Buffalo Bay Development
Functional Stormwater Management Report

May 2016

Engage Engineering Ltd.

File No. 15006

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1.0 Introduction

1.1 Purpose

Engage Engineering Limited (Engage) has been retained by EcoVue Consulting Services Inc. (EcoVue) to prepare a Stormwater Management Functional Servicing Report (SWM FSR) in support of the proposed Draft Plan of Subdivision for Part of Lot 17, Concession 14 in the Geographic Township of Harvey. The purpose of this report is to functionally identify the level of impact that a recreation-based, residential Plan of Subdivision together with a common elements condominium incorporating the internal roads and open space areas (i.e. 30 metre setback from the Bay, 15 metre setbacks from water courses and the docking areas) will have from a stormwater management (SWM) perspective. This report will provide guidance on the most appropriate methods to provide quality and quantity control of the runoff from the site, so that the development does not impact downstream receivers.

1.2 Site Description

The subject property is fronting Buffalo Bay located on the north east side of Pigeon Lake. The property is legally described as Part of Lot 17, Concession 14 in the Geographic Township of Harvey, Municipality of Trent Lakes, in the County of Peterborough. The site is bordered to the east by Nichols Cove Road, to the north by a low lying wetland area, to the west by Fire Route 96B and the South by Pigeon Lake. The location of the site that is the subject of this report is identified on the Site Plan, prepared by EcoVue, dated January 28 2016, and is included as **Figure 1**.

2.0 Methodology

2.1 Drainage Areas and Site Characteristics

The existing site is primarily tree covered with some low lying wetland areas. A topographic survey was provided by Coe Fisher Cameron, Ontario Land Surveyors, dated August 7, 2014. The survey was utilized to determine existing elevations, locations of existing features on the site, and to establish functional grading design for the proposed rural development.

The existing topography and drainage patterns of the property were assessed based on the contour information generated from the topographic survey provided by Coe, Fisher, Cameron. There are four (4) existing drainage catchment areas on the property that are identified on the Drainage Area Plan, attached as **Figure 2**. The respective catchment areas can be identified based on the following properties:

Existing catchment area **EXWS1** consists of 1.81 ha of land on the north west portion of the subject property. The catchment is comprised predominately of wooded areas, but also includes low lying wetland areas. All surface runoff from this catchment drains to the north west and into the existing wetland area.

Existing catchment area **EXWS2** consists of 2.87 ha of land on the west portion of the proposed development. The catchment is comprised predominately of wooded areas, but also low lying wetland areas. All surface runoff from this catchment drains towards the northwest corner of the property, and ultimately flows to the same large wetland to the north.

Existing catchment area **EXWS3** consists of a 11.03 ha of land that includes the majority of the proposed development. This drainage area is mostly forested and sheet flows to Pigeon Lake. Some small intermittent creeks also run through this drainage area and ultimately outlet into Pigeon Lake.

Existing catchment area **EXWS4** is a small self-contained drainage area that consists of 0.27ha of forested area. Under the proposed condition this area will drain to Pigeon Lake.

Under the proposed condition, the topography of the site will change from that of the existing conditions to a proposed rural condominium. There are three (3) proposed drainage catchment areas that are identified on the Post-Development Drainage Area Plan, attached as **Figure 3**. Preliminary grading for the rural condominium was established based on Street 'A' following the existing ground as closely as possible while maintaining existing drainage patterns. Due to site conditions and the amount of bedrock encountered, the road profile is entirely in fill. The proposed road profile is attached as **Figure 5**.

The respective catchment areas can be identified based on the following properties:

Proposed catchment area **PRWS1** consists of 2.02 ha of land that is part of the north west portion the proposed Street 'A' road right-of-way. The catchment is comprised of grassed road-side ditch areas, gravel road shoulder, road and driveway gravel areas as well as portions of impervious building envelopes. For the purposes of area calculations, Street 'A' was assumed to be a 6.0m wide gravel surface with 0.5m wide gravel shoulders on either side of the road and driveway dimensions of 6m x 15m. A building footprint of 279m^2 (3,000ft^2) was assumed along with a cleared grassed area of 700m^2 per lot surrounding the proposed building and septic area. All surface runoff from this catchment drains in an east or west direction via road-side ditches, then north to the outlet at the existing wetland in the north west portion of the site.

Proposed catchment area **PRWS2** consists of 2.81 ha of land that encompasses the west portion of the 'Street A' road right-of-way. The catchment is comprised of grassed road-side ditch areas, as well as road and driveway gravel areas and building impervious areas. For the purposes of area calculations, the same road, driveway, building and cleared areas as mentioned in **PRWS1** above were assumed. All surface runoff from this catchment drains in a north or south direction via road-side ditches, then west ultimately to the existing wetland in the north west portion of the site.

Proposed catchment area **PRWS3** consists of 11.15 ha of land encompassing the majority of the property. The catchment is comprised of predominately wooded areas, gravel road shoulders, road and driveway areas and impervious areas from buildings from the majority of the lots. All

surface runoff from this catchment is proposed to drain to Pigeon Lake, either overland south of 'Street A' or through roadside ditches north east of Street 'A'.

The hydrologic parameters for each catchment area under existing and proposed conditions were developed based on the areas, topography, and land-use summarized in **Appendix A**. The hydrologic parameters for all drainage areas are summarized in **Table 1** below.

Table 1 - Existing & Proposed Development Hydrologic Parameters

Hydrologic Parameters	EXWS1	EXWS2	EXWS3	EXWS4	PRWS1	PRWS2	PRWS3
Area	1.81	5.07	11.03	0.27	2.02	2.81	11.15
% Impervious	0.0	0.0	0.0	0.0	3.5	1.4	3.0
Runoff Coefficient	0.11	0.11	0.11	0.11	0.23	0.16	0.19
Tc (min)	23	30	28	9	31	38	26

2.2 Peak Runoff Calculations

The peak runoff for the existing and proposed conditions was calculated for various return periods using the Rational Method. The results are summarized in **Table 2** below. Spreadsheets documenting the calculations are included in **Appendix A**. Rainfall data for the site was taken from the Peterborough rainfall gauging station at the Peterborough Airport.

Table 2 - Pre and Post Development Peak Flows

Design Storm (years)	Peak Flows (m^3/sec)						
	EXWS1	EXWS2	EXWS3	EXWS4	PRWS1	PRWS2	PRWS3
2	0.025	0.033	0.134	0.006	0.048	0.041	0.246
5	0.034	0.045	0.181	0.008	0.065	0.055	0.333
10	0.040	0.054	0.216	0.009	0.077	0.066	0.398
25	0.051	0.070	0.279	0.012	0.100	0.086	0.512
50	0.063	0.085	0.341	0.014	0.122	0.105	0.626
100	0.071	0.097	0.389	0.016	0.139	0.120	0.713

As anticipated, the increase in impervious area under post-development conditions results in an increase in the peak flows. Peak flows outletting to the north west wetland from PRWS1 and PRWS2 will increase as well as PRWS3 to Pigeon Lake.

2.3 Ditch Capacity and Sizing

Using the calculated peak flows, the existing Street 'A' roadside ditch capacity was evaluated to determine its hydraulic performance up to the 100-year event. The flow from drainage area PRWS1 and PRWS2 and the portion of flow that will reach PRWS3 were used to verify the existing roadside ditch sizing. The calculations are included in **Appendix C** and are summarized in **Table 3** below:

Table 3 - Ditch Capacity

Condition	Characteristics	Cross Sectional Area (m^2)	Maximum Flow Rate (m^3)	Percent Capacity at 100-Year Flow
Proposed Lot 1-3 Swale	Triangular; 3:1 side slope 0.8% long (average) slope; 0.3m deep	0.27	0.22	55%
Proposed Lot 4-8 Swale	Triangular; 3:1 side slope 0.8% long (average) slope; 0.3m deep	0.27	0.35	40%
Proposed Lot 9-16 Swale	Triangular; 3:1 side slope 3.0% long (average). slope; 0.3m deep	0.27	0.42	48%

All drainage swales have sufficient capacity to accommodate the runoff from the 100-year storm event without overtopping.

The proposed drainage swale and cross section detail is identified on the Conceptual SWM Plan as **Figure 4**.

2.4 Stormwater Management Options

Some form of on-site stormwater management facility is recommended for the proposed rural condominium to provide quality and quantity control due to the increase in peak flow runoff to the northwest wetland and Pigeon Lake. Quantity control is required to limit peak flows to pre-development levels thereby protecting downstream properties from flooding. Quality controls are required where the change in land use has the potential to increase sediment and contaminants in the runoff. For this site, a "normal" level of quality control as defined in the MOE SWM Planning and Design Manual is appropriate given that the outlet from the proposed rural recreational subdivision is to the northwest wetland and Pigeon Lake.

Within the MOE SWM Planning and Design Manual, stormwater management measures are to be assessed in the descending order of stormwater lot level controls, stormwater conveyance controls, then end-of-pipe stormwater management facilities, per the following examples:

- **Stormwater lot level controls:** represent measures which are implemented at the individual lot level, such as soakaway pits, or flatter lot grading.

- **Stormwater conveyance controls**: represent conveyance systems used to transport stormwater runoff from the lots to the receiving waters, be that by pervious pipes or grassed swales.
- **End-of-pipe stormwater management facilities:** represent stormwater management measures used to service numerous lots or whole subdivisions, be that by either wet ponds, wetlands, or infiltration basins.

Table 3 below provides a comparison of the types of stormwater management options that are available for the proposed site. Storage volumes identified in the Table were calculated using the Modified Rational Method for pre-to post development flows, as included in **Appendix B**.

Table 4 - Stormwater Management Options

SWM Plan	Design Considerations	Comments
Wet Pond	• Requires storage volume of 215 m^3 (total for PRWS1 + PRWS2) for quantity control.	• Provides both quality and quantity control. • Not feasible to locate pond adjacent to Wetland outlet, due to site grading and presence of bed rock.
Reduced Lot Grading	• Proposed grading to be generally less than 5%. • Soil conditions permit minimum infiltration rate of 50mm/hr.	• Site topography allows for minimum lot grading beyond road cut limits.
Individual Detention/ Infiltration Basins	• Requires total storage volume of 215 m^3 for quantity control. • Soil conditions permit minimum infiltration rate of 50mm/hr.	• Proposed lake draining building lots can facilitate detention basin prior to discharge into lake. • May not be feasible due to high presence of bedrock. • Proposed lot grading to be generally less than 5% and contributing area less than 2 ha.
Enhanced Grassed Swales	• Proposed road grading to be less than 5%. • Contributing area less than 2 ha. • Soil conditions permit minimum infiltration rate of 50mm/hr.	• Flat road grade of 0.5-5.0% and right-of-way ditch can be utilized to promote infiltration • Rock check dams located at 30-50m spacing provides for sediment removal by increasing ponding and infiltration.

Based on the above **Table 3** summary, a wet pond facility cannot be functionally located on the property, due to the site topography and road grading. In lieu of a wet pond, a treatment train approach is likely the most feasible stormwater management plan for the proposed rural condominium.

The recommended approach for the proposed drainage catchment areas includes the following:

- **PRWS1** to have quality controls that include enhanced grass swales, minimum grades, and rock check dams. Quantity control via outlet to northwest wetland.

- **PRWS2** to have quality controls that include enhanced grass swales, minimum grades, and rock check dams. Quantity control via outlet to northwest wetland.

- **PRWS3** to have quality controls that include enhanced grassed swales, rock check dams and vegetated buffer along Pigeon Lake. Quantity control not required due to Pigeon Lake being the downstream receiver.

Based on this recommended approach, it is important to note that in lieu of a wet pond facility, no formalized quantity control will be provided for the proposed road outletting into the northwest wetland from drainage areas PRWS1 and PRWS2. It is our understanding that this wetland has not been identified as provincially significant in the Environmental Impact Study provided by the environmental consultant. Based on the size of the wetland (4.0 ha) and the required storage volume based on the increased peak flows (215m^3 total) we can calculate the theoretical increase in the wetland water level at 5.4mm which is very minimal. This wetland ultimately outlets to Pigeon Lake further to the west, thus demonstrating that quantity control is not needed. Volume calculations can be found in **Appendix B.**

Based on the proximity to Pigeon Lake, it is our opinion that no stormwater management quantity controls will be required for the lots in drainage area PRWS3. Quantity controls are typically implemented where an increase in runoff from development is likely to negatively impact downstream receivers. Given that there are no properties downstream of these lots and that the lots outlet directly to Pigeon Lake, there is no risk of flooding and thus no quaintly control is required. Pigeon Lake is sufficiently large that the negligible increase in runoff from development of these lots will have no impact on water levels or water temperature in the lake. It is worth mentioning that given the size of the proposed lots, the increase in peak runoff as a result of home/cottage construction will be minor.

The primary change in land use will be the addition of buildings and for the purposes of stormwater management, runoff from rooftops is considered clean water, free of sediment and contaminants. Further to this, a 30m min. setback along Pigeon Lake fronting these lots will function as a large vegetated buffer and will provide opportunity for infiltration of runoff, as well as acting to reduce the temperature of rooftop runoff, which can be a concern. Based on the results of the geotechnical report, the native sandy site soils have excellent infiltration capacity, with an average rate of 50mm/hour (unfactored). This natural vegetated buffer combined with best practices such as reduced lot grading will provide sufficient quality control for the proposed development, to protect the quality of the water in Pigeon Lake.

3.0 Conclusion

Development of the proposed rural recreation-based residential subdivision, together with common elements condominium will result in an increase in peak runoff and contaminant/sediment loading from the site. Quantity controls are not required due to Pigeon Lake being the downstream receiver, however some form of stormwater management quality controls are recommended to provide protection for downstream receivers. Various methods of quality controls are available however based on the nature of the proposed rural development, a

stormwater management plan that employs a treatment train approach is recommended. Quality controls can functionally be provided through the implementation of lot level controls that include reduced lot grades in combination with conveyance controls on Street 'A' that include enhanced grassed swales at minimum grades with rock check dams. Culvert analysis and sizing for driveways and road crossings will be completed at the detailed design stage.

This report provides guidance at a functional level and is not based on detailed design. When the plan of condominium proceeds to the detailed engineering design phase, a detailed Stormwater Management Report should be prepared to address the specific requirements of the proposed development.

Submitted by:

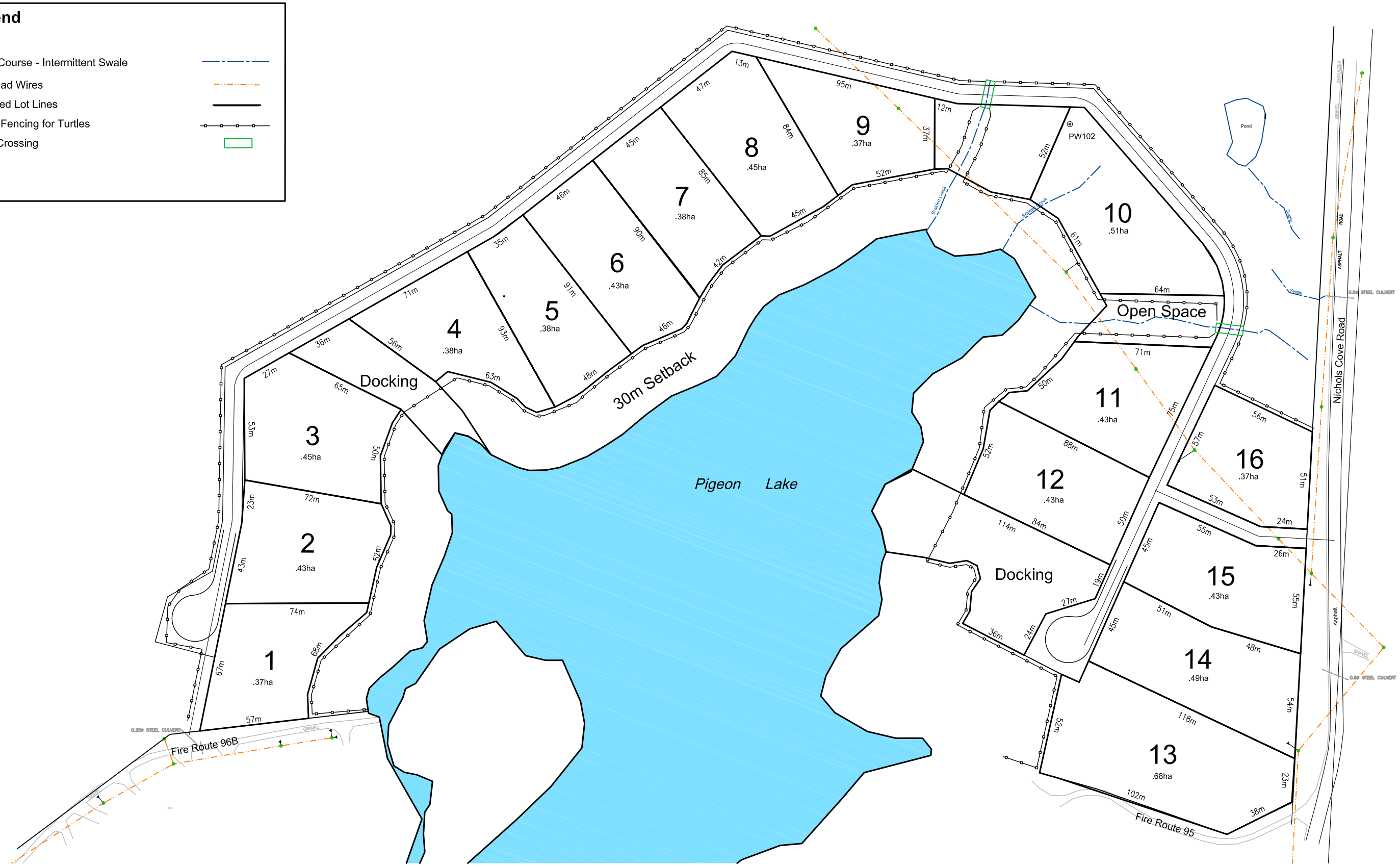
Brad Parsons,
Engineer In Training

Aaron Hill, P. Eng.
Principal

List of Figures

Legend

- Water Course - Intermittent Swale
- Overhead Wires
- Proposed Lot Lines
- Barrier Fencing for Turtles
- Turtle Crossing



ECOVUE consulting services inc.

www.ecovueconsulting.com

PROJECT NO: 14-1396

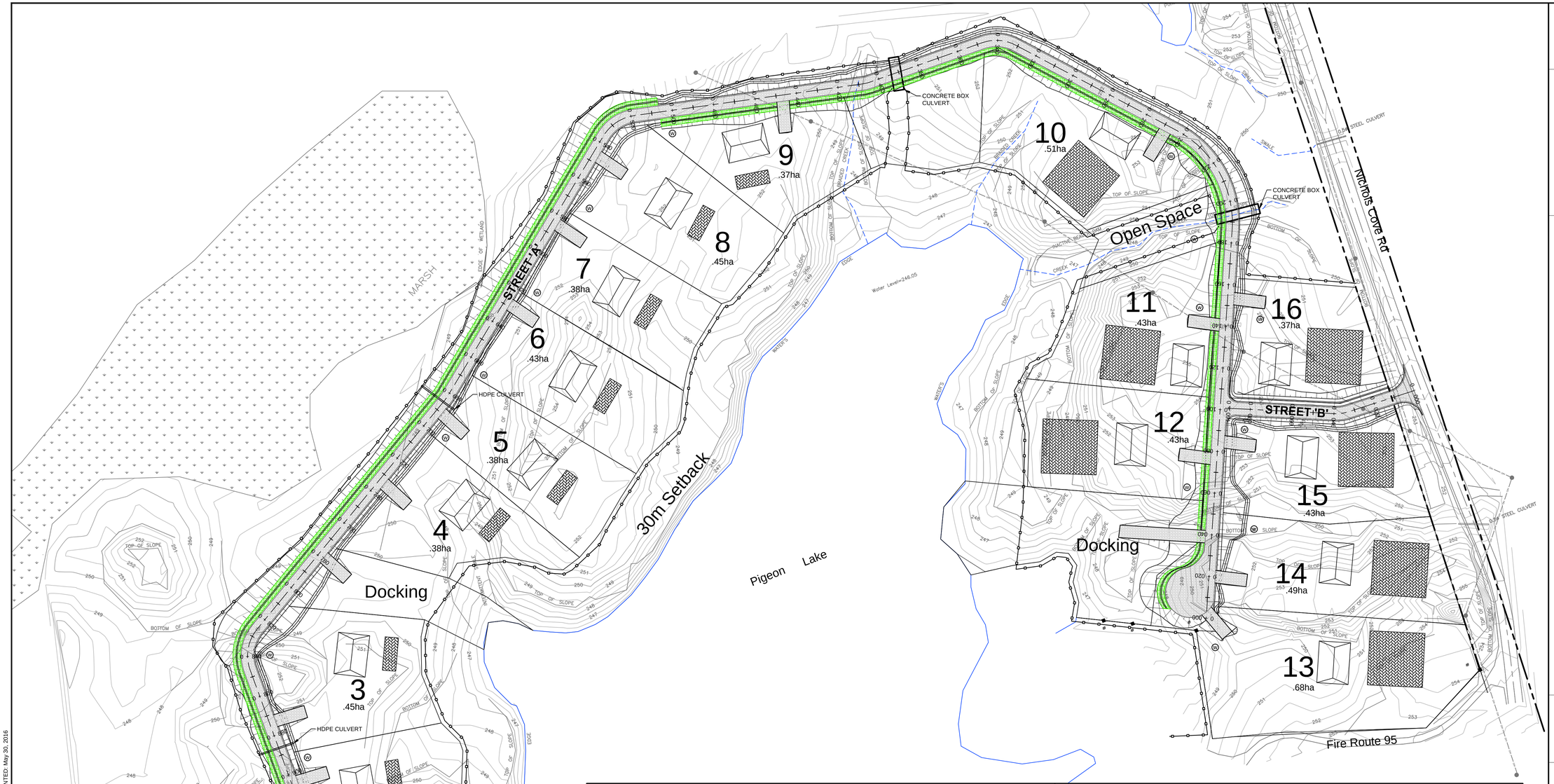
DATE: April 27 2016

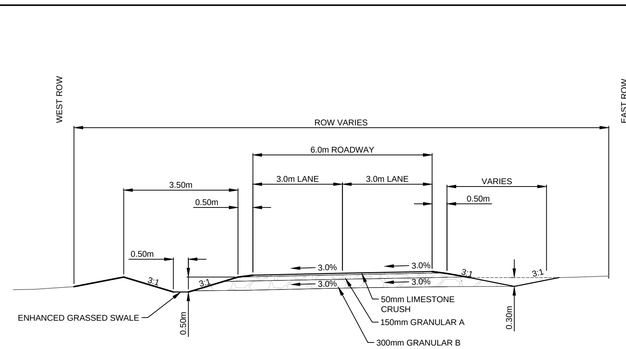
HORIZ. SCALE: 1:2000

Scenario 5

Orion Group

Lot 17 Concession 14
Municipality of Trent Lakes, Cnty of Peterborough





1 TYPICAL ROAD CROSS SECTION STA.0+000 to 0+505
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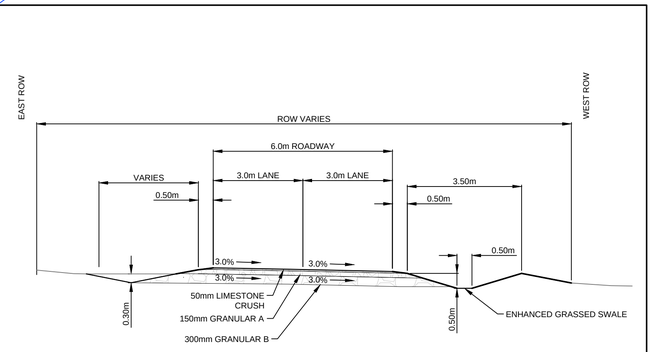

2 TYPICAL ROAD CROSS SECTION STA. 0+505 to 0+978
SCALE: 1:100

KEY PLAN

LEGEND

- PROPOSED LIMESTONE CRUSH
- PROPOSED ENHANCED GRASSED SWALE
- EX./PR. EDGE OF GRAVEL
- EX./PR. ROAD CENTERLINE
- EX./PR. EDGE OF SHOULDER/GRAVEL
- HP EXISTING HYDRO POLE
- BP EXISTING BELL POLE
- EXISTING POLE ANCHOR
- IRON BAR
- O/H O/H EX. OVERHEAD HYDRO
- EX./PR. CULVERT
- EX./PR. DITCH
- EX./PR. FENCE
- R.O.W
- PROPERTY LINE
- EXISTING VEGETATION
- EXISTING TREE
- 100.0 100.0 EX./PR. CONTOUR
- EX./PR. SIGN
- X 215.00 214.00 1.0% EX./PR. ELEVATION(HIGHPOINT/ LOWPOINT) PROPOSED GRADE
- 3:1 GRADING LIMIT
- APPROXIMATE BUILDING LOCATION
- APPROXIMATE SEPTIC LOCATION
- W APPROXIMATE WELL LOCATION
- ARMOUR STONE TURTLE FENCE

BUFFALO BAY

MUNICIPALITY OF TRENT LAKES

CONCEPTUAL STORMWATER MANAGEMENT PLAN

No.	DATE	BY	REVISION
1	30-05-16	BP	ISSUED FOR REVIEW

ENGAGE ENGINEERING

DRAWN: B.PARSONS
DESIGNED: B.PARSONS
APPROVED: A.HILL
DATE: MAY 30, 2016
SCALE: HORZ. 1:1000 VERT. -

PROJECT NO.: 15006
DRAWING FILE NO.: 15006-GP
SHT. NO.: 03

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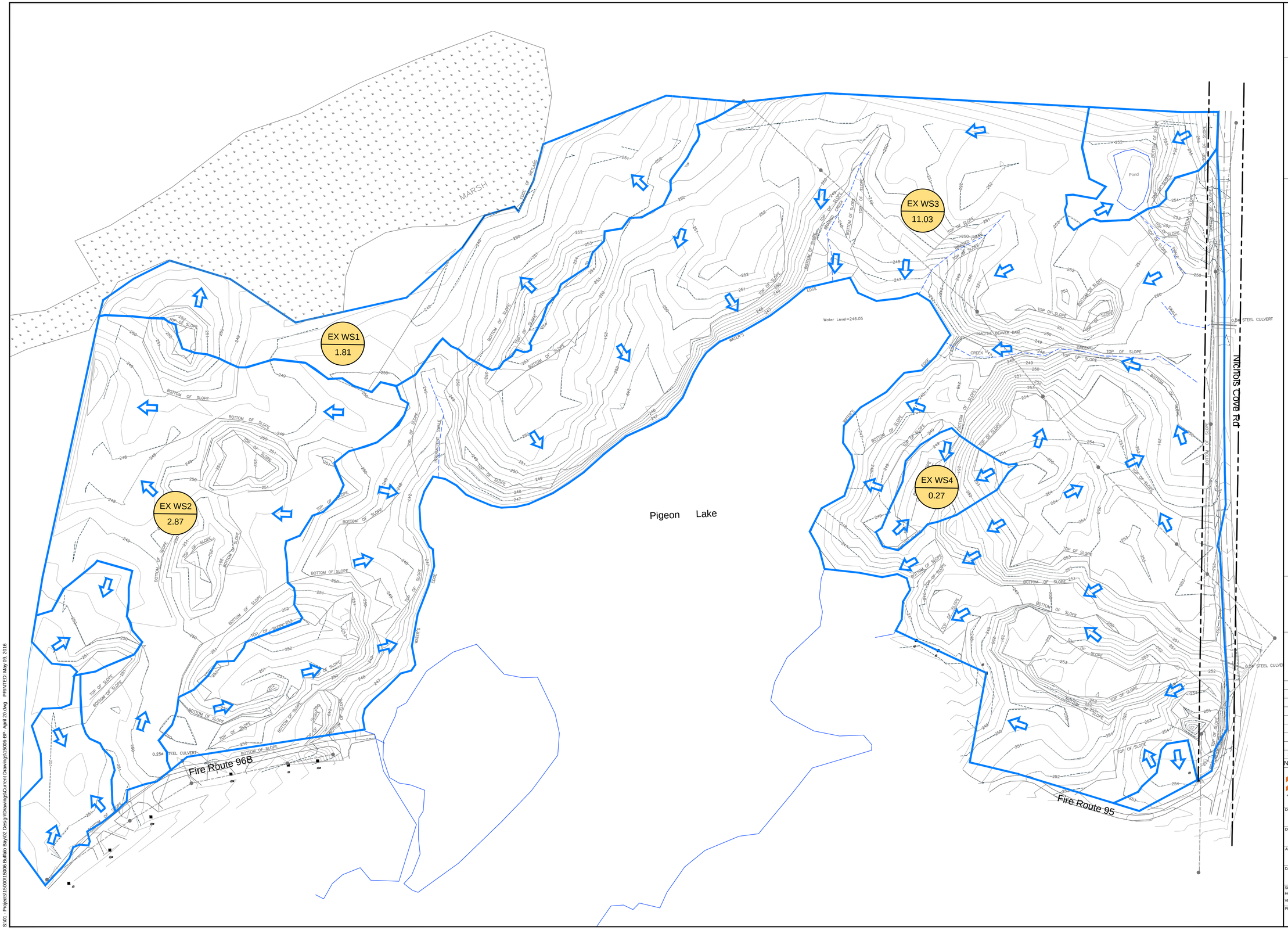

KEY PLAN

LEGEND

STORM DRAINAGE BOUNDARY

EX WS1 — DRAINAGE AREA
0.35ha — AREA(IN ha)

FLOW DIRECTION

BUFFALO BAY

MUNICIPALITY OF TRENT LAKES

PRE-DEVELOPMENT DRAINAGE AREA PLAN

No.	DATE	BY	REVISION
1	09-05-16	BP	ISSUED FOR REVIEW

ENGAGE ENGINEERING

DRAWN: B.PARSONS
DESIGNED: B.PARSONS
APPROVED: A.HILL
DATE: MAY 09, 2016
SCALE: HORZ. 1:1000 VERT. -
PROJECT NO.: 15006
DRAWING FILE NO.: 15006-GP
SHT. NO.: 01

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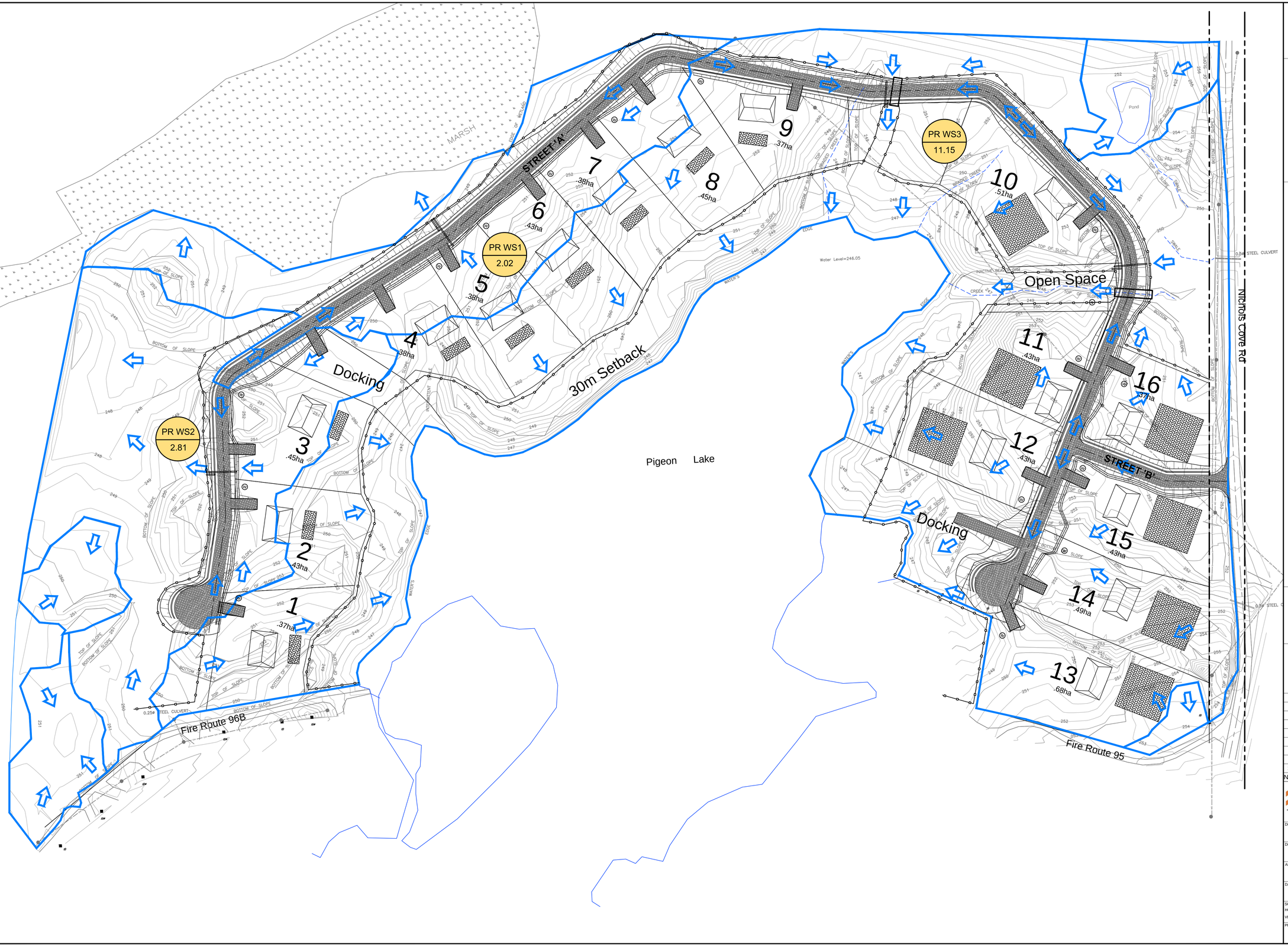

KEY PLAN

LEGEND

- STORM DRAINAGE BOUNDARY
- PR WS1 / 0.35ha — DRAINAGE AREA / AREA(IN ha)
- FLOW DIRECTION

BUFFALO BAY

MUNICIPALITY OF TRENT LAKES

POST-DEVELOPMENT DRAINAGE AREA PLAN

No.	DATE	BY	REVISION
1	30-05-16	BP	ISSUED FOR REVIEW

ENGAGE ENGINEERING

DRAWN:	B.PARSONS
DESIGNED:	B.PARSONS
APPROVED:	A.HILL
DATE:	MAY 30, 2016
SCALE: HORZ.	1:1000
VERT.	-
PROJECT NO.:	15006
DRAWING FILE NO.:	15006-GP
SHT. NO.:	02

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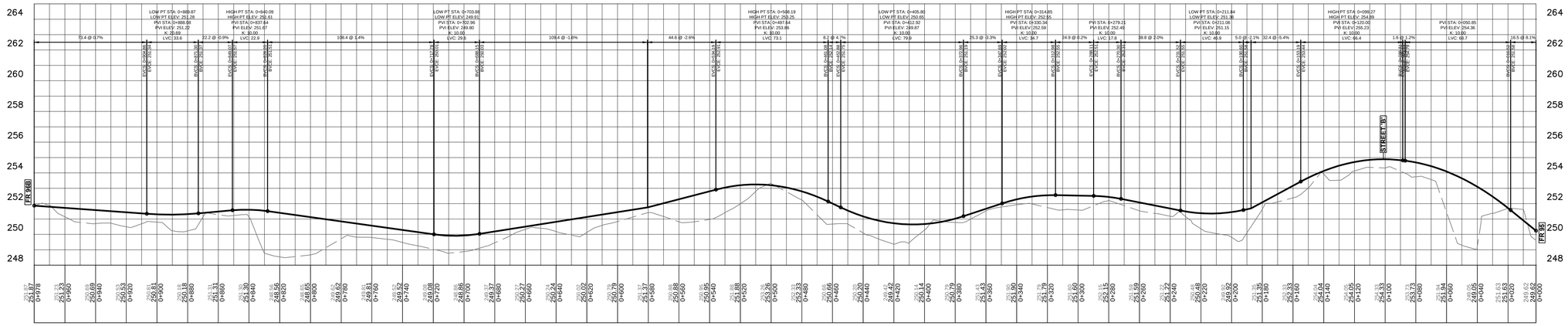
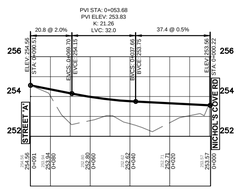
STREET 'A' PROFILE



STREET 'B' PROFILE



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KEY PLAN

LEGEND

BUFFALO BAY

MUNICIPALITY OF TRENT LAKES

CONCEPTUAL ROAD PROFILE

No.	DATE	BY	REVISION
1	30-05-16	BP	ISSUED FOR REVIEW

ENGAGE ENGINEERING

DRAWN: B.PARSONS

DESIGNED: B.PARSONS

APPROVED: A.HILL

DATE: MAY 30, 2016

SCALE:
HORZ. 1:1500
VERT. -

PROJECT NO.:	DRAWING FILE NO.:	SHT. NO.:
15006	15006-GP	04

Appendix A: Peak Flow Calculations

Pre-Development Drainage Area EX WS1
Rational Method Calculations

Project No: 15006 Project Name: Buffalo Bay Designer: BTP

Site Characteristics

Land Use and Areas

Grass:		ha
Agriculture:		ha
Woods:	1.8075	ha
Wetland:		ha
Gravel:		ha
Bare Earth:		ha
Impervious:		ha
TOTAL:	1.81	ha

Soil Type:		
Hydrologic Soil Group:		
Length of Watershed:	90	m
Slope:	2.5	%
Terrain:	Flat	

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.11

Time of Concentration, Tc	22.63	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	1.81	0.11	22.63	44.9	0.025
5 Year	1.81	0.11	22.63	60.7	0.034
10 Year	1.81	0.11	22.63	72.2	0.040
25 Year	1.81	0.12	22.63	84.5	0.051
50 Year	1.81	0.13	22.63	94.6	0.063
100 Year	1.81	0.138	22.63	103.5	0.071

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

Pre-Development Drainage Area EX WS2
Rational Method Calculations

Project No: 15006 Project Name: Buffalo Bay Designer: BTP

Site Characteristics

Land Use and Areas

Grass:		ha
Agriculture:		ha
Woods:	2.87	ha
Wetland:		ha
Gravel:		ha
Bare Earth:		ha
Impervious:		ha
TOTAL:	2.87	ha

Soil Type:		
Hydrologic Soil Group:		
Length of Watershed:	140	m
Slope:	2.1	%
Terrain:	Flat	

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.11

Time of Concentration, Tc	29.89	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	2.87	0.11	29.89	37.9	0.033
5 Year	2.87	0.11	29.89	51.4	0.045
10 Year	2.87	0.11	29.89	61.6	0.054
25 Year	2.87	0.12	29.89	72.1	0.070
50 Year	2.87	0.13	29.89	81.0	0.085
100 Year	2.87	0.14	29.89	88.5	0.097

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

Pre-Development Drainage Area EX WS3
Rational Method Calculations

Project No: 15006 Project Name: Buffalo Bay Designer: BTP

Site Characteristics

Land Use and Areas

Grass:		ha
Agriculture:		ha
Woods:	11.03	ha
Wetland:		ha
Gravel:		ha
Bare Earth:		ha
Impervious:		ha
TOTAL:	11.03	ha

Soil Type:		
Hydrologic Soil Group:		
Length of Watershed:	140	m
Slope:	2.6	%
Terrain:	Flat	

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.11

Time of Concentration, Tc	27.86	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	11.03	0.11	27.86	39.6	0.134
5 Year	11.03	0.11	27.86	53.7	0.181
10 Year	11.03	0.11	27.86	64.2	0.216
25 Year	11.03	0.12	27.86	75.2	0.279
50 Year	11.03	0.13	27.86	84.3	0.341
100 Year	11.03	0.14	27.86	92.2	0.389

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

Pre-Development Drainage Area EX WS4
Rational Method Calculations

Project No: 15006 Project Name: Buffalo Bay Designer: BTP

Site Characteristics

Land Use and Areas

Grass:		ha	Soil Type:		
Agriculture:		ha	Hydrologic Soil Group:		
Woods:	0.27	ha			
Wetland:		ha	Length of Watershed:	45	m
Gravel:		ha	Slope:	14.0	%
Bare Earth:		ha	Terrain:	Flat	
Impervious:		ha			
TOTAL:	0.27	ha			

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.11

Time of Concentration, Tc	9.06	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	0.27	0.11	9.06	72.1	0.006
5 Year	0.27	0.11	9.06	94.7	0.008
10 Year	0.27	0.11	9.06	109.0	0.009
25 Year	0.27	0.12	9.06	127.0	0.012
50 Year	0.27	0.13	9.06	140.3	0.014
100 Year	0.27	0.14	9.06	153.7	0.016

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

Pre-Development Drainage Area PRWS1
Rational Method Calculations

Project No: 15006 Project Name: Buffalo Bay Designer: BTP

Site Characteristics

Land Use and Areas

Grass:	0.535	ha		Soil Type:	
Agriculture:		ha		Hydrologic Soil Group:	
Woods:	1.14	ha			
Wetland:		ha		Length of Watershed:	150 m
Gravel:	0.275	ha		Slope:	1.5 %
Bare Earth:		ha		Terrain:	Flat
Impervious:	0.07	ha	0.034653465		
TOTAL:	2.02	ha			

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.23

Time of Concentration, Tc	30.50	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	2.02	0.23	30.50	37.4	0.048
5 Year	2.02	0.23	30.50	50.8	0.065
10 Year	2.02	0.23	30.50	60.8	0.077
25 Year	2.02	0.25	30.50	71.2	0.100
50 Year	2.02	0.27	30.50	80.0	0.122
100 Year	2.02	0.283	30.50	87.5	0.139

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

Pre-Development Drainage Area PR WS2
Rational Method Calculations

Project No: 15006 Project Name: Buffalo Bay Designer: BTP

Site Characteristics

Land Use and Areas

Grass:	0.36	ha		Soil Type:		
Agriculture:		ha		Hydrologic Soil Group:		
Woods:	2.25	ha				
Wetland:		ha		Length of Watershed:	120	m
Gravel:	0.16	ha		Slope:	0.7	%
Bare Earth:		ha		Terrain:		
Impervious:	0.04	ha	0.01			
TOTAL:	2.81	ha				

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.16

Time of Concentration, Tc	37.77	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	2.81	0.16	37.77	32.6	0.041
5 Year	2.81	0.16	37.77	44.3	0.055
10 Year	2.81	0.16	37.77	53.2	0.066
25 Year	2.81	0.18	37.77	62.3	0.086
50 Year	2.81	0.19	37.77	70.3	0.105
100 Year	2.81	0.20	37.77	76.7	0.120

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

Pre-Development Drainage Area PR WS3
Rational Method Calculations

Project No: 15006 Project Name: Buffalo Bay Designer: BTP

Site Characteristics

Land Use and Areas

Grass:	2.09	ha		Soil Type:		
Agriculture:		ha		Hydrologic Soil Group:		
Woods:	7.81	ha				
Wetland:		ha		Length of Watershed:	140	m
Gravel:	0.87	ha		Slope:	2.6	%
Bare Earth:		ha		Terrain:		
Impervious:	0.38	ha	0.03			
TOTAL:	11.15	ha				

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.19

Time of Concentration, Tc	25.60	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	11.15	0.19	25.60	41.7	0.246
5 Year	11.15	0.19	25.60	56.5	0.333
10 Year	11.15	0.19	25.60	67.4	0.398
25 Year	11.15	0.21	25.60	78.9	0.512
50 Year	11.15	0.23	25.60	88.5	0.626
100 Year	11.15	0.24	25.60	96.7	0.713

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

ENGAGE ENGINEERING

Pre-Development Drainage Area PR WS3 Cut Off Channel
Rational Method Calculations

Project No: 15006 Project Name: Buffalo Bay Designer: BTP

Site Characteristics

Land Use and Areas

Grass:	0.33	ha		Soil Type:	
Agriculture:		ha		Hydrologic Soil Group:	
Woods:	3.06	ha			
Wetland:		ha		Length of Watershed:	120 m
Gravel:	0.1	ha		Slope:	4.0 %
Bare Earth:		ha		Terrain:	
Impervious:	0.11	ha	0.03		
TOTAL:	3.60	ha			

Hydrologic Parameters

Runoff Coefficient							
Wetland	Woods	Grass	Agriculture	Gravel	Bare Earth	Impervious	Composite C
0.05	0.11	0.17	0.30	0.65	0.63	0.90	0.15

Time of Concentration, Tc	21.37	min.

Rainfall Data

Gauging Station: Peterborough

100 Year, 12 hour Depth: 90

	IDF Parameters - Peterborough					
	2 Year	5 Year	10 Year	25 Year	50 Year	100 Year
A	662.00	1098.00	1560.00	2010.00	2200.00	2507.00
B	7.50	10.10	13.00	14.00	14.60	14.80
C	0.79	0.83	0.86	0.88	0.87	0.88

Peak Flow Calculations

Return Interval	Area (ha)	Composite C	Time of Conc., Tc (min.)	Intensity, I (mm/hr)	Flow, Q (m3/s)
2 Year	3.60	0.15	21.37	46.5	0.072
5 Year	3.60	0.15	21.37	62.7	0.097
10 Year	3.60	0.15	21.37	74.5	0.115
25 Year	3.60	0.17	21.37	87.2	0.148
50 Year	3.60	0.19	21.37	97.5	0.181
100 Year	3.60	0.19	21.37	106.6	0.206

Notes:

1. Soils group taken from MTO Drainage Manual, Chart H2-6A.
2. Runoff coefficients taken from MTO Drainage Manual, Chart 1.07
3. Time of concentration calculated using Airport Equation for C<0.4 and Bransby-Williams for C>0.4
4. Runoff Coefficient has been adjusted as follows for storms exceeding 10-year return period:

   25-year: 10%, 50-year: 20%; 100-year: 25%.

Appendix B: Storage Volume Calculations

Modified Rational Method & Storage Calculationsfor PR WS1

Project Information

Project Name:	Buffalo Bay	Designed By:	BP
Project No:	15006	Date:	2016-05-25

Catchment Area Parameters

Catchment ID:	PR WS1	Discharge Rate:	0.071
Drainage Area:	2.02		
Runoff Coefficient:	0.28		

Rainfall Data

Gauging Station	Peterborough	IDF Parameters	a	2507
Storm Return:	100 Year		b	14.8
			c	0.88

Modified Rational Method Calculations

Time (minutes)	Intensity (mm/hr)	Peak Runoff (mm)	Volume (m3)		
			Inflow	Released	Storage
0	234.06	0.368	0.0	0.0	0.0
5	181.17	0.285	85.5	21.3	64.2
10	148.61	0.234	140.2	42.6	97.6
15	126.43	0.199	178.9	63.9	115.0
20	110.30	0.173	208.1	85.2	122.9
25	98.01	0.154	231.2	106.5	**124.7**
30	88.31	0.139	250.0	127.8	122.2
35	80.46	0.127	265.7	149.1	116.6
40	73.97	0.116	279.1	170.4	108.7
45	68.49	0.108	290.8	191.7	99.1
50	63.82	0.100	301.1	213.0	88.1
55	59.78	0.094	310.2	234.3	75.9
60	56.25	0.088	318.4	255.6	62.8
65	53.14	0.084	325.8	276.9	48.9
70	50.37	0.079	332.6	298.2	34.4
75	47.89	0.075	338.9	319.5	19.4
80	45.66	0.072	344.6	340.8	3.8
85	43.64	0.069	350.0	362.1	0.0
90	41.81	0.066	355.0	383.4	0.0
95	40.13	0.063	359.6	404.7	0.0
100	38.58	0.061	364.0	426.0	0.0
105	37.16	0.058	368.1	447.3	0.0

Modified Rational Method & Storage Calculationsfor PR WS2

Project Information

Project Name:	Buffalo Bay	Designed By:	BP
Project No:	15006	Date:	2016-05-25

Catchment Area Parameters

Catchment ID:	PR WS2	Discharge Rate:	0.097
Drainage Area:	2.81		
Runoff Coefficient:	0.20		

Rainfall Data

Gauging Station	Peterborough	IDF Parameters	a	2507
Storm Return:	100 Year		b	14.8
			c	0.88

Modified Rational Method Calculations

Time (minutes)	Intensity (mm/hr)	Peak Runoff (mm)	Volume (m3)		
			Inflow	Released	Storage
0	234.06	0.366	0.0	0.0	0.0
5	181.17	0.283	84.9	29.1	55.8
10	148.61	0.232	139.3	58.2	81.1
15	126.43	0.198	177.8	87.3	**90.5**
20	110.30	0.172	206.8	116.4	90.4
25	98.01	0.153	229.7	145.5	84.2
30	88.31	0.138	248.4	174.6	73.8
35	80.46	0.126	264.0	203.7	60.3
40	73.97	0.116	277.3	232.8	44.5
45	68.49	0.107	288.9	261.9	27.0
50	63.82	0.100	299.1	291.0	8.1
55	59.78	0.093	308.2	320.1	0.0
60	56.25	0.088	316.4	349.2	0.0
65	53.14	0.083	323.8	378.3	0.0
70	50.37	0.079	330.5	407.4	0.0
75	47.89	0.075	336.7	436.5	0.0
80	45.66	0.071	342.4	465.6	0.0
85	43.64	0.068	347.8	494.7	0.0
90	41.81	0.065	352.7	523.8	0.0
95	40.13	0.063	357.3	552.9	0.0
100	38.58	0.060	361.7	582.0	0.0
105	37.16	0.058	365.8	611.1	0.0

Appendix C: Channel Capacity Calculations

CHANNEL DESIGN SHEET

Project Name: Buffalo Bay
Project Number: 15006
Designed By: BP

Location	Contributing Area and Flow		Channel Properties						Hydraulics					
Channel Description	Description	Flow (m3/s)	Bed Slope	Side Slope (X:1)	Bottom Width	Depth	Lining Material	Mannings n	Channel Capacity	% Capacity	Cross Sectional Area	Wetted Perimter	Flow Depth	Velocity
South Cut Off Swale	**PrWS1**	**0.139**	0.02	3.000	0.0	0.3	Grass	0.03	0.35	40%	0.270	1.90	0.25	0.77
South Cut Off Swale	**PrWS2**	**0.120**	0.008	3.000	0.0	0.3	Grass	0.03	0.22	55%	0.270	1.90	0.22	0.87
North Cut Off Swale	**PrWS3**	**0.206**	0.03	3.000	0.0	0.3	Grass	0.03	0.42	48%	0.270	1.90	0.18	2.12