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Hannan Hills Subdivision

Hydrologic Impact Study

Prepared for: 1384341 Ontario Ltd. (Cavanagh Developments)

Engineering excellence. Planning progress. Liveable landscapes.

Hydrologic Impact Study

Hannan Hills Subdivision

Almonte, ON

Prepared By:

NOVATECH
Suite 200, 240 Michael Cowpland Drive
Ottawa, Ontario
K2M 1P6

June 12, 2024
Revised May 27 2025

Novatech File: 118201
Ref: R-2024-046

May 27, 2025

Lanark County
99 Christie Lake Road
Perth, ON K7H 3C6

Attention: Koren Lam, Senior Planner

Reference: Hannan Hills Subdivision
Hydrologic Impact Study
Our File No.: 118201

Please find enclosed the report entitled "Hydrologic Impact Study" dated June 12, 2024 prepared in support of an amended application for Draft Plan approval for the Hannan Hills Subdivision.

This report has been revised based on comments received from the MVCA dated August 16, 2024.

This report is to be read in conjunction with the Environmental Impact Study (EIS, CIMA+, May 2025) and the Serviceability and Conceptual Stormwater Management Report (Novatech, May 27, 2025).

Yours truly,

NOVATECH

Alex McAuley, P.Eng.
Senior Project Engineer | Land Development Engineering

Cc: Cavanagh Developments
MVCA

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References

Environmental Impact Assessment (EIA) (Muncaster Environmental Planning Inc., May 14, 2021)
Environmental Impact Study (EIS, CIMA+, May 2025)
Serviceability and Conceptual Stormwater Management Report (Novatech, May 27, 2025)

Figures

Tables

Appendices

1.0 INTRODUCTION

Novatech has been retained by Cavanagh Developments to prepare a Hydrologic Impact Study (HIS) in support of an amended application for Draft Plan Approval for the proposed Hannan Hills Subdivision. This report has been revised based on comments received from the MVCA dated August 16, 2024.

1.1 Purpose

This report outlines the characteristics of the existing wetlands located on the subject property, the effects of the proposed development on these existing wetlands, and the proposed mitigation measures. This report has been prepared in response to the MVCA comments letter (September 20, 2021), in which the MVCA provided the following comment: "*A discussion of the current on-site hydrology will need to be coordinated with the EIS findings.*"

This report is to be read in conjunction with the Environmental Impact Study (EIS, CIMA+) and Serviceability and Conceptual Stormwater Management Report (Novatech). The EIS provides discussion on the environmental impacts on the wetland and the Serviceability and Conceptual Stormwater Management Report provides further discussion on implementation of mitigation measures.

1.2 Site Location and Description

The proposed Hannan Hills Subdivision is approximately 4.15 hectares (10.3 acres) in size and located in Almonte, within the Municipality of Mississippi Mills.

The site is bound by undeveloped lands to the north and the Spring Creek Municipal Drain runs adjacent to the east property boundary. The existing Mill Run Residential Subdivision is located immediately east of the Municipal Drain. The site abuts the road allowance for Adelaide Street to the south, with existing residential lands and a future subdivision (Menzie Enclaves) located on the south side of Adelaide Street. The site abuts Florence Street to the west, with existing residential lands on the west side of Florence Street.

Refer to **Figure 1 (Key Plan)** for the site location.

1.3 Existing Conditions

The existing lands, and those to the north, include non-evaluated wetlands. The property is located at the south / downstream end of these wetlands. The total area of the existing wetlands and the area of the on-site wetlands are shown in Table 1 below. The EIS (CIMA+) notes three wetland communities present, tall shrub swamp (willow), deciduous treed swamp (ash), and marsh (reed canary). Refer to **Figure 2 (Existing Conditions)** for an aerial photograph of the property.

Table 1: Area of Non-Evaluated Wetlands

	Total Area (ha)	Area within Subdivision Property Boundary (ha)	Percentage of Area within Property Boundary (%)	Approximate Area within Subdivision Property Boundary to Remain (ha)
Wetlands	46.5	2.69	5.8	0.36
30m Regulation Limit	68.4	3.37	4.9	1.19

There is an existing drainage channel (North Feature) which was constructed through the wetland to provide an outlet for the existing subdivision west of Florence Street adjacent to the north property boundary. There is an existing drainage channel (Spring Creek Municipal Drain) adjacent to the east property boundary, both of which drain along the perimeter of the existing wetland. The existing drainage feature/channel and ground surface topography are shown on **Figure 3 (Existing Topography)**.

The EIS (CIMA+) contains additional details on the existing site conditions, such as existing soil characteristics, existing drainage features, and qualitative descriptions of the existing wetlands.

Refer to **Figure 4 (Existing Non-Evaluated Wetlands and Drainage Courses)** for approximate limits of the existing wetlands.

1.4 Proposed Development

It is proposed to develop a residential subdivision of 106 townhomes and four single family homes. The development would include three connections to the proposed extension of Adelaide Street and a connection to existing Florence Street which would be upgraded as part of this development. A pedestrian connection would be made to the existing Mill Run Subdivision to the northeast east via a pathway from Adelaide Street to Honeyborne Street. Refer to **Figure 2 (Existing Conditions)** for the proposed lotting and street layout.

The proposed development would maintain the general surface drainage pattern and drainage split between drainage to the Spring Creek Municipal Drain and the North Feature running from west-to-east along the north property boundary.

A setback from the existing drainage channels along the east and north boundaries of the site would be provided within a separate block, located outside of the lots. The existing wetlands within the setback/buffer may be temporarily disturbed during construction and would be rehabilitated back into wetland habitat. Rehabilitation measures are discussed further in this report as well as the EIS.

Refer to **Figure 5 (Pre-development vs. Post-development Drainage Areas)** for a comparison of pre-development and post-development drainage areas.

2.0 STEPS 1 TO 5 OF MVCA REGULATION POLICIES DOCUMENT – DEVELOPMENT, INTERFERENCE WITH WETLANDS AND ALTERATION TO SHORELINES AND WATERCOURSES (FIGURE 8, PAGE 85/86)

As outlined in the MVCA Policy Document *“Development, Interference with Wetlands and Alteration to Shorelines and Watercourses”,* this Hydrologic Impact Study is required as part of the Environmental Impact Assessment. The Policy Document outlines the requirements for the Hydrologic Impact Study, included and responded to in steps 1 to 5 below.

2.1 Proposed Development Aspects that Could Trigger Hydrologic Impacts

Step 1: Identify aspects of the Proposed Development or Alteration that could trigger impacts

- Will overland flow pathways to or from the wetland be altered by regrading of surface contours or re-routing of existing ditches or watercourses?
- Does the application involve the installation of any temporary or permanent drainage works, including surface ditches or channels and subsurface piped systems, with or without pumping equipment?
- Will the project result in the removal of native soil and its replacement by structures or materials with different water retention and hydraulic conductivity characteristics?
- Will grades be raised in such a way as to cause consolidation of subgrade materials and changes in their water retention and hydraulic conductivity characteristics?
- Will site runoff, evapo-transpiration or infiltration amounts change (annually, seasonally) due to changes in site imperviousness, land cover, or topography, or due to maintenance practices such as snow removal?
- Is the proposed development or site alteration for the purpose of establishing a land use or activity that will require the withdrawal of water from the wetland?

<u>Overland Flow Pathways</u>

- The proposed development would include alteration to the existing topography within the property boundary. However, the major overland flow route would be similar to the pre-development condition, with the majority of the stormwater runoff from the site entering the Spring Creek Municipal Drain adjacent to the east property boundary. No re-routing of existing ditches or watercourses is proposed.

<u>Permanent Drainage Works</u>

- The proposed development would include the installation of storm sewers. The storm sewers would outlet to a dry pond located at the southeast corner of the property before outletting to the Spring Creek Municipal Drain.

<u>Removal of Native Soil</u>

- The proposed development would involve the removal of native soil (marl and topsoil) which is unsuitable for use beneath roadways and house foundations. Replacement material would consist of clean imported fill, as specified by the geotechnical engineer. Permanent removal of soil within the wetland setback/buffer is not anticipated.

Grade Raise / Consolidation of Subgrade

- The proposed development would include general grade raise, of up to about 2m, throughout the site.

Site Runoff

- The proposed development would provide post-development stormwater runoff flows equal to that of the pre-development condition. Groundwater infiltration measures such as servicing via grassed swales, rearyard infiltration systems where possible, and discharge of roof leaders to grassed areas would be implemented.

Proposed Development / Land Use

- The proposed development would be a residential subdivision and would not require the withdrawal of water from the wetland.

2.2 Hydrologic Characteristics and Functions of Existing Wetland

> **Step 2**: **Characterize the key hydrologic characteristics and functions of the wetland, from a watershed management perspective**
>
> To understand the impact of the development on the wetland and its role in the hydrology of the catchment and sub-watershed in which it is located, the following information is required, at a minimum:
>
> - connectivity of the wetland to the local stream fabric (in terms of streams flowing into the wetlands and streams flowing out of the wetland)
> - a conceptual understanding of the surficial geology of the wetland's surroundings, the wetland's catchment area, the wetland's position within and areal extent relative to the subwatershed in which it is located; watershed report cards and associated catchment reports / data sheets may be of assistance
> - a conceptual understanding of the subsurface conditions within the wetland (the nature of its substrate and underlying materials, depth to bedrock, etc.)
> - an understanding of water table elevations within the wetland and adjacent areas and their normal range of fluctuation throughout a typical year; and characterization of the hydroperiod of the wetland
> - if available for the subcatchment, historical streamflow and water level records should be obtained and interpreted

Watercourse Connectivity

- The existing wetland is adjacent to the local stream fabric. The North Feature captures runoff from existing residential lands to the west and from the undeveloped land to the north of the site. The Spring Creek Municipal Drain drains to the south, ultimately outletting to the Mississippi River. Refer to **Figure 4 (Existing Non-Evaluated Wetlands and Drainage Courses)** for approximate limits of existing wetlands and existing stream fabric.

Surficial Geology of Wetland's Surroundings

- Location of existing wetlands, as shown on **Figure 4 (Existing Non-Evaluated Wetlands and Drainage Courses),** obtained from MVCA online mapping tool (https://mvc.on.ca/development-permits/interactive-property-map/). The area of wetland located within the property boundary (2.69 ha), is a relatively small portion of the total wetland area (46.5 ha). The property is located at the downstream end of the existing wetland area, therefore the area of wetland lost within the property boundary would not reduce the drainage area contributing to the remaining wetland.

Subsurface Conditions

- A preliminary Geotechnical Investigation Report was prepared by Paterson Group (January 17, 2019). The investigation included test pits to determine the subsurface conditions, including bedrock elevations. Per the Geotechnical Investigation Report *"Generally, the subsurface profile at the test pit locations consists of topsoil overlying a thin layer of brown silty sand or glacial till consisting of gravel and cobbles mixed with clayey silt fine soil matrix over a shallow bedrock. The north and eastern portion of the site contained a layer of marl was observed directly under the topsoil surface layer, underlain by a layer of brown clayey silt over a dense grey layer of silty clay."* Bedrock was encountered between 0.33m and 1.7m below ground surface.

Water Table Elevations

- The Geotechnical Investigation included test pits to determine the subsurface conditions, including groundwater elevations. Groundwater elevations were observed between 0.5m and 1.1m below ground surface at the time of observation.

Historical Streamflow and Water Level Records

- Refer to EIS (CIMA+) for water level records associated with CIMA+ field work.

2.3 Drainage and Groundwater Characteristics

> **Step 3: Characterize drainage and groundwater characteristics of the site**
>
> Depending on the nature of the proposed development or alterations and the aspects of it that triggered the need for a hydrologic impact assessment, the following information about the site may be needed:
>
> - topographic mapping of the existing surface, and identification of surface flow pathways that will be interfered with or re-directed
> - characterization of the subsurface determined through test pits or bore holes carried out to a depth below grade that is at least as much as the deepest excavation that is proposed as part of the undertaking; this should include classification of the soil structure and hydraulic properties as they vary with depth, observation the static water levels, and determination of flow directions (to or from the wetland) in the subsurface
> - water balance calculations for the site of the proposed undertaking under existing conditions, and under the proposed conditions, and estimation of the change in infiltration, evapo-transpiration and runoff amounts from the site that can be expected on an average annual basis and during representative dry and wet years (or seasons)

<u>Topographic Mapping of Existing Surface</u>

- The existing ground surface slopes generally from west to east, towards the Spring Creek Municipal Drain, with an approximate elevation difference of 1.5m across the site (0.5% slope). The proposed area of the site to be developed is generally flat and drains overland with no defined drainage channels.
- There is an existing North Feature adjacent to the north property boundary which drains from west to east and connects into the Spring Creek Municipal Drain which runs along the east boundary of the property.
- The existing drainage channels and ground surface topography are shown on **Figure 3 (Existing Topography)**.
- The proposed development would maintain the general drainage pattern from west to east. Stormwater runoff would be conveyed via the proposed storm sewers to the proposed stormwater management facility / dry pond located at the southeast corner of the site prior to outletting to the existing Spring Creek Municipal Drain.
- A portion of the existing wetland, located within proposed buffers recommended by the EIS (CIMA+) would be rehabilitated and would continue to sheet drain (uncontrolled) directly to the existing North Feature and Spring Creek Municipal Drain adjacent to the north and east property boundaries. The buffers are shown on **Figure 3 (Existing Topography),** and buffer cross sections are provided on **Figure 6 (Enhanced Buffer Sections).**

Subsurface Characteristics

- Per the Geotechnical Investigation Report, *"Generally, the subsurface profile at the test pit locations within the south and west portion of the subject site consists of topsoil overlying a thin layer of brown silty sand or glacial till consisting of gravel and cobbles mixed with a clayey silt fine soil matrix over a shallow bedrock. At the test pit completed within the north and eastern portion of the site, a layer of marl was observed directly under the topsoil surface layer underlain by a layer of brown clayey silt over a dense grey layer of silty clay. Ground water was found to be on top of the grey silty clay layer in the northern section of the property."*
- Groundwater elevations were observed between 0.5m and 1.1m below ground surface at the time of observation.

Water Balance

- Post-development drainage areas and surface runoff to the North Feature and Spring Creek Municipal Drain would be similar to pre-development conditions; The surface water component of water balance, to the North Feature and Spring Creek Municipal Drain, would be maintained in the post-development conditions.
- Wetland that would be permanently removed is at the downstream end of the overall wetland area and would not negatively impact the drainage area / recharge of the remaining wetland.
- The proposed development would not affect surface or subsurface drainage to the remaining wetland and therefore would not result in a change to the water balance of the remaining wetland.
- Infiltration measures are not required to maintain water balance to the wetland within the subdivision property boundary as this area of the wetland is being removed. However rear-yard infiltration measures within the site are proposed so as to not dewater the area.
- The remaining wetland along the perimeter of the site, within the buffers, may be temporarily disturbed during construction but would be rehabilitated per the recommendations in the EIS.
- Rear-yard infiltration measures adjacent to the rehabilitated wetland would be proposed to promote infiltration to the wetland.
- Rear-yard infiltration measures within the subdivision would be provided where possible to improve overall groundwater recharge.
- Due to the shallow depth of soil between the dry pond bottom and bedrock there is limited capacity for infiltration within the pond block.
- Based on the review of the water balance calculations, the overall infiltration quantity for the site would decrease. However, the net volume of infiltration relative to the remaining area of the rehabilitated wetland would increase.

Table 2: Water Balance Summary

Scenario	**Drainage Area**	**Total Precipitation**		**Infiltration**		**Runoff**	
	(ha)	**(mm/yr)**	**(m^3/yr)**	**(mm/yr)**	**(m^3/yr)**	**(mm/yr)**	**(m^3/yr)**
Pre-Dev.	4.50	926	41,663	195	8,767	274	12,332
Post-Dev (Unmitigated)	4.50	926	41,663	109	4,888	501	22,503
Post-Dev. (Mitigated)	4.50	926	41,663	157	7,054	452	20,338

Refer to **Appendix B** for detailed water balance calculations.

2.4 Hydrologic Impacts

> **Step 4: Qualitative description of Potential Hydrologic Impacts**
>
> Based on a synthesis of the information obtained in Steps 2 and 3, the potential effects of the development on the hydrologic functions of the wetland should be described in a qualitative fashion.

Hydrologic Impacts

- This development has existing constructed drains (North Feature and Spring Creek Municipal Drain) around the perimeter located between the site and the existing upstream offsite wetland.
- With existing the constructed drainage channel between the site and the existing upstream wetland, it is not anticipated that additional infiltration would flow uphill to feed the offsite wetland.
- The development is anticipated to have minimal impact on the on-site remaining rehabilitated wetlands. The post-development drainage areas and stormwater runoff flows would be similar to pre-development conditions.
- Infiltration measures are proposed adjacent to the remaining rehabilitated onsite wetland to promote groundwater recharge of the remaining onsite wetland.
- It is anticipated that there would be an overall decrease in total annual infiltration volume over the whole site, which would be offset by the smaller remaining rehabilitated wetland which would require less water to maintain.
- The disturbed areas of the rehabilitated wetland should reuse the existing native soils to maintain hydrologic functions.
- Infiltration measures would be proposed where possible to maintain the seasonal groundwater.
- There would be an overall increase in runoff volume from the site to the Municipal Darin, due to the increased impervious area. The detailed design should consider methods to further increase infiltration and reduce runoff volumes.

2.5 Potential Mitigation Measures

> **Step 5: Identification of Preventive or Mitigation Measures**
>
> Measures that are necessary to prevent or mitigate the potential for adverse effects as described in Step 4 should now be identified and incorporated into the application for permission. These could include design changes and structural or non-structural best management practices to be applied during and/or after implementation of the undertaking.
>
> Depending on the anticipated severity or significance of the potential impacts, it may be necessary to undertake quantitative analyses to support the selection and design of proposed preventive/mitigation measures. The need for and scope of such quantitative analyses should be discussed with CA specialists in hydrology, groundwater sciences and wetland ecology prior to the analyses being undertaken.

The following methods should be considered at the time of detailed design to promote infiltration and to maintain groundwater at similar levels to pre-development:

- Raise the grade within the developed portion of the site (up to approximately 2m) to allow for an increased soil volume for infiltration capacity.
- Raise the grade of the site to provide separation between the impermeable rock layer and the underside of any proposed infiltration measures.
- Reinstate disturbed retained wetland to existing grades, including reuse of the native wetland soils.
- Maintain the existing drainage pattern of the rehabilitated wetland buffer.
- Provide infiltration measures in the rear-yard of lots adjacent to the rehabilitated wetland.
- Provide infiltration measures in the rear-yards of the internal lots.
- Install seepage barriers (clay seals) along the mainline servicing trenches to limit groundwater lowering via the granular pipe bedding.
- Basement footing elevations to be placed above the groundwater elevation.
- Reduce impermeable surfaces such as the width of the roads.
- Roof leaders directed to grassed surfaces.
- The stormwater management facility should be unlined to promote infiltration and reduce runoff volumes.

Refer to the EIS (CIMA+) which discusses proposed mitigation measures from an environmental and habitat perspective (i.e. plants and animals).

2.5.1 Implementation of Mitigation Measures

The following measures would be implemented to address the hydrologic impact of the proposed development. These measures are discussed further in the Serviceability and Conceptual Stormwater Management Report (Novatech).

- A Stormwater Management Pond is proposed to provide quantity control, located in the southeast corner of the site. Due to the shallow bedrock, infiltration opportunities are limited but would be explored during detailed design.
- A Hydrodynamic Separator (HDS) providing quality control would be located within the SWM Facility block. The HDS unit would treat the stormwater runoff to Enhanced water quality level of 80% TSS removal prior to outletting to the Spring Creek Municipal Drain.
- The Stormwater Management Pond block would provide opportunity for planting of shrubs and vegetation that would increase the features and functions of the habitat.
- An approximate 9.0m buffer from the top of slope of the North Feature is proposed along the north property boundary. A minimum 15.0m buffer from the top of slope of the Spring Creek Municipal Drain is proposed along the east property boundary. The buffers will *"provide retention of a representation of the wetland habitat and protection for the adjacent fish habitat"* (EIA, Muncaster). The buffer zone would also allow opportunity for rehabilitation of the remaining wetland via plantings.
- Rehabilitation of the retained wetland buffer, including reuse of native wetland soil.
- The existing North Feature and Spring Creek Municipal Drain along the north and east property boundaries would remain in the post-development condition.
- Post-development drainage areas and drainage patterns would remain generally consistent with pre-development drainage. The overall drainage area contributing to the downstream Spring Creek Municipal Drain would remain the same in post-development conditions.
- Measures such as infiltration trenches, roof leaders directed to grassed areas and grassed swales would be implemented to mitigate the reduction in groundwater infiltration/recharge resulting from the development.
- Compensation for loss of on-site wetland is described in the EIS. "*The wetland offsetting plan is currently under development in consultation with MVCA and is a stand alone document."* (EIS, CIMA+)

3.0 SUMMARY AND CONCLUSION

This report outlines the hydrologic characteristics of the existing wetlands located on the subject property, the impact of the proposed development on these existing wetlands, and the proposed mitigation measures. The EIS (CIMA+) and EIA (Muncaster), provide discussion on the environmental impacts on the wetland and the Serviceability and Conceptual Stormwater Management Report (Novatech), provides recommendations for implementation of mitigation measures.

Impact of Proposed Development (Step 1)

- The impact of the proposed development on the existing wetlands is discussed in section 2.1 of this report.

Hydrologic Characteristics (Steps 2 and 3)

- The hydrologic characteristics of the existing wetlands are described in sections 2.2 and 2.3 of this report.

Hydrologic Impacts (Step 4)

- The hydrologic impacts of the development are discussed in section 2.4 of this report.

Mitigation Measures (Step 5)

- Potential mitigation measures are described in section 2.5 of this report.

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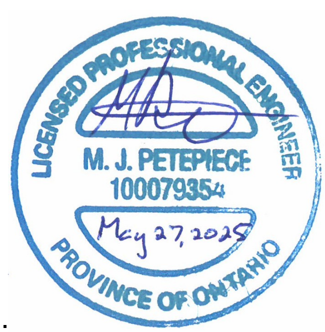
Prepared by:

Mitch Parker, B.Eng.
Land Development Engineering

Prepared by:

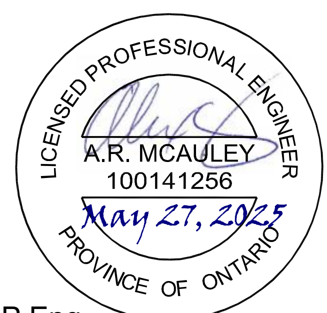
Melanie Schroeder, P.Eng.
Project Engineer | Water Resources

Reviewed by:

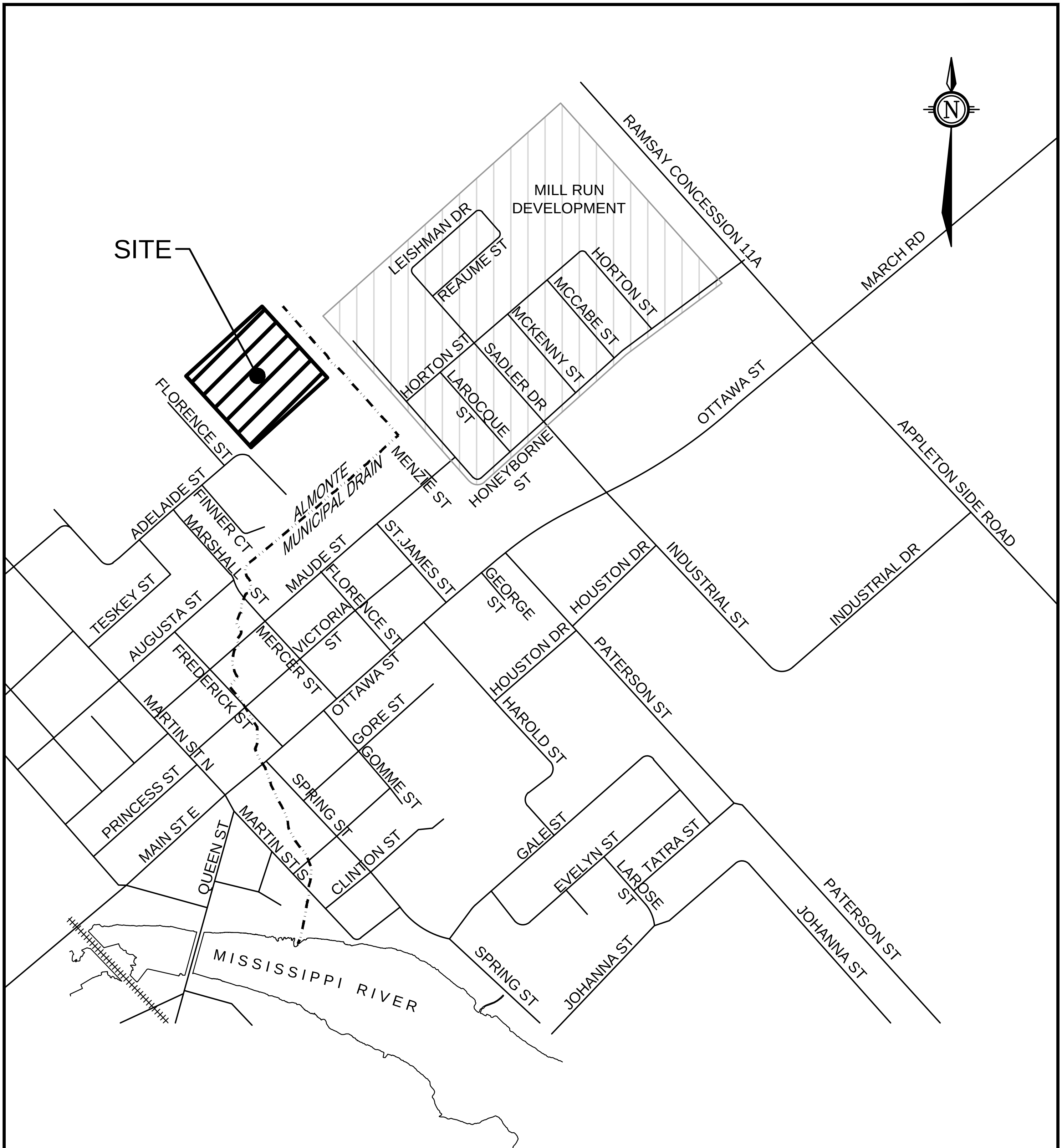


Mike Petepiece, P.Eng.
Senior Project Manager |
Water Resources

Reviewed by:



Alex McAuley, P.Eng
Senior Project Manager | Land
Development Engineering



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NOVATECH

Engineers, Planners & Landscape Architects

Suite 200, 240 Michael Cowpland Drive
Ottawa, Ontario, Canada K2M 1P6

Telephone	(613) 254-9643
Facsimile	(613) 254-5867
Website	www.novatech-eng.com

MUNICIPALITY OF MISSISSIPPI MILLS
HANNAN HILLS SUBDIVISION

KEY PLAN

SCALE		
N.T.S.		
DATE	JOB	FIGURE
MAY 2025	118201	1

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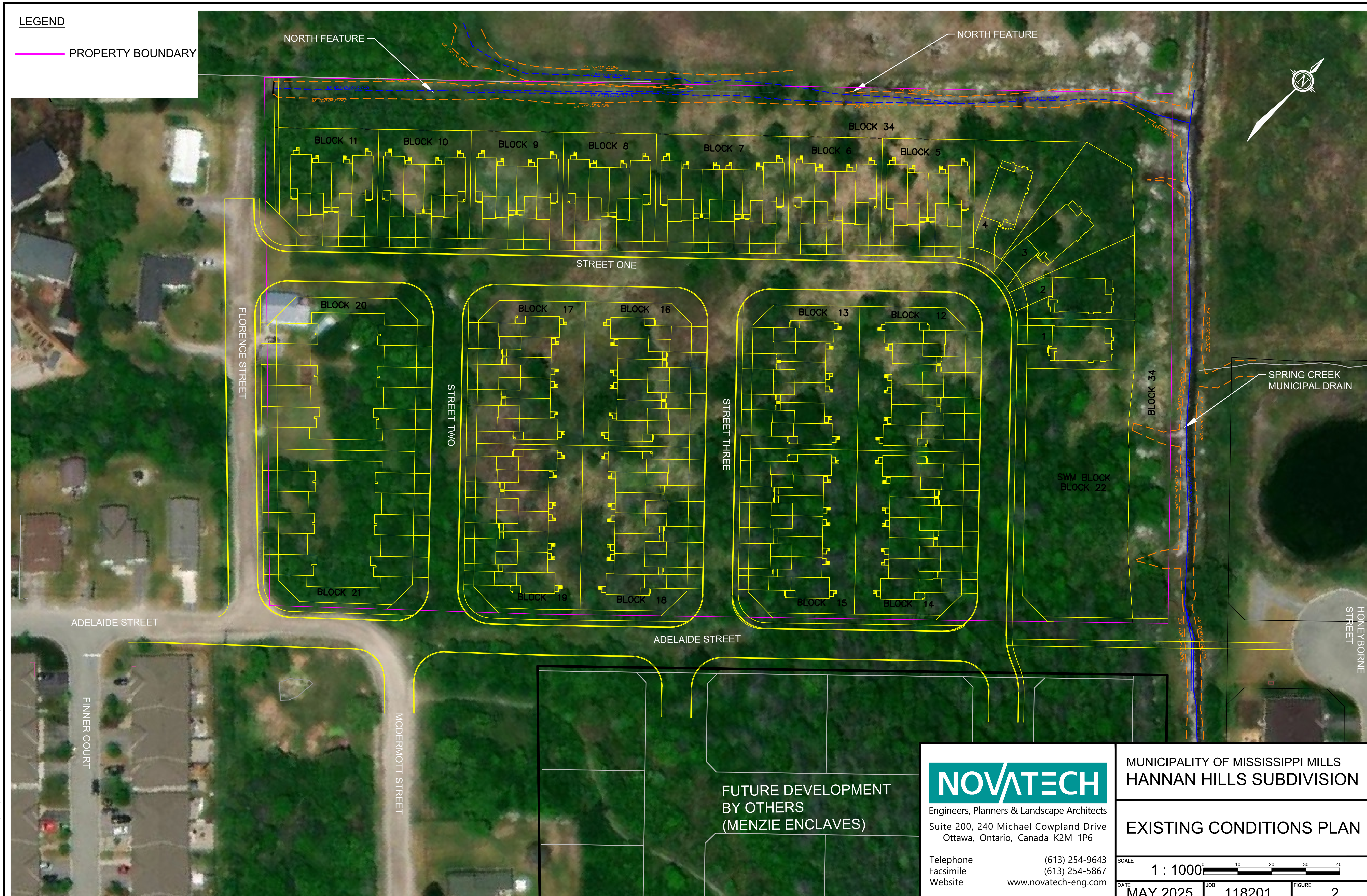

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NOVATECH
Engineers, Planners & Landscape Architects

Suite 200, 240 Michael Cowpland Drive
Ottawa, Ontario, Canada K2M 1P6

Telephone (613) 254-9643
Facsimile (613) 254-5867
Website www.novatech-eng.com

MUNICIPALITY OF MISSISSIPPI MILLS
HANNAN HILLS SUBDIVISION

EXISTING CONDITIONS PLAN

SCALE	DATE	JOB	FIGURE
1 : 1000	MAY 2025	118201	2

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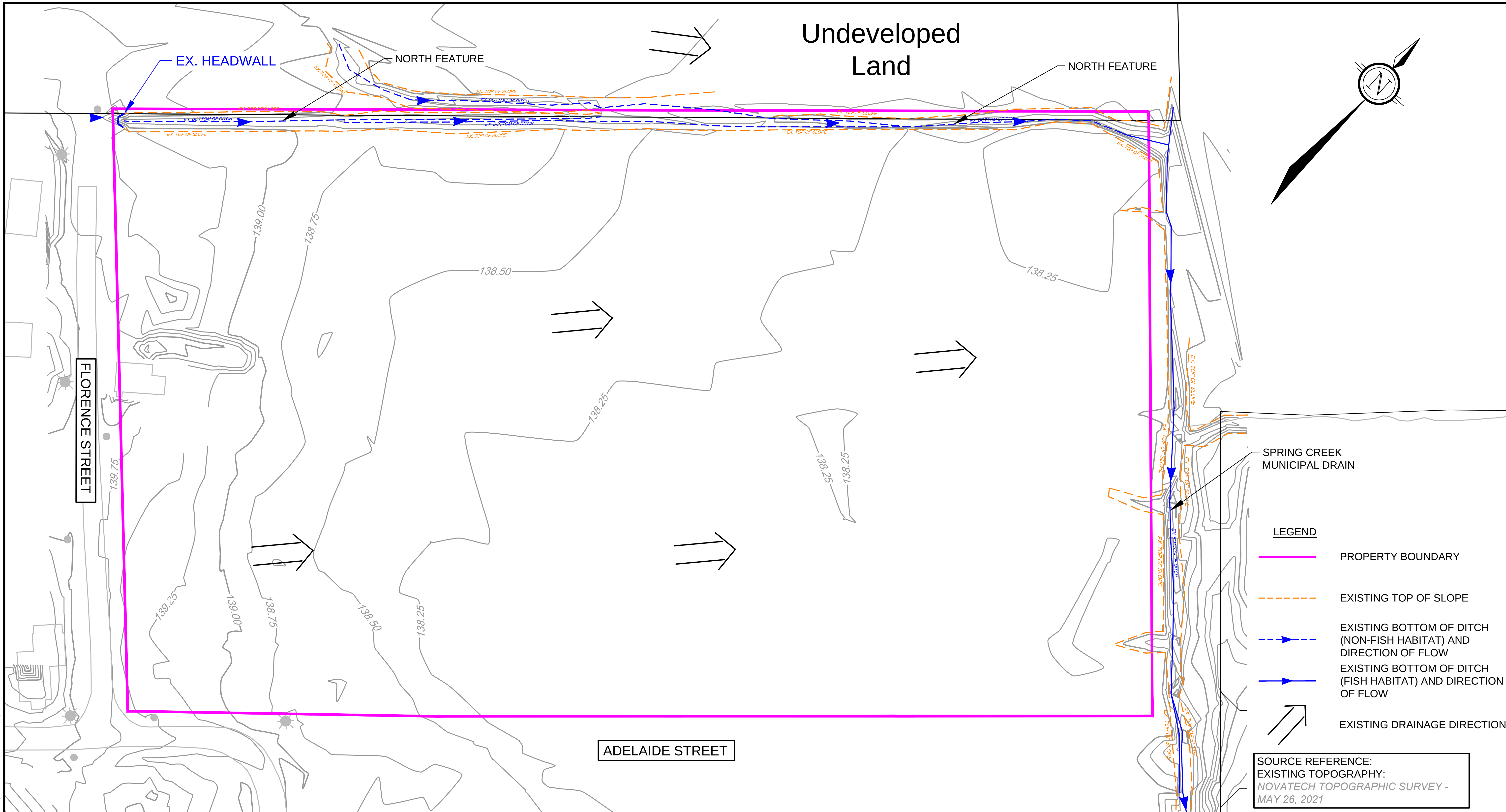

NOVATECH

Engineers, Planners & Landscape Architects

Suite 200, 240 Michael Cowpland Drive
Ottawa, Ontario, Canada K2M 1P6

Telephone (613) 254-9643
Facsimile (613) 254-5867
Website www.novatech-eng.com

MUNICIPALITY OF MISSISSIPPI MILLS
HANNAN HILLS SUBDIVISION

EXISTING TOPOGRAPHY

SCALE		
N.T.S.		
DATE JUN 2024	JOB 118201	FIGURE 3

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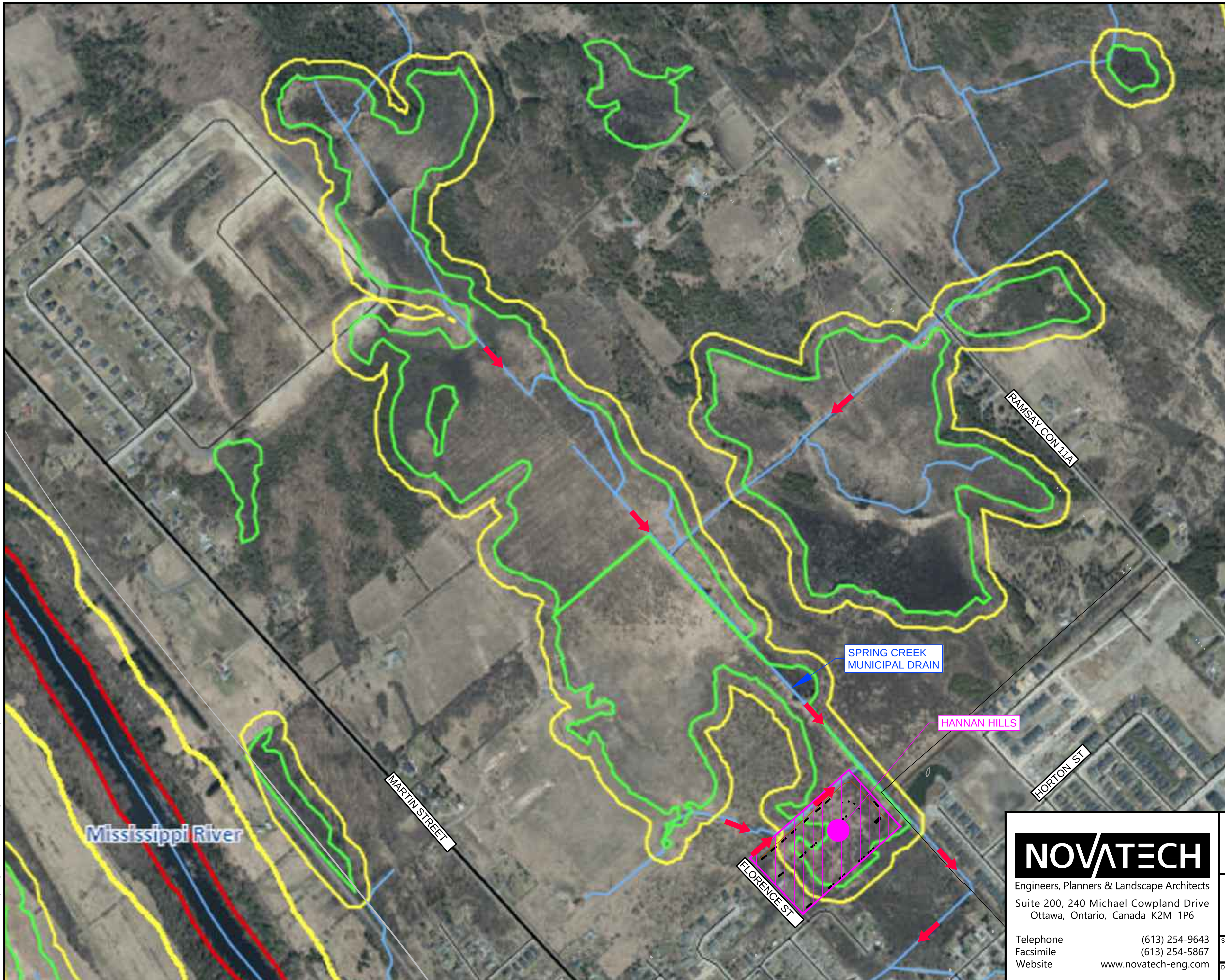

LEGEND

- NON-EVALUATED WETLANDS (MVCA)
- REGULATION LIMIT NON-EVALUATED WETLANDS (MVCA)
- STREAMS (MVCA)
- DRAINAGE DIRECTION

SOURCE REFERENCE:
MVCA - WETLAND LIMITS:
MVCA ONLINE MAPPING TOOL:
https://mvc.on.ca/development-permits/interactive-property-map/

NOVATECH
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Suite 200, 240 Michael Cowpland Drive
Ottawa, Ontario, Canada K2M 1P6
Telephone (613) 254-9643
Facsimile (613) 254-5867
Website www.novatech-eng.com

MUNICIPALITY OF MISSISSIPPI MILLS
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EXISTING NON-EVALUATED WETLANDS + DRAINAGE COURSES

SCALE		
N.T.S.		
DATE JUN 2024	JOB 118201	FIGURE 4

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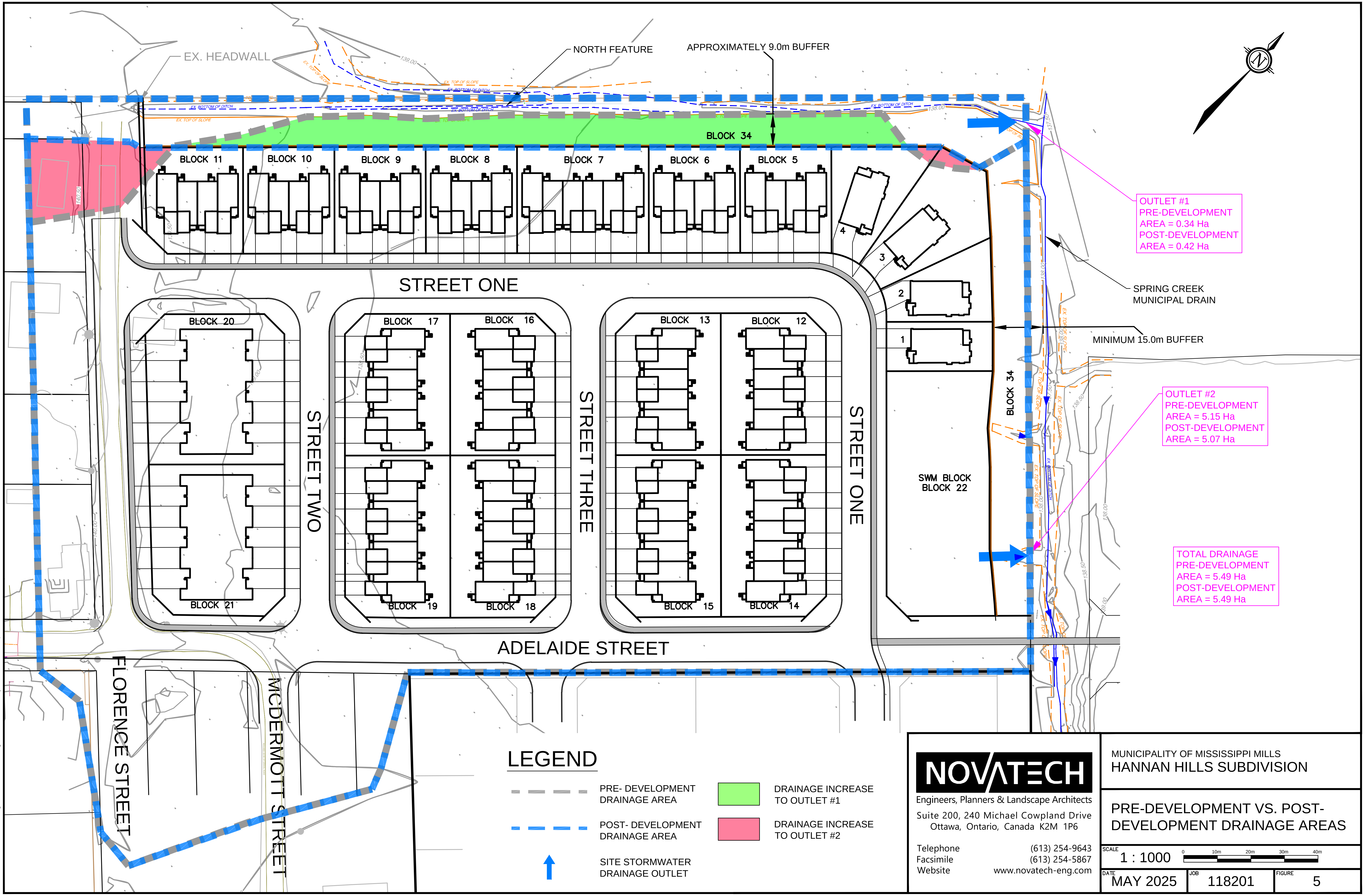

EX. HEADWALL
NORTH FEATURE
APPROXIMATELY 9.0m BUFFER
BLOCK 34
BLOCK 11
BLOCK 10
BLOCK 9
BLOCK 8
BLOCK 7
BLOCK 6
BLOCK 5
STREET ONE
BLOCK 20
BLOCK 21
BLOCK 17
BLOCK 16
BLOCK 19
BLOCK 18
BLOCK 13
BLOCK 12
BLOCK 15
BLOCK 14
STREET TWO
STREET THREE
STREET ONE
ADELAIDE STREET
FLORENCE STREET
MCDERMOTT STREET
SWM BLOCK
BLOCK 22
BLOCK 34
OUTLET #1
PRE-DEVELOPMENT
AREA = 0.34 Ha
POST-DEVELOPMENT
AREA = 0.42 Ha
SPRING CREEK
MUNICIPAL DRAIN
MINIMUM 15.0m BUFFER
OUTLET #2
PRE-DEVELOPMENT
AREA = 5.15 Ha
POST-DEVELOPMENT
AREA = 5.07 Ha
TOTAL DRAINAGE
PRE-DEVELOPMENT
AREA = 5.49 Ha
POST-DEVELOPMENT
AREA = 5.49 Ha
LEGEND
PRE- DEVELOPMENT DRAINAGE AREA
POST- DEVELOPMENT DRAINAGE AREA
SITE STORMWATER DRAINAGE OUTLET
DRAINAGE INCREASE TO OUTLET #1
DRAINAGE INCREASE TO OUTLET #2
NOVATECH
Engineers, Planners & Landscape Architects
Suite 200, 240 Michael Cowpland Drive
Ottawa, Ontario, Canada K2M 1P6
Telephone (613) 254-9643
Facsimile (613) 254-5867
Website www.novatech-eng.com
MUNICIPALITY OF MISSISSIPPI MILLS
HANNAN HILLS SUBDIVISION
PRE-DEVELOPMENT VS. POST-DEVELOPMENT DRAINAGE AREAS
SCALE 1 : 1000
DATE MAY 2025
JOB 118201
FIGURE 5
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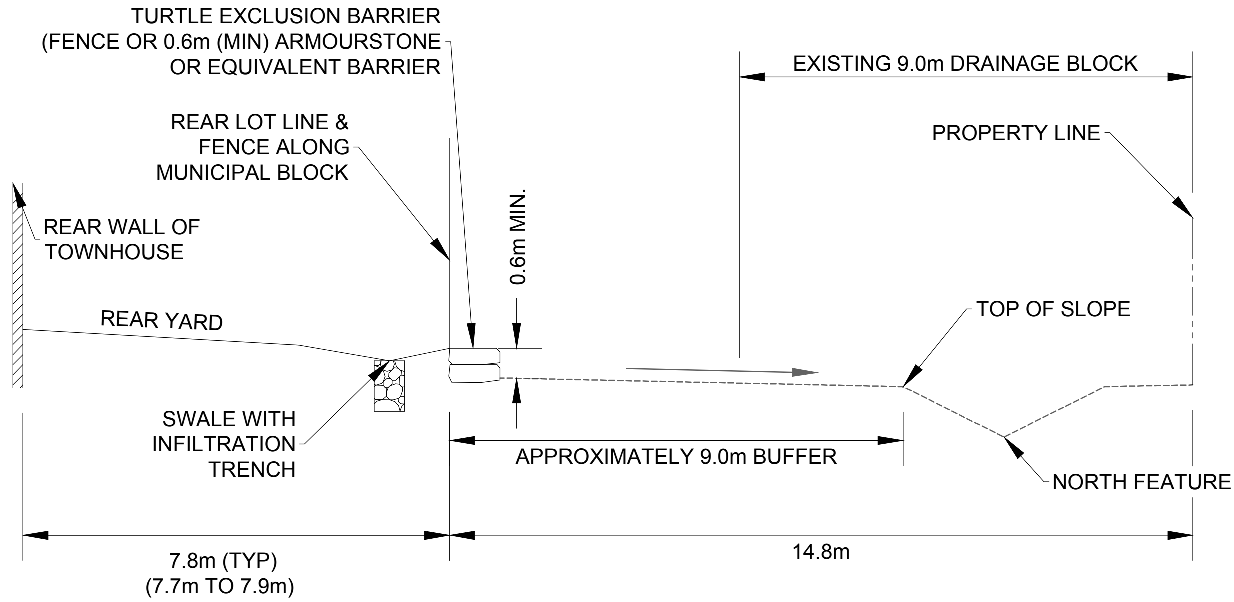
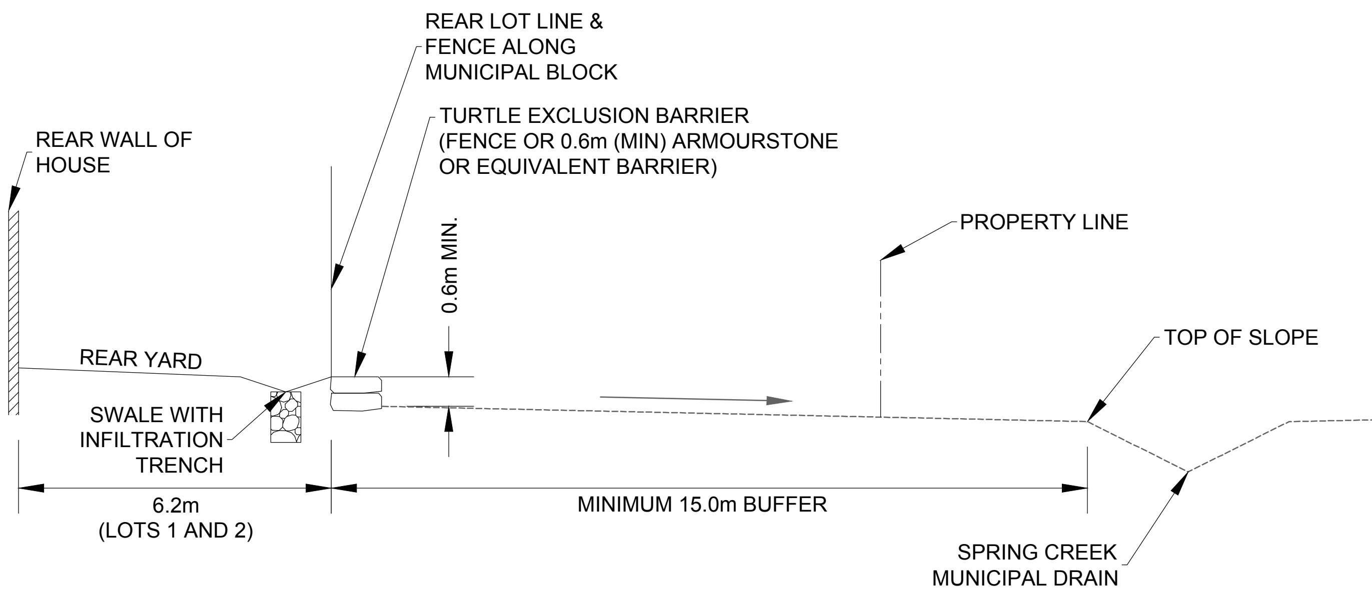


TYPICAL CROSS SECTION
APPROXIMATELY 9m BUFFER
(NORTH PROPERTY LINE)
1:150



TYPICAL CROSS SECTION
MINIMUM 15m BUFFER
(EAST PROPERTY LINE)
1:150

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Ottawa, Ontario, Canada K2M 1P6
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MUNICIPALITY OF MISSISSIPPI MILLS
HANNAN HILLS SUBDIVISION

ENHANCED BUFFER
CROSS SECTIONS

SCALE 1 : 150 (0, 1.5m, 3m, 4.5m, 6m)

DATE MAY 2025 | JOB 118201 | FIGURE 6

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Appendix A

Appendix B

Overview

The Thornthwaite-Mather (1957) water balance models are conceptual models that are used to simulate steady-state climatic averages or continuous values of precipitation (rain + snow), snowpack, snowmelt, soil moisture, evapotranspiration, and water surplus (infiltration + runoff) (refer to **Figure 1**). Input parameters consist of daily precipitation *(PRECIP),* temperature *(MAX / MIN TEMP),* potential evapotranspiration *(PET)*, and the available water content *(AWC)* that can also be referred to as the water holding capacity of the soil. All water quantities in the model are based on monthly calculations and are represented as depths (volume per unit area) of liquid water over the area being simulated. *All model units are in millimetres (mm)*.

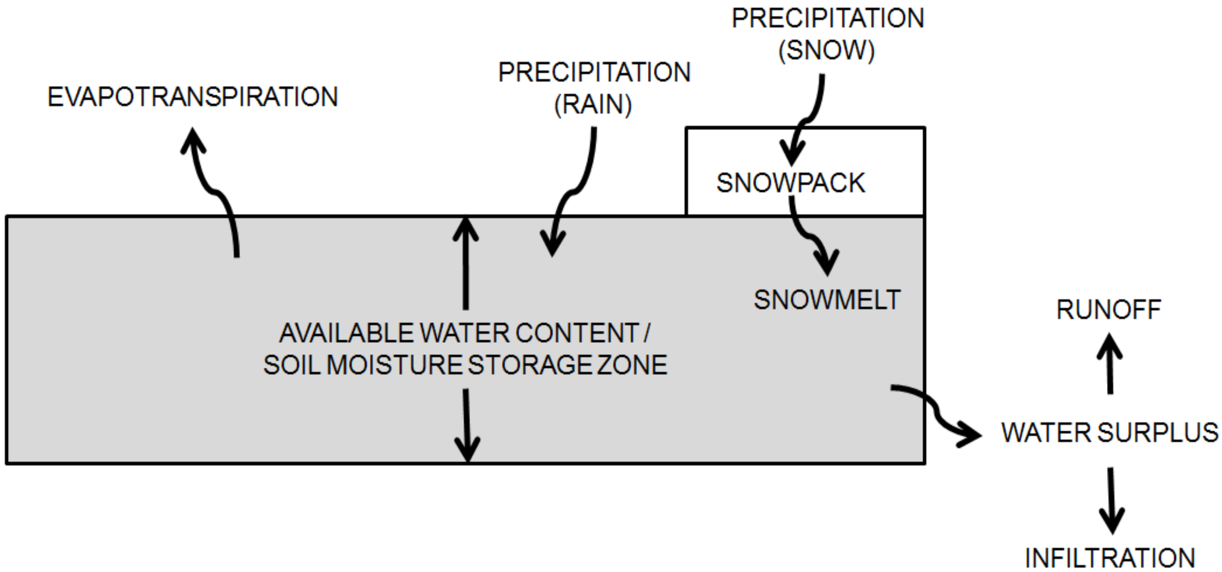

Figure 1: Conceptual Water Balance Model

Available Water Content (Water Holding Capacity)

The available water content (AWC) or water holding capacity of the soil was taken from Table 3.1 from the *Stormwater Management Planning & Design Manual (MOE, 2003)*, which has been reproduced in **Table 1** below. The available water content is the soil-moisture storage zone or the zone between the field capacity and vertical extent of the root zone.

Table 1: Water Holding Capacity Values (MOE, 2003)

Land Use / Soil Type	Hydrologic Soil Group	Water Holding Capacity (mm)
Urban Lawns / Shallow Rooted Crops (spinach, beans, beets, carrots)		
Fine Sand	A	50
Fine Sandy Loam	B	75
Silt Loam	C	125
Clay Loam	CD	100
Clay	D	75

Land Use / Soil Type	Hydrologic Soil Group	Water Holding Capacity (mm)
Moderately Rooted Crops (corn and cereal grains)		
Fine Sand	A	75
Fine Sandy Loam	B	150
Silt Loam	C	200
Clay Loam	CD	200
Clay	D	150
Pasture and Shrubs		
Fine Sand	A	100
Fine Sandy Loam	B	150
Silt Loam	C	250
Clay Loam	CD	250
Clay	D	200
Mature Forests		
Fine Sand	A	250
Fine Sandy Loam	B	300
Silt Loam	C	400
Clay Loam	CD	400
Clay	D	350

Precipitation

Daily precipitation *(PRECIP)* values consist of the total daily rainfall and water equivalent of snowmelt that fell on that day. Based on the mean daily temperature *(MEAN TEMP)* precipitation falls either as rainfall *(RAIN)* or the water equivalent of snowfall *(SNOW)*:

- *RAIN: If (MEAN TEMP >= 0, RAIN, SNOW)*
- *SNOW: If (MEAN TEMP < 0, SNOW, RAIN)*

Snowmelt / Snowpack / Water Input

Snowmelt *(MELT)* occurs if there is available snow (water equivalent) in the snowpack *(SNOWPACK)* and the maximum daily temperature *(MAX TEMP)* is greater than 0. The available snowmelt is limited to the available water in the snowpack.

Snowmelt is computed by a degree-day equation (Haith, 1985):

SNOWMELT (cm/d) = MELT COEFICIENT x [AIR TEMP (^{O}C) – MELT TEMP(^{O}C)]

The melt coefficient is typically 0.45 (cm of depth per degree-day, or cm x C^{-1} x day^{-1}) for northern climates (Haith, 1985). The melt temperature is assumed to be 0^{O}C. The air temperature is assumed to be the max temperature multiplied by a ratio of the max to min temperatures:

AIR TEMP = [*MAX TEMP / (MAX TEMP – MIN TEMP)]*

Therefore, the snowmelt equation is:

- *MELT: If (MAX TEMP > 0, IF(SNOWPACK > 0, MIN((0.45cm/°C-day*MAX TEMP*[MAX TEMP/(MAX TEMP – MIN TEMP)]*10mm/cm), SNOWPACK), 0), 0)*

Snow accumulates in the snowpack from the previous day if precipitation falls as snow and there is no snowmelt or the amount of snow that falls in a day exceeds the daily snowmelt:

$SNOWPACK_N = SNOWPACK_{N-1} + SNOW - MELT$

The initial snowmelt on day 1 (i.e. January 1) is assumed to be 0. The initial snowpack on day 1 is assumed to be the snowpack on the last day of simulation (i.e. December 31).

The total water input (W) is rain + snowmelt. This is the available water that fills the soil moisture storage zone each day.

Evaporation

Measured potential evaporation (PE) data (i.e. lake evaporation) is provided with the Environment Canada Climate Normals (see example below for Ottawa CDA). The data represents daily averages for each month over a 20+ year period.

▼ Evaporation

1981 to 2010 Canadian Climate Normals station data

Evaporation

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
Lake Evaporation (mm)	0	0	0	0	3.6	4.3	4.4	3.7	2.4	1.4	0	0	0	

The daily evaporation data was assumed to represent the middle or 15th of each month and 'smoothed' to represent the transition from month to month (see **Figure 2** below). As shown in **Figure 2**, this produces a more realistic curve of potential evapotranspiration.

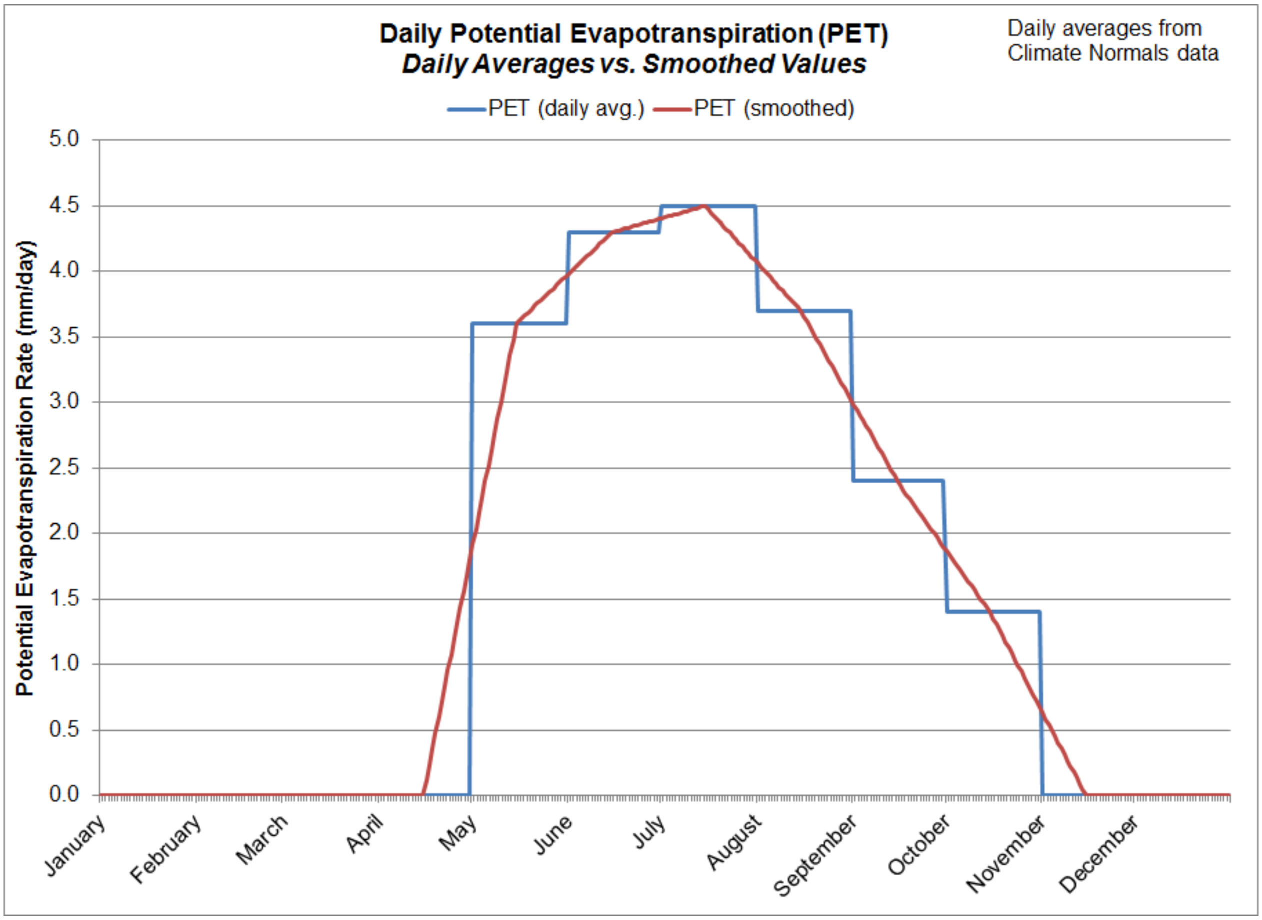

Figure 2: Daily Potential Evapotranspiration Rates (Daily Averages vs. Smoothed Values)

Potential Evapotranspiration

To convert potential evaporation data to potential crop evapotranspiration (PET) data a cover coefficient is applied based on land use and growing / dormant seasons:

PET = PE x Crop Cover Coefficient

Crop cover coefficients are based on the crop growth stages for different crop types (see **Figure 3**). A typical crop coefficient curve is shown in **Figure 4**, which depicts a crop that provides transpiration above the potential evaporation rates during the growing season.

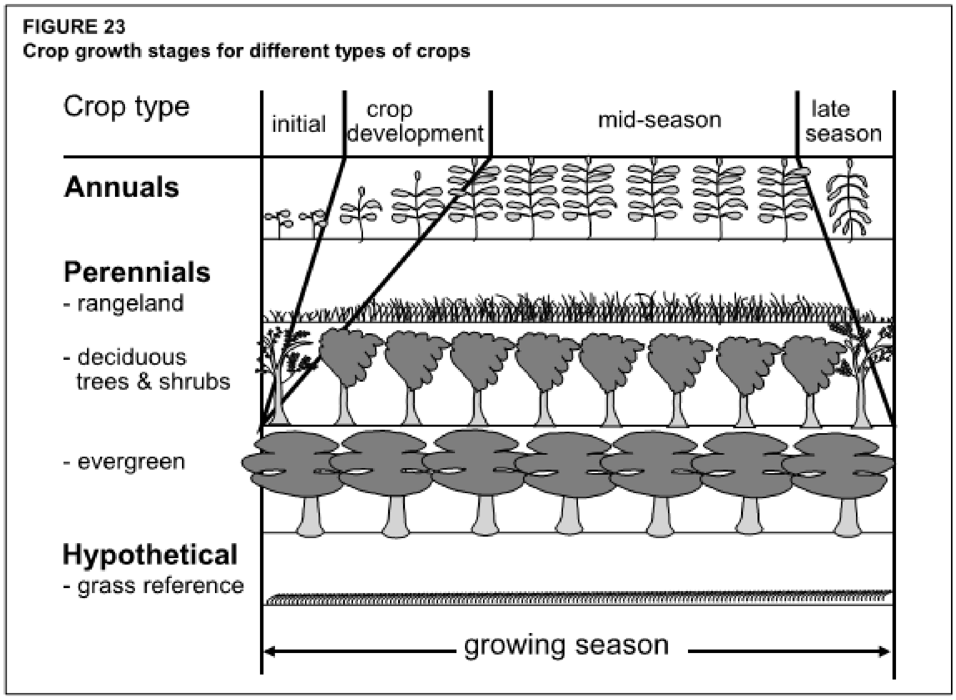

Figure 3: Crop Growth Stages for Different Types of Crops

Source: Food and Agriculture Organization of the United Nations (FAO), 1998, Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage paper 56.

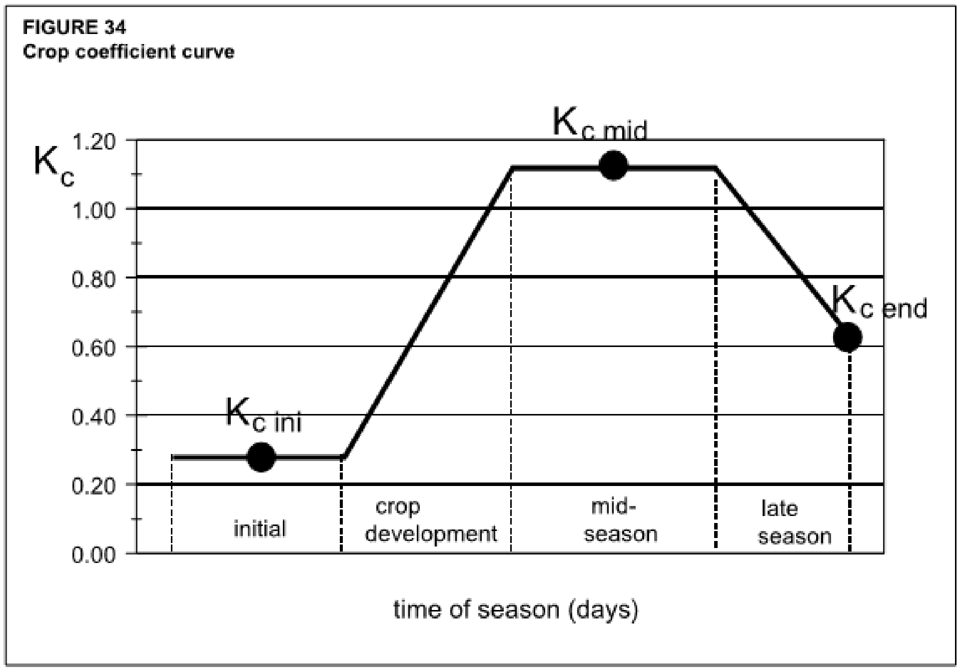

Figure 4: Crop Coefficient Curve

Source: Food and Agriculture Organization of the United Nations (FAO), 1998, Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage paper 56.

The crop cover coefficients used in the water budget model for the various land use types is shown in **Table 2**. The growing / dormant seasons are shown in **Table 3**. The crop cover coefficients for the initial growing season are based on the average value of the dormant and middle of the growing season.

Table 2: Crop Cover Coefficients

Land Use	Dormant Season	Initial Growing Season	Middle of Growing Season	End of Growing Season
Urban Lawns / Shallow Rooted Crops*	0.40	0.78	1.15	0.55
Moderately Rooted Crops**	0.30	0.73	1.15	0.40
Pasture and Shrubs***	0.40	0.68	0.95	0.90
Mature Forest****	0.30	0.75	1.20	0.30
Impervious Areas	1.00	1.00	1.00	1.00

Reference: Data is based on Table 12 from the Food and Agriculture Organization of the United Nations (FAO), 1998, Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements. FAO Irrigation and Drainage paper 56.

**Table 12, e. Legumes*

***Table 12, i. Cereals*

****Table 12, j. Forages (Alfalfa)*

*****Table 12, o. Wetlands*

Table 3: Crop Growing Season

Month(s)	Crop Growing Season
January – April	Dormant Season
May	Initial Growing Season
June - August	Middle of Growing Season
September	End of Growing Season
October - December	Dormant Season (harvest in October)

Reference: Food and Agriculture Organization of the United Nations (FAO), 1977, Crop Water Requirements. FAO Irrigation and Drainage paper 24.

Actual Evapotranspiration

Following Alley (1984), if the monthly water input (i.e. rain + snowmelt) is greater than the potential evapotranspiration (PET) rate, the actual evapotranspiration (AET) rate takes place at the potential evapotranspiration rate:

IF W > PET, then AET = PET

If the monthly water input is less than the potential evapotranspiration rate (i.e. W < PET) then the actual evapotranspiration rate is the sum of the water input and an increment removed from the available water in the soil moisture storage zone (SOIL WATER):

IF W < PET, then AET = W + ΔSOIL WATER

$$\text{WHERE: } \Delta SOIL\ WATER = SOIL\ WATER_{N-1} - SOIL\ WATER_{N}$$

Figure 5 shows a comparison of the average monthly potential evapotranspiration and actual evapotranspiration rates.

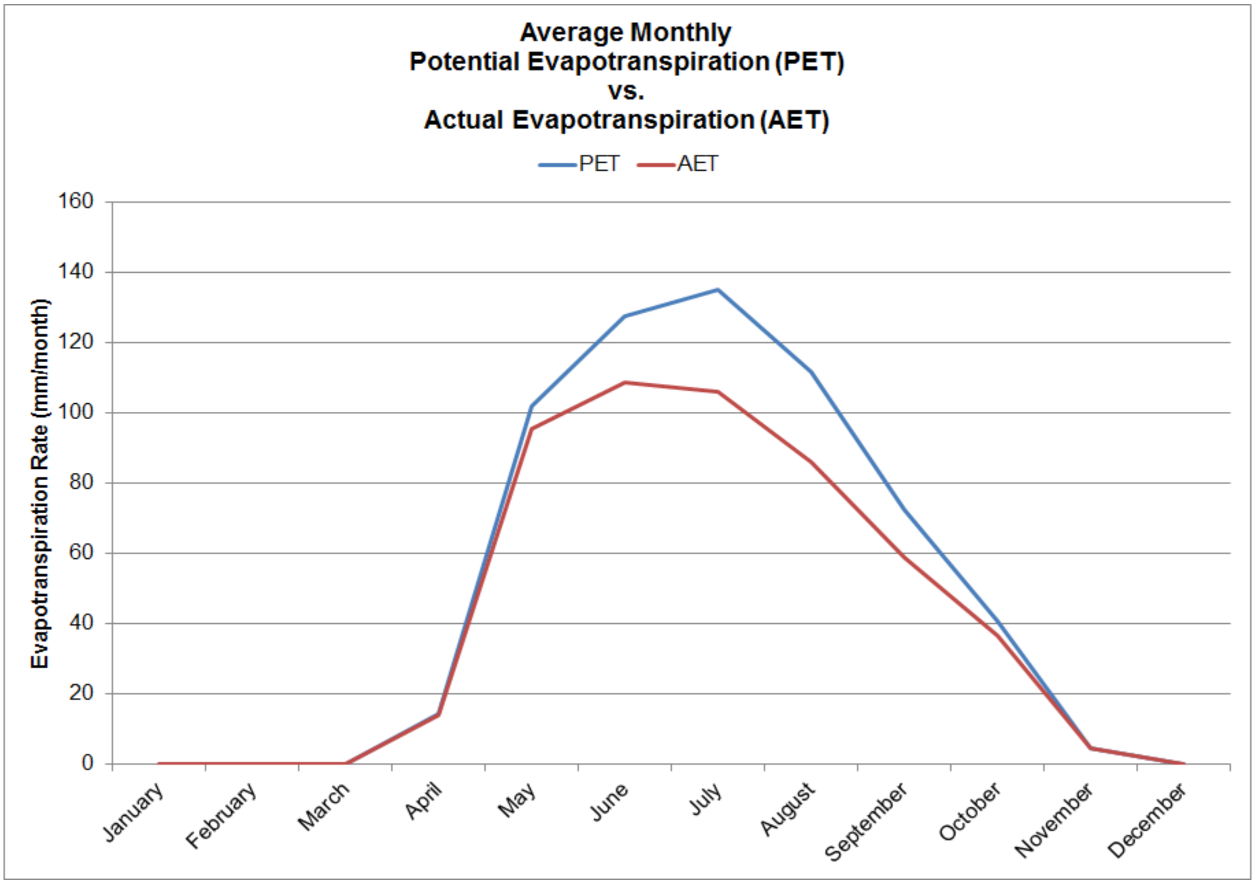

Figure 5: Average Monthly Potential Evapotranspiration vs. Actual Evapotranspiration

<u>Soil Moisture</u>

The soil moisture storage zone (SOIL WATER) is the amount of water available for actual evapotranspiration, but actual evapotranspiration is limited by the potential evapotranspiration rate.

The decrease / change in the soil moisture storage zone (ΔSOIL WATER) is based on the following relationship (Thornthwaite,1948), where AWC represents the available water content:

$$\Delta SOIL\ WATER = SOIL\ WATER_{N-1} \times [1-\exp(-((PET - W) / AWC))]$$

The soil moisture storage zone is replenished with rainwater and snowmelt (i.e. the water input) to the maximum value of the available water content (AWC):

$SOIL\ WATER_N = min[(W - PET) + SOIL\ WATER_{N-1}), AWC]$

Water Surplus

The water surplus (SURPLUS) is defined as the excess water that is greater than the available water content (AWC).

$SURPLUS = W - AET - \Delta SOIL\ WATER$

The water surplus represents the difference between precipitation and evapotranspiration. It is an estimate of the water that is available to contribute to infiltration and runoff (i.e. streamflow).

Infiltration / Runoff

The amount of water surplus that is infiltrated is determined by summing the infiltration factors (IF) based on topography, soils, and land cover. Since the water surplus represents infiltration and runoff; direct runoff is the amount of water surplus remaining after taking into account infiltration: (1.0 – infiltration factor = runoff factor). The infiltration and runoff factors were applied to the average monthly water surplus values:

$INFILTRATION = IF \times SURPLUS$

$RUNOFF = (1.0 - IF) \times SURPLUS$

The infiltration factors are shown in **Table 4**, which was reproduced from Table 3.1 in the *Stormwater Management Planning & Design Manual (MOE, 2003)*. These infiltration factors were initially presented in the document *"Hydrogeological Technical Information Requirements for Land Development Applications" (MOE, 1995)*.

Table 4: Infiltration Factors (MOE, 2003)

Description	Value of Infiltration Factor
Topography	
Flat Land, average slope < 0.6 m/km	0.3
Rolling Land, average slope 2.8 m/km to 3.8 m/km	0.2
Hilly Land, average slope 28 m/km to 47 m/km	0.1
Surficial Soils	
Tight impervious clay	0.1
Medium combination of clay and loam	0.2
Open sandy loam	0.4
Land Cover	
Cultivated Land	0.1
Woodland	0.2

Each soil type been assigned a corresponding infiltration factor as per Table 3.1 in the *Stormwater Management Planning & Design Manual (MOE, 2003),* as shown in **Table 5** below.

Table 5: Soils Infiltration Factors

Soil Type	Hydrologic Soil Group	Infiltration Factor
Coarse Sand	A	0.40
Fine Sand	AB	0.40
Fine Sandy Loam	B	0.40
Loam	BC	0.30
Silt Loam	C	0.20
Clay Loam	CD	0.15
Clay	D	0.10

The land use was combined into five (5) main categories (mature forest, row crops, pasture / meadow, urban lawns, and impervious areas) to be consistent with Table 3.1 in the *Stormwater Management Planning & Design Manual (MOE, 2003)*. The land use infiltration factors are shown in **Table 6** below.

Table 6: Land Use Infiltration Factor

Land Use	Infiltration Factor
Urban Lawns	0.10
Row Crops	0.10
Pasture / Meadow	0.10
Mature Forest	0.20
Impervious Areas	0.00

Land Use / Soils / Topography

The available water content (AWC), infiltration factors (IF), and crop cover coefficients (CROP COEF) are determined based on the combination of land use, soils and topography, as shown in **Table 7**.

Table 7: Model Parameters based on Land Use / Soils (existing areas)

Land Use	Soils (HSG)	AWC (mm)	IF (Land Use)	IF (Soils)	Crop Cover Coefficient: Dormant Season	Crop Cover Coefficient: Initial Growing Season	Crop Cover Coefficient: Middle of Growing Season	Crop Cover Coefficient: End of Growing Season
Urban Lawns	A	50	0.10	0.40	0.40	0.78	1.15	0.55
	AB	62.5		0.40				
	B	75		0.40				
	BC	100		0.30				
	C	125		0.20				
	CD	100		0.15				
	D	75		0.10				
Row Crops	A	75	0.10	0.40	0.30	0.73	1.15	0.40
	AB	112.5		0.40				
	B	150		0.40				
	BC	175		0.30				
	C	200		0.20				
	CD	200		0.15				
	D	150		0.10				
Pasture / Meadow	A	100	0.10	0.40	0.40	0.68	0.95	0.90
	AB	125		0.40				
	B	150		0.40				
	BC	200		0.30				
	C	250		0.20				
	CD	250		0.15				
	D	200		0.10				
Mature Forest	A	250	0.20	0.40	0.30	0.75	1.20	0.30
	AB	275		0.40				
	B	300		0.40				
	BC	350		0.30				
	C	400		0.20				
	CD	400		0.15				
	D	350		0.10				
Impervious Areas	A	1.57	0.00	0.00	1.00	1.00	1.00	1.00
	AB	1.57						
	B	1.57						
	BC	1.57						
	C	1.57						
	CD	1.57						
	D	1.57						

**For impervious areas, potential evapotranspiration is equal to potential evaporation (i.e. crop cover coefficient = 1.00).*

Hannan Hills Subdivision (118201)
Water Balance Model Parameters
Pre-Development

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Potential Evaporation Rates (AVG. mm/d)[3]

January	February	March	April	May	June	July	August	September	October	November	December
0.0	0.0	0.0	0.0	3.6	4.3	4.4	3.7	2.4	1.4	0.0	0.0

Surface Type	Area ID	Catchment Parameters						Infiltration Factor[1]				Crop Cover Coefficient[2]				Potential Evapotranspiration (AVG. mm/d)											
		AREA (m^2)	AREA (ha)	SOILS (HSG)	LAND USE	TOPOGRAPHY	AWC[1]	IF (soils)	IF (cover)	IF (topo)	IF (Total)	Dormant Season	Initial Growing Season	Middle of Growing Season	End of Growing Season	January	February	March	April	May	June	July	August	September	October	November	December
Impervious (roofs / driveways / roads)	1	400	0.04	C/D	IMPERVIOUS	ROLLING / HILLY	1.57	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	3.60	4.30	4.40	3.70	2.40	1.40	0.00	0.00
Pervious (open space / lawns)	2	590	0.06	C/D	LAWNS	ROLLING / HILLY	100.00	0.15	0.10	0.15	0.40	0.40	0.78	1.15	0.55	0.00	0.00	0.00	0.00	2.81	4.95	5.06	4.26	1.32	0.56	0.00	0.00
Pervious (meadow / shrubs)	3	11600	1.16	C/D	PASTURE / SHRUBS	ROLLING / HILLY	250.00	0.15	0.10	0.15	0.40	0.40	0.68	0.95	0.90	0.00	0.00	0.00	0.00	2.45	4.09	4.18	3.52	2.16	0.56	0.00	0.00
Pervious (forest)	4	5500	0.55	C/D	FOREST	ROLLING / HILLY	300.00	0.15	0.20	0.15	0.50	0.30	0.75	1.20	0.30	0.00	0.00	0.00	0.00	2.70	5.16	5.28	4.44	0.72	0.42	0.00	0.00
Pervious (wetland - marsh & shrubs)	5	22400	2.24	C/D	PASTURE / SHRUBS	ROLLING / HILLY	250.00	0.15	0.10	0.15	0.40	0.40	0.68	0.95	0.90	0.00	0.00	0.00	0.00	2.45	4.09	4.18	3.52	2.16	0.56	0.00	0.00
Pervious (wetland - forest)	6	4500	0.45	C/D	FOREST	ROLLING / HILLY	400.00	0.15	0.20	0.15	0.50	0.30	0.75	1.20	0.30	0.00	0.00	0.00	0.00	2.70	5.16	5.28	4.44	0.72	0.42	0.00	0.00

[1]Available Water Content (AWC) and Infiltration Factors (IF) for pervious areas based on Table 3.1 from the Stormwater Management Planning and Design Manual (MOE, 2003)

[2]Crop Cover Coefficients based on Table 12 from the Food and Agriculture Organization of the United Nations (FAO), 1998, Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements - FAO Irrigation and Drainage paper 56

[3]Measured Potential Evaporation Data (i.e. Lake Evaporation) from the Environment Canada Canadian Climate Normals (Ottawa CDA, 1981-2010)

Hannan Hills Subdivision (118201)
Water Balance Model Results
Pre-Development

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Water Balance for Area 1: Impervious (roofs / driveways / roads)

Average Monthly Results												
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	0.0	58.0
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	0.0	52.7
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	0.0	86.4
April	76.6	14.4	73.1	3.5	6.7	79.8	65.4	-1.0	8.0	72.9	0.0	72.9
May	78.2	102.1	78.2	0.0	0.0	78.2	-23.9	0.0	35.9	42.4	0.0	42.4
June	96.0	127.0	96.0	0.0	0.0	96.0	-31.0	-0.1	43.3	52.7	0.0	52.7
July	91.1	133.0	91.1	0.0	0.0	91.1	-41.8	-0.2	40.6	50.7	0.0	50.7
August	87.2	111.4	87.2	0.0	0.0	87.2	-24.2	-0.1	33.4	53.9	0.0	53.9
September	88.2	72.4	88.2	0.0	0.0	88.2	15.8	0.5	28.1	59.5	0.0	59.5
October	88.7	40.8	87.8	0.9	0.6	88.4	47.6	0.1	22.2	66.0	0.0	66.0
November	73.9	4.7	58.3	15.5	12.9	71.2	66.5	0.8	3.3	67.1	0.0	67.1
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	0.0	48.8
ANNUAL TOTAL	**926.1**	**605.8**	**726.2**	**199.8**	**199.8**	**926.0**	**320.3**	**0.0**	**214.9**	**711.2**	**0.0**	**711.2**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	605.8	713.0	123.1	133.9	846.9	241.1	0.0	205.8	641.1	0.0	641.1
1989	817.1	605.8	620.0	197.1	153.8	773.8	168.0	0.0	180.5	593.3	0.0	593.3
1990	976.7	605.8	777.6	199.1	232.7	1010.3	404.5	0.0	207.6	802.7	0.0	802.7
1991	820.2	605.8	619.1	201.1	204.0	823.1	217.4	0.0	191.6	631.5	0.0	631.5
1992	908.3	605.8	651.9	256.4	260.2	912.1	306.4	0.0	211.4	700.8	0.0	700.8
1993	1019.3	605.8	754.0	265.3	266.3	1020.3	414.5	0.0	243.6	776.7	0.0	776.7
1994	909.5	605.8	681.6	227.9	234.2	915.8	310.1	0.0	224.9	690.9	0.0	690.9
1995	1038.4	605.8	809.4	229.0	138.2	947.6	341.9	0.0	197.5	750.2	0.0	750.2
1996	1004.7	605.8	866.9	137.8	213.7	1080.6	474.8	0.0	220.2	860.4	0.0	860.4
1997	773.0	605.8	475.9	297.1	309.5	785.4	179.7	0.0	178.1	607.3	0.0	607.3
1998	841.6	605.8	630.0	211.6	192.8	822.8	217.1	0.0	209.4	613.4	0.0	613.4
1999	830.5	605.8	623.3	207.2	219.8	843.1	237.3	0.0	192.7	650.4	0.0	650.4
2000	987.4	605.8	783.0	204.4	162.0	945.0	339.3	0.0	240.8	704.2	0.0	704.2
2001	753.6	605.8	580.3	173.3	213.1	793.4	187.7	0.0	195.0	598.5	0.0	598.5
2002	867.9	605.8	687.7	180.2	189.6	877.3	271.6	0.0	194.6	682.8	0.0	682.8
2003	1068.5	605.8	820.4	248.1	255.3	1075.7	469.9	0.0	233.9	841.8	0.0	841.8
2004	919.7	605.8	756.2	163.5	124.4	880.6	274.9	0.0	220.1	660.5	0.0	660.5
2005	939.6	605.8	784.9	154.7	175.8	960.7	354.9	0.0	218.2	742.5	0.0	742.5
2006	1152.0	605.8	970.6	181.4	183.1	1153.7	547.9	0.0	241.1	912.6	0.0	912.6
2007	901.0	605.8	728.8	172.2	170.0	898.8	293.1	0.0	205.7	693.1	0.0	693.1
2008	1057.6	605.8	681.6	376.0	391.5	1073.1	467.3	0.0	234.1	838.9	0.0	838.9
2009	946.5	605.8	800.3	146.2	93.4	893.7	288.0	0.0	256.2	637.5	0.0	637.5
2010	970.2	605.8	867.0	103.2	159.0	1026.0	420.2	0.0	245.4	780.5	0.0	780.5
2011	878.2	605.8	676.6	201.6	179.8	856.4	250.7	0.0	217.9	638.6	0.0	638.6
2012	807.5	605.8	596.6	210.9	147.0	743.6	137.8	0.0	208.6	535.0	0.0	535.0
2013	881.4	605.8	704.2	177.2	217.5	921.7	316.0	0.0	231.7	690.0	0.0	690.0
2014	903.1	605.8	759.5	143.6	189.0	948.5	342.7	0.0	230.4	718.0	0.0	718.0
2015	785.7	605.8	648.3	137.4	108.6	756.9	151.2	0.0	200.5	556.4	0.0	556.4
2016	917.9	605.8	656.4	261.5	262.2	918.6	312.9	0.0	171.9	746.8	0.0	746.8
2017	1268.5	605.8	1061.5	207.0	214.0	1275.5	669.7	0.0	236.8	1038.7	0.0	1038.7
AVERAGE	**926.1**	**605.8**	**726.2**	**199.8**	**199.8**	**926.0**	**320.3**	**0.0**	**214.9**	**711.2**	**0.0**	**711.2**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Pre-Development

NOVATECH
Engineers, Planners & Landscape Architects

Water Balance for Area 2: Pervious (open space / lawns)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	23.2	34.8
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	21.1	31.6
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	34.5	51.8
April	76.6	11.2	73.1	3.5	6.7	79.8	68.6	-3.9	11.0	72.7	29.1	43.6
May	78.2	86.6	78.2	0.0	0.0	78.2	-8.4	-18.1	76.9	19.4	7.8	11.6
June	96.0	141.6	96.0	0.0	0.0	96.0	-45.6	-19.3	105.0	10.3	4.1	6.2
July	91.1	152.9	91.1	0.0	0.0	91.1	-61.8	-9.7	96.7	4.1	1.7	2.5
August	87.2	121.8	87.2	0.0	0.0	87.2	-34.6	3.8	77.1	6.2	2.5	3.7
September	88.2	46.5	88.2	0.0	0.0	88.2	41.7	36.7	35.7	15.8	6.3	9.5
October	88.7	17.6	87.8	0.9	0.6	88.4	70.8	9.9	17.0	61.4	24.6	36.8
November	73.9	1.9	58.3	15.5	12.9	71.2	69.3	0.6	1.9	68.8	27.5	41.3
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	19.5	29.3
ANNUAL TOTAL	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	580.0	713.0	123.1	133.9	846.9	266.8	0.0	414.9	432.0	172.8	259.2
1989	817.1	580.0	620.0	197.1	153.8	773.8	193.8	0.0	397.5	376.3	150.5	225.8
1990	976.7	580.0	777.6	199.1	232.7	1010.3	430.2	0.0	417.5	592.8	237.1	355.7
1991	820.2	580.0	619.1	201.1	204.0	823.1	243.1	0.0	337.0	486.1	194.4	291.7
1992	908.3	580.0	651.9	256.4	260.2	912.1	332.1	0.0	451.5	460.6	184.2	276.4
1993	1019.3	580.0	754.0	265.3	266.3	1020.3	440.2	0.0	414.5	605.8	242.3	363.5
1994	909.5	580.0	681.6	227.9	234.2	915.8	335.8	0.0	482.7	433.1	173.2	259.8
1995	1038.4	580.0	809.4	229.0	138.2	947.6	367.6	0.0	422.0	525.6	210.2	315.4
1996	1004.7	580.0	866.9	137.8	213.7	1080.6	500.5	0.0	442.4	638.2	255.3	382.9
1997	773.0	580.0	475.9	297.1	309.5	785.4	205.4	0.0	324.0	461.4	184.5	276.8
1998	841.6	580.0	630.0	211.6	192.8	822.8	242.8	0.0	407.2	415.6	166.3	249.4
1999	830.5	580.0	623.3	207.2	219.8	843.1	263.0	0.0	378.3	464.8	185.9	278.9
2000	987.4	580.0	783.0	204.4	162.0	945.0	365.0	0.0	478.8	466.2	186.5	279.7
2001	753.6	580.0	580.3	173.3	213.1	793.4	213.4	0.0	351.4	442.0	176.8	265.2
2002	867.9	580.0	687.7	180.2	189.6	877.3	297.3	0.0	402.0	475.4	190.1	285.2
2003	1068.5	580.0	820.4	248.1	255.3	1075.7	495.6	0.0	439.9	635.8	254.3	381.5
2004	919.7	580.0	756.2	163.5	124.4	880.6	300.6	0.0	411.4	469.2	187.7	281.5
2005	939.6	580.0	784.9	154.7	175.8	960.7	380.7	0.0	416.9	543.8	217.5	326.3
2006	1152.0	580.0	970.6	181.4	183.1	1153.7	573.6	0.0	468.7	685.0	274.0	411.0
2007	901.0	580.0	728.8	172.2	170.0	898.8	318.8	0.0	421.4	477.4	191.0	286.5
2008	1057.6	580.0	681.6	376.0	391.5	1073.1	493.0	0.0	461.1	612.0	244.8	367.2
2009	946.5	580.0	800.3	146.2	93.4	893.7	313.7	0.0	477.2	416.6	166.6	250.0
2010	970.2	580.0	867.0	103.2	159.0	1026.0	445.9	0.0	434.0	592.0	236.8	355.2
2011	878.2	580.0	676.6	201.6	179.8	856.4	276.4	0.0	396.3	460.2	184.1	276.1
2012	807.5	580.0	596.6	210.9	147.0	743.6	163.5	0.0	363.9	379.7	151.9	227.8
2013	881.4	580.0	704.2	177.2	217.5	921.7	341.7	0.0	454.2	467.5	187.0	280.5
2014	903.1	580.0	759.5	143.6	189.0	948.5	368.4	0.0	461.0	487.5	195.0	292.5
2015	785.7	580.0	648.3	137.4	108.6	756.9	176.9	0.0	424.2	332.7	133.1	199.6
2016	917.9	580.0	656.4	261.5	262.2	918.6	338.6	0.0	389.6	529.0	211.6	317.4
2017	1268.5	580.0	1061.5	207.0	214.0	1275.5	695.4	0.0	500.1	775.4	310.2	465.2
AVERAGE	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Pre-Development

Water Balance for Area 3: Pervious (meadow / shrubs)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	23.2	34.8
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	21.1	31.6
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	34.5	51.8
April	76.6	9.8	73.1	3.5	6.7	79.8	70.1	-3.4	9.7	73.5	29.4	44.1
May	78.2	74.5	78.2	0.0	0.0	78.2	3.7	-16.9	71.6	23.5	9.4	14.1
June	96.0	117.4	96.0	0.0	0.0	96.0	-21.4	-23.2	105.7	13.5	5.4	8.1
July	91.1	126.3	91.1	0.0	0.0	91.1	-35.2	-19.5	105.5	5.2	2.1	3.1
August	87.2	105.3	87.2	0.0	0.0	87.2	-18.1	-3.1	85.6	4.7	1.9	2.8
September	88.2	63.0	88.2	0.0	0.0	88.2	25.2	28.5	53.2	6.5	2.6	3.9
October	88.7	20.5	87.8	0.9	0.6	88.4	67.9	32.6	19.3	36.5	14.6	21.9
November	73.9	1.9	58.3	15.5	12.9	71.2	69.3	5.1	1.9	64.3	25.7	38.6
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	19.5	29.3
ANNUAL TOTAL	**926.1**	**518.7**	**726.2**	**199.8**	**199.8**	**926.0**	**407.4**	**0.0**	**452.4**	**473.6**	**189.4**	**284.2**

Total Number of Years = *30*

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	518.7	713.0	123.1	133.9	846.9	328.2	0.0	452.2	394.7	157.9	236.8
1989	817.1	518.7	620.0	197.1	153.8	773.8	255.1	0.0	439.2	334.6	133.8	200.8
1990	976.7	518.7	777.6	199.1	232.7	1010.3	491.6	0.0	445.1	565.2	226.1	339.1
1991	820.2	518.7	619.1	201.1	204.0	823.1	304.5	0.0	400.4	422.8	169.1	253.7
1992	908.3	518.7	651.9	256.4	260.2	912.1	393.5	0.0	472.8	439.4	175.8	263.6
1993	1019.3	518.7	754.0	265.3	266.3	1020.3	501.6	0.0	453.7	566.6	226.6	340.0
1994	909.5	518.7	681.6	227.9	234.2	915.8	397.1	0.0	482.7	433.1	173.2	259.8
1995	1038.4	518.7	809.4	229.0	138.2	947.6	429.0	0.0	453.8	493.8	197.5	296.3
1996	1004.7	518.7	866.9	137.8	213.7	1080.6	561.9	0.0	470.0	610.6	244.2	366.4
1997	773.0	518.7	475.9	297.1	309.5	785.4	266.7	0.0	387.8	397.6	159.0	238.6
1998	841.6	518.7	630.0	211.6	192.8	822.8	304.1	0.0	447.1	375.7	150.3	225.4
1999	830.5	518.7	623.3	207.2	219.8	843.1	324.4	0.0	429.6	413.5	165.4	248.1
2000	987.4	518.7	783.0	204.4	162.0	945.0	426.4	0.0	481.9	463.1	185.2	277.9
2001	753.6	518.7	580.3	173.3	213.1	793.4	274.8	0.0	409.5	383.9	153.6	230.4
2002	867.9	518.7	687.7	180.2	189.6	877.3	358.7	0.0	435.6	441.8	176.7	265.1
2003	1068.5	518.7	820.4	248.1	255.3	1075.7	557.0	0.0	465.1	610.6	244.2	366.4
2004	919.7	518.7	756.2	163.5	124.4	880.6	362.0	0.0	450.6	430.0	172.0	258.0
2005	939.6	518.7	784.9	154.7	175.8	960.7	442.0	0.0	454.6	506.1	202.4	303.7
2006	1152.0	518.7	970.6	181.4	183.1	1153.7	635.0	0.0	482.5	671.2	268.5	402.7
2007	901.0	518.7	728.8	172.2	170.0	898.8	380.2	0.0	457.9	440.9	176.4	264.5
2008	1057.6	518.7	681.6	376.0	391.5	1073.1	554.4	0.0	475.7	597.3	238.9	358.4
2009	946.5	518.7	800.3	146.2	93.4	893.7	375.1	0.0	483.0	410.7	164.3	246.4
2010	970.2	518.7	867.0	103.2	159.0	1026.0	507.3	0.0	464.0	561.9	224.8	337.1
2011	878.2	518.7	676.6	201.6	179.8	856.4	337.8	0.0	434.9	421.5	168.6	252.9
2012	807.5	518.7	596.6	210.9	147.0	743.6	224.9	0.0	420.0	323.6	129.4	194.1
2013	881.4	518.7	704.2	177.2	217.5	921.7	403.0	0.0	468.4	453.3	181.3	272.0
2014	903.1	518.7	759.5	143.6	189.0	948.5	429.8	0.0	478.6	469.9	188.0	281.9
2015	785.7	518.7	648.3	137.4	108.6	756.9	238.2	0.0	455.2	301.7	120.7	181.0
2016	917.9	518.7	656.4	261.5	262.2	918.6	400.0	0.0	431.6	487.1	194.8	292.2
2017	1268.5	518.7	1061.5	207.0	214.0	1275.5	756.8	0.0	489.0	786.5	314.6	471.9
AVERAGE	**926.1**	**518.7**	**726.2**	**199.8**	**199.8**	**926.0**	**407.4**	**0.0**	**452.4**	**473.6**	**189.4**	**284.2**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Pre-Development

NOVATECH
Engineers, Planners & Landscape Architects

Water Balance for Area 4: Pervious (forest)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	29.0	29.0
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	26.4	26.4
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	43.2	43.2
April	76.6	10.8	73.1	3.5	6.7	79.8	69.0	-3.8	10.7	72.9	36.5	36.5
May	78.2	85.0	78.2	0.0	0.0	78.2	-6.8	-22.5	81.6	19.2	9.6	9.6
June	96.0	146.9	96.0	0.0	0.0	96.0	-50.9	-40.0	129.0	7.0	3.5	3.5
July	91.1	159.6	91.1	0.0	0.0	91.1	-68.4	-34.9	124.4	1.7	0.8	0.8
August	87.2	124.2	87.2	0.0	0.0	87.2	-37.0	-4.9	92.0	0.1	0.0	0.0
September	88.2	33.0	88.2	0.0	0.0	88.2	55.2	57.2	26.3	4.6	2.3	2.3
October	88.7	12.2	87.8	0.9	0.6	88.4	76.1	42.0	11.6	34.7	17.4	17.4
November	73.9	1.4	58.3	15.5	12.9	71.2	69.8	6.8	1.4	63.0	31.5	31.5
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.2	0.0	48.6	24.3	24.3
ANNUAL TOTAL	**926.1**	**573.2**	**726.2**	**199.8**	**199.8**	**926.0**	**352.9**	**0.0**	**477.1**	**449.0**	**224.5**	**224.5**

Total Number of Years = 30

Average Annual Results											
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	573.2	713.0	123.1	133.9	846.9	273.7	0.0	463.3	383.6	191.8	191.8
1989	817.1	573.2	620.0	197.1	153.8	773.8	200.6	0.0	455.5	318.3	159.1	159.1
1990	976.7	573.2	777.6	199.1	232.7	1010.3	437.1	0.0	460.1	550.2	275.1	275.1
1991	820.2	573.2	619.1	201.1	204.0	823.1	250.0	0.0	418.7	404.4	202.2	202.2
1992	908.3	573.2	651.9	256.4	260.2	912.1	339.0	0.0	487.7	424.5	212.2	212.2
1993	1019.3	573.2	754.0	265.3	266.3	1020.3	447.1	0.0	477.3	542.9	271.5	271.5
1994	909.5	573.2	681.6	227.9	234.2	915.8	342.6	0.0	528.5	387.3	193.6	193.6
1995	1038.4	573.2	809.4	229.0	138.2	947.6	374.5	0.0	483.7	463.9	231.9	231.9
1996	1004.7	573.2	866.9	137.8	213.7	1080.6	507.4	0.0	494.3	586.3	293.1	293.1
1997	773.0	573.2	475.9	297.1	309.5	785.4	212.2	0.0	407.8	377.6	188.8	188.8
1998	841.6	573.2	630.0	211.6	192.8	822.8	249.6	0.0	467.7	355.1	177.6	177.6
1999	830.5	573.2	623.3	207.2	219.8	843.1	269.9	0.0	443.7	399.4	199.7	199.7
2000	987.4	573.2	783.0	204.4	162.0	945.0	371.8	0.0	517.5	427.5	213.8	213.8
2001	753.6	573.2	580.3	173.3	213.1	793.4	220.3	0.0	437.6	355.9	177.9	177.9
2002	867.9	573.2	687.7	180.2	189.6	877.3	304.2	0.0	477.1	400.3	200.1	200.1
2003	1068.5	573.2	820.4	248.1	255.3	1075.7	502.5	0.0	486.3	589.4	294.7	294.7
2004	919.7	573.2	756.2	163.5	124.4	880.6	307.4	0.0	473.1	407.6	203.8	203.8
2005	939.6	573.2	784.9	154.7	175.8	960.7	387.5	0.0	472.2	488.5	244.3	244.3
2006	1152.0	573.2	970.6	181.4	183.1	1153.7	580.5	0.0	509.7	644.0	322.0	322.0
2007	901.0	573.2	728.8	172.2	170.0	898.8	325.7	0.0	481.5	417.3	208.7	208.7
2008	1057.6	573.2	681.6	376.0	391.5	1073.1	499.9	0.0	507.1	565.9	283.0	283.0
2009	946.5	573.2	800.3	146.2	93.4	893.7	320.6	0.0	523.0	370.8	185.4	185.4
2010	970.2	573.2	867.0	103.2	159.0	1026.0	452.8	0.0	478.4	547.6	273.8	273.8
2011	878.2	573.2	676.6	201.6	179.8	856.4	283.3	0.0	459.0	397.4	198.7	198.7
2012	807.5	573.2	596.6	210.9	147.0	743.6	170.4	0.0	436.1	307.5	153.7	153.7
2013	881.4	573.2	704.2	177.2	217.5	921.7	348.5	0.0	500.6	421.1	210.6	210.6
2014	903.1	573.2	759.5	143.6	189.0	948.5	375.3	0.0	507.5	441.0	220.5	220.5
2015	785.7	573.2	648.3	137.4	108.6	756.9	183.7	0.0	476.5	280.4	140.2	140.2
2016	917.9	573.2	656.4	261.5	262.2	918.6	345.5	0.0	443.0	475.7	237.8	237.8
2017	1268.5	573.2	1061.5	207.0	214.0	1275.5	702.3	0.0	537.7	737.7	368.9	368.9
AVERAGE	**926.1**	**573.2**	**726.2**	**199.8**	**199.8**	**926.0**	**352.9**	**0.0**	**477.1**	**449.0**	**224.5**	**224.5**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Pre-Development

NOVATECH
Engineers, Planners & Landscape Architects

Water Balance for Area 5: Pervious (wetland - marsh & shrubs)

Average Monthly Results												
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	23.2	34.8
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	21.1	31.6
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	34.5	51.8
April	76.6	9.8	73.1	3.5	6.7	79.8	70.1	-3.4	9.7	73.5	29.4	44.1
May	78.2	74.5	78.2	0.0	0.0	78.2	3.7	-16.9	71.6	23.5	9.4	14.1
June	96.0	117.4	96.0	0.0	0.0	96.0	-21.4	-23.2	105.7	13.5	5.4	8.1
July	91.1	126.3	91.1	0.0	0.0	91.1	-35.2	-19.5	105.5	5.2	2.1	3.1
August	87.2	105.3	87.2	0.0	0.0	87.2	-18.1	-3.1	85.6	4.7	1.9	2.8
September	88.2	63.0	88.2	0.0	0.0	88.2	25.2	28.5	53.2	6.5	2.6	3.9
October	88.7	20.5	87.8	0.9	0.6	88.4	67.9	32.6	19.3	36.5	14.6	21.9
November	73.9	1.9	58.3	15.5	12.9	71.2	69.3	5.1	1.9	64.3	25.7	38.6
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	19.5	29.3
ANNUAL TOTAL	**926.1**	**518.7**	**726.2**	**199.8**	**199.8**	**926.0**	**407.4**	**0.0**	**452.4**	**473.6**	**189.4**	**284.2**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	518.7	713.0	123.1	133.9	846.9	328.2	0.0	452.2	394.7	157.9	236.8
1989	817.1	518.7	620.0	197.1	153.8	773.8	255.1	0.0	439.2	334.6	133.8	200.8
1990	976.7	518.7	777.6	199.1	232.7	1010.3	491.6	0.0	445.1	565.2	226.1	339.1
1991	820.2	518.7	619.1	201.1	204.0	823.1	304.5	0.0	400.4	422.8	169.1	253.7
1992	908.3	518.7	651.9	256.4	260.2	912.1	393.5	0.0	472.8	439.4	175.8	263.6
1993	1019.3	518.7	754.0	265.3	266.3	1020.3	501.6	0.0	453.7	566.6	226.6	340.0
1994	909.5	518.7	681.6	227.9	234.2	915.8	397.1	0.0	482.7	433.1	173.2	259.8
1995	1038.4	518.7	809.4	229.0	138.2	947.6	429.0	0.0	453.8	493.8	197.5	296.3
1996	1004.7	518.7	866.9	137.8	213.7	1080.6	561.9	0.0	470.0	610.6	244.2	366.4
1997	773.0	518.7	475.9	297.1	309.5	785.4	266.7	0.0	387.8	397.6	159.0	238.6
1998	841.6	518.7	630.0	211.6	192.8	822.8	304.1	0.0	447.1	375.7	150.3	225.4
1999	830.5	518.7	623.3	207.2	219.8	843.1	324.4	0.0	429.6	413.5	165.4	248.1
2000	987.4	518.7	783.0	204.4	162.0	945.0	426.4	0.0	481.9	463.1	185.2	277.9
2001	753.6	518.7	580.3	173.3	213.1	793.4	274.8	0.0	409.5	383.9	153.6	230.4
2002	867.9	518.7	687.7	180.2	189.6	877.3	358.7	0.0	435.6	441.8	176.7	265.1
2003	1068.5	518.7	820.4	248.1	255.3	1075.7	557.0	0.0	465.1	610.6	244.2	366.4
2004	919.7	518.7	756.2	163.5	124.4	880.6	362.0	0.0	450.6	430.0	172.0	258.0
2005	939.6	518.7	784.9	154.7	175.8	960.7	442.0	0.0	454.6	506.1	202.4	303.7
2006	1152.0	518.7	970.6	181.4	183.1	1153.7	635.0	0.0	482.5	671.2	268.5	402.7
2007	901.0	518.7	728.8	172.2	170.0	898.8	380.2	0.0	457.9	440.9	176.4	264.5
2008	1057.6	518.7	681.6	376.0	391.5	1073.1	554.4	0.0	475.7	597.3	238.9	358.4
2009	946.5	518.7	800.3	146.2	93.4	893.7	375.1	0.0	483.0	410.7	164.3	246.4
2010	970.2	518.7	867.0	103.2	159.0	1026.0	507.3	0.0	464.0	561.9	224.8	337.1
2011	878.2	518.7	676.6	201.6	179.8	856.4	337.8	0.0	434.9	421.5	168.6	252.9
2012	807.5	518.7	596.6	210.9	147.0	743.6	224.9	0.0	420.0	323.6	129.4	194.1
2013	881.4	518.7	704.2	177.2	217.5	921.7	403.0	0.0	468.4	453.3	181.3	272.0
2014	903.1	518.7	759.5	143.6	189.0	948.5	429.8	0.0	478.6	469.9	188.0	281.9
2015	785.7	518.7	648.3	137.4	108.6	756.9	238.2	0.0	455.2	301.7	120.7	181.0
2016	917.9	518.7	656.4	261.5	262.2	918.6	400.0	0.0	431.6	487.1	194.8	292.2
2017	1268.5	518.7	1061.5	207.0	214.0	1275.5	756.8	0.0	489.0	786.5	314.6	471.9
AVERAGE	**926.1**	**518.7**	**726.2**	**199.8**	**199.8**	**926.0**	**407.4**	**0.0**	**452.4**	**473.6**	**189.4**	**284.2**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Pre-Development

NOVATECH
Engineers, Planners & Landscape Architects

Water Balance for Area 6: Pervious (wetland - forest)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.4	0.0	57.7	28.8	28.8
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	26.4	26.4
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	43.2	43.2
April	76.6	10.8	73.1	3.5	6.7	79.8	69.0	-3.8	10.8	72.9	36.5	36.5
May	78.2	85.0	78.2	0.0	0.0	78.2	-6.8	-23.2	82.4	19.0	9.5	9.5
June	96.0	146.9	96.0	0.0	0.0	96.0	-50.9	-43.5	132.9	6.7	3.3	3.3
July	91.1	159.6	91.1	0.0	0.0	91.1	-68.4	-41.4	131.0	1.6	0.8	0.8
August	87.2	124.2	87.2	0.0	0.0	87.2	-37.0	-9.8	97.0	0.0	0.0	0.0
September	88.2	33.0	88.2	0.0	0.0	88.2	55.2	57.8	27.1	3.3	1.6	1.6
October	88.7	12.2	87.8	0.9	0.6	88.4	76.1	50.1	11.5	26.7	13.4	13.4
November	73.9	1.4	58.3	15.5	12.9	71.2	69.8	12.8	1.4	57.1	28.5	28.5
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.8	0.0	48.0	24.0	24.0
ANNUAL TOTAL	**926.1**	**573.2**	**726.2**	**199.8**	**199.8**	**926.0**	**352.9**	**0.0**	**494.0**	**432.0**	**216.0**	**216.0**

Total Number of Years = *30*

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	573.2	713.0	123.1	133.9	846.9	273.7	0.0	480.7	366.2	183.1	183.1
1989	817.1	573.2	620.0	197.1	153.8	773.8	200.6	0.0	475.8	298.0	149.0	149.0
1990	976.7	573.2	777.6	199.1	232.7	1010.3	437.1	0.0	478.7	531.6	265.8	265.8
1991	820.2	573.2	619.1	201.1	204.0	823.1	250.0	0.0	445.4	377.8	188.9	188.9
1992	908.3	573.2	651.9	256.4	260.2	912.1	339.0	0.0	501.7	410.4	205.2	205.2
1993	1019.3	573.2	754.0	265.3	266.3	1020.3	447.1	0.0	495.5	524.7	262.4	262.4
1994	909.5	573.2	681.6	227.9	234.2	915.8	342.6	0.0	536.9	378.9	189.5	189.5
1995	1038.4	573.2	809.4	229.0	138.2	947.6	374.5	0.0	499.3	448.3	224.2	224.2
1996	1004.7	573.2	866.9	137.8	213.7	1080.6	507.4	0.0	507.3	573.3	286.6	286.6
1997	773.0	573.2	475.9	297.1	309.5	785.4	212.2	-10.6	435.9	360.1	180.1	180.1
1998	841.6	573.2	630.0	211.6	192.8	822.8	249.6	10.6	486.4	325.9	162.9	162.9
1999	830.5	573.2	623.3	207.2	219.8	843.1	269.9	0.0	465.8	377.3	188.6	188.6
2000	987.4	573.2	783.0	204.4	162.0	945.0	371.8	0.0	528.6	416.5	208.2	208.2
2001	753.6	573.2	580.3	173.3	213.1	793.4	220.3	0.0	462.2	331.3	165.6	165.6
2002	867.9	573.2	687.7	180.2	189.6	877.3	304.2	0.0	495.6	381.7	190.9	190.9
2003	1068.5	573.2	820.4	248.1	255.3	1075.7	502.5	0.0	501.9	573.8	286.9	286.9
2004	919.7	573.2	756.2	163.5	124.4	880.6	307.4	0.0	491.0	389.7	194.8	194.8
2005	939.6	573.2	784.9	154.7	175.8	960.7	387.5	0.0	489.8	470.8	235.4	235.4
2006	1152.0	573.2	970.6	181.4	183.1	1153.7	580.5	0.0	520.5	633.1	316.6	316.6
2007	901.0	573.2	728.8	172.2	170.0	898.8	325.7	0.0	497.1	401.7	200.9	200.9
2008	1057.6	573.2	681.6	376.0	391.5	1073.1	499.9	0.0	520.1	553.0	276.5	276.5
2009	946.5	573.2	800.3	146.2	93.4	893.7	320.6	0.0	532.3	361.4	180.7	180.7
2010	970.2	573.2	867.0	103.2	159.0	1026.0	452.8	0.0	494.2	531.7	265.9	265.9
2011	878.2	573.2	676.6	201.6	179.8	856.4	283.3	0.0	479.3	377.2	188.6	188.6
2012	807.5	573.2	596.6	210.9	147.0	743.6	170.4	0.0	459.9	283.7	141.8	141.8
2013	881.4	573.2	704.2	177.2	217.5	921.7	348.5	0.0	514.5	407.2	203.6	203.6
2014	903.1	573.2	759.5	143.6	189.0	948.5	375.3	0.0	520.6	427.9	213.9	213.9
2015	785.7	573.2	648.3	137.4	108.6	756.9	183.7	0.0	493.6	263.3	131.6	131.6
2016	917.9	573.2	656.4	261.5	262.2	918.6	345.5	0.0	464.1	454.5	227.2	227.2
2017	1268.5	573.2	1061.5	207.0	214.0	1275.5	702.3	0.0	545.6	729.9	364.9	364.9
AVERAGE	**926.1**	**573.2**	**726.2**	**199.8**	**199.8**	**926.0**	**352.9**	**0.0**	**494.0**	**432.0**	**216.0**	**216.0**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Results Summary
Pre-Development

NOVATECH
Engineers, Planners & Landscape Architects

Pre-Development Conditions
Overall Site

MONTH	Hannan Hills Subvision (mm/yr)					*4.50 ha*
	TOTAL PRECIP.	PET	AET	SURPLUS	INFILTRATION	RUNOFF
Jan	63.3	0.0	0.0	58.0	24.3	33.7
Feb	51.9	0.0	0.0	52.7	22.1	30.7
Mar	60.0	0.0	0.0	86.4	36.2	50.2
Apr	76.6	10.1	10.0	73.4	30.7	42.6
May	78.2	77.2	73.6	22.6	9.3	13.3
Jun	96.0	124.4	110.7	12.4	4.9	7.5
Jul	91.1	134.1	109.6	4.8	1.8	3.0
Aug	87.2	109.7	87.0	4.1	1.5	2.7
Sep	88.2	56.2	46.8	6.5	2.5	4.0
Oct	88.7	18.8	17.6	35.9	14.8	21.1
Nov	73.9	1.8	1.8	63.5	26.5	37.0
Dec	71.0	0.0	0.0	48.7	20.4	28.3
AVG. ANNUAL	**926.1**	**532.4**	**457.1**	**469.0**	**194.9**	**274.1**

MONTH	Hannan Hills Subvision (m^3/yr)					*4.50 ha*
	TOTAL PRECIP.	PET	AET	SURPLUS	INFILTRATION	RUNOFF
Jan	2,847	0	0	2,609	1,092	1,517
Feb	2,336	0	0	2,373	994	1,380
Mar	2,701	0	0	3,885	1,627	2,258
Apr	3,446	453	448	3,300	1,381	1,919
May	3,518	3,475	3,313	1,018	419	598
Jun	4,319	5,595	4,980	556	221	335
Jul	4,100	6,034	4,932	216	80	136
Aug	3,922	4,937	3,912	186	66	120
Sep	3,968	2,528	2,108	294	112	182
Oct	3,990	846	790	1,615	667	948
Nov	3,323	82	80	2,857	1,192	1,664
Dec	3,194	0	0	2,190	917	1,273
AVG. ANNUAL	**41,663**	**23,951**	**20,564**	**21,099**	**8,767**	**12,332**

5/20/2025
PREPARED BY: NOVATECH

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Hannan Hills Subdivision (118201)
Water Balance Model Parameters
Post-Development

Surface Type	Area ID	AREA (m^2)	AREA (ha)	SOILS (HSG)	LAND USE	TOPOGRAPHY	AWC[1]	IF (soils)	IF (cover)	IF (topo)	IF (Total)	Dormant Season	Initial Growing Season	Middle of Growing Season	End of Growing Season	January	February	March	April	May	June	July	August	September	October	November	December
																Potential Evaporation Rates (AVG. mm/d)[3]											
																0.0	0.0	0.0	0.0	3.6	4.3	4.4	3.7	2.4	1.4	0.0	0.0
		Catchment Parameters						**Infiltration Factor[1]**				**Crop Cover Coefficient[2]**				**Potential Evapotranspiration (AVG. mm/d)**											
Front Yard Impervious (roofs / driveways / roads)	1	18870	1.89	C/D	IMPERVIOUS	ROLLING / HILLY	1.57	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	3.60	4.30	4.40	3.70	2.40	1.40	0.00	0.00
Front Yard Pervious (open space / lawns)	2	8010	0.80	C/D	LAWNS	ROLLING / HILLY	100.00	0.15	0.10	0.15	0.40	0.40	0.78	1.15	0.55	0.00	0.00	0.00	0.00	2.81	4.95	5.06	4.26	1.32	0.56	0.00	0.00
Rear Yard - Internal Impervious (roofs / driveways / roads)	3	2560	0.26	C/D	IMPERVIOUS	ROLLING / HILLY	1.57	0.00	0.00	0.00	0.00	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	3.60	4.30	4.40	3.70	2.40	1.40	0.00	0.00
Rear Yard - Internal Pervious (open space / lawns)	4	3490	0.35	C/D	LAWNS	ROLLING / HILLY	100.00	0.15	0.10	0.15	0.40	0.40	0.78	1.15	0.55	0.00	0.00	0.00	0.00	2.81	4.95	5.06	4.26	1.32	0.56	0.00	0.00
Rear Yard - perimeter Impervious (roofs / driveways / roads)	3	2150	0.22	C/D	IMPERVIOUS	ROLLING / HILLY	1.57	0.15	0.00	0.00	0.15	1.00	1.00	1.00	1.00	0.00	0.00	0.00	0.00	3.60	4.30	4.40	3.70	2.40	1.40	0.00	0.00
Rear Yard - perimeter Pervious (open space / lawns)	4	2330	0.23	C/D	LAWNS	ROLLING / HILLY	100.00	0.15	0.10	0.15	0.40	0.40	0.78	1.15	0.55	0.00	0.00	0.00	0.00	2.81	4.95	5.06	4.26	1.32	0.56	0.00	0.00
Pervious (SWMF)	5	2150	0.22	C/D	LAWNS	ROLLING / HILLY	100.00	0.15	0.10	0.15	0.40	0.40	0.78	1.15	0.55	0.00	0.00	0.00	0.00	2.81	4.95	5.06	4.26	1.32	0.56	0.00	0.00
Pervious (Direct Runoff / Wetland)	6	5400	0.54	C/D	PASTURE / SHRUBS	ROLLING / HILLY	250.00	0.15	0.10	0.15	0.65	0.40	0.68	0.95	0.90	0.00	0.00	0.00	0.00	2.45	4.09	4.18	3.52	2.16	0.56	0.00	0.00

[1]Available Water Content (AWC) and Infiltration Factors (IF) for pervious areas based on Table 3.1 from the Stormwater Management Planning and Design Manual (MOE, 2003)

[2]Crop Cover Coefficients based on Table 12 from the Food and Agriculture Organization of the United Nations (FAO), 1998, Crop Evapotranspiration - Guidelines for Computing Crop Water Requirements - FAO Irrigation and Drainage paper 56

[3]Measured Potential Evaporation Data (i.e. Lake Evaporation) from the Environment Canada Canadian Climate Normals (Ottawa CDA, 1981-2010)

Hannan Hills Subdivision (118201)
Water Balance Model Results
Post-Development

Water Balance for Area 1: Front Yard - Impervious (roofs / driveways / roads)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	0.0	58.0
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	0.0	52.7
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	0.0	86.4
April	76.6	14.4	73.1	3.5	6.7	79.8	65.4	-1.0	8.0	72.9	0.0	72.9
May	78.2	102.1	78.2	0.0	0.0	78.2	-23.9	0.0	35.9	42.4	0.0	42.4
June	96.0	127.0	96.0	0.0	0.0	96.0	-31.0	-0.1	43.3	52.7	0.0	52.7
July	91.1	133.0	91.1	0.0	0.0	91.1	-41.8	-0.2	40.6	50.7	0.0	50.7
August	87.2	111.4	87.2	0.0	0.0	87.2	-24.2	-0.1	33.4	53.9	0.0	53.9
September	88.2	72.4	88.2	0.0	0.0	88.2	15.8	0.5	28.1	59.5	0.0	59.5
October	88.7	40.8	87.8	0.9	0.6	88.4	47.6	0.1	22.2	66.0	0.0	66.0
November	73.9	4.7	58.3	15.5	12.9	71.2	66.5	0.8	3.3	67.1	0.0	67.1
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	0.0	48.8
ANNUAL TOTAL	**926.1**	**605.8**	**726.2**	**199.8**	**199.8**	**926.0**	**320.3**	**0.0**	**214.9**	**711.2**	**0.0**	**711.2**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	605.8	713.0	123.1	133.9	846.9	241.1	0.0	205.8	641.1	0.0	641.1
1989	817.1	605.8	620.0	197.1	153.8	773.8	168.0	0.0	180.5	593.3	0.0	593.3
1990	976.7	605.8	777.6	199.1	232.7	1010.3	404.5	0.0	207.6	802.7	0.0	802.7
1991	820.2	605.8	619.1	201.1	204.0	823.1	217.4	0.0	191.6	631.5	0.0	631.5
1992	908.3	605.8	651.9	256.4	260.2	912.1	306.4	0.0	211.4	700.8	0.0	700.8
1993	1019.3	605.8	754.0	265.3	266.3	1020.3	414.5	0.0	243.6	776.7	0.0	776.7
1994	909.5	605.8	681.6	227.9	234.2	915.8	310.1	0.0	224.9	690.9	0.0	690.9
1995	1038.4	605.8	809.4	229.0	138.2	947.6	341.9	0.0	197.5	750.2	0.0	750.2
1996	1004.7	605.8	866.9	137.8	213.7	1080.6	474.8	0.0	220.2	860.4	0.0	860.4
1997	773.0	605.8	475.9	297.1	309.5	785.4	179.7	0.0	178.1	607.3	0.0	607.3
1998	841.6	605.8	630.0	211.6	192.8	822.8	217.1	0.0	209.4	613.4	0.0	613.4
1999	830.5	605.8	623.3	207.2	219.8	843.1	237.3	0.0	192.7	650.4	0.0	650.4
2000	987.4	605.8	783.0	204.4	162.0	945.0	339.3	0.0	240.8	704.2	0.0	704.2
2001	753.6	605.8	580.3	173.3	213.1	793.4	187.7	0.0	195.0	598.5	0.0	598.5
2002	867.9	605.8	687.7	180.2	189.6	877.3	271.6	0.0	194.6	682.8	0.0	682.8
2003	1068.5	605.8	820.4	248.1	255.3	1075.7	469.9	0.0	233.9	841.8	0.0	841.8
2004	919.7	605.8	756.2	163.5	124.4	880.6	274.9	0.0	220.1	660.5	0.0	660.5
2005	939.6	605.8	784.9	154.7	175.8	960.7	354.9	0.0	218.2	742.5	0.0	742.5
2006	1152.0	605.8	970.6	181.4	183.1	1153.7	547.9	0.0	241.1	912.6	0.0	912.6
2007	901.0	605.8	728.8	172.2	170.0	898.8	293.1	0.0	205.7	693.1	0.0	693.1
2008	1057.6	605.8	681.6	376.0	391.5	1073.1	467.3	0.0	234.1	838.9	0.0	838.9
2009	946.5	605.8	800.3	146.2	93.4	893.7	288.0	0.0	256.2	637.5	0.0	637.5
2010	970.2	605.8	867.0	103.2	159.0	1026.0	420.2	0.0	245.4	780.5	0.0	780.5
2011	878.2	605.8	676.6	201.6	179.8	856.4	250.7	0.0	217.9	638.6	0.0	638.6
2012	807.5	605.8	596.6	210.9	147.0	743.6	137.8	0.0	208.6	535.0	0.0	535.0
2013	881.4	605.8	704.2	177.2	217.5	921.7	316.0	0.0	231.7	690.0	0.0	690.0
2014	903.1	605.8	759.5	143.6	189.0	948.5	342.7	0.0	230.4	718.0	0.0	718.0
2015	785.7	605.8	648.3	137.4	108.6	756.9	151.2	0.0	200.5	556.4	0.0	556.4
2016	917.9	605.8	656.4	261.5	262.2	918.6	312.9	0.0	171.9	746.8	0.0	746.8
2017	1268.5	605.8	1061.5	207.0	214.0	1275.5	669.7	0.0	236.8	1038.7	0.0	1038.7
AVERAGE	**926.1**	**605.8**	**726.2**	**199.8**	**199.8**	**926.0**	**320.3**	**0.0**	**214.9**	**711.2**	**0.0**	**711.2**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Post-Development

Water Balance for Area 2: Front Yard - Pervious (open space / lawns)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	23.2	34.8
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	21.1	31.6
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	34.5	51.8
April	76.6	11.2	73.1	3.5	6.7	79.8	68.6	-3.9	11.0	72.7	29.1	43.6
May	78.2	86.6	78.2	0.0	0.0	78.2	-8.4	-18.1	76.9	19.4	7.8	11.6
June	96.0	141.6	96.0	0.0	0.0	96.0	-45.6	-19.3	105.0	10.3	4.1	6.2
July	91.1	152.9	91.1	0.0	0.0	91.1	-61.8	-9.7	96.7	4.1	1.7	2.5
August	87.2	121.8	87.2	0.0	0.0	87.2	-34.6	3.8	77.1	6.2	2.5	3.7
September	88.2	46.5	88.2	0.0	0.0	88.2	41.7	36.7	35.7	15.8	6.3	9.5
October	88.7	17.6	87.8	0.9	0.6	88.4	70.8	9.9	17.0	61.4	24.6	36.8
November	73.9	1.9	58.3	15.5	12.9	71.2	69.3	0.6	1.9	68.8	27.5	41.3
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	19.5	29.3
ANNUAL TOTAL	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	580.0	713.0	123.1	133.9	846.9	266.8	0.0	414.9	432.0	172.8	259.2
1989	817.1	580.0	620.0	197.1	153.8	773.8	193.8	0.0	397.5	376.3	150.5	225.8
1990	976.7	580.0	777.6	199.1	232.7	1010.3	430.2	0.0	417.5	592.8	237.1	355.7
1991	820.2	580.0	619.1	201.1	204.0	823.1	243.1	0.0	337.0	486.1	194.4	291.7
1992	908.3	580.0	651.9	256.4	260.2	912.1	332.1	0.0	451.5	460.6	184.2	276.4
1993	1019.3	580.0	754.0	265.3	266.3	1020.3	440.2	0.0	414.5	605.8	242.3	363.5
1994	909.5	580.0	681.6	227.9	234.2	915.8	335.8	0.0	482.7	433.1	173.2	259.8
1995	1038.4	580.0	809.4	229.0	138.2	947.6	367.6	0.0	422.0	525.6	210.2	315.4
1996	1004.7	580.0	866.9	137.8	213.7	1080.6	500.5	0.0	442.4	638.2	255.3	382.9
1997	773.0	580.0	475.9	297.1	309.5	785.4	205.4	0.0	324.0	461.4	184.5	276.8
1998	841.6	580.0	630.0	211.6	192.8	822.8	242.8	0.0	407.2	415.6	166.3	249.4
1999	830.5	580.0	623.3	207.2	219.8	843.1	263.0	0.0	378.3	464.8	185.9	278.9
2000	987.4	580.0	783.0	204.4	162.0	945.0	365.0	0.0	478.8	466.2	186.5	279.7
2001	753.6	580.0	580.3	173.3	213.1	793.4	213.4	0.0	351.4	442.0	176.8	265.2
2002	867.9	580.0	687.7	180.2	189.6	877.3	297.3	0.0	402.0	475.4	190.1	285.2
2003	1068.5	580.0	820.4	248.1	255.3	1075.7	495.6	0.0	439.9	635.8	254.3	381.5
2004	919.7	580.0	756.2	163.5	124.4	880.6	300.6	0.0	411.4	469.2	187.7	281.5
2005	939.6	580.0	784.9	154.7	175.8	960.7	380.7	0.0	416.9	543.8	217.5	326.3
2006	1152.0	580.0	970.6	181.4	183.1	1153.7	573.6	0.0	468.7	685.0	274.0	411.0
2007	901.0	580.0	728.8	172.2	170.0	898.8	318.8	0.0	421.4	477.4	191.0	286.5
2008	1057.6	580.0	681.6	376.0	391.5	1073.1	493.0	0.0	461.1	612.0	244.8	367.2
2009	946.5	580.0	800.3	146.2	93.4	893.7	313.7	0.0	477.2	416.6	166.6	250.0
2010	970.2	580.0	867.0	103.2	159.0	1026.0	445.9	0.0	434.0	592.0	236.8	355.2
2011	878.2	580.0	676.6	201.6	179.8	856.4	276.4	0.0	396.3	460.2	184.1	276.1
2012	807.5	580.0	596.6	210.9	147.0	743.6	163.5	0.0	363.9	379.7	151.9	227.8
2013	881.4	580.0	704.2	177.2	217.5	921.7	341.7	0.0	454.2	467.5	187.0	280.5
2014	903.1	580.0	759.5	143.6	189.0	948.5	368.4	0.0	461.0	487.5	195.0	292.5
2015	785.7	580.0	648.3	137.4	108.6	756.9	176.9	0.0	424.2	332.7	133.1	199.6
2016	917.9	580.0	656.4	261.5	262.2	918.6	338.6	0.0	389.6	529.0	211.6	317.4
2017	1268.5	580.0	1061.5	207.0	214.0	1275.5	695.4	0.0	500.1	775.4	310.2	465.2
AVERAGE	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Water Balance for Area 3: Internal Rear Yards - Impervious (roofs / driveways / roads)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	0.0	58.0
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	0.0	52.7
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	0.0	86.4
April	76.6	14.4	73.1	3.5	6.7	79.8	65.4	-1.0	8.0	72.9	0.0	72.9
May	78.2	102.1	78.2	0.0	0.0	78.2	-23.9	0.0	35.9	42.4	0.0	42.4
June	96.0	127.0	96.0	0.0	0.0	96.0	-31.0	-0.1	43.3	52.7	0.0	52.7
July	91.1	133.0	91.1	0.0	0.0	91.1	-41.8	-0.2	40.6	50.7	0.0	50.7
August	87.2	111.4	87.2	0.0	0.0	87.2	-24.2	-0.1	33.4	53.9	0.0	53.9
September	88.2	72.4	88.2	0.0	0.0	88.2	15.8	0.5	28.1	59.5	0.0	59.5
October	88.7	40.8	87.8	0.9	0.6	88.4	47.6	0.1	22.2	66.0	0.0	66.0
November	73.9	4.7	58.3	15.5	12.9	71.2	66.5	0.8	3.3	67.1	0.0	67.1
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	0.0	48.8
ANNUAL TOTAL	**926.1**	**605.8**	**726.2**	**199.8**	**199.8**	**926.0**	**320.3**	**0.0**	**214.9**	**711.2**	**0.0**	**711.2**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	605.8	713.0	123.1	133.9	846.9	241.1	0.0	205.8	641.1	0.0	641.1
1989	817.1	605.8	620.0	197.1	153.8	773.8	168.0	0.0	180.5	593.3	0.0	593.3
1990	976.7	605.8	777.6	199.1	232.7	1010.3	404.5	0.0	207.6	802.7	0.0	802.7
1991	820.2	605.8	619.1	201.1	204.0	823.1	217.4	0.0	191.6	631.5	0.0	631.5
1992	908.3	605.8	651.9	256.4	260.2	912.1	306.4	0.0	211.4	700.8	0.0	700.8
1993	1019.3	605.8	754.0	265.3	266.3	1020.3	414.5	0.0	243.6	776.7	0.0	776.7
1994	909.5	605.8	681.6	227.9	234.2	915.8	310.1	0.0	224.9	690.9	0.0	690.9
1995	1038.4	605.8	809.4	229.0	138.2	947.6	341.9	0.0	197.5	750.2	0.0	750.2
1996	1004.7	605.8	866.9	137.8	213.7	1080.6	474.8	0.0	220.2	860.4	0.0	860.4
1997	773.0	605.8	475.9	297.1	309.5	785.4	179.7	0.0	178.1	607.3	0.0	607.3
1998	841.6	605.8	630.0	211.6	192.8	822.8	217.1	0.0	209.4	613.4	0.0	613.4
1999	830.5	605.8	623.3	207.2	219.8	843.1	237.3	0.0	192.7	650.4	0.0	650.4
2000	987.4	605.8	783.0	204.4	162.0	945.0	339.3	0.0	240.8	704.2	0.0	704.2
2001	753.6	605.8	580.3	173.3	213.1	793.4	187.7	0.0	195.0	598.5	0.0	598.5
2002	867.9	605.8	687.7	180.2	189.6	877.3	271.6	0.0	194.6	682.8	0.0	682.8
2003	1068.5	605.8	820.4	248.1	255.3	1075.7	469.9	0.0	233.9	841.8	0.0	841.8
2004	919.7	605.8	756.2	163.5	124.4	880.6	274.9	0.0	220.1	660.5	0.0	660.5
2005	939.6	605.8	784.9	154.7	175.8	960.7	354.9	0.0	218.2	742.5	0.0	742.5
2006	1152.0	605.8	970.6	181.4	183.1	1153.7	547.9	0.0	241.1	912.6	0.0	912.6
2007	901.0	605.8	728.8	172.2	170.0	898.8	293.1	0.0	205.7	693.1	0.0	693.1
2008	1057.6	605.8	681.6	376.0	391.5	1073.1	467.3	0.0	234.1	838.9	0.0	838.9
2009	946.5	605.8	800.3	146.2	93.4	893.7	288.0	0.0	256.2	637.5	0.0	637.5
2010	970.2	605.8	867.0	103.2	159.0	1026.0	420.2	0.0	245.4	780.5	0.0	780.5
2011	878.2	605.8	676.6	201.6	179.8	856.4	250.7	0.0	217.9	638.6	0.0	638.6
2012	807.5	605.8	596.6	210.9	147.0	743.6	137.8	0.0	208.6	535.0	0.0	535.0
2013	881.4	605.8	704.2	177.2	217.5	921.7	316.0	0.0	231.7	690.0	0.0	690.0
2014	903.1	605.8	759.5	143.6	189.0	948.5	342.7	0.0	230.4	718.0	0.0	718.0
2015	785.7	605.8	648.3	137.4	108.6	756.9	151.2	0.0	200.5	556.4	0.0	556.4
2016	917.9	605.8	656.4	261.5	262.2	918.6	312.9	0.0	171.9	746.8	0.0	746.8
2017	1268.5	605.8	1061.5	207.0	214.0	1275.5	669.7	0.0	236.8	1038.7	0.0	1038.7
AVERAGE	**926.1**	**605.8**	**726.2**	**199.8**	**199.8**	**926.0**	**320.3**	**0.0**	**214.9**	**711.2**	**0.0**	**711.2**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Post-Development

NOVATECH
Engineers, Planners & Landscape Architects

Water Balance for Area 4: Internal Rear Yards - Pervious (open space / lawns)

Average Monthly Results												
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	23.2	34.8
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	21.1	31.6
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	34.5	51.8
April	76.6	11.2	73.1	3.5	6.7	79.8	68.6	-3.9	11.0	72.7	29.1	43.6
May	78.2	86.6	78.2	0.0	0.0	78.2	-8.4	-18.1	76.9	19.4	7.8	11.6
June	96.0	141.6	96.0	0.0	0.0	96.0	-45.6	-19.3	105.0	10.3	4.1	6.2
July	91.1	152.9	91.1	0.0	0.0	91.1	-61.8	-9.7	96.7	4.1	1.7	2.5
August	87.2	121.8	87.2	0.0	0.0	87.2	-34.6	3.8	77.1	6.2	2.5	3.7
September	88.2	46.5	88.2	0.0	0.0	88.2	41.7	36.7	35.7	15.8	6.3	9.5
October	88.7	17.6	87.8	0.9	0.6	88.4	70.8	9.9	17.0	61.4	24.6	36.8
November	73.9	1.9	58.3	15.5	12.9	71.2	69.3	0.6	1.9	68.8	27.5	41.3
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	19.5	29.3
ANNUAL TOTAL	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

Total Number of Years = *30*

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	580.0	713.0	123.1	133.9	846.9	266.8	0.0	414.9	432.0	172.8	259.2
1989	817.1	580.0	620.0	197.1	153.8	773.8	193.8	0.0	397.5	376.3	150.5	225.8
1990	976.7	580.0	777.6	199.1	232.7	1010.3	430.2	0.0	417.5	592.8	237.1	355.7
1991	820.2	580.0	619.1	201.1	204.0	823.1	243.1	0.0	337.0	486.1	194.4	291.7
1992	908.3	580.0	651.9	256.4	260.2	912.1	332.1	0.0	451.5	460.6	184.2	276.4
1993	1019.3	580.0	754.0	265.3	266.3	1020.3	440.2	0.0	414.5	605.8	242.3	363.5
1994	909.5	580.0	681.6	227.9	234.2	915.8	335.8	0.0	482.7	433.1	173.2	259.8
1995	1038.4	580.0	809.4	229.0	138.2	947.6	367.6	0.0	422.0	525.6	210.2	315.4
1996	1004.7	580.0	866.9	137.8	213.7	1080.6	500.5	0.0	442.4	638.2	255.3	382.9
1997	773.0	580.0	475.9	297.1	309.5	785.4	205.4	0.0	324.0	461.4	184.5	276.8
1998	841.6	580.0	630.0	211.6	192.8	822.8	242.8	0.0	407.2	415.6	166.3	249.4
1999	830.5	580.0	623.3	207.2	219.8	843.1	263.0	0.0	378.3	464.8	185.9	278.9
2000	987.4	580.0	783.0	204.4	162.0	945.0	365.0	0.0	478.8	466.2	186.5	279.7
2001	753.6	580.0	580.3	173.3	213.1	793.4	213.4	0.0	351.4	442.0	176.8	265.2
2002	867.9	580.0	687.7	180.2	189.6	877.3	297.3	0.0	402.0	475.4	190.1	285.2
2003	1068.5	580.0	820.4	248.1	255.3	1075.7	495.6	0.0	439.9	635.8	254.3	381.5
2004	919.7	580.0	756.2	163.5	124.4	880.6	300.6	0.0	411.4	469.2	187.7	281.5
2005	939.6	580.0	784.9	154.7	175.8	960.7	380.7	0.0	416.9	543.8	217.5	326.3
2006	1152.0	580.0	970.6	181.4	183.1	1153.7	573.6	0.0	468.7	685.0	274.0	411.0
2007	901.0	580.0	728.8	172.2	170.0	898.8	318.8	0.0	421.4	477.4	191.0	286.5
2008	1057.6	580.0	681.6	376.0	391.5	1073.1	493.0	0.0	461.1	612.0	244.8	367.2
2009	946.5	580.0	800.3	146.2	93.4	893.7	313.7	0.0	477.2	416.6	166.6	250.0
2010	970.2	580.0	867.0	103.2	159.0	1026.0	445.9	0.0	434.0	592.0	236.8	355.2
2011	878.2	580.0	676.6	201.6	179.8	856.4	276.4	0.0	396.3	460.2	184.1	276.1
2012	807.5	580.0	596.6	210.9	147.0	743.6	163.5	0.0	363.9	379.7	151.9	227.8
2013	881.4	580.0	704.2	177.2	217.5	921.7	341.7	0.0	454.2	467.5	187.0	280.5
2014	903.1	580.0	759.5	143.6	189.0	948.5	368.4	0.0	461.0	487.5	195.0	292.5
2015	785.7	580.0	648.3	137.4	108.6	756.9	176.9	0.0	424.2	332.7	133.1	199.6
2016	917.9	580.0	656.4	261.5	262.2	918.6	338.6	0.0	389.6	529.0	211.6	317.4
2017	1268.5	580.0	1061.5	207.0	214.0	1275.5	695.4	0.0	500.1	775.4	310.2	465.2
AVERAGE	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Post-Development

NOVATECH
Engineers, Planners & Landscape Architects

Water Balance for Area 5: Perimeter Rear Yards - Impervious (roofs / driveways / roads)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	0.0	58.0
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	0.0	52.7
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	0.0	86.4
April	76.6	14.4	73.1	3.5	6.7	79.8	65.4	-1.0	8.0	72.9	0.0	72.9
May	78.2	102.1	78.2	0.0	0.0	78.2	-23.9	0.0	35.9	42.4	0.0	42.4
June	96.0	127.0	96.0	0.0	0.0	96.0	-31.0	-0.1	43.3	52.7	0.0	52.7
July	91.1	133.0	91.1	0.0	0.0	91.1	-41.8	-0.2	40.6	50.7	0.0	50.7
August	87.2	111.4	87.2	0.0	0.0	87.2	-24.2	-0.1	33.4	53.9	0.0	53.9
September	88.2	72.4	88.2	0.0	0.0	88.2	15.8	0.5	28.1	59.5	0.0	59.5
October	88.7	40.8	87.8	0.9	0.6	88.4	47.6	0.1	22.2	66.0	0.0	66.0
November	73.9	4.7	58.3	15.5	12.9	71.2	66.5	0.8	3.3	67.1	0.0	67.1
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	0.0	48.8
ANNUAL TOTAL	**926.1**	**605.8**	**726.2**	**199.8**	**199.8**	**926.0**	**320.3**	**0.0**	**214.9**	**711.2**	**0.0**	**711.2**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	605.8	713.0	123.1	133.9	846.9	241.1	0.0	205.8	641.1	0.0	641.1
1989	817.1	605.8	620.0	197.1	153.8	773.8	168.0	0.0	180.5	593.3	0.0	593.3
1990	976.7	605.8	777.6	199.1	232.7	1010.3	404.5	0.0	207.6	802.7	0.0	802.7
1991	820.2	605.8	619.1	201.1	204.0	823.1	217.4	0.0	191.6	631.5	0.0	631.5
1992	908.3	605.8	651.9	256.4	260.2	912.1	306.4	0.0	211.4	700.8	0.0	700.8
1993	1019.3	605.8	754.0	265.3	266.3	1020.3	414.5	0.0	243.6	776.7	0.0	776.7
1994	909.5	605.8	681.6	227.9	234.2	915.8	310.1	0.0	224.9	690.9	0.0	690.9
1995	1038.4	605.8	809.4	229.0	138.2	947.6	341.9	0.0	197.5	750.2	0.0	750.2
1996	1004.7	605.8	866.9	137.8	213.7	1080.6	474.8	0.0	220.2	860.4	0.0	860.4
1997	773.0	605.8	475.9	297.1	309.5	785.4	179.7	0.0	178.1	607.3	0.0	607.3
1998	841.6	605.8	630.0	211.6	192.8	822.8	217.1	0.0	209.4	613.4	0.0	613.4
1999	830.5	605.8	623.3	207.2	219.8	843.1	237.3	0.0	192.7	650.4	0.0	650.4
2000	987.4	605.8	783.0	204.4	162.0	945.0	339.3	0.0	240.8	704.2	0.0	704.2
2001	753.6	605.8	580.3	173.3	213.1	793.4	187.7	0.0	195.0	598.5	0.0	598.5
2002	867.9	605.8	687.7	180.2	189.6	877.3	271.6	0.0	194.6	682.8	0.0	682.8
2003	1068.5	605.8	820.4	248.1	255.3	1075.7	469.9	0.0	233.9	841.8	0.0	841.8
2004	919.7	605.8	756.2	163.5	124.4	880.6	274.9	0.0	220.1	660.5	0.0	660.5
2005	939.6	605.8	784.9	154.7	175.8	960.7	354.9	0.0	218.2	742.5	0.0	742.5
2006	1152.0	605.8	970.6	181.4	183.1	1153.7	547.9	0.0	241.1	912.6	0.0	912.6
2007	901.0	605.8	728.8	172.2	170.0	898.8	293.1	0.0	205.7	693.1	0.0	693.1
2008	1057.6	605.8	681.6	376.0	391.5	1073.1	467.3	0.0	234.1	838.9	0.0	838.9
2009	946.5	605.8	800.3	146.2	93.4	893.7	288.0	0.0	256.2	637.5	0.0	637.5
2010	970.2	605.8	867.0	103.2	159.0	1026.0	420.2	0.0	245.4	780.5	0.0	780.5
2011	878.2	605.8	676.6	201.6	179.8	856.4	250.7	0.0	217.9	638.6	0.0	638.6
2012	807.5	605.8	596.6	210.9	147.0	743.6	137.8	0.0	208.6	535.0	0.0	535.0
2013	881.4	605.8	704.2	177.2	217.5	921.7	316.0	0.0	231.7	690.0	0.0	690.0
2014	903.1	605.8	759.5	143.6	189.0	948.5	342.7	0.0	230.4	718.0	0.0	718.0
2015	785.7	605.8	648.3	137.4	108.6	756.9	151.2	0.0	200.5	556.4	0.0	556.4
2016	917.9	605.8	656.4	261.5	262.2	918.6	312.9	0.0	171.9	746.8	0.0	746.8
2017	1268.5	605.8	1061.5	207.0	214.0	1275.5	669.7	0.0	236.8	1038.7	0.0	1038.7
AVERAGE	**926.1**	**605.8**	**726.2**	**199.8**	**199.8**	**926.0**	**320.3**	**0.0**	**214.9**	**711.2**	**0.0**	**711.2**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Post-Development

Water Balance for Area 6: Perimeter Rear Yards - Pervious (open space / lawns)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	23.2	34.8
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	21.1	31.6
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	34.5	51.8
April	76.6	11.2	73.1	3.5	6.7	79.8	68.6	-3.9	11.0	72.7	29.1	43.6
May	78.2	86.6	78.2	0.0	0.0	78.2	-8.4	-18.1	76.9	19.4	7.8	11.6
June	96.0	141.6	96.0	0.0	0.0	96.0	-45.6	-19.3	105.0	10.3	4.1	6.2
July	91.1	152.9	91.1	0.0	0.0	91.1	-61.8	-9.7	96.7	4.1	1.7	2.5
August	87.2	121.8	87.2	0.0	0.0	87.2	-34.6	3.8	77.1	6.2	2.5	3.7
September	88.2	46.5	88.2	0.0	0.0	88.2	41.7	36.7	35.7	15.8	6.3	9.5
October	88.7	17.6	87.8	0.9	0.6	88.4	70.8	9.9	17.0	61.4	24.6	36.8
November	73.9	1.9	58.3	15.5	12.9	71.2	69.3	0.6	1.9	68.8	27.5	41.3
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	19.5	29.3
ANNUAL TOTAL	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	580.0	713.0	123.1	133.9	846.9	266.8	0.0	414.9	432.0	172.8	259.2
1989	817.1	580.0	620.0	197.1	153.8	773.8	193.8	0.0	397.5	376.3	150.5	225.8
1990	976.7	580.0	777.6	199.1	232.7	1010.3	430.2	0.0	417.5	592.8	237.1	355.7
1991	820.2	580.0	619.1	201.1	204.0	823.1	243.1	0.0	337.0	486.1	194.4	291.7
1992	908.3	580.0	651.9	256.4	260.2	912.1	332.1	0.0	451.5	460.6	184.2	276.4
1993	1019.3	580.0	754.0	265.3	266.3	1020.3	440.2	0.0	414.5	605.8	242.3	363.5
1994	909.5	580.0	681.6	227.9	234.2	915.8	335.8	0.0	482.7	433.1	173.2	259.8
1995	1038.4	580.0	809.4	229.0	138.2	947.6	367.6	0.0	422.0	525.6	210.2	315.4
1996	1004.7	580.0	866.9	137.8	213.7	1080.6	500.5	0.0	442.4	638.2	255.3	382.9
1997	773.0	580.0	475.9	297.1	309.5	785.4	205.4	0.0	324.0	461.4	184.5	276.8
1998	841.6	580.0	630.0	211.6	192.8	822.8	242.8	0.0	407.2	415.6	166.3	249.4
1999	830.5	580.0	623.3	207.2	219.8	843.1	263.0	0.0	378.3	464.8	185.9	278.9
2000	987.4	580.0	783.0	204.4	162.0	945.0	365.0	0.0	478.8	466.2	186.5	279.7
2001	753.6	580.0	580.3	173.3	213.1	793.4	213.4	0.0	351.4	442.0	176.8	265.2
2002	867.9	580.0	687.7	180.2	189.6	877.3	297.3	0.0	402.0	475.4	190.1	285.2
2003	1068.5	580.0	820.4	248.1	255.3	1075.7	495.6	0.0	439.9	635.8	254.3	381.5
2004	919.7	580.0	756.2	163.5	124.4	880.6	300.6	0.0	411.4	469.2	187.7	281.5
2005	939.6	580.0	784.9	154.7	175.8	960.7	380.7	0.0	416.9	543.8	217.5	326.3
2006	1152.0	580.0	970.6	181.4	183.1	1153.7	573.6	0.0	468.7	685.0	274.0	411.0
2007	901.0	580.0	728.8	172.2	170.0	898.8	318.8	0.0	421.4	477.4	191.0	286.5
2008	1057.6	580.0	681.6	376.0	391.5	1073.1	493.0	0.0	461.1	612.0	244.8	367.2
2009	946.5	580.0	800.3	146.2	93.4	893.7	313.7	0.0	477.2	416.6	166.6	250.0
2010	970.2	580.0	867.0	103.2	159.0	1026.0	445.9	0.0	434.0	592.0	236.8	355.2
2011	878.2	580.0	676.6	201.6	179.8	856.4	276.4	0.0	396.3	460.2	184.1	276.1
2012	807.5	580.0	596.6	210.9	147.0	743.6	163.5	0.0	363.9	379.7	151.9	227.8
2013	881.4	580.0	704.2	177.2	217.5	921.7	341.7	0.0	454.2	467.5	187.0	280.5
2014	903.1	580.0	759.5	143.6	189.0	948.5	368.4	0.0	461.0	487.5	195.0	292.5
2015	785.7	580.0	648.3	137.4	108.6	756.9	176.9	0.0	424.2	332.7	133.1	199.6
2016	917.9	580.0	656.4	261.5	262.2	918.6	338.6	0.0	389.6	529.0	211.6	317.4
2017	1268.5	580.0	1061.5	207.0	214.0	1275.5	695.4	0.0	500.1	775.4	310.2	465.2
AVERAGE	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Post-Development

NOVATECH
Engineers, Planners & Landscape Architects

Water Balance for Area 7: Pervious (SWMF)

Average Monthly Results											
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	23.2	34.8
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	21.1	31.6
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	34.5	51.8
April	76.6	11.2	73.1	3.5	6.7	79.8	68.6	-3.9	11.0	72.7	29.1	43.6
May	78.2	86.6	78.2	0.0	0.0	78.2	-8.4	-18.1	76.9	19.4	7.8	11.6
June	96.0	141.6	96.0	0.0	0.0	96.0	-45.6	-19.3	105.0	10.3	4.1	6.2
July	91.1	152.9	91.1	0.0	0.0	91.1	-61.8	-9.7	96.7	4.1	1.7	2.5
August	87.2	121.8	87.2	0.0	0.0	87.2	-34.6	3.8	77.1	6.2	2.5	3.7
September	88.2	46.5	88.2	0.0	0.0	88.2	41.7	36.7	35.7	15.8	6.3	9.5
October	88.7	17.6	87.8	0.9	0.6	88.4	70.8	9.9	17.0	61.4	24.6	36.8
November	73.9	1.9	58.3	15.5	12.9	71.2	69.3	0.6	1.9	68.8	27.5	41.3
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	19.5	29.3
ANNUAL TOTAL	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	580.0	713.0	123.1	133.9	846.9	266.8	0.0	414.9	432.0	172.8	259.2
1989	817.1	580.0	620.0	197.1	153.8	773.8	193.8	0.0	397.5	376.3	150.5	225.8
1990	976.7	580.0	777.6	199.1	232.7	1010.3	430.2	0.0	417.5	592.8	237.1	355.7
1991	820.2	580.0	619.1	201.1	204.0	823.1	243.1	0.0	337.0	486.1	194.4	291.7
1992	908.3	580.0	651.9	256.4	260.2	912.1	332.1	0.0	451.5	460.6	184.2	276.4
1993	1019.3	580.0	754.0	265.3	266.3	1020.3	440.2	0.0	414.5	605.8	242.3	363.5
1994	909.5	580.0	681.6	227.9	234.2	915.8	335.8	0.0	482.7	433.1	173.2	259.8
1995	1038.4	580.0	809.4	229.0	138.2	947.6	367.6	0.0	422.0	525.6	210.2	315.4
1996	1004.7	580.0	866.9	137.8	213.7	1080.6	500.5	0.0	442.4	638.2	255.3	382.9
1997	773.0	580.0	475.9	297.1	309.5	785.4	205.4	0.0	324.0	461.4	184.5	276.8
1998	841.6	580.0	630.0	211.6	192.8	822.8	242.8	0.0	407.2	415.6	166.3	249.4
1999	830.5	580.0	623.3	207.2	219.8	843.1	263.0	0.0	378.3	464.8	185.9	278.9
2000	987.4	580.0	783.0	204.4	162.0	945.0	365.0	0.0	478.8	466.2	186.5	279.7
2001	753.6	580.0	580.3	173.3	213.1	793.4	213.4	0.0	351.4	442.0	176.8	265.2
2002	867.9	580.0	687.7	180.2	189.6	877.3	297.3	0.0	402.0	475.4	190.1	285.2
2003	1068.5	580.0	820.4	248.1	255.3	1075.7	495.6	0.0	439.9	635.8	254.3	381.5
2004	919.7	580.0	756.2	163.5	124.4	880.6	300.6	0.0	411.4	469.2	187.7	281.5
2005	939.6	580.0	784.9	154.7	175.8	960.7	380.7	0.0	416.9	543.8	217.5	326.3
2006	1152.0	580.0	970.6	181.4	183.1	1153.7	573.6	0.0	468.7	685.0	274.0	411.0
2007	901.0	580.0	728.8	172.2	170.0	898.8	318.8	0.0	421.4	477.4	191.0	286.5
2008	1057.6	580.0	681.6	376.0	391.5	1073.1	493.0	0.0	461.1	612.0	244.8	367.2
2009	946.5	580.0	800.3	146.2	93.4	893.7	313.7	0.0	477.2	416.6	166.6	250.0
2010	970.2	580.0	867.0	103.2	159.0	1026.0	445.9	0.0	434.0	592.0	236.8	355.2
2011	878.2	580.0	676.6	201.6	179.8	856.4	276.4	0.0	396.3	460.2	184.1	276.1
2012	807.5	580.0	596.6	210.9	147.0	743.6	163.5	0.0	363.9	379.7	151.9	227.8
2013	881.4	580.0	704.2	177.2	217.5	921.7	341.7	0.0	454.2	467.5	187.0	280.5
2014	903.1	580.0	759.5	143.6	189.0	948.5	368.4	0.0	461.0	487.5	195.0	292.5
2015	785.7	580.0	648.3	137.4	108.6	756.9	176.9	0.0	424.2	332.7	133.1	199.6
2016	917.9	580.0	656.4	261.5	262.2	918.6	338.6	0.0	389.6	529.0	211.6	317.4
2017	1268.5	580.0	1061.5	207.0	214.0	1275.5	695.4	0.0	500.1	775.4	310.2	465.2
AVERAGE	**926.1**	**580.0**	**726.2**	**199.8**	**199.8**	**926.0**	**346.0**	**0.0**	**421.4**	**504.7**	**201.9**	**302.8**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Model Results
Post-Development

NOVATECH
Engineers, Planners & Landscape Architects

Water Balance for Area 8: Pervious (Direct Runoff / Wetland)

Average Monthly Results												
Month	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
January	63.3	0.0	10.9	52.4	47.1	58.0	58.0	0.0	0.0	58.0	37.7	20.3
February	51.9	0.0	10.1	41.8	42.7	52.7	52.7	0.0	0.0	52.7	34.3	18.5
March	60.0	0.0	24.8	35.2	61.5	86.4	86.4	0.0	0.0	86.4	56.1	30.2
April	76.6	9.8	73.1	3.5	6.7	79.8	70.1	-3.4	9.7	73.5	47.8	25.7
May	78.2	74.5	78.2	0.0	0.0	78.2	3.7	-16.9	71.6	23.5	15.3	8.2
June	96.0	117.4	96.0	0.0	0.0	96.0	-21.4	-23.2	105.7	13.5	8.8	4.7
July	91.1	126.3	91.1	0.0	0.0	91.1	-35.2	-19.5	105.5	5.2	3.4	1.8
August	87.2	105.3	87.2	0.0	0.0	87.2	-18.1	-3.1	85.6	4.7	3.1	1.6
September	88.2	63.0	88.2	0.0	0.0	88.2	25.2	28.5	53.2	6.5	4.2	2.3
October	88.7	20.5	87.8	0.9	0.6	88.4	67.9	32.6	19.3	36.5	23.7	12.8
November	73.9	1.9	58.3	15.5	12.9	71.2	69.3	5.1	1.9	64.3	41.8	22.5
December	71.0	0.0	20.5	50.5	28.3	48.8	48.8	0.0	0.0	48.8	31.7	17.1
ANNUAL TOTAL	**926.1**	**518.7**	**726.2**	**199.8**	**199.8**	**926.0**	**407.4**	**0.0**	**452.4**	**473.6**	**307.9**	**165.8**

Total Number of Years = 30

Average Annual Results												
Year	**Precip.**	**PET**	**Rain**	**Snow**	**Snowmelt**	**Water Input**	**W-PET**	**ΔSoil Water**	**AET**	**Surplus**	**Infiltration**	**Runoff**
1988	836.1	518.7	713.0	123.1	133.9	846.9	328.2	0.0	452.2	394.7	256.6	138.1
1989	817.1	518.7	620.0	197.1	153.8	773.8	255.1	0.0	439.2	334.6	217.5	117.1
1990	976.7	518.7	777.6	199.1	232.7	1010.3	491.6	0.0	445.1	565.2	367.4	197.8
1991	820.2	518.7	619.1	201.1	204.0	823.1	304.5	0.0	400.4	422.8	274.8	148.0
1992	908.3	518.7	651.9	256.4	260.2	912.1	393.5	0.0	472.8	439.4	285.6	153.8
1993	1019.3	518.7	754.0	265.3	266.3	1020.3	501.6	0.0	453.7	566.6	368.3	198.3
1994	909.5	518.7	681.6	227.9	234.2	915.8	397.1	0.0	482.7	433.1	281.5	151.6
1995	1038.4	518.7	809.4	229.0	138.2	947.6	429.0	0.0	453.8	493.8	321.0	172.8
1996	1004.7	518.7	866.9	137.8	213.7	1080.6	561.9	0.0	470.0	610.6	396.9	213.7
1997	773.0	518.7	475.9	297.1	309.5	785.4	266.7	0.0	387.8	397.6	258.4	139.2
1998	841.6	518.7	630.0	211.6	192.8	822.8	304.1	0.0	447.1	375.7	244.2	131.5
1999	830.5	518.7	623.3	207.2	219.8	843.1	324.4	0.0	429.6	413.5	268.8	144.7
2000	987.4	518.7	783.0	204.4	162.0	945.0	426.4	0.0	481.9	463.1	301.0	162.1
2001	753.6	518.7	580.3	173.3	213.1	793.4	274.8	0.0	409.5	383.9	249.6	134.4
2002	867.9	518.7	687.7	180.2	189.6	877.3	358.7	0.0	435.6	441.8	287.1	154.6
2003	1068.5	518.7	820.4	248.1	255.3	1075.7	557.0	0.0	465.1	610.6	396.9	213.7
2004	919.7	518.7	756.2	163.5	124.4	880.6	362.0	0.0	450.6	430.0	279.5	150.5
2005	939.6	518.7	784.9	154.7	175.8	960.7	442.0	0.0	454.6	506.1	329.0	177.1
2006	1152.0	518.7	970.6	181.4	183.1	1153.7	635.0	0.0	482.5	671.2	436.3	234.9
2007	901.0	518.7	728.8	172.2	170.0	898.8	380.2	0.0	457.9	440.9	286.6	154.3
2008	1057.6	518.7	681.6	376.0	391.5	1073.1	554.4	0.0	475.7	597.3	388.3	209.1
2009	946.5	518.7	800.3	146.2	93.4	893.7	375.1	0.0	483.0	410.7	267.0	143.7
2010	970.2	518.7	867.0	103.2	159.0	1026.0	507.3	0.0	464.0	561.9	365.2	196.7
2011	878.2	518.7	676.6	201.6	179.8	856.4	337.8	0.0	434.9	421.5	274.0	147.5
2012	807.5	518.7	596.6	210.9	147.0	743.6	224.9	0.0	420.0	323.6	210.3	113.3
2013	881.4	518.7	704.2	177.2	217.5	921.7	403.0	0.0	468.4	453.3	294.6	158.7
2014	903.1	518.7	759.5	143.6	189.0	948.5	429.8	0.0	478.6	469.9	305.4	164.5
2015	785.7	518.7	648.3	137.4	108.6	756.9	238.2	0.0	455.2	301.7	196.1	105.6
2016	917.9	518.7	656.4	261.5	262.2	918.6	400.0	0.0	431.6	487.1	316.6	170.5
2017	1268.5	518.7	1061.5	207.0	214.0	1275.5	756.8	0.0	489.0	786.5	511.2	275.3
AVERAGE	**926.1**	**518.7**	**726.2**	**199.8**	**199.8**	**926.0**	**407.4**	**0.0**	**452.4**	**473.6**	**307.9**	**165.8**

PRECIP	Total Precipitation
PET	Potential Evapotranspiration
W	Water Input (Rain + Snowmelt)
Soil Water (SW)	Available Water in the Soil Moisture Storage Zone
ΔSoil Water	Change in Soil Water
AET	Actual Evapotranspiration

The water balance calculations are conducted on a daily time step
All units in mm

Hannan Hills Subdivision (118201)
Water Balance Results Summary
Post-Development

NOVATECH
Engineers, Planners & Landscape Architects

Post-Development Conditions
Overall Site

MONTH	Hannan Hills Subvision (mm/yr)								*4.50 ha*
	TOTAL PRECIP.	PET	AET	SURPLUS	SOIL INFILTRATION	RUNOFF (NO LID)	LID INFILTRATION(1)	TOTAL INFILTRATION	RUNOFF (with LID)
Jan	63.3	0.0	0.0	58.0	12.8	45.2	0.0	12.8	45.2
Feb	51.9	0.0	0.0	52.7	11.6	41.1	0.0	11.6	41.1
Mar	60.0	0.0	0.0	86.4	19.0	67.3	0.0	19.0	67.3
Apr	76.6	12.7	9.3	72.9	16.1	56.8	0.0	16.1	56.8
May	78.2	93.3	54.8	31.9	4.6	27.3	7.8	12.4	19.5
Jun	96.0	131.0	72.7	32.9	2.5	30.4	6.5	9.0	23.9
Jul	91.1	139.3	68.3	28.7	1.0	27.7	5.9	6.9	21.8
Aug	87.2	114.3	55.2	31.1	1.3	29.8	5.5	6.8	24.3
Sep	88.2	62.1	33.8	37.6	2.8	34.9	8.3	11.0	26.6
Oct	88.7	30.1	20.0	60.8	11.6	49.2	14.1	25.7	35.2
Nov	73.9	3.4	2.6	67.4	14.8	52.6	0.0	14.8	52.6
Dec	71.0	0.0	0.0	48.8	10.7	38.0	0.0	10.7	38.0
AVG. ANNUAL	**926.1**	**586.2**	**316.8**	**609.2**	**108.7**	**500.5**	**48.2**	**156.9**	**452.4**

(1) *Only assume LIDs can infiltrate between the months of May to October*

MONTH	Hannan Hills Subvision (m^3/yr)								*4.50 ha*
	TOTAL PRECIP.	PET	AET	SURPLUS	INFILTRATION		LID INFILTRATION(1)	TOTAL INFILTRATION	RUNOFF
Jan	2,845	0	0	2,609	575	2,034	0	575	2,034
Feb	2,334	0	0	2,372	522	1,849	0	522	1,849
Mar	2,699	0	0	3,882	855	3,027	0	855	3,027
Apr	3,444	572	418	3,277	723	2,555	0	723	2,555
May	3,516	4,193	2,462	1,435	206	1,229	352	559	877
Jun	4,317	5,892	3,270	1,481	113	1,368	293	406	1,075
Jul	4,098	6,262	3,072	1,290	45	1,245	266	311	978
Aug	3,919	5,140	2,482	1,396	56	1,340	249	305	1,091
Sep	3,965	2,790	1,520	1,692	124	1,568	372	496	1,196
Oct	3,987	1,352	900	2,735	521	2,214	633	1,153	1,581
Nov	3,321	152	118	3,029	665	2,364	0	665	2,364
Dec	3,192	0	0	2,193	483	1,710	0	483	1,710
AVG. ANNUAL	**41,636**	**26,353**	**14,243**	**27,391**	**4,888**	**22,503**	**2,165**	**7,054**	**20,338**

(1) *Only assume LIDs can infiltrate between the months of May to October*