HYDROLOGIC IMPACT ASSESSMENT
METRO TOWING – 6776 ROTHBOURNE ROAD

Project No.: 0CP-17-0381
Rev 1. December 2019

Prepared for:

Metro Towing
2759 Lancaster Road
Ottawa, ON K1B 4V8

Prepared by:

McIntosh Perry Consulting Engineers Ltd.
115 Walgreen Road
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MCINTOSH PERRY

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APPENDICES

1.0 PURPOSE

McIntosh Perry Consulting Engineers Limited (McIntosh Perry) has prepared this Hydrologic Impact Assessment in support of the application for Site Plan Control for the development known as Metro Towing located at 6776 Rothbourne Road within the City of Ottawa.

The main purpose of this report, as requested by Mississippi Valley Conservation Authority (MVCA), is to confirm the impact (if any) to the nearby wetland, which form part of the property that is being developed. The report will speak to any proposed mitigation necessary to minimize any adverse impacts to the wetland. This report will present an impact assessment for the development in accordance with the recommendations and guidelines provided by the City of Ottawa (City), MVCA, and the Ministry of the Environment, Conservation and Parks (MECP). Please note that the hydrologic impact assessment procedure prepared by the MVCA was followed in preparation of this report.

2.0 SITE DESCRIPTION

The property is located at 6776 Rothbourne Road. It is described as Part of Lot 18, Concession 12, City of Ottawa, Ontario (see Appendix 'A' for Key Plan). The land in question covers approximately 10.08 ha. The property currently encompasses an existing wetland. Furthermore, the Hazeldean Municipal Drain (adopted under the Drainage Act) passes through the site. The northern portion of the site is currently developed with a building fronting Rothbourne Road and a gravel parking area. There is an existing berm constructed at the south side of the existing development area and north of the wetland area. The wetland and drain are located within the middle section of the site. The south portion of the site is currently undeveloped.

The proposed development consists of a 969 m^2, one-storey warehouse with gravel parking at the rear portion of the site. An access road will be constructed through the middle wetland portion of the site. Swales are proposed adjacent to existing berms at the south side of the site for stormwater management purposes.

3.0 EXISTING CONDITIONS

3.1 LAND USE

The site has been described as three areas. The south area being the "proposed development", the middle area being the wetland, and the north area being the "existing development". For calculation purposes, it has been assumed that the north area is undeveloped in pre-development conditions to represent the site pre-construction (i.e.: a greenfield site). This has been done to be conservative and to account for the site development which occurred prior to stormwater management being necessary on site. There will be an increase in stormwater runoff due to the change in impermeable surface area both north and south of the wetland. To manage the increase in stormwater runoff, grassed swales, ponds, and outlets equipped with orifice plates and earth weirs have been designed to convey and restrict stormwater runoff.

The land use map has been provided in Appendix B and the breakdown per catchment detailed in the water balance calculations is provided in Appendix C. To summarize, the site includes a combination of forested areas and pasture predominately on sandy soils with some areas of sandy silty soils in the northern portions of the site. Please also refer to the Environmental Impact Statement (EIS) completed by McIntosh Perry under separate cover for additional details regarding the forested and pasture lands.

3.2 SOIL CONDITIONS

A Geotechnical Report (2019) was prepared by McIntosh Perry and was reviewed during preparation of this report. The report describes the soil conditions as topsoil (0.075 – 0.45 m) overtop of overburden comprised of mainly sand with varying levels of clay, silt and gravel. Overburden was generally 0.3 – 1.6 m in depth with one area observed at 4.3m deep. Bedrock was occasionally encountered in test pits (1.2 – 2.82 m). Groundwater was observed in open boreholes 0.6 – 0.9 m below ground surface but, predominately towards the south-central areas on site and not in the locations of the stormwater management facilities based on the investigation completed. A copy of the Geotechnical Report prepared by McIntosh Perry is available under separate cover.

3.3 TOPOGRAPHIC AND SOILS MAPS

Topographic maps (pre- and post-development drainage plan) and soils maps have been included in Appendix B, which confirm and illustrate the existing drainage patterns on site as well as the existing soils including their classifications. Further boreholes have confirmed that there are predominately sandy soils and an area of sandy silt underlying soil composition on site. The specific areas have been demarcated within the soils mapping provided; this site-specific information was used in the infiltration and runoff calculations as part of the water balance within this report. Please note that topographic descriptions of on-site soils, as well as how the descriptions were calculated is included in Section 5.1, under Table 2.

4.0 PROPOSED CONDITIONS

4.1 GRADING PLAN

The proposed Grading Plan has been included in Appendix C, which illustrates the proposed lot fabric, parking areas (gravel) and road network within the development. Based on the enclosed, a single roadway is proposed to encroach within the wetland boundary to access the southern portion of the site. All flow is ultimately directed towards the central portion of the site and into the wetland prior to outletting towards the east into the Hazeldean Municipal Drain. The northern portion of the site is currently developed and will see spot improvements to the existing gravel parking area. The overland flow routes will remain consistent with existing. The proposed grading at the southern portion of the site will see the topsoil stripped off the site, the subgrade compacted and granulars placed to achieve positive flow towards the wetland. A proposed warehouse will also be located on the southern portion of the site.

4.2 STORMWATER MANAGEMENT DESIGN

As part of this assignment and to satisfy both MVCA and the City, a stormwater management report has been prepared under separate cover to ensure that the design criteria from both review agencies along with recommendations from the MNRF, MTO and MECP are adhered to. Stormwater management facilities are located in both the north and south portions of the site to ensure that runoff reaching the wetland is controlled to pre-development rates and meets an **enhanced** level of quality control (80% Total Suspended Solids (TSS) removal). Please see the Servicing and Stormwater Management Report prepared by McIntosh Perry under separate cover for additional details.

4.3 EROSION AND SEDIMENT CONTROL

The proposed development will implement on-site temporary and permanent means to manage erosion and sediment control. Prior to the commencement of construction, temporary silt fence, straw bale and rock flow check dams will be installed at all natural runoff outlets from the property. Please refer to the Site Grading, Drainage and Sediment and Erosion Control Plan and the Servicing and Stormwater Management Report prepared by McIntosh Perry for additional details. A copy of the Site Grading, Drainage and Sediment and Erosion Control Plan has been included in Appendix C for ease of reference.

5.0 WATER BALANCE

5.1 DATA

Potential impacts to the existing wetland were reviewed through the use of standard water balance calculations. Data from Environment Canada for the Ottawa International Airport was used to calculate the runoff surplus and total precipitation for the site. Environment Canada data was limited to the precipitation and temperature data, while the remaining information was calculated using the Thornthwaite-Mather water balance methodology as described in the "Instructions and Tables for Computing Potential Evapotranspiration and the Water Balance, C.W. Thornthwaite and J.R. Mather, 1957". Please see sample calculations within Appendix D. The pre- and post-development conditions were subdivided for the water balance as follows:

Soils:

- Sandy soils, noted to be HSG A; and
- Sandy silt, noted to be HSG B.

Pervious Land uses:

- Pasture overtopping sandy soils;
- Pasture overtopping sandy silt;
- Forest overtopping sandy soils; and
- Forest overtopping sandy silt.

Impervious Land Uses:

- Dwellings and asphalt; and
- Gravel (included parking lots and access roadways).

Each of these pervious categories was reviewed based on Table 10 of the Thornthwaite – Mather literature to obtain the applicable soil moisture retention of the underlying soils. The soil moisture retention used in our calculations is provided as "mm/m", therefore once the average on-site soil depth (noted as 1.2 m) was applied, a corresponding site-specific soil moisture retention value was obtained for each category above. These soil moisture retention values are used to determine the soil moisture storage, given the accumulated water losses which are calculated based on the climatic data (temperature and precipitation) for the site. These tables are only noted in specific depths (25 mm and 50 mm intervals), therefore in some instances, the closest possible table was used. Table 1 below illustrates an example at a soil moisture retention value of 75 mm. Located in Appendix D, calculations for 75 mm, 100 mm, 125 mm, 150 mm, 200 mm, 250 mm, 350 mm and 400 mm were completed as part of a bulk sensitivity analysis for the surplus data. Results of this analysis, as calculated for each soil moisture value noted above, indicate that changing moisture retention values by 25 mm to 50 mm yields approximately 1% change in water surplus. This would indicate that regardless of whether the soils had 150 mm or 200 mm of moisture retention, the difference in surplus will be minor.

Table 1 – Monthly Water Balance Example - 75mm - Climate Data per Environment Canada data for Ottawa International Airport (1981 - 2010)

Month	Temp	Heat Index	PET	P	ΔP = P - PET	WL	ST	ΔS	AET	D	S	RO	SMRO	TR	DT
January	-10.3	0	0	65	65		217	0	0	0	0	11	0	11	228
February	-8.1	0	0	54	54		271	0	0	0	0	5	0	5	276
March	-2.3	0	0	64	64		336	0	0	0	0	2	0	2	338
April	6.3	1.4	32	75	43		75	0	32	0	43	22	26	48	166
May	13.3	4.4	79	80	2		75	0	79	0	2	12	117	129	206
June	18.5	7.2	112	93	-19	-19	57	-18	111	1	0	6	59	65	122
July	21	8.8	133	92	-41	-60	33	-24	116	17	0	3	29	32	65
August	19.8	8.0	114	86	-29	-88	22	-11	97	18	0	2	15	17	39
September	15	5.3	73	90	17		39	17	73	0	0	1	7	8	47
October	8	2.0	34	86	52		75	36	34	0	17	9	4	13	105
November	1.5	0.2	5	82	77		75	0	5	0	77	43	2	45	197
December	-6.2	0	0	76	76		151	0	0	0	0	22	1	23	174
Total		37.4	580	944				0	545	35	138	138	260	398	

PET = Potential Evapotranspiration, P = Total Precipitation, ΔP = P-PET, WL = Accumulated Water Loss, ST= Storage, ΔS = Soil Moisture Storage, AET = Actual Evapotranspiration, D = Soil Moisture Deficit, S = Soil Moisture Surplus, RO = Water Runoff, SMRO = Snow Melt Runoff, TR = Total Runoff, DT = Total Moisture Detention

Note: Shaded cells taken from Thornwaite-Mather Tables. See sample calculation in Appendix D for cell by cell calculations. Total Surplus for example above is 398mm.

Monthly T from Environment Canada:

Heat Index (I) = 37.4, a: 1.06

Next, the infiltration factors were chosen based on the following data:

Table 2 - Infiltration Factors from the "Tier 1 Water Budget and Water Quantity Stress Assessment" prepared by the Mississippi-Rideau Source Protection Region, August 2009

Description of Area / Development Site	Value of Infiltration Factor
Topography	
Flat Land (<1.5 slope range)	0.172
Rolling land (1.5 – 3% slope range)	0.120
Hilly land (>3% slope range)	0.073
Soil	
Low (clay, silt)	0.10
Low-Medium (till, sand-silt)	0.15
Medium (till, silty sand)	0.20
Medium-High (sands)	0.30
High (gravel, sands, organic deposits)	0.40
Variable (till)	0.20
Variable (fill)	0.40
Variable (sand)	0.35
Variable (bedrock)	
Precambrian Bedrock	0.20
Paleozoic Bedrock	0.05
Land Cover	
Low Infiltration – urban, aggregate	0.05
Medium Infiltration – agriculture, pasture, abandoned fields, wetland	0.10
High Infiltration – forest and plantation	0.20

For pre-development, the site has slopes generally under 1.5%, and as such was assigned a topographic infiltration factor of 0.172.

The soil classification was predominately sandy soils (infiltration rate of 0.35) for the HSG A soils and 0.30 for the HSG B soils. As this results in a higher volume of infiltration in pre-development, it is believed to be a conservative approach.

The site is comprised of open vegetated areas which will results in a value of 0.10 being used and in forested areas, a land cover infiltration factor of 0.20 was used.

For post-development, the areas of development are not anticipated to have very significant slopes, however they are generally expected to be at or over 1.5%. Therefore, the grassed areas will see an infiltration factor of 0.12 used.

The soil classification for each area will not be changed for the pervious surfaces.

The impervious areas were also reviewed given that, although there is a reduction in infiltration from grass or forest to gravel, it will still see some infiltration. The soil and land cover factors for gravel areas were taken as the minimum 0.05 and 0.05 respectively, along with a topographic infiltration factor of 0.12 given slopes are likely to exceed 1.5% but, be less than 3%.

5.2 PRE-DEVELOPMENT, POST-DEVELOPMENT AND POST-DEVELOPMENT WITH MITIGATION

Under pre-development, post-development, and post-development with mitigation, precipitation, drainage, and infiltration conditions were reviewed for the three main catchment areas on site. The results have been summarized below:

Table 3 - Summary Water Balance Table

Characteristic	Pre-Development	Post-Development	Change (Pre – to Post)	Post-Development with Mitigation	Change (Pre- to Post- with Mitigation
Developed Site (North of Wetland) – A1 = B1 + B2					
Input (Volumes)					
Precipitation (m^3/year)	27089	27115	0%	27115	0%
Output (Volumes)					
Total Infiltration (m^3/year)	6630	2998	-55%	6653	0%
Total Runoff (m^3/year)	4389	8534	94%	4879	11%
Wetland (Centre of Site) – A2 = B5					
Input (Volumes)					
Precipitation (m^3/year)	27812	27813	0%	27813	0%
Output (Volumes)					
Total Infiltration (m^3/year)	7349	7034	-4%	7034	-4%
Total Runoff (m^3/year)	3851	4210	9%	4210	9%
Developed Site (South of Wetland) – A3 = B3 + B4					
Input (Volumes)					
Precipitation (m^3/year)	40295	40295	0%	40295	0%
Output (Volumes)					
Total Infiltration (m^3/year)	11403	4639	-59%	11409	0%
Total Runoff (m^3/year)	4553	12697	179%	5927	30%

Table 3, above, illustrates that the pre- and post-development areas for each catchment remain relatively similar. This ensures that no single outlet will experience an abnormal increase in its respective catchment area.

The total infiltration is illustrated to indicate that in all instances, the development on site (i.e.: when comparing post- to pre-development) results in a reduction in infiltration. To address the deficiency, infiltration-promoting measures will be required to ensure runoff is intercepted and permitted to recharge the groundwater aquifer.

Finally, the total runoff illustrated confirms that each catchment will see an increase in total volume as a result of the development. This will result in additional volume within the wetland temporarily until it is permitted to flow downstream. This information is critical for the natural sciences consultant to confirm that the vegetation communities are capable of withstanding the additional volume of runoff over the short term. Please see Appendix D for the water balance tables broken out for each catchment.

6.0 MITIGATION

As a result of the lack of recharge when comparing post- to pre-development, the project will require infiltration trenches to ensure that the volume of runoff required enters the ground, providing groundwater recharge and continuing to ensure that the aquifer is maintained. Please note that this mitigation does not take into account the additional infiltration from the septic system that will ultimately aid in reducing any infiltration deficiency on site.

In order to design the trenches, the 10 mm event was reviewed. Environment Canada data indicate that an annual average of 25.2 days have more than 10 mm rain events. Multiplying the 25.2 days by the 10 mm will result in a minimum of 252 mm of volume delivered during >10mm rain events on an annual basis. Please note that this is considered conservative as there are a total of 118.4 days that have rain over 0.2 mm in a given year. By accommodating the 10 mm storm in the trenches, the site is effectively storing all the runoff less than 10 mm as well which will greatly increase the volume of water that is not runoff from the site.

Table 4 - Environment Canada - Days with Precipitation

1981 to 2010 Canadian Climate Normals station data

Days with Rainfall

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year	Code
>= 0.2 mm	4.4	3.9	6.7	10.9	13.4	13.2	11.9	11	12.3	13.7	11	6	118.4	A
>= 5 mm	1.6	1.2	2.1	4	4.9	5.8	5.4	4.8	5.1	5	4.2	2.3	46.5	A
>= 10 mm	0.87	0.57	1	2	2.7	2.9	3.1	2.8	3.2	2.7	2.1	1.2	25.2	A
>= 25 mm	0.13	0.07	0.10	0.33	0.47	0.73	0.77	0.67	0.60	0.47	0.43	0.13	4.9	A

As described above, the mitigation measures were reviewed for each catchment. The exact geometry and location within the catchment have been completed by the civil engineering team during the detailed design of the development. Based on the volume to be infiltrated, mitigation measures meet or exceed the required infiltration volume required to balance the site.

Table 5 - Mitigation Measure Sizing

	North of Wetland Area A1 = Area B1 and B2	Wetland Areas A2 = Areas B5	South of Wetland Area A3 = Areas B3 and B4
Area of Granular (m^2)	25204	0	35198
Granular Runoff Coefficient	0.78	0.78	0.78
Volume of Runoff in 10 mm Event (m^3) to be infiltrated	**197**	0	**275**
Mitigation Required (m^3/year)	3655	0	6688
Annual Volume to be infiltrated by designing for 10mm Event (m^3)	4954	0	6919

The civil engineering team will be required to facilitate infiltration measures to provide 197 m^3 and 275 m^3 for the north and southern portions of the site respectively in order to meet the mitigation requirements. Mitigation requirements have not been proposed in the central portion of the wetland given that the percent decrease is relatively minor in nature.

7.0 HYDROLOGICAL IMPACTS

7.1 GROUNDWATER CONDITIONS

Groundwater was encountered in boreholes 18-3, 18-4, 18-5 and 18-9 ranging from 0.6 – 0.9 m below existing grade. Based on the location of these boreholes, being upstream of the wetland, it is not anticipated that groundwater influences will be a concern of the trenches required closer to the wetland area.

While it is possible that during certain times of the year (e.g. spring) surface water may have some residence time in the overburden, any saturation would be considered ephemeral and of a temporary nature. Please see the Geotechnical Report prepared by McIntosh Perry for more detailed information.

8.0 ANALYSIS OF IMPACTS TO THE WETLAND

Drainage will be directed via overland sheet flow and offtake swales, which during major precipitation events will result in runoff reaching the wetland at the centre of the site. Riprap and other flow spreaders will be used in the grassed swales to disperse surface flows and dissipate the associated energy of the flows directed to the wetland. This will ensure that any concentrated flows are spread out to reduce the potential for downstream erosion. The discharge from this swale is expected to be reduced through infiltration and evaporation between the outlet of the stormwater management feature and the edge of the wetland. The swales and ponding areas on site will promote infiltration through the use of flat bottom ditches, riprap-lined corners and bends, and the presence of sandy soils.

This hydrologic impact assessment determined that there was a change in total infiltration when comparing post- to pre-development. This has resulted in the requirement of proposed mitigation measures for both the north and southern catchments discharging to the wetland. The change in total runoff entering the wetland will be mitigated by the stormwater management facilities which will reduce the peak flows to pre-development rates. As outlined in the stormwater management report prepared by McIntosh Perry, the proposed measures will provide additional on-site storage outside of the wetland to reduce the volumes reaching the wetland. Given the size of the downstream concrete box culvert (2700 mm x 1100 mm, concrete box culvert) on Rothbourne Road, the discharge capacity is relatively significant and the isolated flooding and/or backing up of runoff is not anticipated to be a concern to the site. Any additional volume from the site reaching the wetland is not anticipated to take any appreciable time to discharge through a culvert of this size, resulting in minimal residence time in the system. The Provincially Significant Wetland (PSW) is dominated by broad-leaved cattails and shrub willows, which are relatively insensitive to changes in standing water levels. Furthermore, the stormwater management facilities will provide control of runoff which will mitigate any significant changes in water levels in the PSW.

No measurable changes are anticipated for the water elevations in the wetland parcels during a 100-year storm event, given the stormwater management that is proposed upstream of the wetland.

9.0 ENVIRONMENTAL IMPACTS

9.1 HEADWATER DRAINAGE FEATURES

Headwater drainage features are assessed for hydrology, fish and fish habitat, riparian corridor characteristics and terrestrial habitat including amphibians. As the above analysis has indicated, flows will be similar to existing conditions given that stormwater management will be proposed prior to runoff reaching the wetland. The riparian corridor of the headwater drainage features will not be impacted except for one road crossing in the PSW in the northwest portion of the site. No impacts on the features and functions of the headwater drainage features are anticipated as the design of the culvert associated with the road crossing adheres to City of Ottawa standard design practices in which overtopping of the culvert will not occur during the 100-year return period. The extensive wetlands and adjacent upland habitats will remain as part of the open space corridor. No fish habitat is associated with the study area due to downstream migration barriers. Mitigation measures will be implemented to address potential sediment and erosion concerns associated with vegetation clearing and grading activities within the study area. Refer to the Environmental Impact Study prepared by McIntosh Perry for environmental details pertaining to the study area.

10.0 SUMMARY

- Through the development of the site plan, increased runoff into the wetland is expected, with a corresponding shortfall in infiltration.
- To combat these increases and shortfalls, stormwater management and infiltration mitigation measures are proposed to minimize any potential impacts.
- Infiltration measures will be proposed on both the north and south portions of the site to ensure that the total infiltration meets pre-development infiltration volumes.

11.0 RECOMMENDATIONS

Based on the information presented in this report, we recommend that the Mississippi Valley Conservation Authority approve this *Hydrologic Impact Assessment* in support of the proposed Metro Towing development.

Sincerely,
McIntosh Perry Consulting Engineers Ltd.

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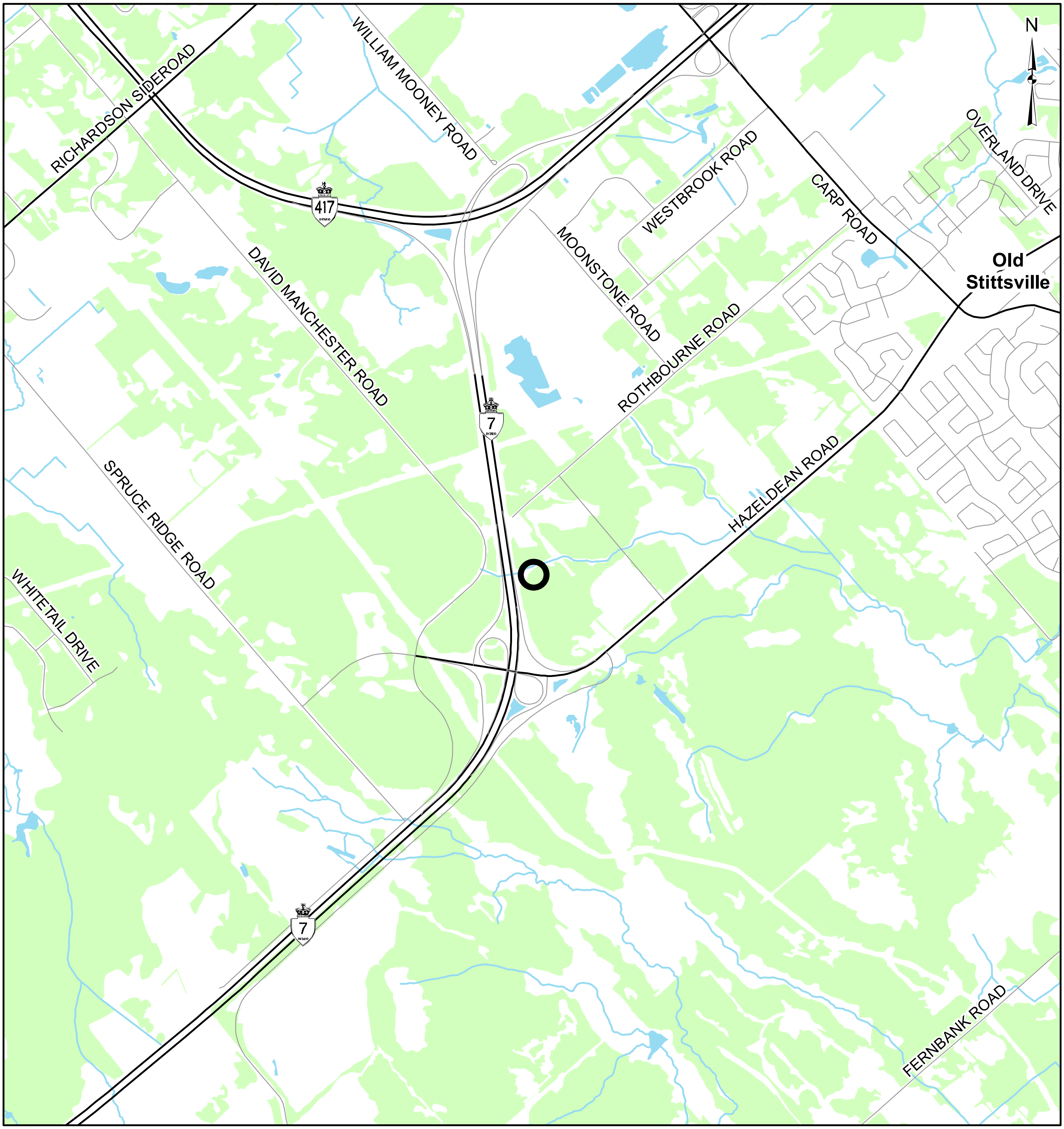
HYDROLOGIC IMPACT ASSESSMENT
METRO TOWING – 6776 ROTHBOURNE ROAD

APPENDIX A
KEY PLAN

MCINTOSH PERRY



LEGEND

- Site Location
- Local Road
- Major Road
- Watercourse
- Waterbody
- Wooded Area

REFERENCE

GIS data provided by the Ontario Ministry of Natural Resources and Forestry, 2019.
Note: Property and severance boundaries are approximate.

CLIENT: METRO TOWING

PROJECT: 6776 ROTHBORNE ROAD

TITLE: SITE LOCATION

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PROJECT NO: CP-17-0381		FIGURE:
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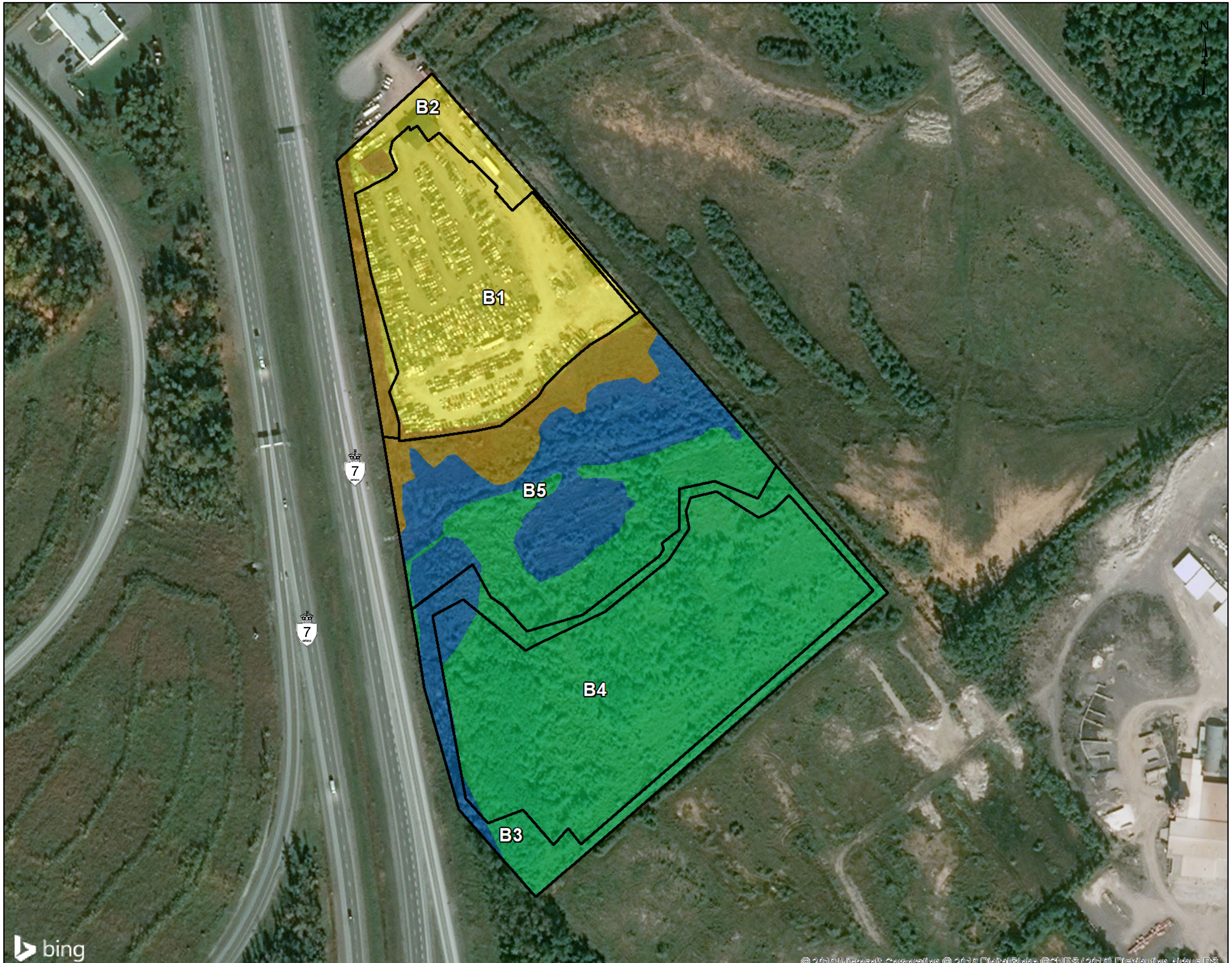
HYDROLOGIC IMPACT ASSESSMENT
METRO TOWING – 6776 ROTHBOURNE ROAD

APPENDIX B
TOPOGRAPHIC AND SOILS MAPS

MCINTOSH PERRY



LEGEND

Drainage Area

Land Classification

- Developed
- Forest
- Grass/Shrub
- Wetland

REFERENCE

GIS data provided by the Ontario Ministry of Natural Resources, 2015.

1:2,500 — 50 25 0 50 Meters

CLIENT: METRO TOWING

PROJECT: 6776 ROTHBORNE ROAD

TITLE: LAND CLASSIFICATION

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PROJECT NO: CP-17-0381	
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GIS	LC
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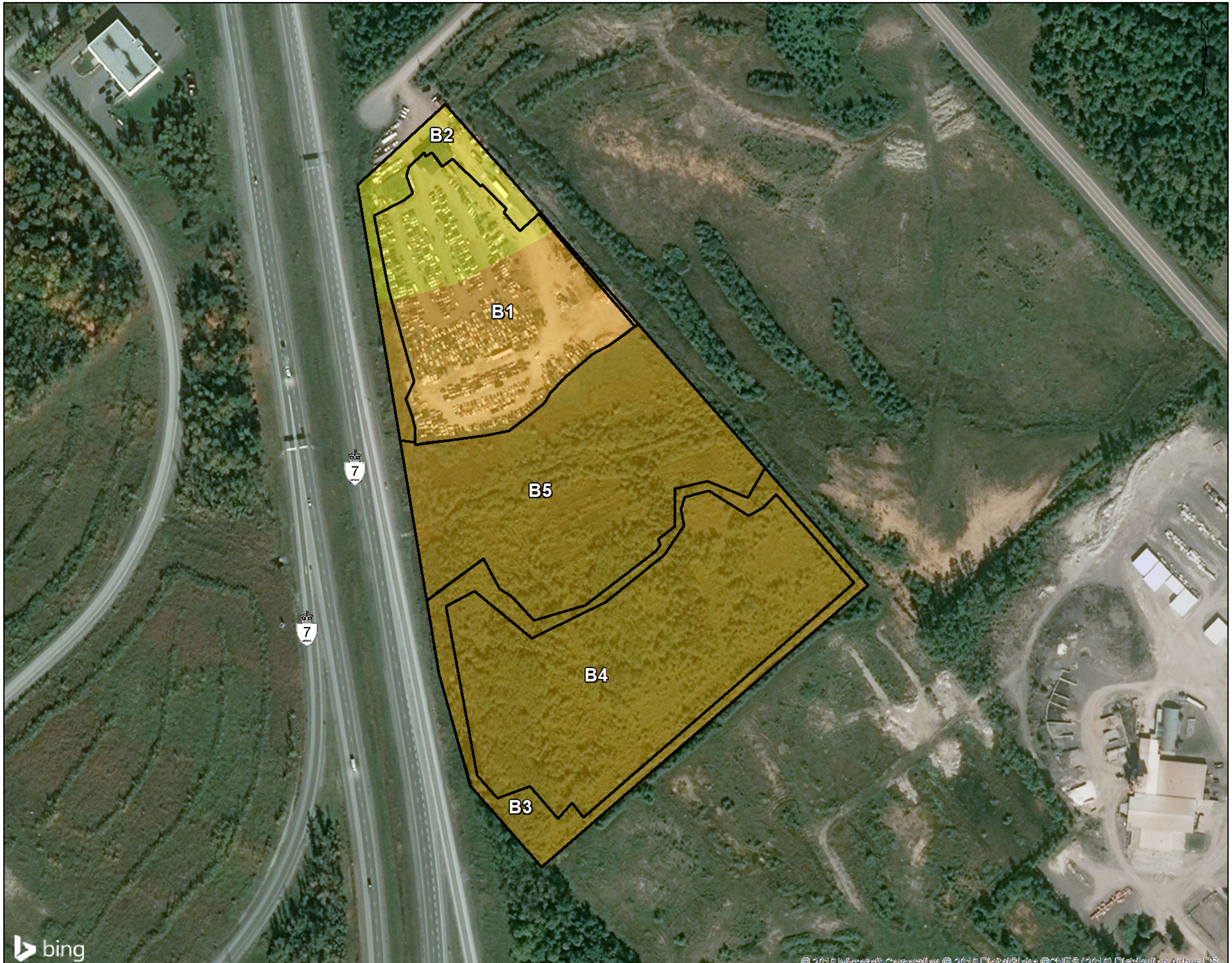

LEGEND

Drainage Area

Hydro1

A

B

REFERENCE

GIS data provided by the Ontario Ministry of Natural Resources, 2015.

50 25 0 50

1:2,698 Meters

CLIENT: METRO TOWING

PROJECT: 6776 ROTHBORNE ROAD

TITLE: SOIL CLASSIFICATION

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GIS	LC
Checked By	JS

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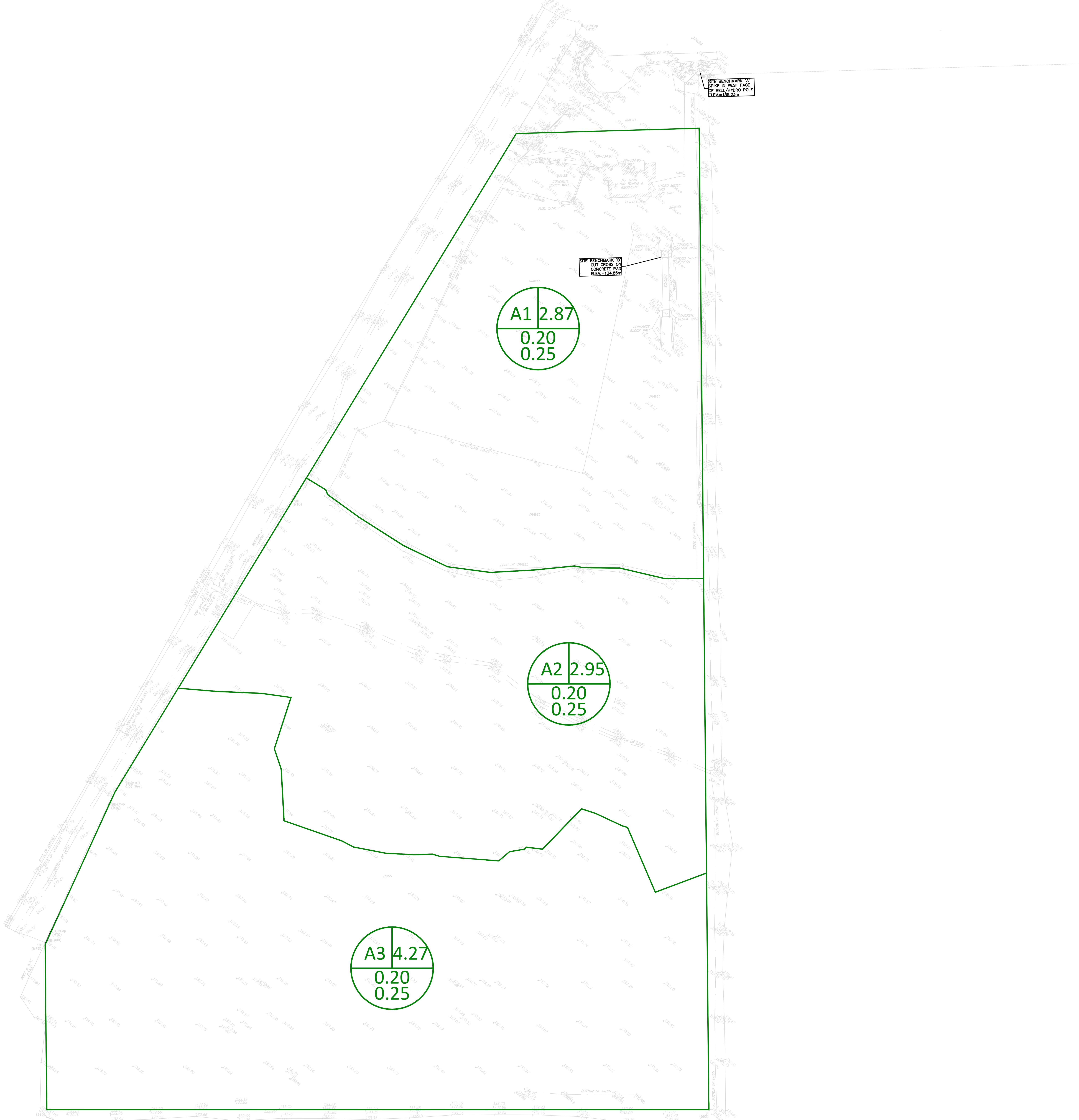

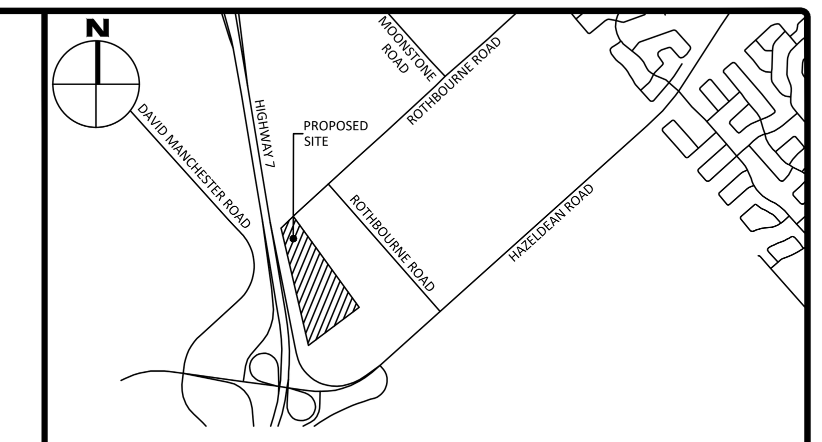

LOCATION PLAN

LEGEND

AREA NAME
AREA (Ha)
A1 0.25
0.90
1.00
5yr & 100yr COEFFICIENT

FOR REVIEW ONLY
NOT FOR CONSTRUCTION

No.	Revisions	Date
1	ISSUED FOR SITE PLAN CONTROL	JULY 17, 2019

Check and verify all dimensions before proceeding with the work — Do not scale drawings

SCALE 1 : 1000
0 25 50 75 100 Metres

MCINTOSH PERRY
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Stamp:

Client:
METRO TOWING
2759 LANCASTER ROAD
OTTAWA, ON K1B 4V8

Project:
METRO TOW TRUCK
WAREHOUSE BUILDING
6776 ROTHBOURNE RD.
OTTAWA, ON

Drawing Title:
PRE-DEVELOPMENT
DRAINAGE AREA PLAN

Scale:	1:1000	Project Number:	CP-17-0381
Drawn By:	S.V.L.		
Checked By:	R.P.K.	Drawing Number:	PRE
Designed By:	S.V.L.		

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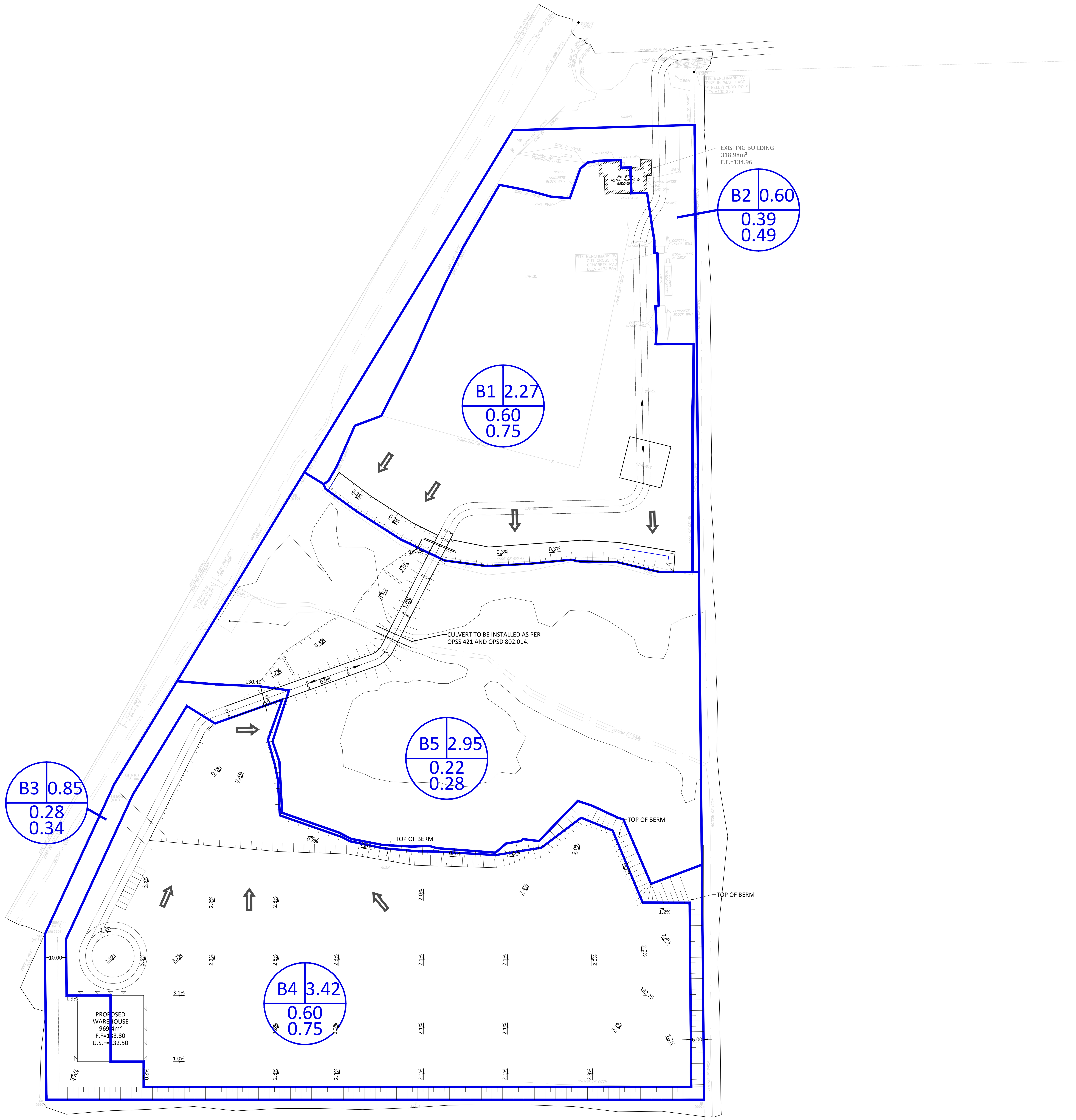

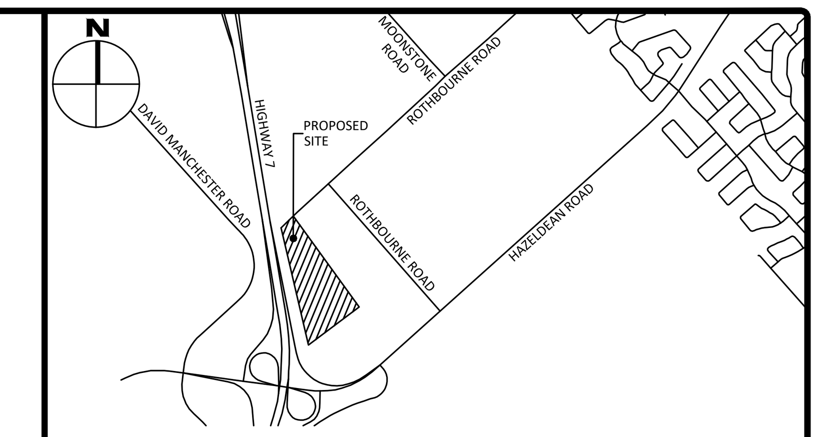

LOCATION PLAN

LEGEND

AREA NAME
AREA (Ha)
5yr & 100yr COEFFICIENT

B1 0.25
0.90
1.00

FOR REVIEW ONLY
NOT FOR CONSTRUCTION

No.	Revisions	Date
2	REVISED AS PER COMMENTS	DEC. 17, 2019
1	ISSUED FOR SITE PLAN CONTROL	JULY 17, 2019

Check and verify all dimensions before proceeding with the work
Do not scale drawings

SCALE 1 : 1000
0 25 50 75 100 Metres

McINTOSH PERRY
115 Walgreen Road, RR3, Carp, ON K0A 1L0
Tel: 613-836-2184 Fax: 613-836-3742
www.mcintoshperry.com

Stamp:

Client:
METRO TOWING
2759 LANCASTER ROAD
OTTAWA, ON K1B 4V8

Project:
METRO TOW TRUCK
WAREHOUSE BUILDING
6776 ROTHBOURNE RD.
OTTAWA, ON

Drawing Title:
POST-DEVELOPMENT
DRAINAGE AREA PLAN

Scale:	1:1000	Project Number:	CP-17-0381
Drawn By:	S.V.L.		
Checked By:	R.P.K.	Drawing Number:	POST
Designed By:	S.V.L.		

D07-12--XX-XXXX

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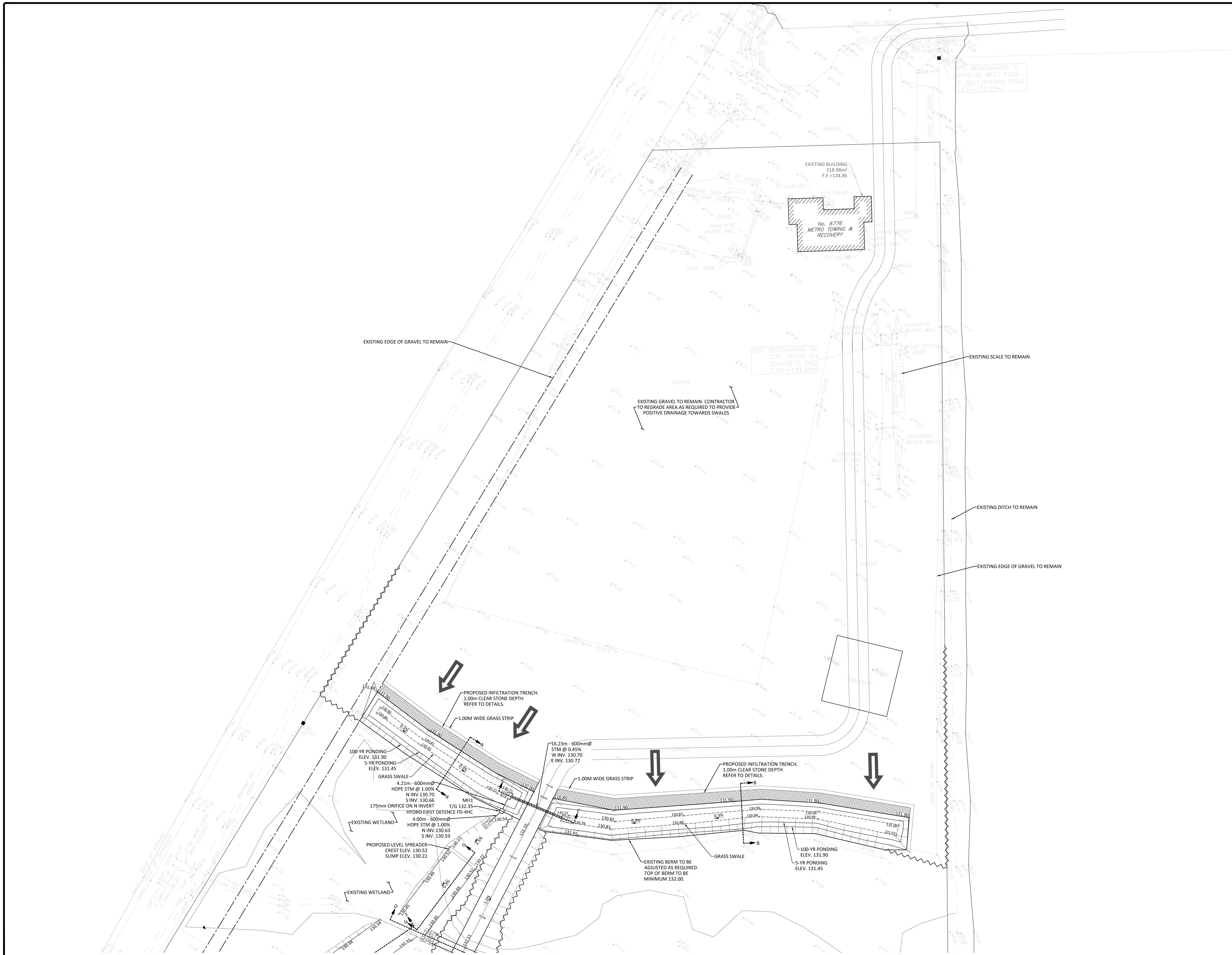
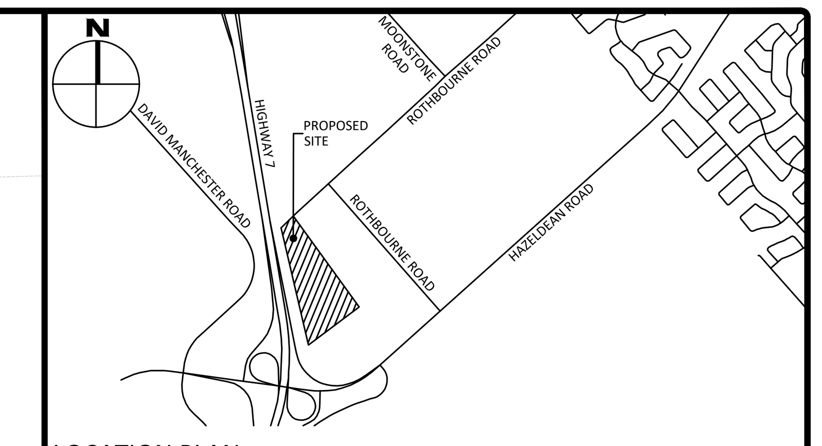
HYDROLOGIC IMPACT ASSESSMENT
METRO TOWING – 6776 ROTHBOURNE ROAD

APPENDIX C
SITE GRADING, DRAINAGE AND EROSION AND SEDIMENT CONTROL PLAN

McINTOSH PERRY





LOCATION PLAN

LEGEND

BC	BARRIER CURB / CURB DEPRESSION
	MOUNTABLE CURB
	EASEMENT
	HEAVY DUTY ASPHALT
	CONCRETE SIDEWALK
	PAVING STONE
MH7	STORM MANHOLE
CB6 DI6	CATCHBASIN OR DITCH INLET
ECB4	LANDSCAPE CATCHBASIN
MH7A	SANITARY MANHOLE
	PERFORATED PIPE IN SWALES
	WATER VAVLE/CHAMBER
	FIRE HYDRANT
	CENTRELINE OF SWALE
	SLOPING AT 3:1 (UNLESS SPECIFIED)
95.94 / 93.20	PROPOSED ELEVATION / EXISTING ELEVATION
95.94 (S)	SWALE ELEVATION
T/W100.50 B/W90.50	TOP OF WALL ELEVATION / BOTTOM OF WALL ELEVATION
	EMERGENCY OVERLAND FLOW ROUTE
	SILT FENCE (AS PER OPSD 219.130)
	STRAW BALE CHECK DAM (AS PER OPSD 219.180)
O/H	BUILDING ENTRANCES (MAIN, SIDE, OVERHEAD)
	RIP-RAP (AS PER OPSD 810.010 OR OPSD 810.020)
	INFILTRATION TRENCH (REFER TO DETAILS)

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No.	Revisions	Date
2	REVISED AS PER COMMENTS	DEC. 17, 2019
1	ISSUED FOR SITE PLAN CONTROL	JULY 17, 2019

Check and verify all dimensions before proceeding with the work — Do not scale drawings

SCALE 1 : 500
0 10 20 30 40 50 Metres

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Stamp:

Client:
METRO TOWING
2759 LANCASTER ROAD
OTTAWA, ON K1B 4V8

Project:
METRO TOW TRUCK WAREHOUSE BUILDING
6776 ROTHBOURNE RD.
OTTAWA, ON

Drawing Title:
SITE GRADING AND DRAINAGE PLAN
NORTH SIDE OF SITE

Scale:	1:500	Project Number:	CP-17-0381
Drawn By:	C.D.H.		
Checked By:	R.P.K.	Drawing Number:	C101
Designed By:	C.D.H.		

D07-12--XX-XXXX

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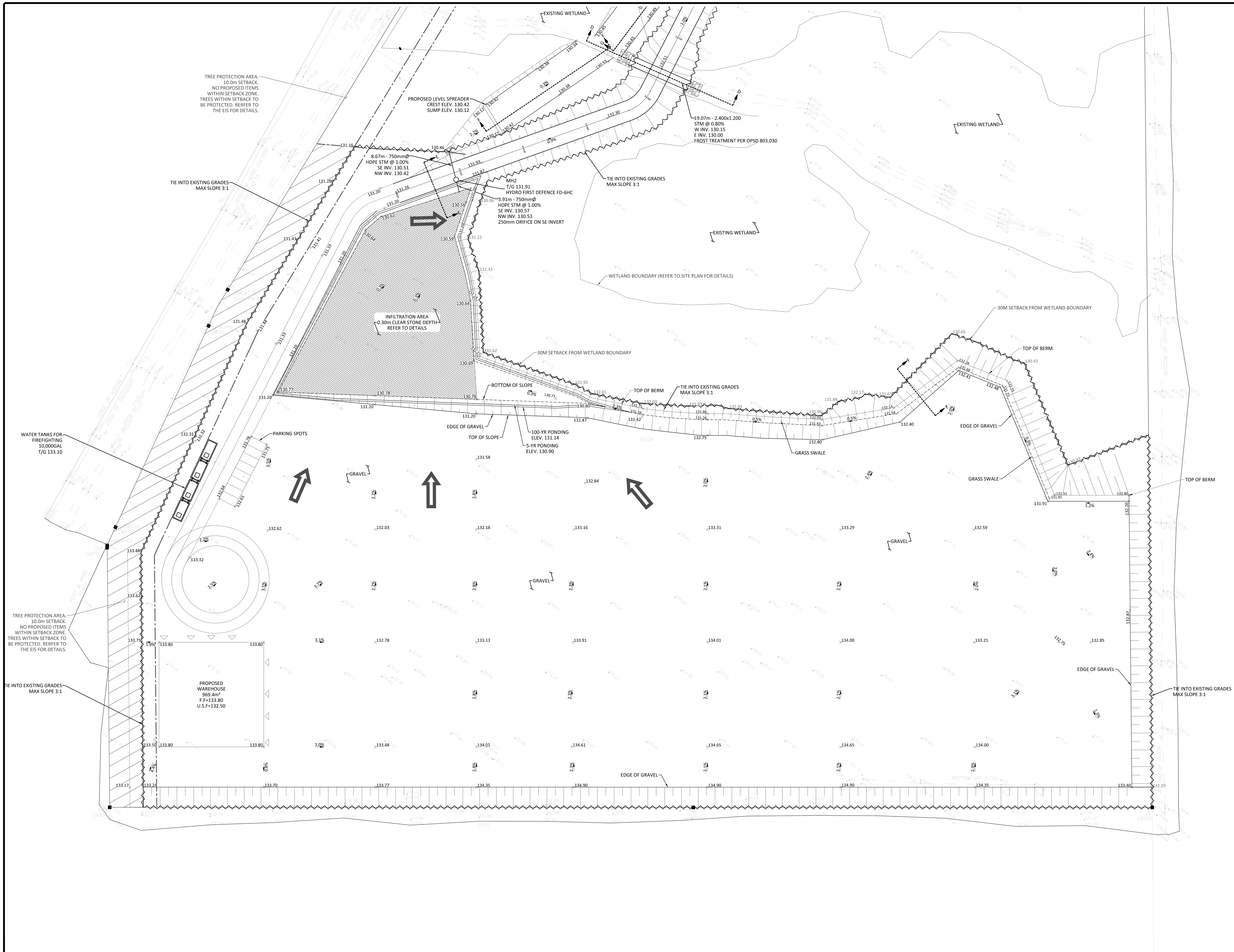
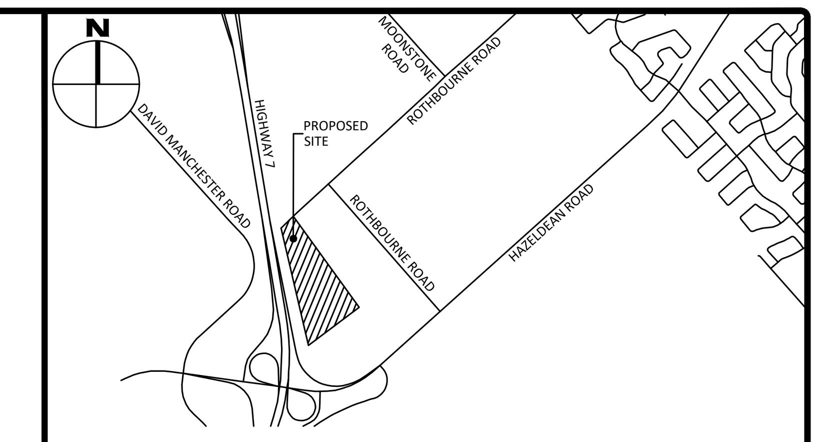
LAST SAVED: Wednesday, December 18, 2019 LAST SAVED BY: c.hampel
LAST PLOTTED: Thursday, December 19, 2019 CTB FILE USED: ---





LOCATION PLAN

LEGEND

- BARRIER CURB / CURB DEPRESSION
- MOUNTABLE CURB
- EASEMENT
- HEAVY DUTY ASPHALT
- CONCRETE SIDEWALK
- PAVING STONE
- MH7 STORM MANHOLE
- CB6 / DI6 CATCHBASIN OR DITCH INLET
- ECB4 LANDSCAPE CATCHBASIN
- MH7A SANITARY MANHOLE
- PERFORATED PIPE IN SWALES
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- CENTRELINE OF SWALE
- SLOPING AT 3:1 (UNLESS SPECIFIED)
- 95.94 / 93.20 PROPOSED ELEVATION / EXISTING ELEVATION
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No.	Revisions	Date
2	REVISED AS PER COMMENTS	DEC. 17, 2019
1	ISSUED FOR SITE PLAN CONTROL	JULY 17, 2019

Check and verify all dimensions before proceeding with the work — Do not scale drawings

SCALE 1 : 500
0 10 20 30 40 50 Metres

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Project:
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6776 ROTHBOURNE RD.
OTTAWA, ON

Drawing Title:
SITE GRADING, DRAINAGE AND SEDIMENT & EROSION CONTROL

Scale:	1:500	Project Number:	CP-17-0381
Drawn By:	C.D.H.		
Checked By:	R.P.K.	Drawing Number:	C102
Designed By:	C.D.H.		

D07-12--XX-XXXX

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LAST SAVED: Thursday, December 19, 2019 LAST SAVED BY: c.hampel
LAST PLOTTED: Thursday, December 19, 2019 CTB FILE USED: ---

HYDROLOGIC IMPACT ASSESSMENT
METRO TOWING – 6776 ROTHBOURNE ROAD

APPENDIX D
WATER BALANCE CALCULATIONS

McINTOSH PERRY

CP-17-0381 - Metro Towing - Water Balance Information - Monthly Review

The site exhibits five primary types of pervious land use / soil combinations:

	Values from Thornthwaite-Mather Table 10				Table 10 Values Applied to Site Conditions		
Pre-development	Soil Type	Available Water (mm)	Root Zone (m)	Applicable Soil Moisture Rentention Table	Available Average Soil Depth (m)	Soil Moisture Retention Table Given Soil Depth (mm)	Values to use (mm)
Pasture overtopping sandy soils (class A soils)	Sand	150	1	150	1.2	180	150
Pasture overtopping sandy soils (class B soils)	Sandy Loam	150	1	150	1.2	180	150
Forest overtopping sandy soils (class A soils)	Sand	150	2	300	1.2	360	350
Forest overtopping sandy soils (class B soils)	Sandy Loam	150	2	300	1.2	360	350
Post-development							
Pasture overtopping sand (class A soils)	Sand	100	1	100	1.2	120	100

Summary of data below:

Soil Moisture Storage	Surplus
75	398
100	391
125	387
150	384
200	380
250	377
350	373
400	371

Soil Moisture Storage Data

75mm															
Month	Temperature	Heat Index	PET	P = Total Precipitation	ΔP = P-PET	Acc Pot WL	ST= Storage	ΔS = Soil Moisture Storage	AET	Soil Moisture Deficit (D)	Soil Moisture Surplus (S)	Water Runoff RO	Snow Melt Runoff	Total Runoff	Total Moisture Detention
January	-10.3	0	0	65	65		217	0	0	0	0	11	0	11	228
February	-8.1	0	0	54	54		271	0	0	0	0	5	0	5	276
March	-2.3	0	0	64	64		336	0	0	0	0	2	0	2	338
April	6.3	1.4	32	75	43		75	0	32	0	43	22	26	48	166
May	13.3	4.4	79	80	2		75	0	79	0	2	12	117	129	206
June	18.5	7.2	112	93	-19	-19	57	-18	111	1	0	6	59	65	122
July	21	8.8	133	92	-41	-60	33	-24	116	17	0	3	29	32	65
August	19.8	8.0	114	86	-29	-88	22	-11	97	18	0	2	15	17	39
September	15	5.3	73	90	17		39	17	73	0	0	1	7	8	47
October	8	2.0	34	86	52		75	36	34	0	17	9	4	13	105
November	1.5	0.2	5	82	77		75	0	5	0	77	43	2	45	197
December	-6.2	0	0	76	76		151	0	0	0	0	22	1	23	174
		37.4	580	944				0	545	35	138	138	260	398	

Monthly T and P from Environment Canada — Table 25 - 75mm soil moisture retention in Thornthwaite [1957]

Heat Index (I) 37.4

a: 1.06

100mm															
Month	Temperature	Heat Index	PET	P = Total Precipitation	ΔP = P-PET	Acc Pot WL	ST= Storage	ΔS = Soil Moisture Storage	AET	Soil Moisture Deficit (D)	Soil Moisture Surplus (S)	Water Runoff RO	Snow Melt Runoff	Total Runoff	Total Moisture Detention
January	-10.3	0	0	65	65		241	0	0	0	0	11	0	11	252
February	-8.1	0	0	54	54		296	0	0	0	0	5	0	5	301
March	-2.3	0	0	64	64		360	0	0	0	0	2	0	2	362
April	6.3	1.4	32	75	43		100	0	32	0	43	22	26	48	191
May	13.3	4.4	79	80	2		100	0	79	0	2	12	117	129	231
June	18.5	7.2	112	93	-19	-19	82	-18	111	1	0	6	59	65	147
July	21	8.8	133	92	-41	-60	54	-28	120	13	0	3	29	32	86
August	19.8	8.0	114	86	-29	-88	40	-14	100	15	0	2	15	17	57
September	15	5.3	73	90	17		57	17	73	0	0	1	7	8	65
October	8	2.0	34	86	52		100	43	34	0	10	5	4	9	119
November	1.5	0.2	5	82	77		100	0	5	0	77	41	2	43	220
December	-6.2	0	0	76	76		176	0	0	0	0	21	1	22	198
		37.4	580	944				0	552	28	131	131	260	391	

Monthly T and P from Environment Canada — Table 26 - 100mm soil moisture retention in Thornthwaite [1957]
Heat Index (I)
a: 37.4

125mm															
Month	Temperature	Heat Index	PET	P = Total Precipitation	ΔP = P-PET	Acc Pot WL	ST= Storage	ΔS = Soil Moisture Storage	AET	Soil Moisture Deficit (D)	Soil Moisture Surplus (S)	Water Runoff RO	Snow Melt Runoff	Total Runoff	Total Moisture Detention
January	-10.3	0	0	65	65		267	0	0	0	0	10	0	10	277
February	-8.1	0	0	54	54		321	0	0	0	0	5	0	5	326
March	-2.3	0	0	64	64		386	0	0	0	0	2	0	2	388
April	6.3	1.4	32	75	43		125	0	32	0	43	23	26	49	217
May	13.3	4.4	79	80	2		125	0	79	0	2	12	117	129	256
June	18.5	7.2	112	93	-19	-19	106	-19	112	0	0	6	59	65	171
July	21	8.8	133	92	-41	-60	76	-30	122	11	0	3	29	32	108
August	19.8	8.0	114	86	-29	-88	61	-15	101	14	0	2	15	17	78
September	15	5.3	73	90	17		78	17	73	0	0	1	7	8	86
October	8	2.0	34	86	52		125	47	34	0	6	3	4	7	138
November	1.5	0.2	5	82	77		125	0	5	0	77	40	2	42	244
December	-6.2	0	0	76	76		201	0	0	0	0	20	1	21	222
		37.4	580	944				0	556	24	127	127	260	387	

Monthly T from Environment Canada — Table 27 - 100mm soil moisture retention in Thornthwaite [1957]
Heat Index (I) 37.4
a: 1.06

150mm															
Month	Temperature	Heat Index	PET	P = Total Precipitation	ΔP = P-PET	Acc Pot WL	ST= Storage	ΔS = Soil Moisture Storage	AET	Soil Moisture Deficit (D)	Soil Moisture Surplus (S)	Water Runoff RO	Snow Melt Runoff	Total Runoff	Total Moisture Detention
January	-10.3	0	0	65	65		292	0	0	0	0	10	0	10	302
February	-8.1	0	0	54	54		346	0	0	0	0	5	0	5	351
March	-2.3	0	0	64	64		411	0	0	0	0	2	0	2	413
April	6.3	1.4	32	75	43		150	0	32	0	43	23	26	49	242
May	13.3	4.4	79	80	2		150	0	79	0	2	12	117	129	281
June	18.5	7.2	112	93	-19	-19	132	-18	111	1	0	6	59	65	197
July	21	8.8	133	92	-41	-60	100	-32	124	9	0	3	29	32	132
August	19.8	8.0	114	86	-29	-88	83	-17	103	12	0	2	15	17	100
September	15	5.3	73	90	17		100	17	73	0	0	1	7	8	108
October	8	2.0	34	86	52		150	50	34	0	3	2	4	6	159
November	1.5	0.2	5	82	77		150	0	5	0	77	39	2	41	268
December	-6.2	0	0	76	76		226	0	0	0	0	19	1	20	246
		37.4	580	944				0	559	21	124	124	260	384	

Monthly T from Environment Canada

Table 28 - 150mm soil moisture retention in Thornthwaite [1957]

Heat Index (I) 37.4

a: 1.06

200mm															
Month	Temperature	Heat Index	PET	P = Total Precipitation	ΔP = P-PET	Acc Pot WL	ST= Storage	ΔS = Soil Moisture Storage	AET	Soil Moisture Deficit (D)	Soil Moisture Surplus (S)	Water Runoff RO	Snow Melt Runoff	Total Runoff	Total Moisture Detention
January	-10.3	0	0	65	65		341	0	0	0	0	10	0	10	351
February	-8.1	0	0	54	54		396	0	0	0	0	5	0	5	401
March	-2.3	0	0	64	64		460	0	0	0	0	2	0	2	462
April	6.3	1.4	32	75	43		200	0	32	0	43	22	26	48	291
May	13.3	4.4	79	80	2		200	0	79	0	2	12	117	129	331
June	18.5	7.2	112	93	-19	-19	182	-18	111	1	0	6	59	65	247
July	21	8.8	133	92	-41	-60	148	-34	126	7	0	3	29	32	180
August	19.8	8.0	114	86	-29	-88	128	-20	106	9	0	2	15	17	145
September	15	5.3	73	90	17		145	17	73	0	0	1	7	8	153
October	8	2.0	34	86	52		198	52	34	0	0	0	4	4	202
November	1.5	0.2	5	82	77		200	2	5	0	75	38	2	40	315
December	-6.2	0	0	76	76		276	0	0	0	0	19	1	20	296
		37.4	580	944				0	564	16	120	120	260	380	

Monthly T from Environment Canada

Table 29 - 200mm soil moisture retention in Thornthwaite [1957]

Heat Index (I) 37.4

a: 1.06

250mm														
Month	Temperature	Heat Index	PET	P = Total Precipitation	ΔP = P-PET	Acc Pot WL	ST= Storage	ΔS = Soil Moisture Storage	AET	Soil Moisture Deficit (D)	Soil Moisture Surplus (S)	Water Runoff RO	Snow Melt Runoff	Total Runoff	Total Moisture Detention
January	-10.3	0	0	65	65		392	0	0	0	0	9	0	9	401
February	-8.1	0	0	54	54		446	0	0	0	0	5	0	5	451
March	-2.3	0	0	64	64		511	0	0	0	0	2	0	2	513
April	6.3	1.4	32	75	43		250	0	32	0	43	23	26	49	342
May	13.3	4.4	79	80	2		250	0	79	0	2	12	117	129	381
June	18.5	7.2	112	93	-19	-19	231	-19	112	0	0	6	59	65	296
July	21	8.8	133	92	-41	-60	196	-35	127	6	0	3	29	32	228
August	19.8	8.0	114	86	-29	-88	175	-21	107	8	0	2	15	17	192
September	15	5.3	73	90	17		192	17	73	0	0	1	7	8	200
October	8	2.0	34	86	52		245	52	34	0	0	0	4	4	249
November	1.5	0.2	5	82	77		250	5	5	0	72	36	2	38	360
December	-6.2	0	0	76	76		326	0	0	0	0	18	1	19	345
		37.4	580	944				0	567	13	117	117	260	377	

Monthly T from Environment Canada — Table 30 - 250mm soil moisture retention in Thornthwaite [1957]
Heat Index (I) 37.4
a: 1.06

350mm														
Month	Temperature	Heat Index	PET	P = Total Precipitation	ΔP = P-PET	Acc Pot WL	ST= Storage	ΔS = Soil Moisture Storage	AET	Soil Moisture Deficit (D)	Soil Moisture Surplus (S)	Water Runoff RO	Snow Melt Runoff	Total Runoff	Total Moisture Detention
January	-10.3	0	0	65	65		492	0	0	0	0	9	0	9	501
February	-8.1	0	0	54	54		546	0	0	0	0	4	0	4	550
March	-2.3	0	0	64	64		611	0	0	0	0	2	0	2	613
April	6.3	1.4	32	75	43		350	0	32	0	43	23	26	49	442
May	13.3	4.4	79	80	2		350	0	79	0	2	12	117	129	481
June	18.5	7.2	112	93	-19	-19	331	-19	112	0	0	6	59	65	396
July	21	8.8	133	92	-41	-60	294	-37	129	4	0	3	29	32	326
August	19.8	8.0	114	86	-29	-88	271	-23	109	6	0	2	15	17	288
September	15	5.3	73	90	17		288	17	73	0	0	1	7	8	296
October	8	2.0	34	86	52		341	52	34	0	0	0	4	4	345
November	1.5	0.2	5	82	77		350	9	5	0	68	34	2	36	454
December	-6.2	0	0	76	76		426	0	0	0	0	17	1	18	444
		37.4	580	944				0	571	9	113	113	260	373	

Monthly T from Environment Canada — Table 32 - 350mm soil moisture retention in Thornthwaite [1957]
Heat Index (I) 37.4
a: 1.06

400mm															
Month	Temperature	Heat Index	PET	P = Total Precipitation	ΔP = P-PET	Acc Pot WL	ST= Storage	ΔS = Soil Moisture Storage	AET	Soil Moisture Deficit (D)	Soil Moisture Surplus (S)	Water Runoff RO	Snow Melt Runoff	Total Runoff	Total Moisture Detention
January	-10.3	0	0	65	65		542	0	0	0	0	8	0	8	550
February	-8.1	0	0	54	54		596	0	0	0	0	4	0	4	600
March	-2.3	0	0	64	64		661	0	0	0	0	2	0	2	663
April	6.3	1.4	32	75	43		400	0	32	0	43	23	26	49	492
May	13.3	4.4	79	80	2		400	0	79	0	2	12	117	129	531
June	18.5	7.2	112	93	-19	-19	381	-19	112	0	0	6	59	65	446
July	21	8.8	133	92	-41	-60	344	-37	129	4	0	3	29	32	376
August	19.8	8.0	114	86	-29	-88	320	-24	110	5	0	2	15	17	337
September	15	5.3	73	90	17		337	17	73	0	0	1	7	8	345
October	8	2.0	34	86	52		390	52	34	0	0	0	4	4	394
November	1.5	0.2	5	82	77		400	10	5	0	66	33	2	35	501
December	-6.2	0	0	76	76		476	0	0	0	0	17	1	18	494
		37.4	580	944				0	572	8	111	111	260	371	

Monthly T from Environment Canada — Table 33 - 450mm soil moisture retention in Thornthwaite [1957]

Heat Index (I) 37.4

a: 1.06

6776 Rothbourne Road – Metro Towing
Sample Water Balance Calculations
Monthly Information received from Environment Canada Climate Normal 1981 – 2010:

- Temperature (T); and
- Precipitation (P).

Data retrieved from Environment Canada, the remainder of the calculations were derived using the methodology of Thornthwaite and Mather (1957)

PET = Potential Evapotranspiration, P = Total Precipitation, ΔP = P-PET, WL = Accumulated Water Loss, ST= Storage, ΔS = Soil Moisture Storage, AET = Actual Evapotranspiration, D = Soil Moisture Deficit, S = Soil Moisture Surplus, RO = Water Runoff, SMRO = Snow Melt Runoff, TR = Total Runoff, DT = Total Moisture Detention

Month	Temp	Heat Index	PET	P	ΔP = P - PET	WL	ST	ΔS	AET	D	S	RO	SMRO	TR	DT
January	-10.3	0	0	65	65		217	0	0	0	0	11	0	11	228
February	-8.1	0	0	54	54		271	0	0	0	0	5	0	5	276
March	-2.3	0	0	64	64		336	0	0	0	0	2	0	2	338
April	6.3	1.4	32	75	43		75	0	32	0	43	22	26	48	166
May	13.3	4.4	79	80	2		75	0	79	0	2	12	117	129	206
June	18.5	7.2	112	93	-19	-19	57	-18	111	1	0	6	59	65	122
July	21	8.8	133	92	-41	-60	33	-24	116	17	0	3	29	32	65
August	19.8	8.0	114	86	-29	-88	22	-11	97	18	0	2	15	17	39
September	15	5.3	73	90	17		39	17	73	0	0	1	7	8	47
October	8	2.0	34	86	52		75	36	34	0	17	9	4	13	105
November	1.5	0.2	5	82	77		75	0	5	0	77	43	2	45	197
December	-6.2	0	0	76	76		151	0	0	0	0	22	1	23	174
Total		37.4	580	944				0	545	35	138	138	260	398	

*Calculations completed in excel, rounding may occur.

Water Budget - Pre - Development
Water Balance / Water Budget Assessment

Existing Developed Site (North of Wetland) – Area A1

	Forest		Pasture				
	Sand (350)	*Sandy Loam (350)*	*Sand (150)*	*Sandy Loam (150)*	Gravel	Asphalt	Total
Area (m^2)	0	0	17019	11677	-	-	28696
Pervious Area (m^2)	0	0	17019	11677	-	-	28696
Impervious Area (m^2)	-	-	-	-	-	-	-
Infiltration Factors							
Topographic Infiltration Factor	0.172	0.172	0.172	0.172	-	-	
Soil Infiltration Factor	0.35	0.3	0.35	0.3	-	-	
Land Cover Infiltration Factor	0.2	0.2	0.1	0.1	-	-	
MOE infiltration Factor	0.722	0.672	0.622	0.572	-	-	
Actual Infiltration Factor	0.722	0.672	0.622	0.572	-	-	
Run-off Coefficient	0.278	0.328	0.378	0.428	-	-	
Runoff from Impervious Surfaces*	0	0	0	0	-	-	
Inputs (per Unit Area)							
Precipitation (mm/year)	944	944	944	944	-	-	944
Run-on (mm/year)	0	0	0	0	-	-	0
Other Inputs (mm/year)	0	0	0	0	-	-	0
Total Inputs (mm/year)	944	944	944	944	-	-	944
Outputs (per Unit Area)							
Precipitation Surplus (mm/year)	373	373	384	384	-	-	384
Net Surplus (mm/year)	373	373	384	384	-	-	384
Evapotranspiration (mm/year)	571	571	560	560	-	-	560
Infiltration (mm/year)	269	251	239	220	-	-	231
Rooftop Infiltration (mm/year)	0	0	0	0	-	-	0
Total Infiltration (mm/year)	269	251	239	220	-	-	231
Runoff Pervious Areas	104	122	145	164	-	-	536
Runoff Impervious Areas	0	0	0	0	-	-	0
Total Runoff (mm/year)	104	122	145	164	-	-	153
Total Outputs (mm/year)	944	944	944	944	-	-	944
Difference (Inputs - Outputs)	0	0	0	0	-	-	0
Inputs (Volume)							
Precipitation (m^3/year)	0	0	16066	11023	-	-	27089
Run-on (m^3/year)	0	0	0	0	-	-	0
Other Inputs m^3/year)	0	0	0	0	-	-	0
Total Inputs (m^3/year)	0	0	16066	11023	-	-	27089
Outputs (Volume)							
Precipitation Surplus (m^3/year)	0	0	6535	4484	-	-	11019
Net Surplus (m^3/year)	0	0	6535	4484	-	-	11019
Evapotranspiration (m^3/year)	0	0	9531	6539	-	-	16070
Infiltration (m^3/year)	0	0	4065	2565	-	-	6630
Rooftop infiltration (m^3/year)	0	0	0	0	-	-	0
Total Infiltration (m^3/year)	0	0	4065	2565	-	-	6630
Runoff Pervious Areas (m^3/year)	0	0	2470	1919	-	-	4389
Runoff Impervious Areas (m^3/year)	0	0	0	0	-	-	0
Total Runoff (m^3/year)	0	0	2470	1919	-	-	4389
Total Outputs (m^3/year)	**0**	**0**	**16066**	**11023**	-	-	**27089**
Difference (Inputs - Outputs)	0	0	0	0	-	-	0

Existing Wetland (Centre of Site) – Areas A2

	Forest		Pasture				
	Sand (350)	*Sandy Loam (350)*	*Sand (150)*	*Sandy Loam (150)*	Gravel	Asphalt	Total
Area (m^2)	10253	0	19209	0	-	-	29462
Pervious Area (m^2)	10253	0	19209	0	-	-	29462
Impervious Area (m^2)	-	-	-	-	-	-	0
Infiltration Factors							
Topographic Infiltration Factor	0.172	0.172	0.172	0.172	-	-	
Soil Infiltration Factor	0.35	0.3	0.35	0.3	-	-	
Land Cover Infiltration Factor	0.2	0.2	0.1	0.1	-	-	
MOE infiltration Factor	0.722	0.672	0.622	0.572	-	-	
Actual Infiltration Factor	0.722	0.672	0.622	0.572	-	-	
Run-off Coefficient	0.278	0.328	0.378	0.428	-	-	
Runoff from Impervious Surfaces*	0	0	0	0	-	-	
Inputs (per Unit Area)							
Precipitation (mm/year)	944	944	944	944	-	-	944
Run-on (mm/year)	0	0	0	0	-	-	0
Other Inputs (mm/year)	0	0	0	0	-	-	0
Total Inputs (mm/year)	944	944	944	944	-	-	944
Outputs (per Unit Area)							
Precipitation Surplus (mm/year)	373	373	384	384	-	-	380
Net Surplus (mm/year)	373	373	384	384	-	-	380
Evapotranspiration (mm/year)	571	571	560	560	-	-	564
Infiltration (mm/year)	269	251	239	220	-	-	249
Rooftop Infiltration (mm/year)	0	0	0	0	-	-	0
Total Infiltration (mm/year)	269	251	239	220	-	-	249
Runoff Pervious Areas	104	122	145	164	-	-	536
Runoff Impervious Areas	0	0	0	0	-	-	0
Total Runoff (mm/year)	104	122	145	164	-	-	131
Total Outputs (mm/year)	944	944	944	944	-	-	944
Difference (Inputs - Outputs)	0	0	0	0	-	-	0
Inputs (Volume)							
Precipitation (m^3/year)	9679	0	18133	0	-	-	27812
Run-on (m^3/year)	0	0	0	0	-	-	0
Other Inputs m^3/year)	0	0	0	0	-	-	0
Total Inputs (m^3/year)	9679	0	18133	0	-	-	27812
Outputs (Volume)							
Precipitation Surplus (m^3/year)	3824	0	7376	0	-	-	11201
Net Surplus (m^3/year)	3824	0	7376	0	-	-	11201
Evapotranspiration (m^3/year)	5854	0	10757	0	-	-	16612
Infiltration (m^3/year)	2761	0	4588	0	-	-	7349
Rooftop infiltration (m^3/year)	0	0	0	0	-	-	0
Total Infiltration (m^3/year)	2761	0	4588	0	-	-	7349
Runoff Pervious Areas (m^3/year)	1063	0	2788	0	-	-	3851
Runoff Impervious Areas (m^3/year)	0	0	0	0	-	-	0
Total Runoff (m^3/year)	1063	0	2788	0	-	-	3851
Total Outputs (m^3/year)	**9679**	**0**	**18133**	**0**	-	-	**27812**
Difference (Inputs - Outputs)	0	0	0	0	-	-	0

Undeveloped Site (South of Wetland) – Area A3

	Forest		Pasture				
	Sand (350)	*Sandy Loam (350)*	*Sand (150)*	*Sandy Loam (150)*	Gravel	Asphalt	Total
Area (m^2)	39638	0	3047	0	-	-	42685
Pervious Area (m^2)	39638	0	3047	0	-	-	42685
Impervious Area (m^2)	-	-	-	-	-	-	-
Infiltration Factors							
Topographic Infiltration Factor	0.172	0.172	0.172	0.172	-	-	
Soil Infiltration Factor	0.35	0.3	0.35	0.3	-	-	
Land Cover Infiltration Factor	0.2	0.2	0.1	0.1	-	-	
MOE infiltration Factor	0.722	0.672	0.622	0.572	-	-	
Actual Infiltration Factor	0.722	0.672	0.622	0.572	-	-	
Run-off Coefficient	0.278	0.328	0.378	0.428	-	-	
Runoff from Impervious Surfaces*	0	0	0	0	-	-	
Inputs (per Unit Area)							
Precipitation (mm/year)	944	944	944	944	-	-	944
Run-on (mm/year)	0	0	0	0	-	-	0
Other Inputs (mm/year)	0	0	0	0	-	-	0
Total Inputs (mm/year)	944	944	944	944	-	-	944
Outputs (per Unit Area)							
Precipitation Surplus (mm/year)	373	373	384	384	-	-	374
Net Surplus (mm/year)	373	373	384	384	-	-	374
Evapotranspiration (mm/year)	571	571	560	560	-	-	570
Infiltration (mm/year)	269	251	239	220	-	-	267
Rooftop Infiltration (mm/year)	0	0	0	0	-	-	0
Total Infiltration (mm/year)	269	251	239	220	-	-	267
Runoff Pervious Areas	104	122	145	164	-	-	536
Runoff Impervious Areas	0	0	0	0	-	-	0
Total Runoff (mm/year)	104	122	145	164	-	-	107
Total Outputs (mm/year)	944	944	944	944	-	-	944
Difference (Inputs - Outputs)	0	0	0	0	-	-	0
Inputs (Volume)							
Precipitation (m^3/year)	37418	0	2876	0	-	-	40295
Run-on (m^3/year)	0	0	0	0	-	-	0
Other Inputs m^3/year)	0	0	0	0	-	-	0
Total Inputs (m^3/year)	37418	0	2876	0	-	-	40295
Outputs (Volume)							
Precipitation Surplus (m^3/year)	14785	0	1170	0	-	-	15955
Net Surplus (m^3/year)	14785	0	1170	0	-	-	15955
Evapotranspiration (m^3/year)	22633	0	1706	0	-	-	24340
Infiltration (m^3/year)	10675	0	728	0	-	-	11403
Rooftop infiltration (m^3/year)	0	0	0	0	-	-	0
Total Infiltration (m^3/year)	10675	0	728	0	-	-	11403
Runoff Pervious Areas (m^3/year)	4110	0	442	0	-	-	4553
Runoff Impervious Areas (m^3/year)	0	0	0	0	-	-	0
Total Runoff (m^3/year)	4110	0	442	0	-	-	4553
Total Outputs (m^3/year)	**37418**	**0**	**2876**	**0**	-	-	**40295**
Difference (Inputs - Outputs)	0	0	0	0	-	-	0

Water Budget - Post - Development
Water Balance / Water Budget Assessment

	Developed Site (North of Wetland) Area B1 and B2							
	Forest		Pasture					
	Sand (350)	*Sandy Loam (350)*	*Sand (150)*	*Sandy Loam (150)*	*Sand (100)*	Gravel	Asphalt	Total
Area (m^2)	0	0	3198	0	0	25204	321	28723
Pervious Area (m^2)	0	0	3198	0	0	-	-	3198
Impervious Area (m^2)	-	-	-	-	-	25204	321	25525
Infiltration Factors								
Topographic Infiltration Factor	0.172	0.172	0.172	0.172	0.12	0.12	0	
Soil Infiltration Factor	0.35	0.3	0.35	0.3	0.35	0.05	0	
Land Cover Infiltration Factor	0.2	0.2	0.1	0.1	0.1	0.05	0	
MOE infiltration Factor	0.722	0.672	0.622	0.572	0.57	0.22	0.1	
Actual Infiltration Factor	0.722	0.672	0.622	0.572	0.57	0.22	0	
Run-off Coefficient	0.278	0.328	0.378	0.428	0.43	0.78	0.9	
Runoff from Impervious Surfaces*	0	0	0	0	0	0.78	0.9	
Inputs (per Unit Area)								
Precipitation (mm/year)	944	944	944	944	944	944	944	944
Run-on (mm/year)	0	0	0	0	0	0	0	0
Other Inputs (mm/year)	0	0	0	0	0	0	0	0
Total Inputs (mm/year)	944	944	944	944	944	944	944	944
Outputs (per Unit Area)								
Precipitation Surplus (mm/year)	373	373	384	384	398	398	850	401
Net Surplus (mm/year)	373	373	384	384	398	398	850	401
Evapotranspiration (mm/year)	571	571	560	560	546	546	94	543
Infiltration (mm/year)	269	251	239	220	227	88	85	104
Rooftop and Trench Infiltration (mm/year)	0	0	0	0	0	0	0	0
Total Infiltration (mm/year)	269	251	239	220	227	88	85	104
Runoff Pervious Areas	104	122	145	164	171	0	0	707
Runoff Impervious Areas	0	0	0	0	0	310	765	1075
Total Runoff (mm/year)	104	122	145	164	171	310	765	297
Total Outputs (mm/year)	944	944	944	944	944	944	944	944
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0
Inputs (Volume)								
Precipitation (m^3/year)	0	0	3019	0	0	23793	303	27115
Run-on (m^3/year)	0	0	0	0	0	0	0	0
Other Inputs m^3/year)	0	0	0	0	0	0	0	0
Total Inputs (m^3/year)	0	0	3019	0	0	23793	303	27115
Outputs (Volume)								
Precipitation Surplus (m^3/year)	0	0	1228	0	0	10031	273	11532
Net Surplus (m^3/year)	0	0	1228	0	0	10031	273	11532
Evapotranspiration (m^3/year)	0	0	1791	0	0	13761	30	15583
Infiltration (m^3/year)	0	0	764	0	0	2207	27	2998
Rooftop and Trench Infiltration (m^3/year)	0	0	0	0	0	0	0	0
Total Infiltration (m^3/year)	0	0	764	0	0	2207	27	2998
Runoff Pervious Areas (m^3/year)	0	0	464	0	0	0	0	464
Runoff Impervious Areas (m^3/year)	0	0	0	0	0	7824	245	8070
Total Runoff (m^3/year)	0	0	464	0	0	7824	245	8534
Total Outputs (m^3/year)	**0**	**0**	**3019**	**0**	**0**	**23793**	**303**	**27115**
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0

	Existing Wetland (Centre of Site) Areas B5							
	Forest		Pasture					
	Sand (350)	*Sandy Loam (350)*	*Sand (150)*	*Sandy Loam (150)*	*Sand (100)*	Gravel	Asphalt	Total
Area (m^2)	8518	0	19210	0	0	1735	0	29463
Pervious Area (m^2)	8518	0	19210	0	0	-	-	27728
Impervious Area (m^2)	-	-	-	-	-	1735	0	1735
Infiltration Factors								
Topographic Infiltration Factor	0.172	0.172	0.172	0.172	0.12	0.12	0	
Soil Infiltration Factor	0.35	0.3	0.35	0.3	0.3	0.05	0	
Land Cover Infiltration Factor	0.2	0.2	0.1	0.1	0.1	0.05	0	
MOE infiltration Factor	0.722	0.672	0.622	0.572	0.52	0.22	0	
Actual Infiltration Factor	0.722	0.672	0.622	0.572	0.52	0.22	0	
Run-off Coefficient	0.278	0.328	0.378	0.428	0.48	0.78	0.9	
Runoff from Impervious Surfaces*	0	0	0	0	0	0.78	0.9	
Inputs (per Unit Area)								
Precipitation (mm/year)	944	944	944	944	944	944	944	944
Run-on (mm/year)	0	0	0	0	0	0	0	0
Other Inputs (mm/year)	0	0	0	0	0	0	0	0
Total Inputs (mm/year)	944	944	944	944	944	944	944	944
Outputs (per Unit Area)								
Precipitation Surplus (mm/year)	373	373	384	384	398	398	850	382
Net Surplus (mm/year)	373	373	384	384	398	398	850	382
Evapotranspiration (mm/year)	571	571	560	560	546	546	94	562
Infiltration (mm/year)	269	251	239	220	207	88	0	239
Rooftop and Trench Infiltration (mm/year)	0	0	0	0	0	0	0	0
Total Infiltration (mm/year)	269	251	239	220	207	88	0	239
Runoff Pervious Areas	104	122	145	164	191	0	0	727
Runoff Impervious Areas	0	0	0	0	0	310	850	1160
Total Runoff (mm/year)	104	122	145	164	191	310	850	143
Total Outputs (mm/year)	944	944	944	944	944	944	944	944
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0
Inputs (Volume)								
Precipitation (m^3/year)	8041	0	18134	0	0	1638	0	27813
Run-on (m^3/year)	0	0	0	0	0	0	0	0
Other Inputs m^3/year)	0	0	0	0	0	0	0	0
Total Inputs (m^3/year)	8041	0	18134	0	0	1638	0	27813
Outputs (Volume)								
Precipitation Surplus (m^3/year)	3177	0	7376	0	0	691	0	11244
Net Surplus (m^3/year)	3177	0	7376	0	0	691	0	11244
Evapotranspiration (m^3/year)	4864	0	10757	0	0	947	0	16568
Infiltration (m^3/year)	2294	0	4588	0	0	152	0	7034
Rooftop and Trench Infiltration (m^3/year)	0	0	0	0	0	0	0	0
Total Infiltration (m^3/year)	2294	0	4588	0	0	152	0	7034
Runoff Pervious Areas (m^3/year)	883	0	2788	0	0	0	0	3672
Runoff Impervious Areas (m^3/year)	0	0	0	0	0	539	0	539
Total Runoff (m^3/year)	883	0	2788	0	0	539	0	4210
Total Outputs (m^3/year)	**8041**	**0**	**18134**	**0**	**0**	**1638**	**0**	**27813**
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0

	Developed Site (South of Wetland) Areas B3 and B4							
	Forest		Pasture					
	Sand (350)	*Sandy Loam (350)*	*Sand (150)*	*Sandy Loam (150)*	*Sand (100)*	Gravel	Asphalt	Total
Area (m^2)	0	0	6518	0	0	35198	970	42686
Pervious Area (m^2)	0	0	6518	0	0	-	-	6518
Impervious Area (m^2)	-	-	-	-	-	35198	970	36168
Infiltration Factors								
Topographic Infiltration Factor	0.172	0.172	0.172	0.172	0.12	0.12	0	
Soil Infiltration Factor	0.35	0.3	0.35	0.3	0.3	0.05	0	
Land Cover Infiltration Factor	0.2	0.2	0.1	0.1	0.1	0.05	0	
MOE infiltration Factor	0.722	0.672	0.622	0.572	0.52	0.22	0	
Actual Infiltration Factor	0.722	0.672	0.622	0.572	0.52	0.22	0	
Run-off Coefficient	0.278	0.328	0.378	0.428	0.48	0.78	0.9	
Runoff from Impervious Surfaces*	0	0	0	0	0	0.78	0.9	
Inputs (per Unit Area)								
Precipitation (mm/year)	944	944	944	944	944	944	944	944
Run-on (mm/year)	0	0	0	0	0	0	0	0
Other Inputs (mm/year)	0	0	0	0	0	0	0	0
Total Inputs (mm/year)	944	944	944	944	944	944	944	944
Outputs (per Unit Area)								
Precipitation Surplus (mm/year)	373	373	384	384	398	398	850	406
Net Surplus (mm/year)	373	373	384	384	398	398	850	406
Evapotranspiration (mm/year)	571	571	560	560	546	546	94	538
Infiltration (mm/year)	269	251	239	220	207	88	0	109
Rooftop and Trench Infiltration (mm/year)	0	0	0	0	0	0	0	0
Total Infiltration (mm/year)	269	251	239	220	207	88	0	109
Runoff Pervious Areas	104	122	145	164	191	0	0	727
Runoff Impervious Areas	0	0	0	0	0	310	850	1160
Total Runoff (mm/year)	104	122	145	164	191	310	850	297
Total Outputs (mm/year)	944	944	944	944	944	944	944	944
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0
Inputs (Volume)								
Precipitation (m^3/year)	0	0	6153	0	0	33227	916	40295
Run-on (m^3/year)	0	0	0	0	0	0	0	0
Other Inputs m^3/year)	0	0	0	0	0	0	0	0
Total Inputs (m^3/year)	0	0	6153	0	0	33227	916	40295
Outputs (Volume)								
Precipitation Surplus (m^3/year)	0	0	2503	0	0	14009	824	17336
Net Surplus (m^3/year)	0	0	2503	0	0	14009	824	17336
Evapotranspiration (m^3/year)	0	0	3650	0	0	19218	92	22960
Infiltration (m^3/year)	0	0	1557	0	0	3082	0	4639
Rooftop and Trench Infiltration (m^3/year)	0	0	0	0	0	0	0	0
Total Infiltration (m^3/year)	0	0	1557	0	0	3082	0	4639
Runoff Pervious Areas (m^3/year)	0	0	946	0	0	0	0	946
Runoff Impervious Areas (m^3/year)	0	0	0	0	0	10927	824	11751
Total Runoff (m^3/year)	0	0	946	0	0	10927	824	12697
Total Outputs (m^3/year)	**0**	**0**	**6153**	**0**	**0**	**33227**	**916**	**40295**
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0

Water Budget - Post - Development - With Mitigation
Water Balance / Water Budget Assessment

Developed Site (North of Wetland) – Area B1 and B2

	Forest		Pasture					
	Sand (350)	*Sandy Loam (350)*	*Sand (150)*	*Sandy Loam (150)*	*Sand (100)*	Gravel	Asphalt	Total
Area (m^2)	0	0	3198	0	0	25204	321	28723
Pervious Area (m^2)	0	0	3198	0	0	-	-	3198
Impervious Area (m^2)	-	-	-	-	-	25204	321	25525
Infiltration Factors								
Topographic Infiltration Factor	0.172	0.172	0.172	0.172	0.12	0.12	0	
Soil Infiltration Factor	0.35	0.3	0.35	0.3	0.35	0.05	0	
Land Cover Infiltration Factor	0.2	0.2	0.1	0.1	0.1	0.05	0	
MOE infiltration Factor	0.722	0.672	0.622	0.572	0.57	0.22	0.1	
Actual Infiltration Factor	0.722	0.672	0.622	0.572	0.57	0.22	0	
Run-off Coefficient	0.278	0.328	0.378	0.428	0.43	0.78	0.9	
Runoff from Impervious Surfaces*	0	0	0	0	0	0.78	0.9	
Inputs (per Unit Area)								
Precipitation (mm/year)	944	944	944	944	944	944	944	944
Run-on (mm/year)	0	0	0	0	0	0	0	0
Other Inputs (mm/year)	0	0	0	0	0	0	0	0
Total Inputs (mm/year)	944	944	944	944	944	944	944	944
Outputs (per Unit Area)								
Precipitation Surplus (mm/year)	373	373	384	384	398	398	850	401
Net Surplus (mm/year)	373	373	384	384	398	398	850	401
Evapotranspiration (mm/year)	571	571	560	560	546	546	94	543
Infiltration (mm/year)	269	251	239	220	227	88	85	104
Rooftop and Trench Infiltration (mm/year)	0	0	0	0	0	145	0	127
Total Infiltration (mm/year)	269	251	239	220	227	233	85	232
Runoff Pervious Areas	104	122	145	164	171	0	0	707
Runoff Impervious Areas	0	0	0	0	0	165	765	930
Total Runoff (mm/year)	104	122	145	164	171	165	765	170
Total Outputs (mm/year)	944	944	944	944	944	944	944	944
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0
Inputs (Volume)								
Precipitation (m^3/year)	0	0	3019	0	0	23793	303	27115
Run-on (m^3/year)	0	0	0	0	0	0	0	0
Other Inputs m^3/year)	0	0	0	0	0	0	0	0
Total Inputs (m^3/year)	0	0	3019	0	0	23793	303	27115
Outputs (Volume)								
Precipitation Surplus (m^3/year)	0	0	1228	0	0	10031	273	11532
Net Surplus (m^3/year)	0	0	1228	0	0	10031	273	11532
Evapotranspiration (m^3/year)	0	0	1791	0	0	13761	30	15583
Infiltration (m^3/year)	0	0	764	0	0	2207	27	2998
Rooftop and Trench Infiltration (m^3/year)	0	0	0	0	0	3655	0	3655
Total Infiltration (m^3/year)	0	0	764	0	0	5861	27	6653
Runoff Pervious Areas (m^3/year)	0	0	464	0	0	0	0	464
Runoff Impervious Areas (m^3/year)	0	0	0	0	0	4170	245	4415
Total Runoff (m^3/year)	0	0	464	0	0	4170	245	4879
Total Outputs (m^3/year)	**0**	**0**	**3019**	**0**	**0**	**23793**	**303**	**27115**
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0

Existing Wetland (Centre of Site) – Areas B5

	Forest		Pasture					
	Sand (350)	*Sandy Loam (350)*	*Sand (150)*	*Sandy Loam (150)*	*Sand (100)*	Gravel	Asphalt	Total
Area (m^2)	8518	0	19210	0	0	1735	0	29463
Pervious Area (m^2)	8518	0	19210	0	0	-	-	27728
Impervious Area (m^2)	-	-	-	-	-	1735	0	1735
Infiltration Factors								
Topographic Infiltration Factor	0.172	0.172	0.172	0.172	0.12	0.12	0	
Soil Infiltration Factor	0.35	0.3	0.35	0.3	0.3	0.05	0	
Land Cover Infiltration Factor	0.2	0.2	0.1	0.1	0.1	0.05	0	
MOE infiltration Factor	0.722	0.672	0.622	0.572	0.52	0.22	0.1	
Actual Infiltration Factor	0.722	0.672	0.622	0.572	0.52	0.22	0	
Run-off Coefficient	0.278	0.328	0.378	0.428	0.48	0.78	0.9	
Runoff from Impervious Surfaces*	0	0	0	0	0	0.78	0.9	
Inputs (per Unit Area)								
Precipitation (mm/year)	944	944	944	944	944	944	944	944
Run-on (mm/year)	0	0	0	0	0	0	0	0
Other Inputs (mm/year)	0	0	0	0	0	0	0	0
Total Inputs (mm/year)	944	944	944	944	944	944	944	944
Outputs (per Unit Area)								
Precipitation Surplus (mm/year)	373	373	384	384	398	398	850	382
Net Surplus (mm/year)	373	373	384	384	398	398	850	382
Evapotranspiration (mm/year)	571	571	560	560	546	546	94	562
Infiltration (mm/year)	269	251	239	220	207	88	85	239
Rooftop and Trench Infiltration (mm/year)	0	0	0	0	0	0	0	0
Total Infiltration (mm/year)	269	251	239	220	207	88	85	239
Runoff Pervious Areas	104	122	145	164	191	0	0	727
Runoff Impervious Areas	0	0	0	0	0	310	765	1075
Total Runoff (mm/year)	104	122	145	164	191	310	765	143
Total Outputs (mm/year)	944	944	944	944	944	944	944	944
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0
Inputs (Volume)								
Precipitation (m^3/year)	8041	0	18134	0	0	1638	0	27813
Run-on (m^3/year)	0	0	0	0	0	0	0	0
Other Inputs m^3/year)	0	0	0	0	0	0	0	0
Total Inputs (m^3/year)	8041	0	18134	0	0	1638	0	27813
Outputs (Volume)								
Precipitation Surplus (m^3/year)	3177	0	7376	0	0	691	0	11244
Net Surplus (m^3/year)	3177	0	7376	0	0	691	0	11244
Evapotranspiration (m^3/year)	4864	0	10757	0	0	947	0	16568
Infiltration (m^3/year)	2294	0	4588	0	0	152	0	7034
Rooftop and Trench Infiltration (m^3/year)	0	0	0	0	0	0	0	0
Total Infiltration (m^3/year)	2294	0	4588	0	0	152	0	7034
Runoff Pervious Areas (m^3/year)	883	0	2788	0	0	0	0	3672
Runoff Impervious Areas (m^3/year)	0	0	0	0	0	539	0	539
Total Runoff (m^3/year)	883	0	2788	0	0	539	0	4210
Total Outputs (m^3/year)	**8041**	**0**	**18134**	**0**	**0**	**1638**	**0**	**27813**
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0

Developed Site (South of Wetland) – Areas B3 and B4

	Forest		Pasture					
	Sand (350)	*Sandy Loam (350)*	*Sand (150)*	*Sandy Loam (150)*	*Sand (100)*	Gravel	Asphalt	Total
Area (m^2)	0	0	6518	0	0	35198	970	42686
Pervious Area (m^2)	0	0	6518	0	0	-	-	6518
Impervious Area (m^2)	-	-	-	-	-	35198	970	36168
Infiltration Factors								
Topographic Infiltration Factor	0.172	0.172	0.172	0.172	0.12	0.12	0	
Soil Infiltration Factor	0.35	0.3	0.35	0.3	0.3	0.05	0	
Land Cover Infiltration Factor	0.2	0.2	0.1	0.1	0.1	0.05	0	
MOE infiltration Factor	0.722	0.672	0.622	0.572	0.52	0.22	0.1	
Actual Infiltration Factor	0.722	0.672	0.622	0.572	0.52	0.22	0	
Run-off Coefficient	0.278	0.328	0.378	0.428	0.48	0.78	0.9	
Runoff from Impervious Surfaces*	0	0	0	0	0	0.78	0.9	
Inputs (per Unit Area)								
Precipitation (mm/year)	944	944	944	944	944	944	944	944
Run-on (mm/year)	0	0	0	0	0	0	0	0
Other Inputs (mm/year)	0	0	0	0	0	0	0	0
Total Inputs (mm/year)	944	944	944	944	944	944	944	944
Outputs (per Unit Area)								
Precipitation Surplus (mm/year)	373	373	384	384	398	398	850	406
Net Surplus (mm/year)	373	373	384	384	398	398	850	406
Evapotranspiration (mm/year)	571	571	560	560	546	546	94	538
Infiltration (mm/year)	269	251	239	220	207	88	85	111
Rooftop and Trench Infiltration (mm/year)	0	0	0	0	0	190	0	157
Total Infiltration (mm/year)	269	251	239	220	207	278	85	267
Runoff Pervious Areas	104	122	145	164	191	0	0	727
Runoff Impervious Areas	0	0	0	0	0	120	765	885
Total Runoff (mm/year)	104	122	145	164	191	120	765	139
Total Outputs (mm/year)	944	944	944	944	944	944	944	944
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0
Inputs (Volume)								
Precipitation (m^3/year)	0	0	6153	0	0	33227	916	40295
Run-on (m^3/year)	0	0	0	0	0	0	0	0
Other Inputs m^3/year)	0	0	0	0	0	0	0	0
Total Inputs (m^3/year)	0	0	6153	0	0	33227	916	40295
Outputs (Volume)								
Precipitation Surplus (m^3/year)	0	0	2503	0	0	14009	824	17336
Net Surplus (m^3/year)	0	0	2503	0	0	14009	824	17336
Evapotranspiration (m^3/year)	0	0	3650	0	0	19218	92	22960
Infiltration (m^3/year)	0	0	1557	0	0	3082	82	4721
Rooftop and Trench Infiltration (m^3/year)	0	0	0	0	0	6688	0	6688
Total Infiltration (m^3/year)	0	0	1557	0	0	9770	82	11409
Runoff Pervious Areas (m^3/year)	0	0	946	0	0	0	0	946
Runoff Impervious Areas (m^3/year)	0	0	0	0	0	4239	742	4981
Total Runoff (m^3/year)	0	0	946	0	0	4239	742	5927
Total Outputs (m^3/year)	**0**	**0**	**6153**	**0**	**0**	**33227**	**916**	**40295**
Difference (Inputs - Outputs)	0	0	0	0	0	0	0	0

Water Budget Summary
Water Balance / Water Budget Assessment

Developed Site (North of Wetland) Area A1 = Area B1 and B2					
Characteristic	Pre-Development	Post-Development	Change (Pre- to Post)	Post-Development with Mitigation	Change (Pre- to Post-with Mitigation
Inputs (Volumes)					
Precipitation (m^3/year)	27089	27115	0%	27115	0%
Run-on (m^3/year)	0	0	0%	0	0%
Other Inputs m^3/year)	0	0	0%	0	0%
Total Inputs (m^3/year)	27089	27115	0%	27115	0%
Outputs (Volumes)					
Precipitation Surplus (m^3/year)	11019	11532	5%	11532	5%
Net Surplus (m^3/year)	11019	11532	5%	11532	5%
Evapotranspiration (m^3/year)	16070	15583	-3%	15583	-3%
Infiltration (m^3/year)	6630	2998	-55%	2998	-55%
Rooftop infiltration (m^3/year)	0	0	0%	3655	0%
Total Infiltration (m^3/year)	6630	2998	-55%	6653	0%
Runoff Pervious Areas (m^3/year)	4389	464	-89%	464	-89%
Runoff Impervious Areas (m^3/year)	0	8070	0%	4415	0%
Total Runoff (m^3/year)	4389	8534	94%	4879	11%
Total Outputs (m^3/year)	27089	27115	0%	27115	0%

Wetland (Centre of Site) Areas A2 = Areas B5					
Characteristic	Pre-Development	Post-Development	Change (Pre- to Post)	Post-Development with Mitigation	Change (Pre- to Post-with Mitigation
Inputs (Volumes)					
Precipitation (m^3/year)	27812	27813	0%	27813	0%
Run-on (m^3/year)	0	0	0%	0	0%
Other Inputs m^3/year)	0	0	0%	0	0%
Total Inputs (m^3/year)	27812	27813	0%	27813	0%
Outputs (Volumes)					
Precipitation Surplus (m^3/year)	11201	11244	0%	11244	0%
Net Surplus (m^3/year)	11201	11244	0%	11244	0%
Evapotranspiration (m^3/year)	16612	16568	0%	16568	0%
Infiltration (m^3/year)	7349	7034	-4%	7034	-4%
Rooftop infiltration (m^3/year)	0	0	0%	0	0%
Total Infiltration (m^3/year)	7349	7034	-4%	7034	-4%
Runoff Pervious Areas (m^3/year)	3851	3672	-5%	3672	-5%
Runoff Impervious Areas (m^3/year)	0	539	0%	539	0%
Total Runoff (m^3/year)	3851	4210	9%	4210	9%
Total Outputs (m^3/year)	27812	27813	0%	27813	0%

Developed Site (South of Wetland) Area A3 = Areas B3 and B4					
Characteristic	Pre-Development	Post-Development	Change (Pre- to Post)	Post-Development with Mitigation	Change (Pre- to Post-with Mitigation
Inputs (Volumes)					
Precipitation (m^3/year)	40295	40295	0%	40295	0%
Run-on (m^3/year)	0	0	0%	0	0%
Other Inputs m^3/year)	0	0	0%	0	0%
Total Inputs (m^3/year)	40295	40295	0%	40295	0%
Outputs (Volumes)					
Precipitation Surplus (m^3/year)	15955	17336	9%	17336	9%
Net Surplus (m^3/year)	15955	17336	9%	17336	9%
Evapotranspiration (m^3/year)	24340	22960	-6%	22960	-6%
Infiltration (m^3/year)	11403	4639	-59%	4721	-59%
Rooftop infiltration (m^3/year)	0	0	0%	6688	0%
Total Infiltration (m^3/year)	11403	4639	-59%	11409	0%
Runoff Pervious Areas (m^3/year)	4553	946	-79%	946	-79%
Runoff Impervious Areas (m^3/year)	0	11751	0%	4981	0%
Total Runoff (m^3/year)	4553	12697	179%	5927	30%
Total Outputs (m^3/year)	40295	40295	0%	40295	0%

Mitigation Requirements
Water Balance / Water Budget Assessment

Data Input	
944	mm of precipitation per year avg.
118.4	days with precipitation per year avg.
10	mm design rainfall event
25.2	Events per year with 10 mm design rainfall event (Environment Canada)

	Developed Site (North of Wetland) Area A1 = Area B1 and B2	**Wetland (Centre of Site) Areas A2 = Areas B5**	**Developed Site (South of Wetland) Area A3 = Areas B3 and B4**
Area of Granular (m^2)	25204	0	35198
Granular Runoff Coefficient	0.78	0.78	0.78
Volume of Runoff in 10mm Event (m^3) to be infiltrated	197	0	275
Mitigation Required (m^3/year)	3655	0	6688
Annual Volume to be infiltrated by designing for 10mm Event	4954	0	6919

*Environment Canada notes 25.2 days per year of rainfall above 10mm. Therefore, if the 10mm event is the design criteria for infiltration measures, then it is conservative to assume a minimum of 10mm x 25.2 x the runoff coefficient of the upstream land use will be able to be infiltrated.

Sample Calculations:

Calculated Potential Evapotranspiration (PET)

Thornthwaite Equation:

$$PET = 16\left(\frac{L}{12}\right)\left(\frac{N}{30}\right)\left(\frac{10Ta}{I}\right)^{\propto}$$

L = Average Daylight (hours)

N = Number of Days per Month

Ta = Average Temperature (°C)

I = Heat Index =

$$I = \sum_{i=1}^{12}\left(\frac{Tai}{5}\right)^{1.514}$$

α = $(6.75x\ 10^{-7})\ I^3 - (7.71 \times 10^{-5})\ I^2 + (1.792 \times 10^{-2})\ I + 0.492$

Example April

Temperature (Ta) = 6.3°C

I = (Tai/5)^1.514 = (6.3/5)^1.514 = 1.4

Sum of all months I = 37.4

α = $(6.75x\ 10^{-7})\ 37.4^3 - (7.71 \times 10^{-5})\ 37.4^2 + (1.792 \times 10^{-2})\ 37.4 + 0.49239 = 1.06$

L = 13.6 hours, N = 30 days

PET = 16 x (13.6/12) x (30/30) x ((10x6.3)/37.4)^1.06 = 32mm

Change between Precipitation and Potential Evapotranspiration (ΔP = P-PET)

Example April

P = 75mm

PET = 32mm

ΔP = P – APET = 75mm – 32mm = 43mm

Accumulated Water Loss

All Values where the ΔP are negative are brought forward and accumulated on a monthly basis

Example July

ΔP June = -19mm

ΔP July = -41mm

WL July = -19mm + -41mm = -60mm

Soil Moisture Storage

Starting Values Taken from Table 10 of Thornthwaite Mather's Water Balance 1957 for individual soil type.

For sample calculations below, assumed soil moisture storage maximum of 75mm. Start in first month with positive temperature (April), carry (75mm) to next month where ΔP is positive. When ΔP becomes negative, accumulated water loss (WL) is reviewed and the reduced soil moisture storage is inserted into the spreadsheet based on the Tables within the Thornthwaite Mather's Water Balance 1957. For the example, Table 25 is used for 75mm soil water retention. The values are then inserted into the ST table based on the corresponding WL for the given month.

WL July = -60mm
Table 25 is used and a ST of 33mm is obtained

Upon positive ΔP values, the ΔP and ST_{i-1} are added together for that months ST value until the maximum soil moisture storage is achieved.
ST September = ΔP September + ST_{i-1} (August) = 17mm + 22mm = 39mm

Upon achieving the maximum soil moisture storage, no additional storage is available until the temperature falls below -1°C, when snow is said to be able to be stored above the ground. At that time the P is added to the previous months ST (ST_{i-1}) until the temporary is above -1°C and snow melt occurs.

Change in Soil Moisture Storage

Change in Soil Moisture Storage = Soil Moisture Storage – Soil Moisture Storage of the previous month ($\Delta S = ST - ST_{i-1}$)

Example June

Storage (ST - May) = 75mm
ST June (Table 25, Thornthwaite Mather, 1957) = 57mm
ΔS= 57mm – 75mm = -18mm

Actual Evapotranspiration (AET)

Three Situations Exist:

1) No PET therefore, AET = 0 if, PET = 0;
2) WL > 0. AET = PET if, Soil Moisture Storage Capacity is positive; and
3) WL < 0. AET = Soil Moisture Storage Capacity + Total Precipitation ($AET = \Delta S + P_T$).

1) Example January

AET = 0 as PET = 0

2) Example April

WL = 0mm

ST = 75mm

PET = 32mm = AET

3) Example July

WL = -41 mm

ΔS = -18mm (June)

P (June) = 93mm

AET (June) = 18mm + 93mm = 111mm *Note disregard ΔS sign.

Monthly Soil Moisture Deficit or Surplus

Three Situations Exist:

1) Where Accumulated Potential Water Loss is lower than 0mm, a deficit exists;
2) Where Soil Moisture Capacity is above its maximum, a surplus exist; and
3) Where Soil Moisture Capacity is less than the maximum but there is no Accumulated Potential Water Loss, the runoff is being absorbed by the soil (soil is either wetting or drying).

1) Example Deficit (July):

WL = -41mm

ST (July) = 33mm

ΔS (July) = -24mm

PET = 133mm

AET = 116mm

Soil Moisture Deficit (July) = PET – AET = 133mm – 116mm = 17mm

2) Example Wetting (September)

WL = 0mm

ST (August) = 22mm

ΔP = 17mm

ST (September) = ΔP + ST (August) = 17mm + 22mm = 39mm, less than 75mm therefore wetting, no surplus, S = 0

3) Example Surplus (October):

WL = 0mm
S (September) = 39mm
ΔP = 52mm
Soil Moisture Surplus (October) = ΔP + S(September) = 39mm + 52mm = 91mm, as it is over 75mm, 75 is carried and the additional volume is a surplus of 91mm – 75mm = 16mm

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Water Runoff

Thornthwaite Mather (1957) noted that the surplus water runoff values in no month can cause a runoff higher than 50% of the its total surplus volume, therefore, 50% is attributed to the month with the initial surplus, then carried forward at a 50% per month value until it is dissipated (i.e.: reaches 0mm).

For this example (rounded to the nearest mm), start at October;
S_{Oct} = 17mm,
RO_{Oct} = 17mm/2 = 9mm,
November
S_{Nov} = 77mm,
RO_{Nov} = (Remaining RO_{Oct} + S_{Nov})/2 = (9mm + 77mm)/2 = 43mm,
December
RO = (Remaining RO_{Nov} + S)/2 = (43mm + 0mm)/2 = 22mm.
This continues until 0mm is reached.

Snow Melt Runoff (SMRO)

Thornthwaite Mather (1957) noted that in areas with an elevation under 500m above sea level, that in the first month with temperatures above -1°C, only 10% of snow melt runoff occurs. A maximum of 50% melt will occur in each successive month until it is dissipated (i.e.: reaches 0mm).

For this example (rounded to the nearest mm), start at April (first positive average temperature, total snow fall is 260mm, note: 260mm = precipitation accumulated in months with negative temperatures (December through to March);
April
SMRO = 10% = 26mm, remaining 90% (234mm) brought forward to May;
May, 234mm x 50% = 117mm, carry remaining 117mm to June;
June, 117mm x 50% = 59mm.
This continues until 0mm is reached and all snow melt has been accounted for.

Total Runoff

Total runoff is the sum of the water runoff and snow runoff for each month.

TR (April) = RO_{April} + $SMRO_{April}$ = 22mm + 26mm = 48mm

Sensitivity Analysis for Soil Moisture Maximum Capacity

McIntosh Perry completed a sensitivity analysis on the soil moisture capacity and found that for soil depths above 100mm, the annual surplus volume in millimetres diminished at a rate of less than 1%/year per 25mm of available soil. Therefore, as the depths of soils have been averaged across the site and a conservative approach has been pushed forward, it is not expected that in concentrated areas where the soil is less than the indicated depth that the soils will function materially different.

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