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July 15, 2020



Millford Development Limited
P.O. Box 215
Newmarket, Ontario
L3Y 4X1

Attention: Mr. Frank Orsi

**Re: Pre- and Post-Development Water Balance Assessment**
**Proposed Residential Development**
**55 Eagle Street**
**Town of Newmarket**

Dear Sir:

We have completed a pre- and post-development water balance assessment for a proposed residential development, at the captioned site, located at 55 Eagle Street in the Town of Newmarket, and our findings are presented in this Letter Report.

## Introduction

The subject site is located on the north side of Eagle Street, at the captioned address, approximately 200 m east of Regional Road 1, in the Town of Newmarket. The surrounding land use consists of residential properties to the north, commercial/residential properties to the east, Eagle Street and residential properties to the south, and commercial/residential properties to the west of the subject site. The subject site is currently vacant and is covered with grass, trees and shrubs. A watercourse flows through the northern portion of the subject property, which will remain undeveloped. The proposed residential development will consist of a series of townhouse blocks, having associated roads, sidewalks and landscaped areas.

## **Background**

Soil Engineers Ltd. (SEL) previously completed a hydrogeological investigation for the subject site in April 2011 (SEL Project Reference No. 1102-W017). The previous study revealed that beneath the topsoil horizon or earth fill layers, the native subsoils underlying the subject site consists of sandy silt till/silty sand till, silty clay and silty clay till with deposits of silty sand, and fine sand in places, extending to the maximum depth of investigation at 15.7 m below the prevailing ground surface. Shallow groundwater was measured during two monitoring periods, extending from March 3 to March 22, 2011 and from March 23 to June 19, 2020. The recorded groundwater levels ranged in depth from 0.18 to 4.84 mbgs during the 2011 monitoring events, and from 0.08 to 4.30 mbgs during the 2020 monitoring events.

## **Water Balance Assessment**

The water balance for the proposed development site is based on the following equation:

Where:

$$P = ET + R + I + \Delta S$$

P -- Average Annual Precipitation

ET -- Evapotranspiration

R -- Surface Water Runoff

I -- Infiltration

Δs -- Change in Groundwater Storage, taken as 0

- **Precipitation**

The long-term (30-year average from 1981 to 2010) precipitation records for monthly and annual precipitation received at the subject site were adopted from the Environment Canada's King Smoke Tree Weather Station (Climate ID 6154142), located about 4.6 km southwest of the subject site. The 30-year, mean annual precipitation record of 857.70 mm/year was adopted from this station. The 30-year records for average annual and monthly temperatures were also adopted from this station. The water balance calculations for the pre- and post-developed assessments for the subject site are summarized in the Appendix.

- **Interception**

Based on the adoption of the SWM Planning and Design Manual (MECP, 2003), evapotranspiration includes the evaporation from all sources; including; precipitation, water, snow, vegetation and from water droplets on plant surfaces plus the transpiration from plants, not involving water droplets retained on leaves. As such, interception was not included for the current pre- and post-development water balance assessments as it has been included in the estimate for evapotranspiration.

- **Groundwater Storage**

Although groundwater storage experiences both gains and losses on a short-term basis, the net change in groundwater storage ($\Delta s$) over the long-term is generally zero. For this reason, the change in groundwater storage is shown as zero (0) which has not been included in the water balance calculations.

- **Evapotranspiration**

In general, evapotranspiration (ET) refers to the transfer of water from vegetation and the soil surface to the atmosphere in the form of water vapour. The term considers the evaporation from the soil surface, man-made infrastructure surfaces (asphaltic and concrete roads, and from building roofs), and from the transpiration from plants and trees together because of the difficulties in separating these processes. Potential evapotranspiration (PET) refers to the transfer/loss of water from vegetated surfaces to the atmosphere under the condition of unlimited water supply.

The actual rate of evapotranspiration (AET) is generally less than PET under dry conditions (i.e., during the summer season when there is a soil moisture deficit). Variations in water holding capacity which affects ET depends on soil type and rooted vegetation. The sandy silt till/silty sand till and silty clay till subsurface material, as disclosed by the previous drilling program, has been assigned a water holding capacity of -200 mm (Soil and Water Conservation Table 18.2 PP 392 G. Schwab et. al.).

Chart 40 from the Climate of the Great Lakes Basin (Environment Canada 1972) suggests that the PET for the King Smoke Tree weather station should be about 558.8 to 609.6 mm/year (22 to 24 in/year). Simulations using Thornthwaite and Mather model developed by US Geological Survey (USGS) indicates that the average (AET) for the study area is about 550.70 mm/year, which generally agrees with the mapped PET values for the general area; therefore, an AET value of 550.70 mm/year has been applied to pre- and post-development water balance assessments for the subject site.

- **Infiltration and Runoff**

According to the Ministry of the Environment, Conservation and Parks (MECP) Guidance Manual (MECP 1995), a series of infiltration components can be applied to the subject site based on its slope, soil and vegetation coverage. The cumulative values of these sub-components is termed the infiltration factor, with the values ranging from 0 to 1. The difference between the value 1 and the infiltration factor is referred to as the runoff factor.

Slope has an influence on both infiltration and runoff. The topography of the site is considered rolling to hilly land, based on its elevation relief, from a review of available topographic mapping for the area.

Surficial soil, vegetation coverage, and cropping practices also contribute to the infiltration and runoff factors. The subject site is currently covered with grass, trees and shrubs and the surficial soil consists predominantly of sandy silt till/silty sand till, silty clay and silty clay till with deposits of silty sand, and fine sand in places. The selected cumulative infiltration and corresponding runoff factors, based on the site's topography and predominant surface soil and vegetation coverage are provided in Table 1.

The difference between the average annual precipitation and actual evapo-transpiration is termed the water surplus. As mentioned above, a precipitation value of 857.70 mm/year was adopted for the site. Subtracting the averaged Thornthwaite and Mather derived AET estimate of 550.70 mm/year from the net precipitation gives a water surplus estimate of 307.00 mm/year. The site's average annual infiltration is calculated by multiplying the cumulative infiltration factor by the water surplus estimate, and the site's runoff is calculated by applying its difference from 1, or 1 minus the cumulative infiltration factor multiplied by the water surplus estimate. Based on the MECP factors, a cumulative infiltration factor of 0.45 was considered for this assessment. The average annual depth estimates for infiltration and runoff for the subject site are given in Table 1.

**Table 1 -** Summary of Infiltration and Runoff Estimation

| Land Characteristics | MECP Infiltration Factors | Water Surplus Estimate (mm/yr.) | Infiltration Estimate (mm/yr.) | Runoff Estimate (mm/yr.) |
|---|---|---|---|---|
| Soil: (silty sand till/sandy silt till, silty clay till) | 0.15 | **307.00** | I = 0.45×307.00 | R = (1-0.45) ×307.00 |
| Slope: (rolling to hilly land) | 0.15 | | | |
| Vegetation Cover: (grass/shrubs/trees) | 0.15 | | | |
| Cumulative Infiltration Factor | **0.45** | | **138.15** | **168.85** |

Runoff from impervious surfaces is calculated differently than for pervious soil/ vegetated covered surfaces. As a general rule, the ET for impervious surfaces on an average annualized basis is calculated by taking 10% of the average annual precipitation, while runoff is calculated by taking 90% of the average annual precipitation. The proposed residential development will consist of townhouse blocks, paved roads and sidewalks, which are considered as impervious surfaces. Based on this approach, the ET and runoff estimates for impervious surfaces on an average annualized depth basis are 85.77 mm/year and 771.93 mm/year, respectively.

- **Pre-Development Water Balance**

Since there are no pre-existing structures or paved areas within the undeveloped subject site, the pre-development water balance for the subject site was calculated by multiplying the existing undeveloped site areas by the various, averaged annualized depth estimates for Precipitation, ET, Infiltration and Runoff. The average annual volumetric estimates for each pre-development water balance component are given in Table 2.

**Table 2 -** Summary of Pre-Development Volumetric Water Balance Components

| Pre-Development Site Areas | Area Coverage ($m^2$) | Precipitation ($m^3$/year) | AET ($m^3$/year) | Infiltration ($m^3$/year) | Runoff (Pervious) ($m^3$/year) |
|---|---|---|---|---|---|
| Pervious Area (Entire Site Area) | 20,339.95 | 17,445.58 | 11,201.21 | 2,809.96 | 3,434.40 |
| **Total Area/Volume** | **20,339.95** | **17,445.58** | **11,201.21** | **2,809.96** | **3,434.40** |

The pre-development water balance for the subject site is calculated on an annualized depth basis by dividing the annualized volumetric estimates for each water balance component from above by the total site area. Based on this approach, the annualized depth estimates, presented in mm, for each of the water balance components for the pre-developed site are given as follows:

$$P\ (857.70) = ET\ (550.70) + I\ (138.15) + R\ (168.85)$$

- **Post-Development Water Balance**

An untitled preliminary concept plan, provided by the client was reviewed for the current assessment. Based on the information provided, the proposed development will involve the establishment of 54 townhouse units, 20 back to back townhouse units and a triplex with associated roads, sidewalks and landscaped areas. Impervious areas will include the buildings, roads and sidewalks, which will cover an area of about 13,352.33 $m^2$. Pervious areas, including landscaped areas will comprise the remaining area, of about 6,987.62 $m^2$.
The post-development water balance for the site was calculated using the same pre-

development water balance components, i.e., average annual precipitation and average annual ET, as adopted for the pre-development water balance calculations. For developed, impervious site areas, there is no infiltration, and the depth estimates for runoff and ET become 90% and 10% of the average annual precipitation, respectively. The estimated post-development water balance volumes for the developed site are provided in Table 3.

**Table 3 - Summary of Post-Development Volumetric Water Balance Components**

| Post-Development Site Areas | Area Coverage ($m^2$) | Precipitation ($m^3$/year) | AET (Pervious) ($m^3$/year) | AET (Impervious) ($m^3$/year) | Infiltration ($m^3$/year) | Runoff (Pervious) ($m^3$/year) | Runoff (Impervious) ($m^3$/year) |
|---|---|---|---|---|---|---|---|
| Pervious Areas (Green/Landscaped Areas) | 6,987.62 | 5,993.28 | 3,862.06 | 0.00 | 1,172.17 | 959.05 | 0.00 |
| Impervious Areas (Buildings) | 7,864.50 | 6,745.38 | 0.00 | 674.54 | 0.00 | 0.00 | 6,070.84 |
| Impervious Areas (Roads) | 4,898.59 | 4,201.52 | 0.00 | 420.15 | 0.00 | 0.00 | 3,781.37 |
| Impervious Areas (Sidewalks) | 589.24 | 505.39 | 0.00 | 50.54 | 0.00 | 0.00 | 454.85 |
| **Total Area/ Volume** | **20,339.95** | **17,445.58** | **3,862.06** | **1,145.23** | **1,172.17** | **959.05** | **10,307.06** |

Based on the volumetric water balance estimates, shown above in Table 3, the depth-based post-development water balance components, presented in mm, are given as follows:

$$P\ (857.70) = ET\ (246.18) + I\ (57.63) + R\ (553.89)$$

Comparison of the pre- and post-development water balance assessments indicates a decrease of 304.52 mm/year, or 55.30%, in annual evapo-transpiration, a decrease of 80.52 mm/year, or 58.29%, in annual infiltration, and a gain in runoff of 385.04 mm/year or 328.04%.

The pre- and post-development water balance calculations for the subject site are summarized in the Appendix.

Volumetric comparisons in evapotranspiration, infiltration and runoff between the pre, and post-developed sites are summarized at Table 4. A review of the findings indicates that decreases of 6,193.92 $m^3$/year and 1,637.79 $m^3$/year are anticipated for ET and infiltration, respectively. In addition, an increase of 7,831.71 $m^3$/year is expected for runoff for the post-developed site compared with the pre-developed site.

**Table 4 - Comparison Summary of Pre- and Post-Development Water Balance/ Budget Components**

| | **Precipitation ($m^3$/year)** | **ET ($m^3$/year)** | **Infiltration ($m^3$/year)** | **Runoff ($m^3$/year)** |
|---|---|---|---|---|
| Pre-development | 17,445.58 | 11,201.21 | 2,809.96 | 3,434.40 |
| Post- development | 17,445.58 | 5,007.29 | 1,172.17 | 11,266.11 |
| Volumetric Change in Pre- and Post-Development Water Balance Parameters | - | -6,193.92 | -1,637.79 | +7,831.71 |

○ **<u>Water Balance Mitigation Plan</u>**

The difference between the pre- and post-development water balances can be attributed to establishment of impervious surfaces, such as roads, sidewalks, and building rooftops. Proposed LID measures to maintain the pre-development water balance should consider the low to moderate permeability for the existing surface soil, comprised, mainly of silty clay and glacial till (silty sand till/sandy silt till), which may limit the amount of infiltration and groundwater recharge to the subsurface.

Review of the results of the hydraulic conductivity estimates from the previous hydrogeological report indicates that the estimated hydraulic conductivities ranges from 2.8 x $10^{-6}$ m/sec for the silty clay units to 8.4 x $10^{-5}$ m/sec for silty sand till/fine sand unit, confirming the low permeability for the native silty clay subsoil and the moderate permeability for the native sand till/fine sand horizons. This confirms the presence of lower permeability shallow native subsoils which should be considered for any proposed infiltration infrastructure designs.

The proposed development will consist of a series of townhouses with associated roads, sidewalks and landscaped area. An area of 7,864.50 $m^2$ of the subject site has been considered as rooftop area, and an area of 4,898.59 m$^2$ of the developed site has been considered as roads, and an area of 589.24 m$^2$ of the developed site has been considered as sidewalks. The anticipated volume of runoff, derived from rooftops, roads and sidewalk areas (i.e. 90% of annual precipitation), is provided in Table 5.

**Table 5 - Anticipated Volumetric Runoff from Rooftops**

| Proposed Rooftop/ Paved Parking Areas | Approximate Area Coverage (m$^2$) | Runoff (mm/year) | Runoff (m$^3$/year) |
|---|---|---|---|
| Proposed Building Rooftops | 7,894.50 | 771.93 | 6,094.00 |
| Proposed Roads | 4,898.59 | 771.93 | 3,781.37 |
| Proposed Sidewalks | 589.24 | 771.93 | 454.85 |

Implementation of rainwater harvesting (dual use cisterns) could reduce runoff by about 23% to 42%, based on an assessment conducted by Toronto Region Conservation Authority (TRCA) in 2010 (Table 4.1.2, Low Impact Development Stormwater Management Planning and Design). As shown above in Table 5, the total rooftop generated runoff for the developed subject site is 6,094.00 m$^3$/year, and therefore, about 1,401.62 to 2,559.48 m$^3$/year of the runoff could be managed using a proposed rainwater harvesting method. Rainwater harvesting systems could be installed underground, indoors, on the ground, next to a building or on the roof. The collected runoff water could also be used for non-potable uses such as for irrigation watering during spring and summer, or to recharge the shallow groundwater table, and to increase evapotranspiration (Low Impact Development Stormwater Management Planning and Design Guide, 2010).

The bioretention swale technique, associated with an under-drain conveyance pipe within the landscaped areas could also be considered to manage some of the generated runoff from rooftops. Based on the 2010 TRCA assessment, consideration for a bio-retention swale could manage 45% or 2,742.30 m$^3$/year of the generated roof top run off (Table 4.5.2, Low Impact Development Stormwater Management Planning and Design). Alternatively, use of imported fill materials could also be considered for usage during site grading to enhance infiltration, to promote groundwater recharge penetration to shallow depths through placement of imported pervious fill soil. The placement of uncompacted, permeable imported fill soil, such as medium to coarse sand having a silt content of less than 8% is recommended for usage at the grading stage of construction. Ideally, this fill would be used within proposed landscaped areas.

Other techniques, including the implementation of permeable pavers, soak-away pits, infiltration tanks/galleries and/or dry wells may be feasible as a means to recharge the groundwater table, following site development. Alternatively, clean roof-generated runoff can be directed to recharge groundwater by means of grass swales, or using an infiltration trench, or having it directed to any landscaped yards to further enhance infiltration without the need to design LID infrastructure. The flow path for re-directed runoff to landscaped areas should be at least 5 m to facilitate a portion of its infiltration to the subsurface.

Any of above-mentioned techniques, or a combination of them, along with the thickening of topsoil within the landscaped areas as proposed LID infrastructure should be considered for promoting infiltration to maintain the site's existing water balance after development. In order to apply these techniques, the shallow groundwater level should, ideally, be a minimum of 1.0 m below the ground surface, or the bases for any proposed any LID structure. Based on the results of the most recent groundwater monitoring period, groundwater levels were measured at depths of 0.08 to 4.30 m below the prevailing ground surface. As such implementation of LIDs may only be feasible beneath certain areas of the developed site.

The stormwater management engineer should be consulted to prepare the final designs for any proposed LID infrastructure to maintain the site's pre-development water balance after development. Furthermore, a mitigated water balance estimate is anticipated as being required based on any runoff volumes being directed to the proposed LID infiltration infrastructure. The mitigated water balance for the subject site can be provided in the future, once the proposed LID infrastructure plans have been finalized. Designs for any proposed LID infrastructure will be provided by others.

We trust the above satisfies your present requirements. Should you have any further queries, please feel free to contact this office.

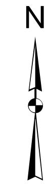
Yours truly,
**SOIL ENGINEERS LTD.**

Vivian Yu, B.Sc.

Gavin O'Brien, M.Sc., P.Geo.
VY/GO

## ENCLOSURES


Source: Ministry of Natural Resources and Forestry


Approximate Boundary of Subject Site

Watercourse

Local Road

*Soil Engineers Ltd.*

Title: Borehole and Monitoring Well Location Plan

Project:

Hydrogeological Assessment
Proposed Residential Development
55 Eagle Street
Town of Newmarket

Reference No. 2003-W045

Date: July 2, 2020

Scale:

0 5 10 20 30 40 50
Metres

Drawing No. 1

## Pre-Development Water Balance/Budget

**ET Estimates**

| | | | |
|---|---|---|---|
| Average for 200 mm sandy silt till/silty sand till, sitly clay till at 43 and 44 deg N. lat from USGS model: **550.7 mm/yr** | Avg Annual Precipitation | **857.7** | **mm/yr** |
| Sandy silt till/Silty sand till and Silty clay till 200 mm 44 lat **552.70 mm/yr** ET | | | |
| Sandy silt till/Silty sand till and Silty clay till 200 mm 43 lat **548.70 mm/yr** | | | |

| | | | |
|---|---|---|---|
| ET | impervious surfaces | 0.1 | 10% |
| R | impervious surfaces | 0.9 | 90% |

| Type | MOE factors | |
|---|---|---|
| cover | 0.15 | shrubs/trees |
| slope | 0.15 | Rolling to Hilly Land |
| soil texture | 0.15 | sandy silt till/silty sand till, silty clay till |
| MECP Inf. F. | 0.45 | |

Site Area **20,339.95** $m^2$

| Site Areas | Areas ($m^2$) | Impervious factor | Cum. Infilt | Assigned ET (mm/yr) | Water Surplus (mm/yr) | Infiltration (mm/yr) | Runoff (mm/yr) | precipitation ($m^3$/yr) | Infilt Vol ($m^3$/yr) | RO Vol ($m^3$/yr) | ET Vol ($m^3$/yr) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Approximate Pervious Area | **20,339.95** | **0** | **0.45** | **550.7** | **307** | **138.15** | **168.85** | **17,445.58** | **2,809.96** | **3,434.40** | **11,201.21** | |
| Total Area | **20,339.95** | | | | | | | **17,445.58** | **2,809.96** | **3,434.40** | **11,201.21** | check |
| | | | | | | | **percentages** | 17,445.58 | **0.16** | **0.20** | **0.64** | 1.00 |

**Parcel A: Pre Development Water Balance/Budget**

| P | = | ET | + | I | + | R | + | DS | | Check |
|---|---|---|---|---|---|---|---|---|---|---|
| **857.70** | = | **550.70** | + | **138.15** | + | **168.85** | + | 0.00 | | **857.70** |

Total Area **20339.95** $m^2$

## Post-Development Water Balance/Budget

| | | | |
|---|---|---|---|
| Average for 200 mm Silty Clay and Earth Fill 43 and 44 deg N. lat from USGS model: **550.7 mm/yr** | Avg Annual Precipitation | **857.7** | **mm/yr** |
| Sandy silt till/Silty sand till and Silty clay till 200 mm 44 lat **552.70 mm/yr** ET | | | |
| Sandy silt till/Silty sand till and Silty clay till 200 mm 43 lat **548.70 mm/yr** | | | |
| Site Area **39,562.00 $m^2$** | | | |

| | | | |
|---|---|---|---|
| ET | impervious surfaces | 0.1 | 10% |
| R | impervious surfaces | 0.9 | 90% |

| Type | MOE factors | |
|---|---|---|
| cover | 0.15 | shrubs/trees |
| slope | 0.15 | rolling to hilly land |
| soil texture | 0.15 | sandy silt till/silty sand till, silty clay till |
| MOECC Inf. F | 0.45 | |

| Future Developed Site Areas | Areas | Impervious factor | Cum. Infiltration | Assigned ET Pervious Portion | Water Surplus | Infiltration - Pervious Portion | ET - Impervious Portion | Runoff - Impervious Areas | Runoff Pervious Portion | precipitation | Pervious Area: Infilt Vol. Pervious Areas | Pervious Area: RO Vol. Pervious Areas | Pervious Area: ET Vol Pervious Areas | Impervious Area: RO Vol. Impervious Areas | Impervious Area: ET Vol Imperv Areas | Total Et and Ro.: Total ET | Total Et and Ro.: Total RO |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $m^2$ | | | mm/yr | mm/yr | mm/yr | mm/yr | mm/yr | mm/yr | $m^3$/yr | $m^3$/yr | $m^3$/yr | $m^3$/yr | $m^3$/yr | $m^3$/yr | $m^3$/yr | $m^3$/yr |
| Pervious Areas (Proposed Landscape Area) | 6,987.62 | 0 | 0.55 | 552.70 | 305.00 | 167.75 | 0.00 | 0.00 | 137.25 | 5,993.28 | 1,172.17 | 959.05 | 3,862.06 | 0.00 | 0.00 | 3,862.06 | 959.05 |
| Impervious Areas (Proposed Buildings) | 7,864.50 | 1 | 0.00 | 0.00 | 771.93 | 0.00 | 85.77 | 771.93 | 0.00 | 6,745.38 | 0.00 | 0.00 | 0.00 | 6,070.84 | 674.54 | 674.54 | 6,070.84 |
| Impervious Areas (Proposed Roads) | 4,898.59 | 1 | 0.00 | 0.00 | 771.93 | 0.00 | 85.77 | 771.93 | 0.00 | 4,201.52 | 0.00 | 0.00 | 0.00 | 3,781.37 | 420.15 | 420.15 | 3,781.37 |
| Impervious Areas (Proposed Sidewalks) | 589.24 | 1 | 0.00 | 0.00 | 771.93 | 0.00 | 85.77 | 771.93 | 0.00 | 505.39 | 0.00 | 0.00 | 0.00 | 454.85 | 50.54 | 50.54 | 454.85 |
| Total Area | 20,339.95 | | | | | | | | Total | 17,445.58 | 1,172.17 | 959.05 | 3,862.06 | 10,307.06 | 1,145.23 | 5,007.29 | 11,266.11 |
| | | | | | | | | | | Totals | | | | Total RO | 11,266.11 | Total ET | 5,007.29 |

Total Area **39,562.00 $m^2$**

**Parcel A: Post Development Water Balance/Budget**

| P | = | ET | + | I | + | R | + | DS | | Check |
|---|---|---|---|---|---|---|---|---|---|---|
| 857.7 | = | 246.18 | + | 57.63 | + | 553.89 | + | 0 | | 857.70 |

**Pre Development Water Balance/Budget**

| P | = | ET | + | I | + | R | + | DS | | Check |
|---|---|---|---|---|---|---|---|---|---|---|
| 857.70 | = | 550.70 | + | 138.15 | + | 168.85 | + | 0 | | 857.70 |

| Loss/Gain in Post | | ET | | I | | R | DS |
|---|---|---|---|---|---|---|---|
| | loss: | 304.52 | loss: | 80.52 | gain: | 385.04 | 0 |
| | % loss: | 55.30 | %loss: | 58.29 | %gain | 328.037 | |