PROPOSED NINE-STOREY APARTMENT
BUILDING RESIDENTIAL DEVELOPMENT SITE

PART OF LOT L CONCESSION A (RIDEAU FRONT)

GEOGRAPHICAL TOWNSHIP OF NEPEAN

1110 FISHER AVENUE

CITY OF OTTAWA

STORM DRAINAGE REPORT

REPORT No. R-818-71

T.L. MAK ENGINEERING CONSULTANTS LTD.

MAY 2019

FILE REF. No. 818-71

INTRODUCTION

The proposed nine-storey apartment building site is located on the west side of Fisher Avenue and situated just south of Trent Street and north of Baseline Road. Its legal property description is Part of Lot L Concession A (Rideau Front). The property proposed for redevelopment is part of the development located within an area identified as Meadowvale Terrace Park.

Presently, a two-storey vinyl-sided residential building and a detached wooden frame garage occupy the site. An existing asphalt driveway located south of the house and a gravel laneway located north of the house provide vehicular access to the lot and car parking.

The developer is proposing to redevelop this ±0.1353 ha. property into a nine-storey residential apartment building site with a Mechanical Penthouse Floor above the ninth floor and a common joint use three-level underground parking garage.

Storm-water outlet for the said redevelopment property under consideration is a proposed extension of the existing 300 mm diameter storm sewer along Fisher Avenue.

According to the City of Ottawa Engineering Department's guidelines, the allowable runoff into the proposed 300 mm diameter storm sewer for this site shall be based on the lesser of pre-development runoff coefficient or C=0.5 (max.), Tc=10 minutes, and a two-year storm event for a storm sewer built pre-1970. If the uncontrolled storm-water runoff exceeds the specified requirements, then on-site Storm-water Management (SWM) control measures are necessary. The average post-development runoff coefficient for this site is estimated at C=0.68 which exceeds the City's criteria of C_{pre}=0.38. Storm-water runoff, if uncontrolled, will exceed the calculated pre-development flow based on a higher post-development "C" value, therefore, SWM measures are required for this redevelopment property.

At this site, the maximum allowable rate of discharge established to be directed into the proposed 300 mm diameter storm sewer is ± 11.02 L/s. A new 300mm diameter storm sewer approximately 69.5m in length is proposed to be extended from an existing storm manhole at Trent Street to the site.

The SWM calculations that follow will detail the extent of on-site SWM control to be implemented and the storage volume required on-site to attain the appropriate runoff release that will conform to the City's established drainage criteria.

SITE DATA

1) Development Property Area

- Area characteristics of development lot

Roof Area	=738.7 m^2
Asphalt Area	=115.3 m^2

Concrete Paver Area =79.8 m^2
Grass Area =418.6 m^2

Total Area =1,352.4 m^2

$$C = \frac{(738.7 \times 0.9) + (79.8 \times 0.8) + (418.6 \times 0.2) + (115.3 \times 0.9)}{1352.4}$$

$$C = \frac{916.16}{1352.4}$$

$$C = 0.677$$

Therefore, average post-development "C" for the site = 0.68.

- Tributary area consisting of approximately 252.3 m^2 is directed off-site uncontrolled.

The controlled site tributary area

= 1,352.4 m^2 – 252.3 m^2
= 1,100.1 m^2

2.) Controlled Area Data

Roof Surface Area =738.7 m^2
Asphalt Area =0 m^2
Concrete/Paver Area =0 m^2
Grass Area =361.4 m^2

Total Storm-water Controlled Area = 1,100.1 m^2

$$C = \frac{(738.7 \times 0.9) + (361.4 \times 0.2)}{1100.1}$$

$$C = \frac{737.11}{1100.1}$$

$$C = 0.67$$

Therefore, post-development "C" for the controlled storm-water drainage area is C = 0.67.

3.) Uncontrolled Area Data

Asphalt Area =115.3 m^2

Concrete/Paver Area =79.8 m^2
Grass Area =57.2 m^2

Total Storm-water Uncontrolled Area = 252.3 m^2

$$C = \frac{(79.8 \times 0.8) + (115.3 \times 0.9) + (57.2 \times 0.2)}{252.3}$$

$$C = \frac{216.54}{252.3}$$

$$C = 0.818$$

Therefore, average post-development "C" for the uncontrolled storm-water drainage area is C = 0.82.

- Tributary Area consisting of approximately 252.30 square meters will be outletting off-site uncontrolled from the residential apartment building site.

- The SWM area to be controlled is 1,100.1 square meters. Refer to the attached "Drainage Area Plan" in Figure 1 for details.

PRE-DEVELOPMENT FLOW ESTIMATION

Maximum allowable off-site flow: two (2)-year storm

Pre-Development Site Area Characteristics

Development Lot Area =1352.40 m^2
Roof Area =162.5 m^2
Asphalt Area =80.3 m^2
Gravel Area =112.6 m^2
Grass Area =997.0 m^2

$$C = \frac{(162.5 \times 0.9) + (80.3 \times 0.9) + (112.6 \times 0.8) + (997.0 \times 0.2)}{1352.4}$$

$$C = \frac{508.0}{1352.4}$$

$$C = 0.376$$

Use C_{pre} = 0.38 allowable for redevelopment
T_c = D/V where D = 58.5 m, ΔH = 1.0 m, S = 1.7%, and V = 0.9 ft./s = 0.27 m/s

Therefore,

$$\mathrm{Tc} = \frac{58.5\ \mathrm{m}}{0.27\ \mathrm{m/s}}$$

$$= 3.61\ \mathrm{minutes}$$

Use T_c = 10 minutes
I_2 = 77.10 mm/hr. [City of Ottawa, Two (2)-year storm]

Using the Rational Method

Q = 2.78 (0.38) (77.10) (0.13524)
= 11.02 L/s

Since 252.3 square meters is drained uncontrolled off-site, the **net** allowable discharge for this site into the Fisher Avenue storm sewer system is Q = {2.78 (0.38) (77.10) (0.13524) – [2.78 (0.82) (120.0) (0.0252)]} = 11.02 L/s – 6.90 L/s = 4.12 L/s.

The allowable discharge for the site (controlled area) = 11.02 L/s - 6.90 L/s = 4.12 L/s which is the pumping rate from the pumps of the pumping chamber in the building to be constructed in ground below the P3 parking level. All roof and landscape area drains will discharge into the holding tanks which in turn will be pumped out to the proposed Fisher Avenue storm sewer from the pumping chamber.

STORMWATER MANAGEMENT ANALYSIS

The established flow rate of ± 11.02 L/s from this site is to be directed into the proposed ± 69.5m length 300 mm diameter storm sewer which will be located on the road right of way on Fisher Avenue. Storm-water management attenuation for this site will incorporate flat rooftop storage, landscape area storage and in the building by means of holding tanks.

It is proposed that the flat rooftop areas of the residential building (Roof Area #1, #2, and #3) will each incorporate a controlled roof drain to provide on-site storm-water detention. Also, the grass area storage at the rear of the building (Drainage Area #4 and #5) will each incorporate a controlled drain to provide on-site storm-water detention. All roof and landscape drains will direct flow into the storage tanks in the building and then be pumped up to discharge into the 125 mm diameter storm lateral that will in turn outlet into the proposed 300 mm diameter storm sewer.

For SWM attenuation purposes, each of the three designated flat rooftop areas will incorporate a controlled drain to control flow off-site. The smallest standard roof drain flow rate of 0.63 L/s (10 U.S. gal/min.) will be specified to release as low a flow as possible from the rooftops. As for the landscape area drains, at each drain, the flow rate of 0.63 L/s (10 U.S. gal/min.) per drain will be specified to release flow from these areas for SWM purposes.

Roof Area #1 = 148.0 m^2
Roof Area #2 = 148.0 m^2
Roof Area #3 = 135.6 m^2
Grass Area #4 = 182.6 m^2
Grass Area #5 = 178.8 m^2

Remainder of Site (Controlled Area) Flat Roof Area from Various Levels = 307.1 m^2

DESIGN DISCHARGE COMPUTATION

The Rational Method was used to estimate peak flows.

Q = 2.78 CIA

To Calculate Roof Storage

C = 0.9 will be used for sizing roof storage volume in this case.

Inflow rate (Q_A) = 2.78 CIA

Where C = 0.9
A = Surface area of roof
I = (mm/hr)

The inflow rate or Q_{ACTUAL} during the 5 and 100-year storm for each of the five sub-tributary areas of this site can be calculated as follows:

For Tributary Area #1 (Roof Area #1)

5 Year

Q_{A1} = 2.78 CIA_1

C = 0.90
A = 148.0 m^2
I = (mm/hr)

= 2.78 (0.9) (0.0148 ha.) I
= 0.037I

100 Year

Q_{A1} = 2.78 (1.0) (0.0148) I
= 0.0411 I

For Tributary Area #2 (Roof Area #2)

5 Year

$Q_{A2} = 2.78\ CIA_2$

C = 0.90
A = 148.0 m^2
I = (mm/hr)
= 2.78 (0.9) (0.0148 ha.) I
= 0.037I

100 Year

$Q_{A2} = 2.78\ (1.0)\ (0.0148)\ I$
= 0.0411 I

For Tributary Area #3 (Roof Area #3)

5 Year

$Q_{A3} = 2.78\ CIA_3$

C= 0.90
A= 135.6 m^2
I = (mm/hr)

= 2.78 (0.9) (0.0136 ha.) I
= 0.034 I

100 Year

$Q_{A3} = 2.78\ (1.0)\ (0.0136)\ I$
= 0.0378 I

For Tributary Area #4 (Grass Area #4)

5 Year

$Q_{A4} = 2.78\ CIA_4$

C = 0.5
A = 182.6 m^2
I = (mm/hr)

$= 2.78\ (0.5)\ (0.0183\ \text{ha.})\ I$
$= 0.0254\ I$

100 Year

$Q_{A4} = 2.78\ (1.25 \times 0.5)\ (0.0183)\ I$
$= 0.0318\ I$

For Tributary Area #5 (Grass Area #5)

5 Year

$Q_{A5} = 2.78\ CIA_5$

$C = 0.5$
$A = 178.8\ m^2$
$I = (mm/hr)$

$= 2.78\ (0.5)\ (0.0179\ \text{ha.})\ I$
$= 0.0249\ I$

100 Year

$Q_{A5} = 2.78\ (1.25 \times 0.5)\ (0.0179)\ I$
$= 0.0311\ I$

To Calculate Storage for Remainder of Roof Area that are without Controlled Roof Drain

For Tributary Area #6 (Underground Building Holding Tank Storage System)

5 Year

$Q_{A5} = 2.78\ CIA_5$

$C = 0.9$
$A = 307.1\ m^2$
$I = (mm/hr)$

$= 2.78\ (0.9)\ (0.03071\ \text{ha.})\ I$
$= 0.0768\ I$

100 Year

$Q_{A5} = 2.78\ (1.0)\ (0.03071)\ I$
$= 0.0854\ I$

The allowable discharge for Roof Area #1
- 1 roof drain @ release rate of 10.0 U.S. gal/min. or 0.63 L/s.

The allowable discharge for Roof Area #2
- 1 roof drain @ release rate of 10.0 U.S. gal/min. or 0.63 L/s.

The allowable discharge for Roof Area #3
- 1 roof drain @ release rate of 10.0 U.S. gal/min. or 0.63 L/s.

The allowable discharge for Roof Area #4
- 1 roof drain @ release rate of 10.0 U.S. gal/min. or 0.63 L/s.

The allowable discharge for Roof Area #5
- 1 roof drain @ release rate of 10.0 U.S. gal/min. or 0.63 L/s.

Refer to Dwg. No. 818-71 SWM-1 for typical standard roof drain details or equivalent to be used on this site. Please note the specified 10 U.S. gal/min. or 0.63 L/s roof drain for each of the (3) building roof areas will be made by the manufacturer to allow for a maximum release of 0.63 L/s. As well, the specified 10 U.S. gal/min. or 0.63 L/s landscape area drain for each of the (2) grass areas will be made by the manufacturer to allow for a maximum release rate of 0.63 L/s.

This can now be used to determine the storage volume for the site using the Modified Rational Method.

- Actual flow Q_{ACTUAL} is calculated as:
  $Q_{A(i)} = 2.78\ CIA_{(i)}$

- Q_{STORED} is calculated as:
  $Q_{S(i)} = Q_{A(i)} - Q_{ALLOW}$

Summary results of the calculated inflow and the required storage volume of these (3) roof areas, (2) landscape areas, and underground storage tank system on this site to store storm events up to and including the 100-year storm event are shown in Tables 1 to 12 inclusive.

CONCLUSION

In order to control the 5-year storm-water release rate off-site to an allowable rate of 11.02 L/s, a site storage volume of approximately 15.66 m^3 (min.) is required during the 5-year event. We estimate that approximately 7.11 m^3 (min.) of rooftop storage, 2.72 m^3 of landscape grass area storage and 5.83 m^3 (min.) storage volume from the remainder of the uncontrolled roof area are necessary to attenuate the 5-year storm event.

Based on the proposed design as shown (on Dwg. No. 818-71, SWM-l), the available flat rooftop storage is 8.20 m^3 from the (3) flat roof areas #1, #2, and #3.

During the <u>5-year storm event</u> for Roof Area #1, the ponding depth on this rooftop is estimated at 110 mm at the drain and 0 mm at the roof perimeter assuming a 1.7% (min.) roof pitch to the drain. The rooftop storage available is 2.89 m^3 which is greater than the required volume of 2.47 m^3.

For Roof Area #2, the ponding depth on this rooftop is estimated at 110 mm at the drain and 0 mm at the roof perimeter assuming a 1.7% (min.) roof pitch to the drain. The rooftop storage available is 2.89 m^3 which is greater than the required volume of 2.47 m^3.

For Roof Area #3, the ponding depth is estimated at 110 mm at the drain and 0 mm at the roof perimeter assuming a 1.3% (min.) roof pitch to the drain. The rooftop storage available is 2.42 m^3 which is greater than the required volume of 2.17 m^3.

For Landscape Area #4, the ponding depth is estimated at 100 mm at the drain. The landscape area storage available is 1.67 m^3 which is greater than the required volume of 1.38 m^3.

For Landscape Area #5, the ponding depth is estimated at 100 mm at the drain. The landscape area storage available is 1.58 m^3 which is greater than the required volume of 1.34 m^3.

As for the remaining storage volume of 5.83 m^3 (min.) required from the remainder of the uncontrolled rooftops, it is proposed that the underground concrete storage tank(s) be provided with an effective storage of 5.93 m^3. In total the 5-year available site storage volume is 17.38 m^3 which is greater than the required storage volume of 15.66 m^3. Pump out rate from the holding tank and storage tank configuration to be determined by the owner's mechanical engineer is at 4.12 L/s.

During the <u>100-year storm event</u>, in order to control the 100-year storm-water release rate off-site to an allowable rate of 11.02 L/s, a site storage volume of approximately 39.58 m^3 (min.) is required during the 100-year event. We estimate that approximately 17.41 m^3 (min.) of rooftop storage, 8.35 m^3 (min.) of landscape grass area storage and 13.82 m^3 (min.) storage volume from the remainder of the uncontrolled roof area are necessary to attenuate the 100-year storm event.

Based on the proposed design as shown (on Dwg. No. 818-71, SWM-1), the available flat rooftop storage is <u>21.33 m^3</u> from the (3) flat roof areas #1, #2, and #3.

For Roof Area #1, the ponding depth on this rooftop is estimated at 150 mm at the drain and 0 mm above the roof perimeter assuming a 1.7% (min.) roof pitch to the drain. The rooftop storage available is 7.29 m^3 which is greater than the required volume of 6.02 m^3.

For Roof Area #2, the ponding depth on this rooftop is estimated at 150 mm at the drain and 0 mm above the roof perimeter assuming a 1.7% (min.) roof pitch to the drain. The rooftop storage available is 7.29 m^3 which is greater than the required volume of 6.02 m^3.

For Roof Area #3, the ponding depth on this rooftop is estimated at 150 mm at the drain and 0 mm above the roof perimeter assuming a 1.3% (min.) roof pitch to the drain. The rooftop storage available is 6.75 m^3 which is greater than the required volume of 5.37 m^3.

For Landscape Area #4, the ponding depth is estimated at 150 mm at the drain and 0 mm above the roof perimeter. The landscape area storage available is 5.54 m^3 which is greater than the required volume of 4.24 m^3.

For Landscape Area #5, the ponding depth is estimated at 150 mm at the drain and 0 mm above the roof perimeter. The landscape area storage available is 5.12 m^3 which is greater than the required volume of 4.11 m^3.

As for the remaining storage volume of 13.82 m^3 (min.) required from the remainder of the uncontrolled rooftop, it is proposed that the underground concrete storage tank(s) be provided with a minimum effective storage volume of 2.0 x 15.06 m^3 = 30.12 m^3 (min.). We would recommend a storage tank with an effective volume of (3.65 m x 2.5 m x 1.65 m= 15.06 m^3) be connected to a holding tank/pumping chamber the same size as the storage tank (3.65 m x 2.5 m x 1.65 m = 15.06 m^3) which houses the duplex pumps set at a pump out rate of 4.12 L/s. The total available storage volume from the (2) tanks is 30.12 m^3. In total, the 100-year available storage volume is 62.11 m^3 which is greater than the required storage volume of 39.58 m^3. (See Appendix B for details.)

Therefore, by grading the site to the proposed grades and installing the proposed controlled roof and landscape drains and concrete storage/holding tanks as detailed in this report and shown on the Proposed Site Servicing and Grading Plan Dwg. No. 818-71, G-1, and Proposed Rooftop Storm-water Management Plan Dwg. No. 818-71 SWM-1, the designed storm-water storage volume available will be able to attenuate flow from this site to 11.02 L/s. The pump out rate from the underground holding tank/pumping chamber is 4.12 L/s with pumps (duplex) to be designed by the owner's mechanical engineer.

A backup pumping chamber and pumping system is recommended to discharge and outlet to street level in case of emergencies or problems from the main pump(s) and chamber located below the underground parking level P3.

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1110 FISHER AVENUE
PROPOSED NINE-STOREY APARTMENT BUILDING
RESIDENTIAL DEVELOPMENT SITE

<u>TABLE 1</u>

5-YEAR EVENT
REQUIRED BUILDING ROOF AREA #1
STORAGE VOLUME

t_c TIME (minutes)	**I FIVE(5)-YEAR** (mm/hr)	**Q ACTUAL** (L/s)	**Q ALLOW** (L/s)	**Q STORED** (L/s)	**VOLUME STORED** (m^3)
5	141.20	5.22	0.63	4.59	1.38
10	104.20	3.86	0.63	3.23	1.94
15	83.50	3.09	0.63	2.46	2.21
20	70.25	2.60	0.63	1.97	2.36
25	60.90	2.25	0.63	1.62	2.43
30	53.93	2.00	0.63	1.37	2.47
35	48.60	1.80	0.63	1.17	2.46

Therefore, the required storage volume is 2.47 m^3.

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TABLE 2

5-YEAR EVENT
REQUIRED BUILDING ROOF AREA #2
STORAGE VOLUME

t_c TIME (minutes)	**I FIVE(5)-YEAR** (mm/hr)	**Q ACTUAL** (L/s)	**Q ALLOW** (L/s)	**Q STORED** (L/s)	**VOLUME STORED** (m^3)
5	141.20	5.22	0.63	4.59	1.38
10	104.20	3.86	0.63	3.23	1.94
15	83.50	3.09	0.63	2.46	2.21
20	70.25	2.60	0.63	1.97	2.36
25	60.90	2.25	0.63	1.62	2.43
30	53.93	2.00	0.63	1.37	2.47
35	48.60	1.80	0.63	1.17	2.46

Therefore, the required storage volume is 2.47 m^3.

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TABLE 3

5-YEAR EVENT
REQUIRED BUILDING ROOF AREA #3
STORAGE VOLUME

t_c TIME (minutes)	**I FIVE(5)-YEAR** (mm/hr)	**Q ACTUAL** (L/s)	**Q ALLOW** (L/s)	**Q STORED** (L/s)	**VOLUME STORED** (m^3)
5	141.20	4.80	0.63	4.17	1.25
10	104.20	3.54	0.63	2.91	1.75
15	83.50	2.84	0.63	2.21	1.99
20	70.25	2.39	0.63	1.76	2.11
25	60.90	2.07	0.63	1.44	2.16
30	53.93	1.83	0.63	1.20	2.17
35	48.60	1.65	0.63	1.02	2.14

Therefore, the required storage volume is 2.17 m^3.

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TABLE 4

5-YEAR EVENT
REQUIRED LANDSCAPE GRASS AREA #4
STORAGE VOLUME

t_c TIME (minutes)	**I FIVE(5)-YEAR** (mm/hr)	**Q ACTUAL** (L/s)	**Q ALLOW** (L/s)	**Q STORED** (L/s)	**VOLUME STORED** (m^3)
5	141.20	3.59	0.63	2.96	0.89
10	104.20	2.65	0.63	2.02	1.21
15	83.50	2.12	0.63	1.49	1.34
20	70.25	1.78	0.63	1.15	1.38
25	60.90	1.55	0.63	0.92	1.38
30	53.93	1.37	0.63	0.74	1.33
35	48.60	1.23	0.63	0.60	1.26

Therefore, the required storage volume is 1.38 m^3.

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TABLE 5

5-YEAR EVENT
REQUIRED LANDSCAPE GRASS AREA #5
STORAGE VOLUME

t_c **TIME** (minutes)	**I** **FIVE(5)-YEAR** (mm/hr)	**Q** **ACTUAL** (L/s)	**Q** **ALLOW** (L/s)	**Q** **STORED** (L/s)	**VOLUME** **STORED** (m^3)
5	141.20	3.52	0.63	2.89	0.87
10	104.20	2.60	0.63	1.97	1.18
15	83.50	2.08	0.63	1.45	1.31
20	70.25	1.75	0.63	1.12	1.34
25	60.90	1.52	0.63	0.89	1.34
30	53.93	1.34	0.63	0.71	1.28
35	48.60	1.21	0.63	0.58	1.22

Therefore, the required storage volume is 1.34 m^3.

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TABLE 6

5-YEAR EVENT
UNDERGROUND STORM STORAGE TANK SYSTEM
REQUIRED STORAGE VOLUME

t_c **TIME** (minutes)	**I** **FIVE(5)-YEAR** (mm/hr)	**Q** **ACTUAL** (L/s)	**Q** **ALLOW** (L/s)	**Q** **STORED** (L/s)	**VOLUME** **STORED** (m^3)
5	141.20	10.84	0.97	9.87	2.96
10	104.20	8.00	0.97	7.21	4.33
15	83.50	6.41	0.97	5.44	4.90
20	70.25	5.40	0.97	4.43	5.32
25	60.90	4.68	0.97	3.71	5.57
30	53.93	4.14	0.97	3.17	5.71
35	48.60	3.73	0.97	2.76	5.80
40	44.20	3.40	0.97	2.43	5.83
45	40.60	3.12	0.97	2.15	5.81

Therefore, the required storage volume is 5.83 m^3.

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TABLE 7

100-YEAR EVENT
REQUIRED BUILDING ROOF AREA #1
STORAGE VOLUME

t_c **TIME** (minutes)	**I** **FIVE(5)-YEAR** (mm/hr)	**Q** **ACTUAL** (L/s)	**Q** **ALLOW** (L/s)	**Q** **STORED** (L/s)	**VOLUME STORED** (m^3)
10	178.6	7.35	0.63	6.72	4.03
15	142.9	5.88	0.63	5.25	4.73
20	120.0	4.94	0.63	4.31	5.17
25	103.8	4.27	0.63	3.64	5.46
30	91.9	3.78	0.63	3.15	5.67
35	82.6	3.40	0.63	2.77	5.82
40	75.1	3.09	0.63	2.46	5.90
45	69.1	2.84	0.63	2.21	5.97
50	63.9	2.63	0.63	2.00	6.00
55	59.6	2.45	0.63	1.82	6.02
60	55.9	2.30	0.63	1.67	6.01

Therefore, the required storage volume is 6.02 m^3.

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TABLE 8

100-YEAR EVENT
REQUIRED BUILDING ROOF AREA #2
STORAGE VOLUME

t_c TIME (minutes)	**I FIVE(5)-YEAR** (mm/hr)	**Q ACTUAL** (L/s)	**Q ALLOW** (L/s)	**Q STORED** (L/s)	**VOLUME STORED** (m^3)
10	178.6	7.35	0.63	6.72	4.03
15	142.9	5.88	0.63	5.25	4.73
20	120.0	4.94	0.63	4.31	5.17
25	103.8	4.27	0.63	3.64	5.46
30	91.9	3.78	0.63	3.15	5.67
35	82.6	3.40	0.63	2.77	5.82
40	75.1	3.09	0.63	2.46	5.90
45	69.1	2.84	0.63	2.21	5.97
50	63.9	2.63	0.63	2.00	6.00
55	59.6	2.45	0.63	1.82	6.02
60	55.9	2.30	0.63	1.67	6.01

Therefore, the required storage volume is 6.02 m^3.

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PROPOSED NINE-STOREY APARTMENT BUILDING
RESIDENTIAL DEVELOPMENT SITE

TABLE 9

100-YEAR EVENT
REQUIRED BUILDING ROOF AREA #3
STORAGE VOLUME

t_c **TIME** (minutes)	**I** **FIVE(5)-YEAR** (mm/hr)	**Q** **ACTUAL** (L/s)	**Q** **ALLOW** (L/s)	**Q** **STORED** (L/s)	**VOLUME** **STORED** (m^3)
10	178.6	6.75	0.63	6.12	3.67
15	142.9	5.40	0.63	4.77	4.29
20	120.0	4.54	0.63	3.91	4.69
25	103.8	3.92	0.63	3.29	4.94
30	91.9	3.47	0.63	2.84	5.11
35	82.6	3.12	0.63	2.49	5.23
40	75.1	2.84	0.63	2.21	5.30
45	69.1	2.61	0.63	1.98	5.35
50	63.9	2.42	0.63	1.79	5.37
55	59.6	2.25	0.63	1.62	5.35
60	55.9	2.11	0.63	1.48	5.33

Therefore, the required storage volume is 5.37 m^3.

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PROPOSED NINE-STOREY APARTMENT BUILDING
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TABLE 10

100-YEAR EVENT
REQUIRED LANDSCAPE GRASS AREA #4
STORAGE VOLUME

t_c TIME (minutes)	**I FIVE(5)-YEAR** (mm/hr)	**Q ACTUAL** (L/s)	**Q ALLOW** (L/s)	**Q STORED** (L/s)	**VOLUME STORED** (m^3)
10	178.6	5.68	0.63	5.05	3.03
15	142.9	4.54	0.63	3.91	3.52
20	120.0	3.82	0.63	3.19	3.83
25	103.8	3.30	0.63	2.67	4.01
30	91.9	2.92	0.63	2.29	4.12
35	82.6	2.63	0.63	2.00	4.20
40	75.1	2.39	0.63	1.76	4.22
45	69.1	2.20	0.63	1.57	4.24
50	63.9	2.03	0.63	1.40	4.20
55	59.6	1.90	0.63	1.27	4.19

Therefore, the required storage volume is 4.24 m^3.

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TABLE 11

100-YEAR EVENT
REQUIRED LANDSCAPE GRASS AREA #5
STORAGE VOLUME

t_c TIME (minutes)	**I FIVE(5)-YEAR** (mm/hr)	**Q ACTUAL** (L/s)	**Q ALLOW** (L/s)	**Q STORED** (L/s)	**VOLUME STORED** (m^3)
10	178.6	5.56	0.63	4.93	2.96
15	142.9	4.44	0.63	3.81	3.43
20	120.0	3.73	0.63	3.10	3.72
25	103.8	3.23	0.63	2.60	3.90
30	91.9	2.86	0.63	2.23	4.01
35	82.6	2.57	0.63	1.54	4.07
40	75.1	2.34	0.63	1.71	4.10
45	69.1	2.15	0.63	1.52	4.11
50	63.9	1.99	0.63	1.36	4.08
55	59.6	1.85	0.63	1.22	4.03

Therefore, the required storage volume is 4.11 m^3.

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PROPOSED NINE-STOREY APARTMENT BUILDING
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TABLE 12

100-YEAR EVENT
UNDERGROUND STORM STORAGE TANK SYSTEM
REQUIRED STORAGE VOLUME

t_c **TIME** (minutes)	**I FIVE(5)-YEAR** (mm/hr)	**Q ACTUAL** (L/s)	**Q ALLOW** (L/s)	**Q STORED** (L/s)	**VOLUME STORED** (m^3)
10	178.6	15.25	0.97	14.28	8.57
15	142.9	12.20	0.97	11.23	10.11
20	120.0	10.25	0.97	9.28	11.14
25	103.8	8.87	0.97	7.90	11.85
30	91.9	7.85	0.97	6.88	12.38
35	82.6	7.05	0.97	6.08	12.77
40	75.1	6.41	0.97	5.44	13.06
45	69.1	5.90	0.97	4.93	13.31
50	63.9	5.46	0.97	4.49	13.47
55	59.6	5.09	0.97	4.12	13.60
60	55.9	4.77	0.97	3.80	13.68
65	52.6	4.49	0.97	3.52	13.73
70	49.8	4.25	0.97	3.28	13.78
75	47.3	4.04	0.97	3.07	13.82
80	44.99	3.84	0.97	2.87	13.78

Therefore, the required storage volume is 13.82 m^3.

PROPOSED NINE-STOREY APARTMENT BUILDING

RESIDENTIAL DEVELOPMENT SITE

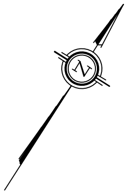
1110 FISHER AVENUE

CITY OF OTTAWA

APPENDIX A

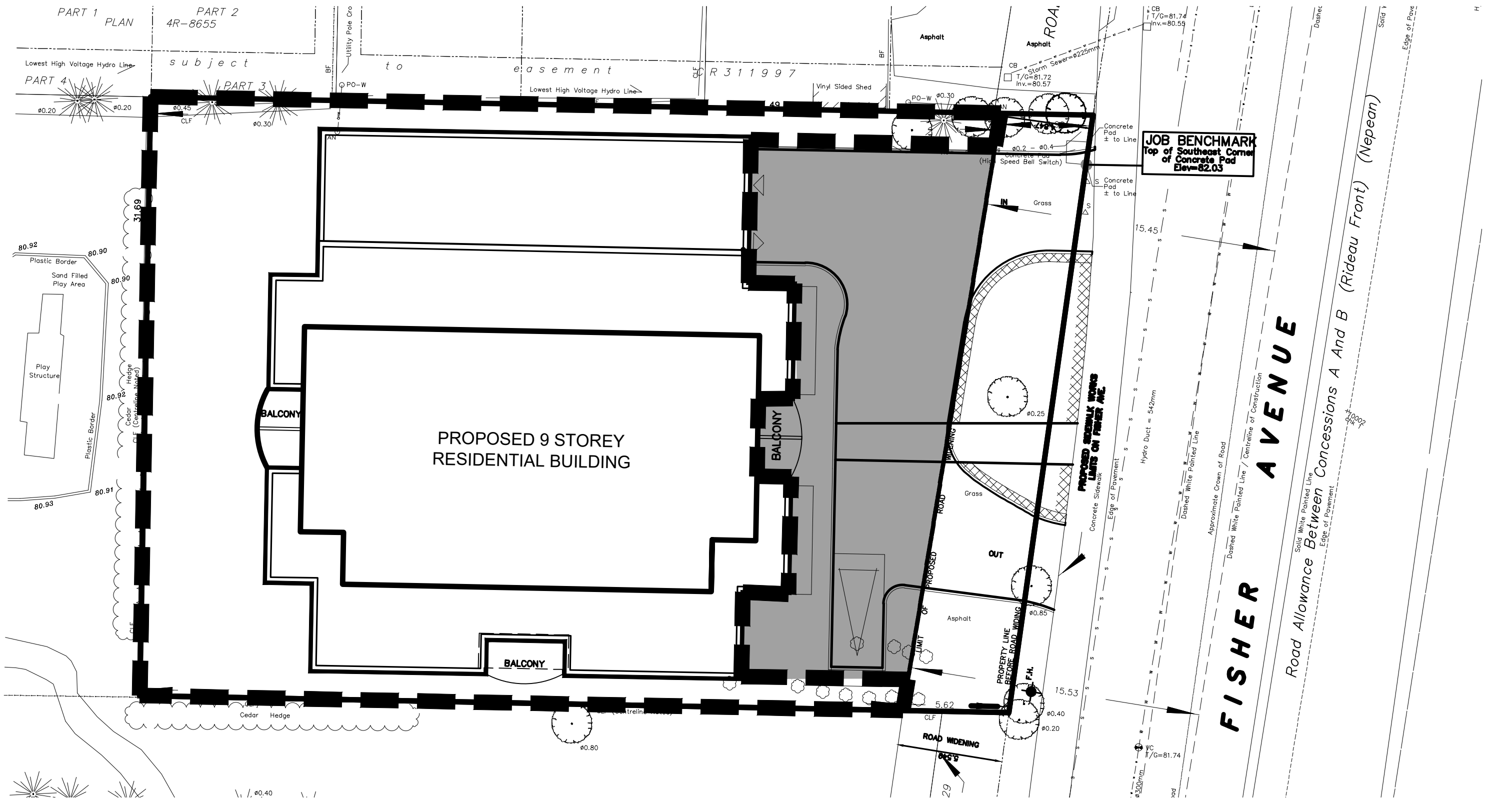
STORM DRAINAGE AREA PLAN

FIGURE 1



PROPOSED 1110 FISHER AVE.
SITE DEVELOPMENT
DRAINAGE AREA PLAN

N.T.S.



LEGEND

LIMIT OF CONTROLLED STORM
DRAINAGE AREA = 1100.1 SQ. M

UNCONTROLLED STORM
DRAINAGE AREA = 252.3 SQ. M

TOTAL AREA = 1352.4 SQ. M

POST-DEVELOPMENT SITE
AVERAGE "C" =0.68

T.L. MAK ENGINEERING CONSULTANTS LTD.
CONSULTING ENGINEERS

PROJECT No.	DATE	DRAWING No.
818-71	MAY 2019	FIGURE 1

PROPOSED NINE-STOREY APARTMENT BUILDING

RESIDENTIAL DEVELOPMENT SITE

1110 FISHER AVENUE

CITY OF OTTAWA

APPENDIX B

DETAILED CALCULATIONS

FOR THE 5-YEAR AND 100-YEAR

AVAILABLE SOTRAGE VOLUME

AVAILABLE STORAGE VOLUME CALCULATIONS

A.) Five (5)-Year Event

Roof Area #1 and Roof Area #2 on top of the mechanical room and Roof Area #3 above the garage entrance will be used for storm-water detention. Each roof area will be drained by a controlled drain designed for a release rate of 10 U.S. gal/min. or 0.63L/s. The landscape grass area (Drainage Area #4 and #5) will be used for storm-water detention and each landscape drain will also be designed for a release rate of 0.63 L/s or 10 U.S. gal/min. The proposed underground concrete storage tank structures in the building are designed to provide storm-water detention to control the allowable release rate to 4.12 L/s by pumping. The pumping rate from the proposed holding tank shall therefore be set at 4.12 L/s.

1.) Roof Storage Area #1

- Available flat roof area for storage =145.89 m^2 @ roof slope of 1.7% (min.). Therefore, the available roof area will store a volume as shown below using the reservoir volume equation.

$$V = \frac{(0.11\ \text{m})[78.96 + 4(19.65) + 0]}{6}$$

$$V = \frac{(0.11)(157.56)}{6}$$

$$\underline{V = 2.89\ \text{m}^3}$$

The available Roof Area #1 storage volume of 2.89 m^3 > required five (5)-year storage volume of 2.47 m^3 from Table 1.

Therefore, ponding depth at the proposed Drain #1 location is approximately 0.11 m (110 mm) and the five (5)-year level is estimated not to reach the roof perimeter of the building.

2.) Roof Storage Area #2

- Available flat roof area for storage =145.89 m^2 @ roof slope of 1.7% (min.). Therefore, the available roof area will store a volume as shown below using the reservoir volume equation.

$$V = \frac{(0.11\ \text{m})[78.96 + 4(19.65) + 0]}{6}$$

$$V = \frac{(0.11)(157.56)}{6}$$

$$\underline{V = 2.89\ \text{m}^3}$$

The available Roof Area #2 storage volume of 2.89 m^3 > required five (5)-year storage volume of 2.47 m^3 from Table 2.

Therefore, the ponding depth at the proposed Drain #2 location is approximately 0.11 m (110mm) and the five (5)-year level is estimated not to reach the roof perimeter of the building.

3.) <u>Roof Storage Area #3</u>

- Available flat roof area for storage =135.6 m^2 @ roof slope of 1.3% (min.). Therefore, the available roof area will store a volume as shown below using the reservoir volume equation.

$$V = \frac{(0.11\text{ m})[70.98 + 4(18.48) + 0]}{6}$$

$$V = \frac{(0.11)(144.9)}{6}$$

$$\underline{V = 2.42\text{ m}^3}$$

The available Roof Area #3 storage volume of 2.42 m^3 > required five (5)-year storage volume of 2.17 m^3 from Table 3.

Therefore, the ponding depth at the proposed Drain #3 location is approximately 0.11 m (110mm) and the five (5)-year level is estimated not to reach the roof perimeter of the building.

4.) <u>Landscape Grass Area #4</u>

$$V = \frac{(0.10\text{ m})[50.0 + 4(12.5) + 0]}{6}$$

$$V = \frac{(0.10)(100.0)}{6}$$

$$\underline{V = 1.67\text{ m}^3}$$

The available Landscape Grass Area #4 storage volume of 1.67 m^3 > required five (5)-year storage volume of 1.38 m^3 from Table 4.

Therefore, the ponding depth at the proposed Drain #4 location is approximately 0.10 m (100mm) and the five (5)-year high water level is shown on Dwg. No. 818-71 SWM-1.

5.) <u>Roof Storage Area #5</u>

$$V = \frac{(0.10\ \mathrm{m})[47.0 + 4(12.0) + 0]}{6}$$
$$V = \frac{(0.10)(95.0)}{6}$$
$$\underline{V = 1.58\ \mathrm{m}^3}$$

The available Landscape Grass Area #5 storage volume of 1.58 m^3 > required five (5)-year storage volume of 1.34 m^3 from Table 5.

Therefore, the ponding depth at the proposed Drain #5 location is approximately 0.10 m (100mm) and the five (5)-year high water level is shown on Dwg. No. 818-71 SWM-1.

6.) Storm-water Storage Tank Structure

In the building, a storage tank structure with an effective storage volume of the following is required for the five (5)-year event.

$$V = \mathrm{L\ x\ W\ x\ H}$$
$$V = 3.65\ \mathrm{m}\ x\ 2.5\ \mathrm{m}\ x\ 0.65\ \mathrm{m}$$
$$\underline{V = 5.93\ \mathrm{m}^3}$$

Final tank sizing and configuration is proposed in sub-section B6 in Appendix A.

Hence, the building flat rooftop storage and rear yard landscape grass storage are adequate to store the minimum required five (5)-year storm event volume of 9.83 m^3 (min.) given that they can store up to 11.45 m^3. The building storage tank volume (min.) is 5.93 m^3 (assuming tank size of 3.65 m long by 2.5 m wide at a depth of 0.65 m) which is greater than the required 5.83 m^3 from Table 6. Total site storage available for the five (5)-year event is 17.38 m^3 which is greater than the minimum required volume of 15.66 m^3.

AVAILABLE STORAGE VOLUME CALCULATIONS

B.) 100-Year Event

Roof Area #1 and Roof Area #2 on top of the mechanical room and Roof Area #3 above the garage entrance will be used for storm-water detention. Each roof area will be drained by a controlled drain designed for a release rate of 10 U.S. gal/min. or 0.63L/s. The landscape grass area (Drainage Area #4 and #5) will be used for storm-water detention and each landscape drain will also be designed for a release rate of 0.63 L/s or 10 U.S. gal/min. The proposed underground concrete storage tank structures in the building are designed to provide storm-water detention to control the allowable release rate to 4.12 L/s by pumping. The pumping rate from the proposed holding tank shall therefore be set at 4.12 L/s.

1.) Roof Storage Area #1

- Available flat roof area for storage =145.89 m^2 @ roof slope of 1.7% (min.). Therefore, the available roof area will store a volume as shown below using the reservoir volume equation.
-

$$V = \frac{(0.15 \text{ m})[145.89 + 4(36.38) + 0]}{6}$$

$$V = \frac{(0.15)(291.41)}{6}$$

$$\underline{V = 7.29 \text{ m}^3}$$

The available Roof Area #1 storage volume of 7.29 m^3 > required 100-year storage volume of 6.02 m^3 from Table 7.

Therefore, the ponding depth at the proposed Drain #1 location is approximately 0.15 m (150mm), and at the perimeter of Roof Area #1 is 0 mm above the roof perimeter surface. Accordingly, it is recommended that roof scuppers be installed at the perimeter height of the rooftop for emergency overflow purposes in case of blockage from debris buildup at the roof drain

2.) Roof Storage Area #2

- Available flat roof area for storage =145.89 m^2 @ roof slope of 1.7% (min.). Therefore, the available roof area will store a volume as shown below.

$$V = \frac{(0.15 \text{ m})[145.89 + 4(36.38) + 0]}{6}$$

$$V = \frac{(0.15)(291.41)}{6}$$

$$\underline{V = 7.29 \text{ m}^3}$$

The available Roof Area #2 storage volume of 7.29 m^3 > required 100-year storage volume of 6.02 m^3 from Table 8.

Therefore, the ponding depth at the Roof Drain #2 location is approximately 0.15 m (150mm), and at the perimeter of the Roof Area #2 is 0 mm above the roof perimeter surface. Accordingly, it is recommended that roof scuppers be installed at the perimeter height of the rooftop for emergency overflow purposes in case of blockage from debris buildup at the roof drain.

3.) <u>Roof Storage Area #3</u>

- Available flat roof area for storage =135.6 m^2 @ roof slope of 1.3% (min.). Therefore, the available roof area will store a volume as shown below.

$$V = \frac{(0.15\ \text{m})[135.6 + 4(33.63) + 0]}{6}$$
$$V = \frac{(0.15)(270.12)}{6}$$
$$\underline{V = 6.75\ \text{m}^3}$$

The available Roof Area #3 storage volume of 6.75 m^3 > required 100-year storage volume of 5.37 m^3 from Table 9.

Therefore, the ponding depth at the Roof Drain #3 location is approximately 0.15 m (150mm), and at the perimeter of the Roof Area #3 is 0 mm above the roof perimeter surface. Accordingly, it is recommended that roof scuppers be installed at the perimeter height of the rooftop for emergency overflow purposes in case of blockage from debris buildup at the roof drain.

4.) <u>Landscape Grass Area #4</u>

$$V = \frac{(0.15\ \text{m})[109.7 + 4(28.0) + 0]}{6}$$
$$V = \frac{(0.15)(221.7)}{6}$$
$$\underline{V = 5.54\ \text{m}^3}$$

The available Landscape Grass Area #4 storage volume of 5.54 m^3 > required 100-year storage volume of 4.24 m^3 from Table 10.

Therefore, the ponding depth at the proposed Drain #4 location is approximately 0.15 m (150mm), and the 100-year high water level is shown on Dwg. No. 818-71 SWM-1.

5.) Landscape Grass Area #5

$$V = \frac{(0.15\ \text{m})[105.0 + 4(25.0) + 0]}{6}$$
$$V = \frac{(0.15)(205.0)}{6}$$
$$\underline{V = 5.12\ \text{m}^3}$$

The available Landscape Grass Area #5 storage volume of 5.12 m^3 > required 100-year storage volume of 4.11 m^3 from Table 11.

Therefore, the ponding depth at the proposed Drain #5 location is approximately 0.15 m (150mm), and the 100-year high water level is shown on Dwg. No. 818-71 SWM-1.

6.) Storm-water Storage Tank Structure

In the building, a storage tank structure with an effective (min.) storage volume of the following is required for the 100-year event.

$$V = L \times W \times H$$
$$V = 3.65\ \text{m} \times 2.5\ \text{m} \times 1.65\ \text{m}$$
$$\underline{V = 15.06\ \text{m}^3}$$

It is recommended that the storage volume (2.0 x 15.06 m^3 = 30.12 m^3) be provided to attenuate the storm-water flow up to the 100-year event from building rooftops and rear yard landscape areas. From Table 12, the required storage volume (min.) is 13.82 m^3.

One possible configuration would be to install a storage tank connected to a holding tank/pumping chamber that houses the duplex pumps set at 4.12 L/s. The effective storage volume of the storage tank is 15.06 m^3 and the holding tank effective storage volume would also be 15.06 m^3 to attenuate the storm flows up to the 100-year event with a safety factor two times the required volume included in the design.

Hence, the building flat rooftop storage from Area #1, #2, and #3 and the landscape grass areas #4 and #5 are adequate to store the minimum required 100-year storm event volume of 25.76 m^3 given that they can store up to 31.99 m^3. The building storage tank volume recommended is at 30.12 m^3 which is greater than the required 13.82 m^3 from Table 12. Total site storage available is 62.11 m^3 which is greater than the minimum required volume of 39.58 m^3.