from the catchment delineation completed for the stormwater management servicing assessment, which needs to include hydraulic components, and therefore drainage areas in the continuous simulation models are not consistent with the DST drawing for the site.

Three models have been produced for the water balance assessment:

- PRE CONT – Continuous simulation of the pre-development condition;
- PRE POST – Continuous simulation of the post development condition without any mitigation measures; and,
- PRE LID - Continuous simulation of the post development condition with mitigation measures in place.

4.2 Model Inputs

4.2.1 Land Cover

Under the pre-development condition, the land cover has been taken as current conditions with the level of impervious set based on the cover set out in Table 4-1. Under post-development conditions, the land cover is predominately impervious surfaces due to the road and property construction.

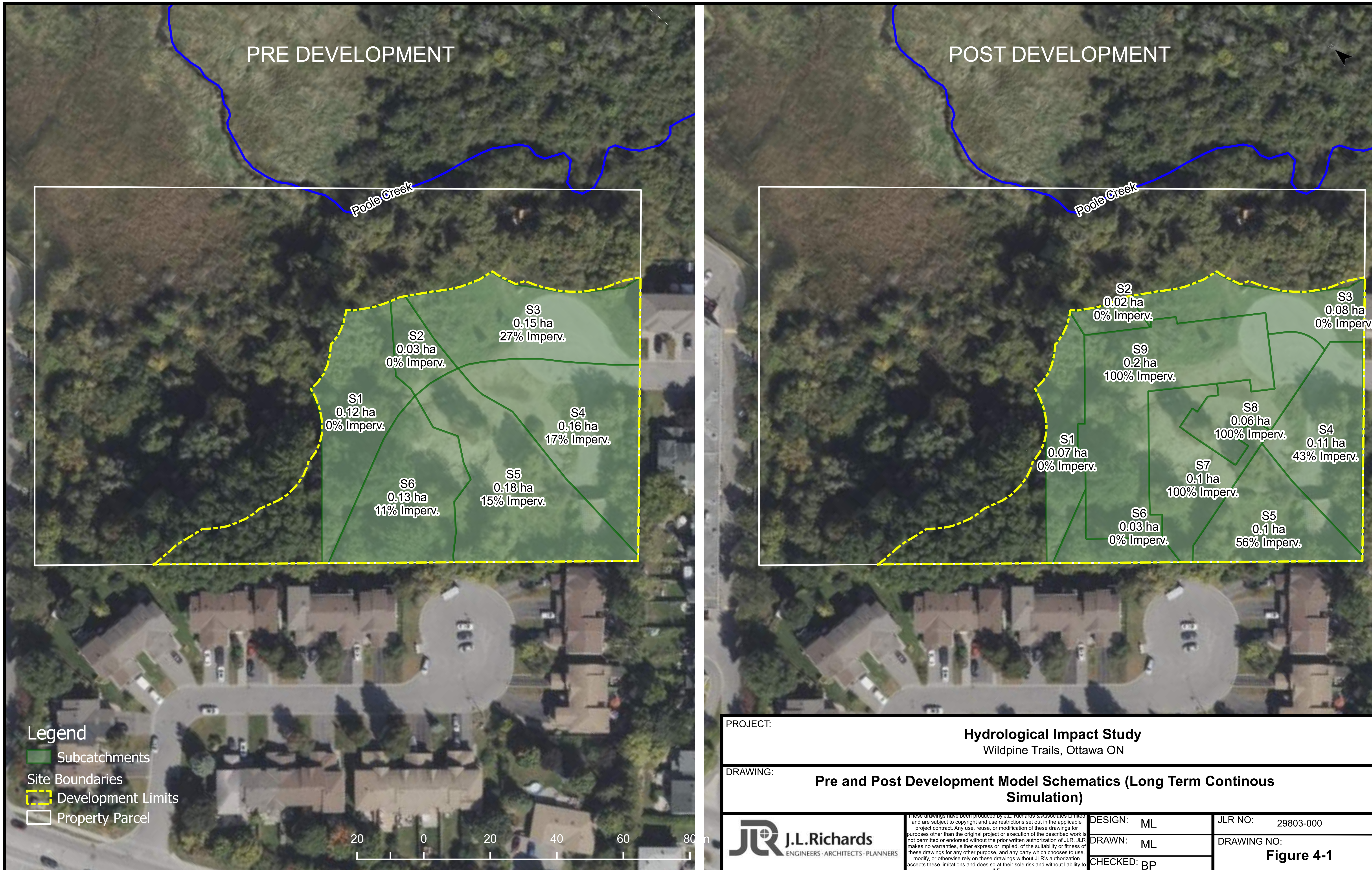
Table 4-1: Model Land Cover Inputs

Land Cover Type	Impervious (%)	Pre-Development Area (ha)	Pre-Development Area (%)	Post Development Area (ha)	Post Development Area (%)
Grassed	0	0.32	42	0.32	42
Forest	0	0.31	40		

Land Cover Type	Impervious (%)	Pre-Development Area (ha)	Pre-Development Area (%)	Post Development Area (ha)	Post Development Area (%)
Gravel	75	0.08	10		
Roof	100	0.06	8	0.36	47
Street	100			0.08	10
Driveway	100			0.01	1
TOTAL		0.77	100	0.77	100

It should be noted that in the table, areas covering the underground garage roof structure have been identified as roof as no infiltration will occur and all flows will be captured in the building drainage system.

The average impervious under the pre-development condition is 5% while under the post development condition the average imperviousness across the site, including the areas draining to Poole Creek, increases to 58%.



PROJECT:

Hydrological Impact Study

Wildpine Trails, Ottawa ON

DRAWING:

Pre and Post Development Model Schematics (Long Term Continous Simulation)

J.L.Richards
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DESIGN:	ML	JLR NO:	29803-000
DRAWN:	ML	DRAWING NO:	**Figure 4-1**
CHECKED:	BP		

4.2.2 Topography, Soils and Groundwater

The model has been delineated into subcatchments based on the overland flow directions, groundwater flow and soils divides. It has been assumed that the organics is present in the north-east of the site and is consistent with the divide between the glacial till and underlying sandy silts. Under the pre-development conditions, it is assumed that the organics are present across the site; however, under post-development the organics have been removed and the underlying sandy silts are the governing soil group within the disturbed areas.

Groundwater levels in the aquifers are based on the average groundwater elevation across the subcatchment. The SWMM 5.0 engine analyzes groundwater flow for each subcatchment independently. It represents the subsurface region beneath a subcatchment as consisting of an unsaturated upper zone that lies above a lower saturated zone. The elevation of the lower saturated zone, the water table, varies in time depending on the rates of inflow and outflow of the lower saturated zone. The flow to the lower saturated zone is controlled by percolation, which is dictated by the soils data. The upper unsaturated soil zone receives water via infiltration from surface runoff. Evapotranspiration occurs from the upper unsaturated zone and can occur from the lower saturated zone depending on root depth. If the water table, or elevation of the lower saturated zone, reaches the surface level then as the soil becomes saturated, infiltration will be declining to a point where it will no longer occur.

Soil parameters are described in Appendix A and are consistent with the soil types and infiltration rates summarized from the geotechnical report in Section 2.2.

Percolation rates for each of the proposed bioretention cells were determined from field testing undertaken by EXP on November 2, 2023. Testing was undertaken at each of the bioretention cells, and the results are shown in Table 4-2 below. The model rate applied for the west bioretention cell is calculated from the average of the two tests, 18.2 mm/hr, which is greater than 15 mm/hr, then a factor of safety of 2.5 applied. The testing results for the east bioretention cell is too low for infiltration and so this cell is a filtration cell with an impermeable linear and an underdrain releasing to Poole Creek.

Table 4-2: Bioretention Cell Percolation Rates

Test Location	Soil Type	Percolation Rate (mm/hr)	Model Rate (mm/hr)
West Bioretention Cell 1	Silty Sand with organics, cobbles and some gravels.	28.3	7.28
West Bioretention Cell 2	Silty Sand with organics, cobbles and some gravels.	8.1	
East Bioretention Cell 1	Silty Sand with organics, cobbles and some gravels.	2.7	-

4.2.3 Climate Data

The continuous simulation model input precipitation is from the Environment Canada weather station at the Experimental Farm in Ottawa, “CDA”. Twenty (20) years of hourly precipitation data, between April 19, 2004 and April 10, 2024, is used in the model with the average annual rainfall during the period being 820 mm/year. Maximum and minimum daily temperatures from the same weather station and time period are also entered into the model.

The model simulates evaporation based on average monthly rates from Environment Canada Monthly Normals for the same station.

Snowmelt is an additional mechanism by which runoff may be generated in a continuous simulation model. The current SWMM implementation utilizes the Canadian SWMM snowmelt routines with extensions for long term continuous modelling.

Snowfall rates are determined directly from hourly precipitation data by using a pre-set temperature: snowfall will occur when the temperature is below the pre-set point and rainfall when above. Snowmelt is handled differently by the SWMM engine depending on the occurrence of rainfall. During rain on snowmelt events, the model takes into account the rainfall intensity and the air temperature as well as the saturation vapour pressure. When snowmelt occurs without any rainfall, the snowmelt is linearly proportional to the air temperature, which varies with the user supplied melt coefficients.

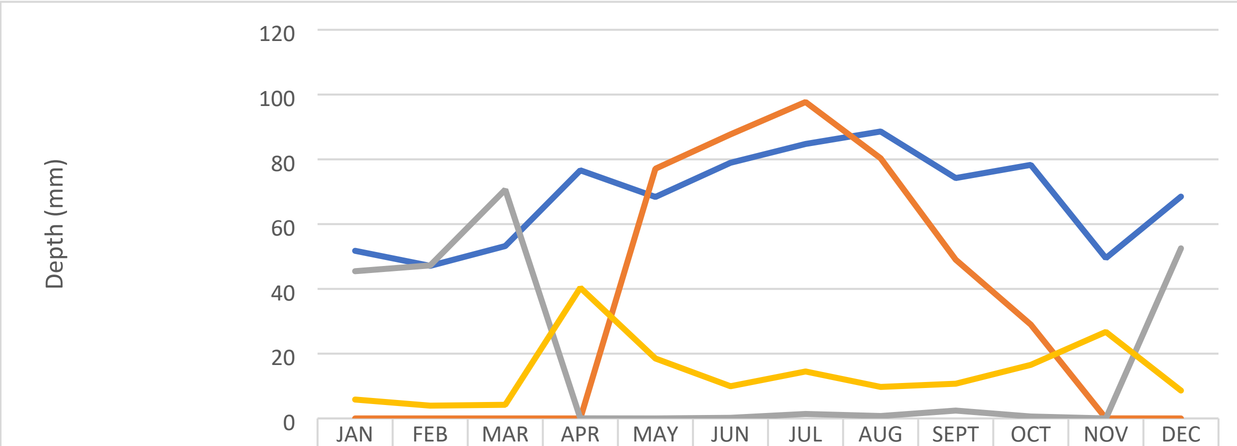
For the pre-development model, it has been assumed that all snow occurs on pervious land cover and there is no snow removal or grit operations. The post-development model assumes that the roads are cleared, and snow hauled off-site.

4.3 Model Results

4.3.1 Pre-Development

The water budget results for the pre-development condition across the site are shown in Figure 4-2 and Table 4-3. Note that the values in the table and graphs sum to the rainfall plus or minus the modelling errors.

Figure 4-2: Pre-Development Continuous Simulation Monthly Average Results



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Rainfall	52	47	53	77	68	79	85	89	74	78	50	68
Evapotranspiration	0	0	0	0	77	88	98	80	49	29	0	0
Runoff	45	47	71	0	0	0	1	1	2	1	0	53
Infiltration	6	4	4	40	19	10	14	10	11	17	27	9

Table 4-3: Pre-Development Continuous Simulation Annual Average Results

Water Budget Component	Annual Average Depth (mm)	Percent of Water Budget (%)
Rainfall	820	100%
Evapotranspiration	421	51%
Runoff	221	27%
Infiltration	170	21%

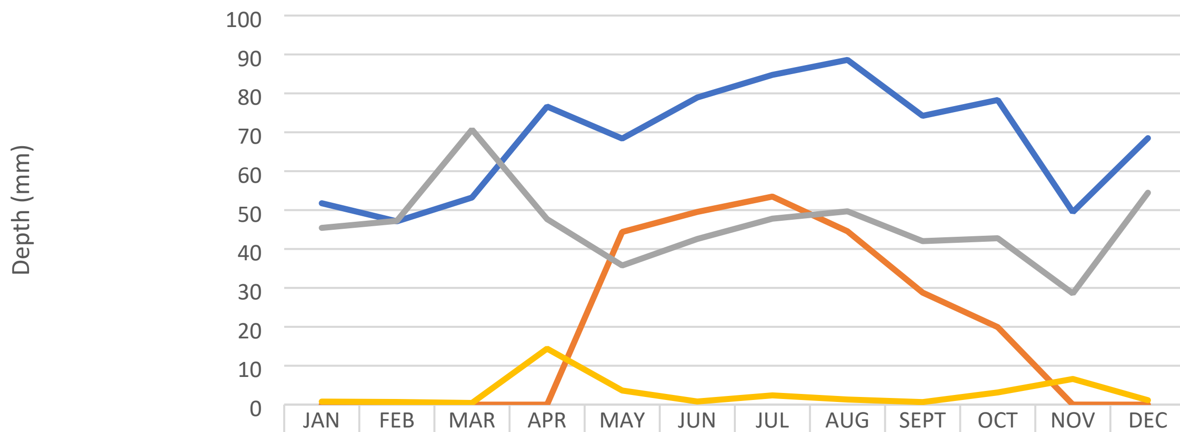
The Evapotranspiration component includes evaporation from the surface as well as transpiration from the vegetation in uptake of moisture through the soil in the upper and lower zones.

Infiltration includes only surface infiltration into the soil zone and excludes any infiltrated runoff that is then subject to transpiration.

4.3.2 Post Development

Under the post-development condition, with no mitigation measures, the water balance simulation results for the site are shown in Figure 4-3 and Table 4-4. Note that the values in the table and graphs sum to the rainfall plus or minus the modelling errors. The post-development scenario includes removal of the organics on the development land area to the north of the site as well as applying a 2.5 factor reduction factor to the horton infiltration rates in the development extents as per Credit Valley Conservation Authority LID guidance to allow for increased compaction as a result of earthworks and construction. This approach is conservative as it reduces the effectiveness of the infiltration.

Figure 4-3: Post Development (no mitigation) Continuous Simulation Average Monthly Results



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Rainfall	52	47	53	77	68	79	85	89	74	78	50	68
Evapotranspiration	0	0	0	0	44	50	53	45	29	20	0	0
Runoff	45	47	71	48	36	43	48	50	42	43	29	54
Infiltration	1	1	0	14	4	1	2	1	1	3	7	1

Table 4-4: Post Development (no mitigation) Continuous Simulation Annual Average Results

Water Budget Component	Annual Average Depth (mm)	Percent of Water Budget (%)
Rainfall	820	100%
Evapotranspiration	241	29%
Runoff	555	68%
Infiltration	36	4%

The impact of the increased impervious surface results is an increase in runoff on average of 334 mm per year while infiltration rates is reduced by an average of 134 mm per year. Mitigation measures are, therefore, required to increase overall infiltration from the site.

4.4 Mitigation Modelling

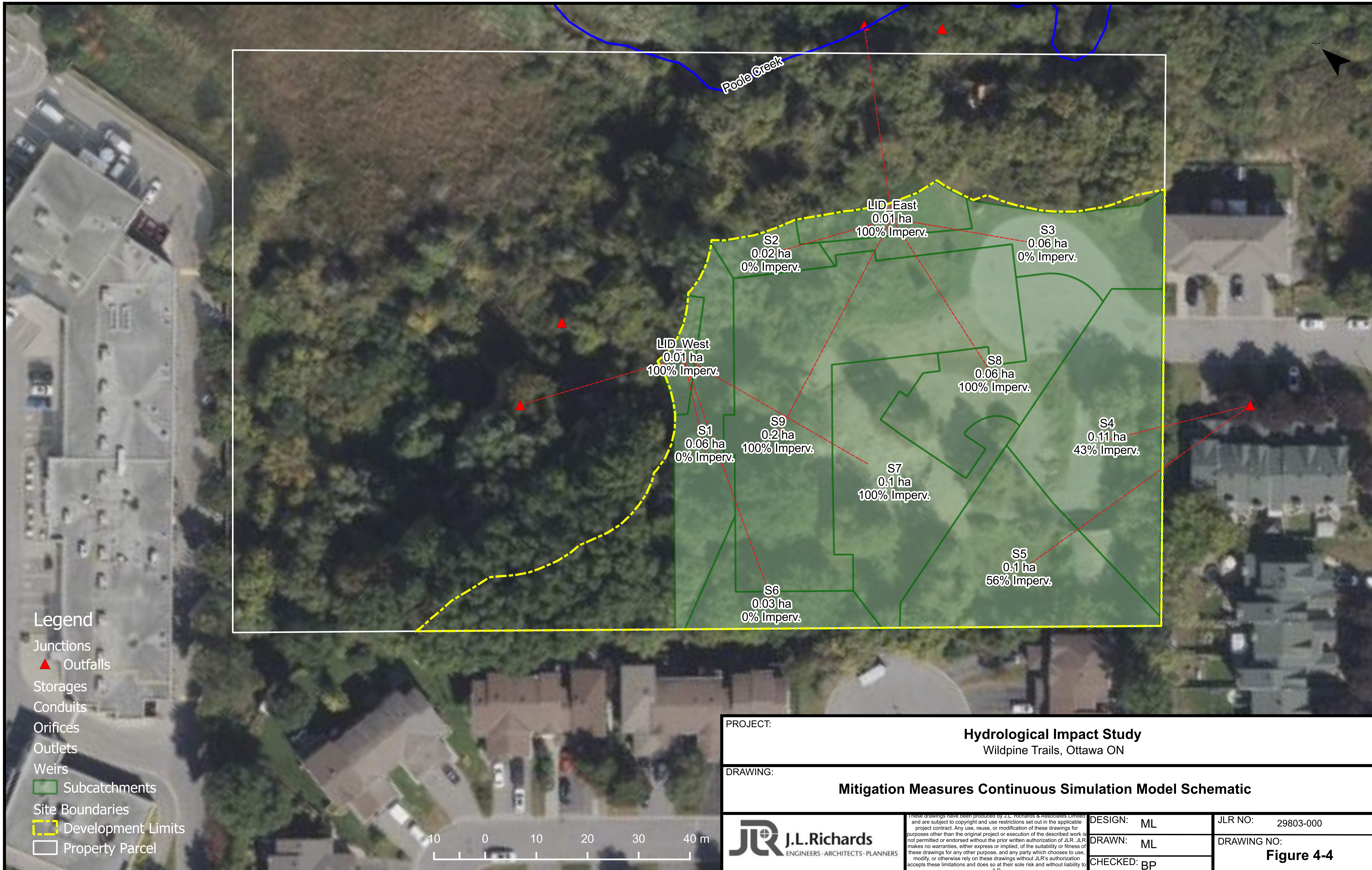
4.4.1 Model Inputs

The long-term continuous simulation model of the mitigation measures across the site is similar to the pre- and post-development models except that:

- As per the post-development model (no mitigation), it is assumed that the organics layer has been removed across the development extents and the underlying sandy silt layer is the critical soil component.

- Under post development the subcatchments reflect that the majority of the site is conveyed via the building structure.
- In order to facilitate model run time, internal conveyance by the minor system network or building conveyance system has been removed and the flows are directed straight to the downstream receiver or the bioretention cell.

The model schematic with the mitigation measures included is shown in Figure 4-4.



PROJECT:

Hydrological Impact Study

Wildpine Trails, Ottawa ON

DRAWING:

Mitigation Measures Continuous Simulation Model Schematic

J.L.Richards ENGINEERS · ARCHITECTS · PLANNERS

DESIGN: ML
DRAWN: ML
CHECKED: BP

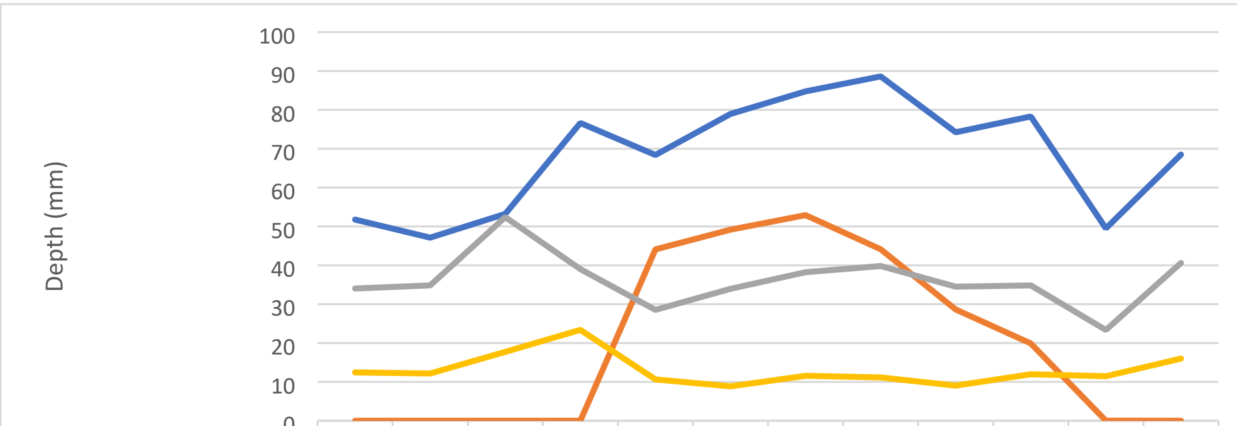
JLR NO: 29803-000

DRAWING NO: **Figure 4-4**

4.4.2 Mitigation Water Budget Results

The results for the water budget continuous simulation with the mitigation measures in place are shown in Figure 4-5 and Table 4-5 below. Note that the values in the table and graphs sum to the rainfall plus or minus the modelling errors.

Figure 4-5: Post Development (with mitigation) Continuous Simulation Average Monthly Results



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
Rainfall	52	47	53	77	68	79	85	89	74	78	50	68
Evapotranspiration	0	0	0	0	44	49	53	44	29	20	0	0
Runoff	34	35	52	39	29	34	38	40	35	35	23	41
Infiltration	12	12	18	23	11	9	12	11	9	12	11	16

Table 4-5: Post Development (with mitigation) Continuous Simulation Annual Average Results

Water Budget Component	Annual Average Depth (mm)	Percent of Water Budget (%)
Rainfall	820	100%
Evapotranspiration	239	29%
Runoff	434	53%
Infiltration	156	19%

The simulation results have shown that the mitigation measures are found to increase the infiltration capacity of the site to around pre-development levels and reduce runoff. Infiltration levels reduce overall from 170mm annually, 21% of the water budget, to 156mm annually, 19% of the water budget. Due to the lack of infiltration capacity in the underlying soils in the location of the eastern bioretention cell this cell only filtrates runoff for water quality and to extend the duration of runoff to Poole Creek. The majority of the mitigation infiltration occurs at the west cell, adjacent to the wetland. Further increases of infiltration at the west cell may skew the water budget to the wetland. Isolated comparison of the water budget to the wetland is provided in Section 5.2. The majority of increase in runoff occurs from the catchment to the east bioretention cell, which discharges to Poole Creek. The impact on Poole Creek from increased flows is considered in the Assessment of Adequacy of Public Services Report (JLR, 2024), Section 4.7.1.

4.4.3 Operation of Mitigation Measures

As part of the stormwater management design process documented in the Assessment of Adequacy of Public Services Report (JLR, 2024), the mitigation measures were simulated under a range of design event storms, including the 1:2 year, 1:5 year, 1:10 year and 1:100 year 3-hour Chicago and the 1:2 year 24-hour SCS and 1:100 year 24-hour SCS events. The operation of the bioretention cells controls the site to pre-development release rates, or below, to the downstream receivers. The berm from the bioretention cells will overtop in the 1:10 year event or greater to the wetland, or in the 1:2-year events to Poole Creek. Overflow rates are no greater than 42 L/s for either cell in the largest event and velocities over the level spreader berm are less than 0.26 m/s to minimise erosion impacts.

5.0 Impacts

5.1 Groundwater Conditions

Groundwater, when encountered in the boreholes, was recorded at elevations of around 113.68 metres or greater than 1 metre below the proposed bioretention cell depths. As such, it is not anticipated that the bioretention cell will adversely impact groundwater in the area as this system is perched by more than 1 metre. Infiltration rates with the mitigation measures in place are such that recharge of groundwater will be maintained to pre-development levels.

Table 5-1: Groundwater level comparisons

Bioretention Cell	Highest Groundwater Recorded (m)	Bottom Elevation of LID (m)	Difference (m)
West Cell	113.68	115.05	+1.37
East Cell	113.16	115.0	+1.84

5.2 Wetland Impacts

Section 4.4.2 above demonstrated that overall, across the site, the water balance is maintained to pre-development levels with the incorporation of the LID bioretention cell mitigation measures. To assess the impacts on the wetland the results from the model for those catchments draining to the wetland have been isolated and are shown in Table 5-2 and Figure 5-1.

Table 5-2: Site Catchments to Wetland Water Balance

Water Budget Component	Pre-Development Annual Average Depth (mm)	Pre-Development Percent of Water Budget	Mitigated Post Development Annual Average Depth (mm)	Mitigated Post Development Percent of Water Budget
Rainfall	820	100%	820	100%
Evapotranspiration	351	43%	246	30%
Runoff	223	27%	13	2%
Infiltration	274	33%	550	67%

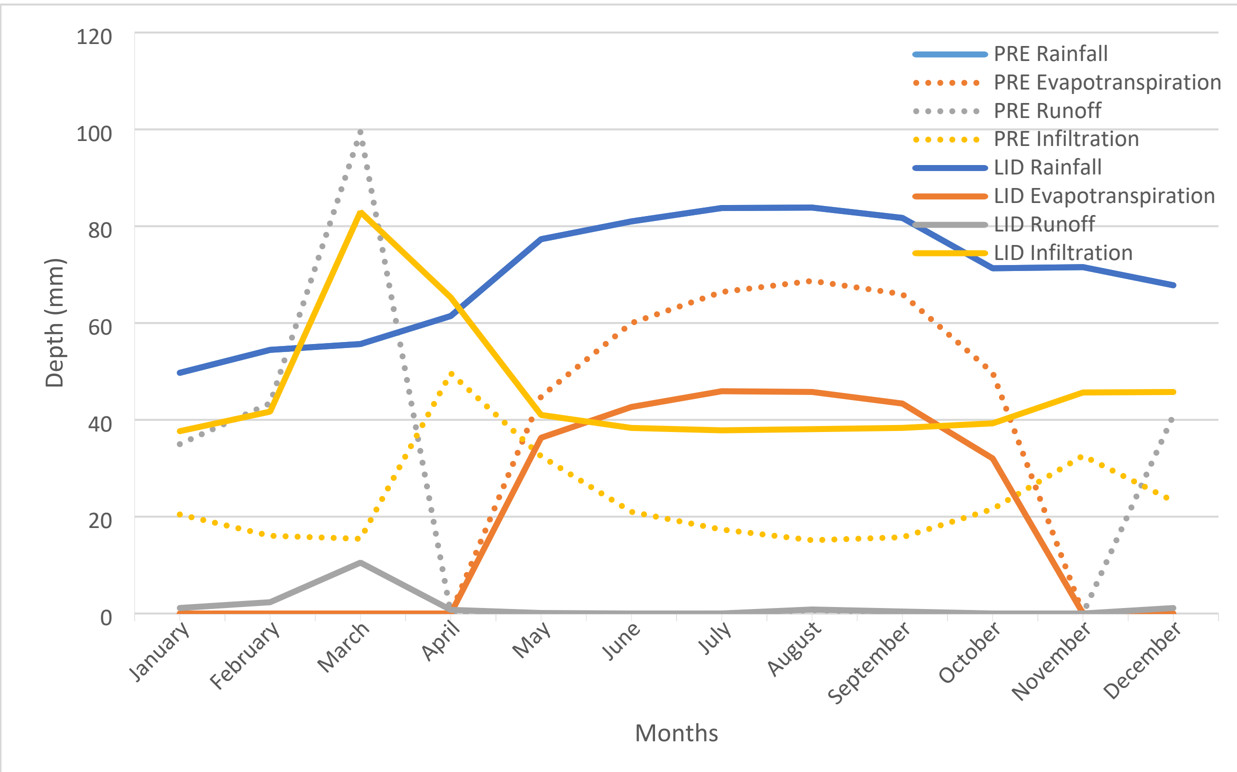
Note that values in Table 5-2 sum to 100% plus or minus the modelling error.

The overall volume of runoff going to the wetland increases slightly due to the reduced evaporation from the developed area. Pre-development a combined 497 mm, 61%, of annual rainfall either infiltrated or directly flowed towards the wetland. Following development with the LID measures the volume of precipitation to the wetland increases to 562 mm, or 69%, of annual rainfall is conveyed to the wetland. The increase occurs during the summer months and there is shown to be a slight reduction in flow to the wetland potentially in the winter months.

The reduction in flow during the winter months occurs when the vegetation in the wetland is predominately dormant and therefore the wetland should not be impacted. In the summer months it is understood that where there is augmentation of tree cover in the urban area then this is being carried out with a majority of Red and/or Silver Maples and an additional minimum of 12 trees of other species including a mix of Tamarack, Balsam Fir and Bur Oak as the recommended candidate species for replacement trees in the Tree Conservation Report (KAL, 2024). The Red and Silver Maples tree species prefer wetter soils compared to the, now mostly missing, Ash and Manitoba Maple trees, and therefore the increase in soil moisture would be a net positive gain for the area with the new species mix that is recommended for the area.

Overland flow to the wetland will be via the level spreader from the LID which will mitigate the potential erosion impacts along the slopes to the wetland.

Figure 5-1: Site Catchments to Wetland Water Balance Monthly Breakdown



5.3 Environmental Impacts

The site has maintained a 15-metre buffer to the wetland and the stormwater management measures have been predominantly kept within the development area and are outside of any treed areas. The approach is consistent with the Environmental Impact Statement and, therefore, there should be no measurable environmental impacts on the wetland.

6.0 Summary

The proposed development at Wildpine Trails will result in increased runoff and reduced infiltration in the water budget for the site. However, the long-term continuous simulation modelling has shown that the mitigation measures proposed in the stormwater management for the site, including the infiltration trench and outlet control, will increase infiltration beyond what is currently experienced and impact on the wetland will be minimal.

J.L. RICHARDS & ASSOCIATES LIMITED

Prepared by:	Reviewed by:
	April 22, 2024
Mathieu Lacelle EIT Civil Engineering Intern	Bobby Pettigrew P.Eng. Associate, Senior Water Resources Engineer

Appendix A

Hydrological Input Parameters

PCSWMM Hydrologic Model Parameters

The following sets out a description of each of the parameters used in the continuous simulation modelling for the water balance assessment. Any differences from the below at any of the specific elements are noted in the description in the model.

The continuous simulation is different from the event modelling for the servicing assessment and the parameters values described below do not necessarily reflect the event modelling.

Only those elements which impact the soil infiltration affect the continuous simulation model and to save run time the continuous simulation model has much of the sewer network and major system network removed. The pond is maintained in the continuous simulation model as it is intended to provide addition infiltration into the soils and groundwater table as a post development mitigation measure.

1.0 Subcatchments

1.1 General Parameters

Parameter	Units	Description / Values
Name	-	Subcatchments are numbered sequentially with the prefix 'S'.
Tag	-	No tags have been used for the subcatchments.
Rain Gauge	-	The 20 year data was used from the Environment Canada weather station at the Experimental Farm.
Outlet	-	The downstream major system node to which the subcatchment overland flow drains.
Area	ha	The area is calculated internally by PCSWMM and the value varies.
Width / Flow Length	m	Widths have been calculated by assessing the width of the overland flows across the catchment.
Slope	%	Under the pre-development condition the slope is set at the average slope on the DEM underlying the catchment. In the post development condition the developed catchments have the slope set at 3%.

Parameter	Units	Description / Values
Imperv	%	The percent impervious is area weighted based on the following percent impervious for the various land uses: **Land Cover** — **Impervious (%)** Open Space — 0 Gravel — 75 Roof — 100 ROW — 100
N Imperv	-	A constant of 0.013 is selected as the Manning's N for impervious surfaces such as roads, sidewalk and parking areas. The value is representative of smooth impervious surface as per Table 3-5 of the EPA Storm Water Management Model Reference Manual Vol I – Hydrology (EPA, 2016).
N Perv	-	A constant of 0.25 is selected as the Manning's N for pervious areas. The value is representative of light to tense turf land cover as per Table 3-5 of the EPA Storm Water Management Model Reference Manual Vol I – Hydrology (EPA, 2016).
DStore Imperv	mm	A constant of 1.57 mm is used as the impervious depression storage as per the OSDG Section 5.4.5.4.
DStore Perv	mm	A constant of 4.67 mm is used as the impervious depression storage as per the OSDG Section 5.4.5.4.
Zero Imperv	%	This is the percent of impervious surface that has no depression storage and is usually applied to areas of water. It has not been applied here.
Subarea Routing	-	The constant 'PERVIOUS' is entered to simulate the subarea of impervious surface, such as the rear part of roofs, which may flow over pervious areas prior to discharging to the outlet of the subcatchment.

<table>
<tr><th>Parameter</th><th>Units</th><th>Description / Values</th></tr>
<tr><td>Percent Routed</td><td>%</td><td>The percentage of impervious area which is routed across the pervious area. The percentages are area weighted in PCSWMM based on the following impervious types:
<table><tr><th>Land Cover</th><th>Percent Routed</th></tr><tr><td>Open Space</td><td>100</td></tr><tr><td>Gravel</td><td>100</td></tr><tr><td>Roof</td><td>50</td></tr><tr><td>ROW</td><td>0</td></tr></table></td></tr>
<tr><td>Infiltration</td><td>-</td><td>The Horton infiltration methodology is used, consistent with the City's OSDG. The Maximum Infiltration Rate for the Horton coefficients are as per the results of the EXP field testing of soil infiltration rates. The Minimum Infiltration Rate is taken from Akan 1993 for each of the soil types. The following values were used for each of the identified soil types:
<table><tr><th>Soil Type</th><th>Max. Infiltration Rate (mm/hr)</th><th>Min. Infiltration Rate (mm/hr)</th><th>Decay Constant (hr^{-1})</th></tr><tr><td>Organics</td><td>131</td><td>11.4</td><td>4.14</td></tr><tr><td>Sandy Silt</td><td>14</td><td>3.8</td><td>4.14</td></tr><tr><td>Glacial Till</td><td>300</td><td>7.6</td><td>4.14</td></tr></table>
For the post development conditions the values have been reduced by a factor of 2.5 in developed catchments as per guidance from the Credit Valley Conservation Authority and Toronto and Region Conservation Authority Low Impact Development Stormwater Management Planning and Design Guide Appendix C. The Guide states that a safety correction factor of 2.5 should be applied where there is a ratio between the mean measured infiltration rates of 1 or less. The safety factor represents the potential loss of infiltration due to compaction during construction and gradual accumulation of fine sediments.</td></tr>
<tr><td>Infiltration Pattern</td><td>-</td><td>An infiltration pattern has been applied to the subcatchments so that there is no infiltration during the months of January, February, March or December when average temperatures are below freezing and the ground is considered impervious as it is frozen. During the other months full infiltration is simulated.</td></tr>
</table>

The parameters Curb Length, LID Controls and Erosion are not used in the model.

1.2 Snowmelt

Parameter	Units	Description / Values
Dividing Temperature	°C	The temperature below which precipitation will fall as snow. Generally accepted as being 0°C. Value: 0
Snow Capture Factor	Fraction	It is assumed that the data from Environment Canada has captured all snowfall in the gauges. This factor can be used to increase snowfall where the gauges may not be accurate. Value: 1.0
ATI Weight	Fraction	Applied over the entire subwatershed, the ATI weighting factor is an indication of the thickness of the surface layer of snow. A low value will indicate a thicker surface layer with weighting to temperatures over the previous week while a value closer to 0.5 will indicate a normal surface layer. The lower the ATI Weight the snow will cool and warm more slowly. A value of 0.5 has been found to give reasonable results in watersheds and has been used here. Value: 0.5
Negative Melt Ratio	Fraction	The effect of the heat transfer during non-melt periods and the standard value is used. Value 0.6
Elevation above MS	m	The elevation will affect atmospheric pressure for the melt calculations. Value: 113
Latitude	°	The latitude will dictate the sunrise and sunset times in temperature calculations. Value: 45.0
Longitude Correction	minutes	Used to correct for in separation of the position of site versus the meridian of the standard time zone. This will have negligible effects. Value: 0

Parameter	Units	Description / Values
Melt Coefficients	mm/hr /°C	The Melt Coefficient has been taken from the AES snowmelt equations for southern Ontario (MNR Technical Guide Flooding Hazard Limit, 2002). The AES equations have a melt coefficient of 3.66 mm/day/°C for mean daily air temperatures. This equates to 0.1525 mm/hr/°C. Value: 0.153
Base Temperature	°C	The base temperature at which the snowpack will melt has been assumed as 0°C. A lower value could be used for rooftops where there will be heat transfer through the roof. Value: 0
Fraction Free Water Capacity	Fraction	Since snow is considered a porous medium some of the melt water may be contained within the snow pack. The fraction of the free water capacity is the fraction of the snow pack void space which will retain meltwater. This fraction is normally less than 0.1 and 0.05 has been used here to represent a deep snowpack. A value of 0.25 may represent a shallow slush layer. Value: 0.05
Initial Snow Depth	mm	The initial snow depth on the site is considered as zero. Value: 0
Initial Free Water	mm	Since there is no initial snow depth the initial free water has also been considered as zero. Value: 0
Depth at 100% Cover	mm	The snowmelt model assumes that there will always be a depth of snow above which there will be 100% coverage of the snow, even in areas which may be affected by shading, drifting of topography. Typical depths are 25 mm to 100 mm. Since the area is relatively open with limited shading then the lower end of the value range has been used. Value: 25

Parameter	Units	Description / Values
Fraction of impervious area that is plowable	fraction	It is assumed that for the developed areas where the 'future' snow pack is used that 20% of impervious areas will be plowed. Value: 0.2 For the area that is plowable the following parameters are applied: Depth at which snow removal begins (mm) 25.4 Fraction transferred out of the watershed 0.8 Fraction transferred to the impervious area 0.1 Fraction transferred to the pervious area 0.1 Fraction transferred into immediate melt 0.0 Faction moved to another subcatchment 0.0
Areal Depletion	Fraction	The areal depletion curve represents the area of snow cover for depths of the snow less than the depth at 100% coverage. Natural areal depletion curves are suggested by the software and are used here.

1.3 Groundwater

Used in the continuous simulation modelling only.

Parameter	Units	Description / Values
Aquifer Name	-	Name of the aquifer representing soil conditions. Three aquifers have been created to define the different soil types present in the site, approximated from Tables II, III, and IV in the Geotechnical Report by EXP. **Aquifer** / **Clay (%)** / **Sand (%)** / **Texture Class** Organics / 7 / 59 / Sandy Loam Sandy Silt / 5 / 36 / Silty Loam Glacial Till / 13 / 48 / Loam Texture Classes were taken from the SPAW Calculator texture class for the split of clay and sand components.
Receiving Node	-	Name of the receiving node for groundwater outflow to baseflow. This is based on the groundwater subwatershed delineation.

Parameter	Units	Description / Values
Surface Elevation	m	Elevation of the ground surface for the subcatchment was averaged from the surface DEM and varied per subcatchment.
Coefficients		The coefficients were set for the saturated groundwater zone to represent a storage reservoir where outflow is linear proportional to the water table depth without surface water interaction. The groundwater equation used is: $f_G = A1\ (d_L - h^*) - A2(h_{sw} - h^*)$ Where: f_G = groundwater flow dL = depth of the lower saturated subsurface zone h_{sw} = height of surface water above the bottom of the groundwater zone h* = height of bed of surface water above the groundwater zone $A1 = A2 = K_s/2L^2$ Where K_s = Soil saturated hydraulic conductivity L = Length of midpoint of catchment to the surface water channel
Surface Water Depth	m	Water surface elevation depths in relation to the catchment location and varies with subcatchment.
Initial Elevation	m	Initial elevation of the water table as per the EXP Geotechnical Investigations. Values vary per catchment.
		All other parameters used as per the receiving node or aquifer

1.4 Aquifer

Used in the continuous simulation modelling only.

Parameter	Units	Description / Values
Porosity	Fraction	The following values were used for the volumetric water content of the soil at saturation (i.e. volume of water per total volume): **Aquifer** — **Texture Class** — **Porosity** Organics — Sandy Loam — 0.453 Sandy Silt — Silty Loam — 0.501 Glacial Till — Loam — 0.463 *(Source: Table 4-7, (Rossman & Huber, 2016))*

<table>
<tr><th>Parameter</th><th>Units</th><th>Description / Values</th></tr>
<tr><td>Wilting Point</td><td>Fraction</td><td>This is soil moisture contact at which plants cannot obtain sufficient moisture from the soil to meet transpiration requirements and they will die. It is roughly equivalent to the moisture content of soil at 15 atmospheres. The following values were used:
<table>
<tr><th>Aquifer</th><th>Texture Class</th><th>Wilting Point</th></tr>
<tr><td>Organics</td><td>Sandy Loam</td><td>0.115</td></tr>
<tr><td>Sandy Silt</td><td>Silty Loam</td><td>0.100</td></tr>
<tr><td>Glacial Till</td><td>Loam</td><td>0.079</td></tr>
</table>
(Source: SPAW Calculator)</td></tr>
<tr><td>Field Capacity</td><td>Fraction</td><td>Considered to be the amount of water a well-drained soil holds after free water has drained off. The following values were used:
<table>
<tr><th>Aquifer</th><th>Texture Class</th><th>Field Capacity</th></tr>
<tr><td>Organics</td><td>Sandy Loam</td><td>0.267</td></tr>
<tr><td>Sandy Silt</td><td>Silty Loam</td><td>0.318</td></tr>
<tr><td>Glacial Till</td><td>Loam</td><td>0.187</td></tr>
</table>
(Source: SPAW Calculator)</td></tr>
<tr><td>Conductivity</td><td>mm/hr</td><td>Within the Aquifer Parameters, the soil saturated conductivity is a governing parameter of the percolation rate between the upper unsaturated soil layer and the lower saturated soil layer. This is not the same as any permeability rate used for the surface infiltration. The values have been selected from the SPAW calculator and are:
<table>
<tr><th>Aquifer</th><th>Texture Class</th><th>Conductivity</th></tr>
<tr><td>Organics</td><td>Sandy Loam</td><td>115</td></tr>
<tr><td>Sandy Silt</td><td>Silty Loam</td><td>126</td></tr>
<tr><td>Glacial Till</td><td>Loam</td><td>3.7</td></tr>
</table>
(Source: SPAW Calculator)</td></tr>
<tr><td>Conductivity Slope</td><td>-</td><td>Conductivity slope measures the rate at which a soil's hydraulic conductivity decreases with decreasing moisture content.
<table>
<tr><th>Aquifer</th><th>Texture Class</th><th>Conductivity Slope</th></tr>
<tr><td>Organics</td><td>Sandy Loam</td><td>18.7</td></tr>
<tr><td>Sandy Silt</td><td>Silty Loam</td><td>15.9</td></tr>
<tr><td>Glacial Till</td><td>Loam</td><td>28.9</td></tr>
</table></td></tr>
<tr><td>Tension Slope</td><td></td><td>Used for backward compatibility in the software and not used in this model</td></tr>
</table>

<table>
<tr><th>Parameter</th><th>Units</th><th>Description / Values</th></tr>
<tr><td>Upper Evaporation Factor</td><td>Fraction</td><td>This factor determines the fraction of available subsurface evaporation rate used in the upper subsurface zone (compared to the lower subsurface zone). A higher evaporation rate is associated with looser soils, lower water table elevations and shallow root zones. It was assumed that in all soils 80% of the available subsurface evaporation would be used in the upper zone due to the depth of the water table.

Value: 0.8</td></tr>
<tr><td>Lower Evaporative Depth</td><td>m</td><td>The depth of the lower subsurface zone which can be used for evapotranspiration should be approximate to the expected average depth of root penetration. This does not impact this type of model but the following values were used:

Aquifer | Texture Class | Lower Evaporative Depth
Organics | Sandy Loam | 2.3
Sandy Silt | Silty Loam | 5.2
Glacial Till | Loam | 3.7
(Source: Shah et al 2007 from EPA 2015)</td></tr>
<tr><td>Lower Groundwater Loss Rate</td><td>mm/hr</td><td>This is the rate of percolation from the lower subsurface zone to a deep aquifer and is approximate to the rate at which the water table elevation will drop over a prolonged dry period. The saturated hydraulic conductivity of a compacted clay soil was used in all cases however it does not affect the model.

Value: 0.004</td></tr>
<tr><td>Bottom Elevation</td><td>m</td><td>Taken as the average refusal or testhole depth from the EXP geotechnical investigations.

Value: varies</td></tr>
<tr><td>Unsaturated Zone Moisture</td><td></td><td>The moisture content of the unsaturated upper subsurface zone at the start of the simulation. Cannot be less than the wilting point and cannot be more that porosity. Assumed to be field capacity at the start of the simulation.

Aquifer | Texture Class | Unsaturated Zone Moisture
Organics | Sandy Loam | 0.267
Sandy Silt | Silty Loam | 0.318
Glacial Till | Loam | 0.187</td></tr>
</table>

Appendix B

Percolation Testing Results

November 7, 2023

Raad Akrawi
Project Manager
Heafey Group
768 Boulevard St-Joseph, Bureau 100
Gatineau, Quebec J8Y 4B8

Re: OTT-00263154-A0 Percolation Tests at 37 Wildpine Court, Stittsville site

Dear Mr. Akrawi:

EXP Services Inc. (EXP) is pleased to present you with the results of percolation tests at the 37 Wildpine Court site on November 2, 2023. The tests were performed at two (2) locations suggested by Bobby Pettigrew of JL Richard Associates.

We understand that this was completed to address City of Ottawa comment about the previously performed percolation test. The test on November 2, 2023 was performed using Guelph Permeameter. The test locations are presented in Figure 1. Three (3) tests were performed (two at Location 1 and one at Location 2). Guelph Permeameter (GP) was used for the tests.

The result of the test is summarized below:

Test Location	Soil Type tested	Percolation Rate in cm/sec	Percolation Rate in mm/hour
Location 1 • Test 1 • Test 2	Up to 40 cm depth silty sand with organics, cobbles with some gravels	6.48×10^{-4} 2.26×10^{-4}	28.3 8.1
Location 2	Up to 25 cm depth silty sand with organics, cobbles with some gravels	7.52×10^{-5}	2.7

Based on the above rate estimates Location 1 appears to be marginally suitable for bioretention infiltration basins as the native soil has a percolation rate of 28.3 mm/h. Location 2 with a percolation rate of 2.7 mm/hr is not suitable and infiltration enhancing measures may have to be considered to potentially increase the percolation rate.

As an example, considering a bioretention cell of 40 m length and 2 m width at Location 1 and hypothetical storm water volume of 50 m^3 with an estimated percolation rate of 28.3 mm/hr it will take about 2 days to infiltrate the stored 50 m^3 storm water. Typical percolation rates and soil types are provided in Table 4.4 (of the Stormwater Management Planning and Design Manual, MOE March 2003 195-stormwater-planning-and-design-en.pdf (ontario.ca). Table 4.4 should be used as a screening tool to determine if a site may be suitable for an infiltration basin.

To increase infiltration at the site some engineering measures may further be explored such as rain garden, bioswales, rain barrels etc.

Feel free to contact the undersigned if you have questions or concerns.

Sincerely,

EXP Services Inc.

Delwar Ahmed, P.Geo.
Senior Hydrogeologist
Earth and Environmental Services

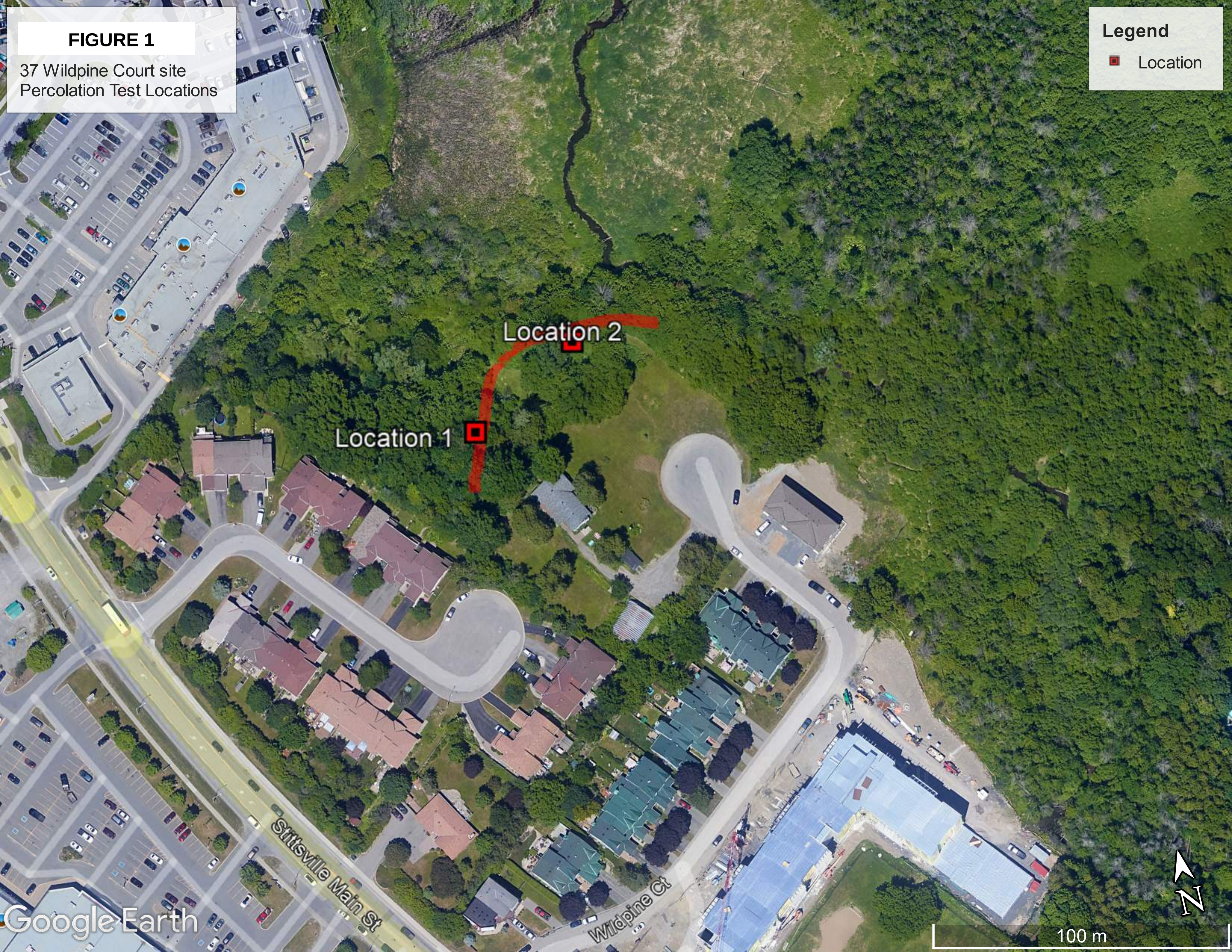


FIGURE 1

37 Wildpine Court site
Percolation Test Locations

www.jlrichards.ca

Ottawa

864 Lady Ellen Place
Ottawa ON Canada
K1Z 5M2
Tel: 613 728-3571

ottawa@jlrichards.ca

Kingston

203-863 Princess Street
Kingston ON Canada
K7L 5N4
Tel: 613 544-1424

kingston@jlrichards.ca

Sudbury

314 Countryside Drive
Sudbury ON Canada
P3E 6G2
Tel: 705 522-8174

sudbury@jlrichards.ca

Timmins

834 Mountjoy Street S
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P4N 7C5
Tel: 705 360-1899

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North Bay

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P1B 8L3
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Hawkesbury

326 Bertha Street
Hawkesbury ON Canada
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