PRELIMINARY STORMWATER
MANAGEMENT REPORT
DRAFT PLAN OF PROPOSED SUBDIVISION
NORTH HALF LOT 9, WEST COMMUNICATIONS ROAD
TOWNSHIP OF SELWYN
COUNTY OF PETERBOROUGH

Prepared By:

LANDMARK ASSOCIATES LIMITED
PLANNERS AND ENGINEERS

Time Square
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March 2017

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1.0: Introduction

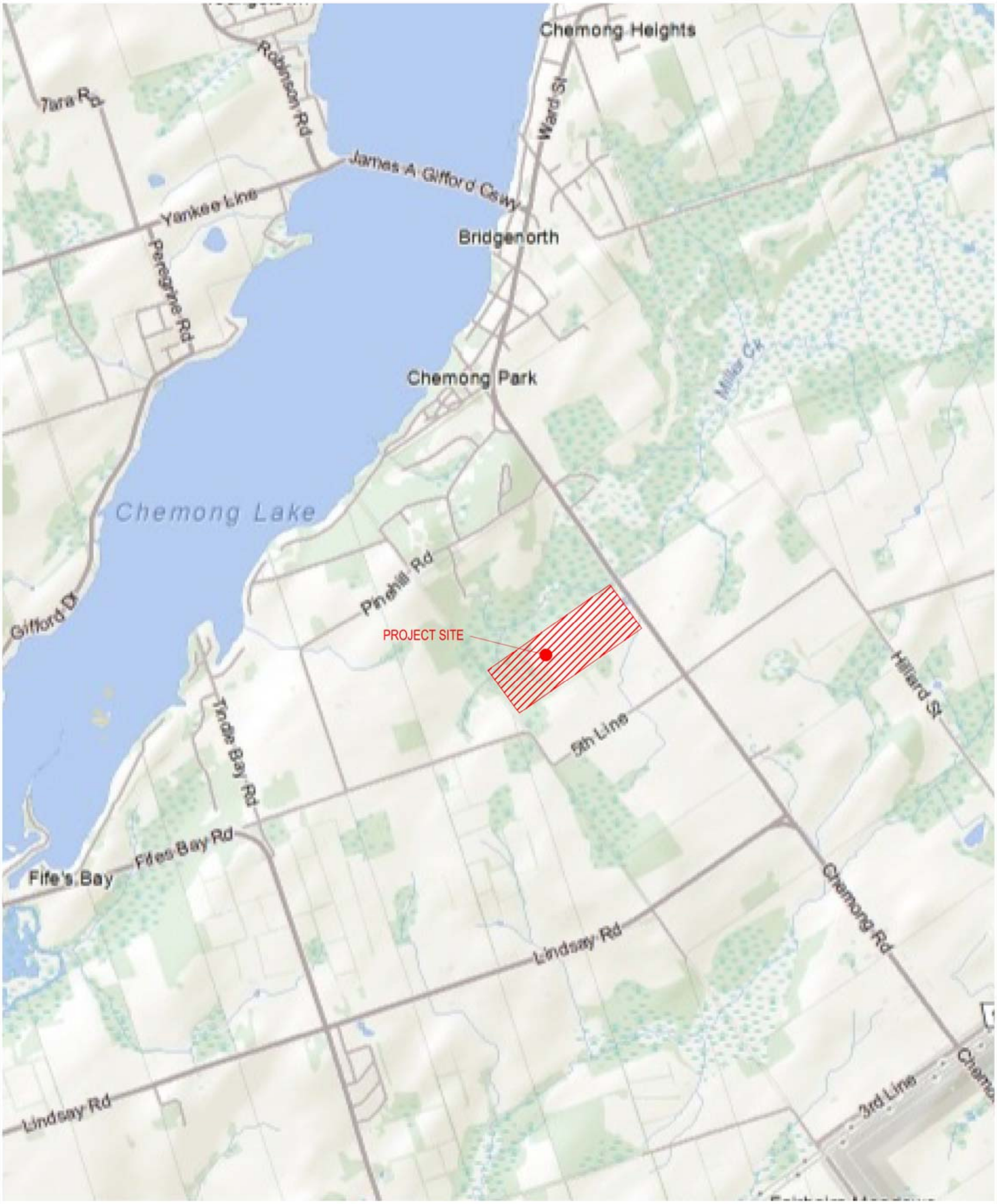
1.0 Introduction

This report is a Preliminary Stormwater Management assessment for a residential subdivision development of lands comprising North Half of Lot 9, West Community Road, located in the Township of Selwyn, County of Peterborough.

The subject property is approximately 38 hectares in area; being located approximately 1.5 kilometres south of the Village of Bridgenorth, approximately 3.5 kilometres north of Peterborough.

The site is situated on the west side of County Road 18 (Chemong Road) (refer to Figure 1, Location Plan). The property is to be developed for 24 residential lots and 2 commercial blocks.

The report has been prepared in support of Draft Plan Approval.



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DRAFT PLAN OF
PROPOSED SUBDIVISION

NORTH HALF LOT 9
WEST COMMUNICATION ROAD
TOWNSHIP OF SMITH-ENNISMORE LAKEFIELD
COUNTY OF PETERBOROUGH

PROJECT NO.	DATE:
P11-896	MARCH, 2017
SCALE:	DRAWING NO.
N.T.S.	FIGURE 1

2.0: Topography and Drainage

2.0 Topography and Drainage

Figure No. 2, Catchment Drainage Areas, illustrates the surrounding extraneous drainage catchment areas discharging surface water runoff onto the proposed development area. There are four (4) extraneous catchment areas identified.

- Extraneous Area Ext-1 is a wooded area and is approximately 10.37 hectares in size. Ext-1 drains to the north away from the property toward the creek.
- Extraneous Area Ext-2 is 27.44 hectares. Surface drainage is towards the southwest corner of the property and towards the wetland.
- Extraneous Area Ext-3 is 53.81 hectares. Surface runoff drains to the east towards the low-lying area which eventually flows into the roadside ditch.
- Extraneous Area Ext-4 is 18.13 hectares, drains towards the northerly low-lying area, which then heads to the roadside ditch.

Figure No. 3, Pre-Development Plan illustrates the existing site drainage catchment areas. The property is divided into three (3) drainage catchment areas.

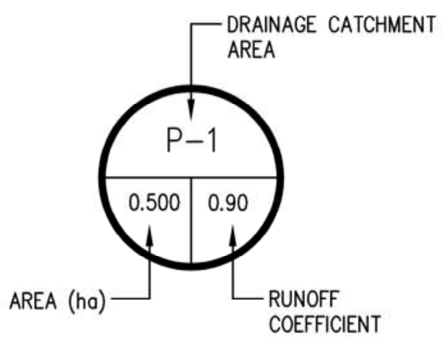
- Area P1 is part of the western portion of the property, and comprises a 12.75 hectare area. The area surface runoff is directed to the northwest corner of the property, and discharges into Miller Creek.
- Area P2 is the eastern portion of 18.44 hectares. The surface runoff from this area is directed into Miller Creek to the north end and to the east. An existing dwelling is located on this catchment.
- Area P3 is the 6.90 hectare wetland area in the northwest corner of the property. This area will not be disturbed during construction. Surface runoff from this area is directed into Miner Creek which crosses through the northwest corner of the property.

DRAFT PLAN OF PROPOSED SUBDIVISION
NORTH HALF LOT 9
WEST COMMUNICATION ROAD
TOWNSHIP OF SMITH-ENNISMORE LAKEFIELD
COUNTY OF PETERBOROUGH

SCALE 1:7500

0 30 120 250 250 metres

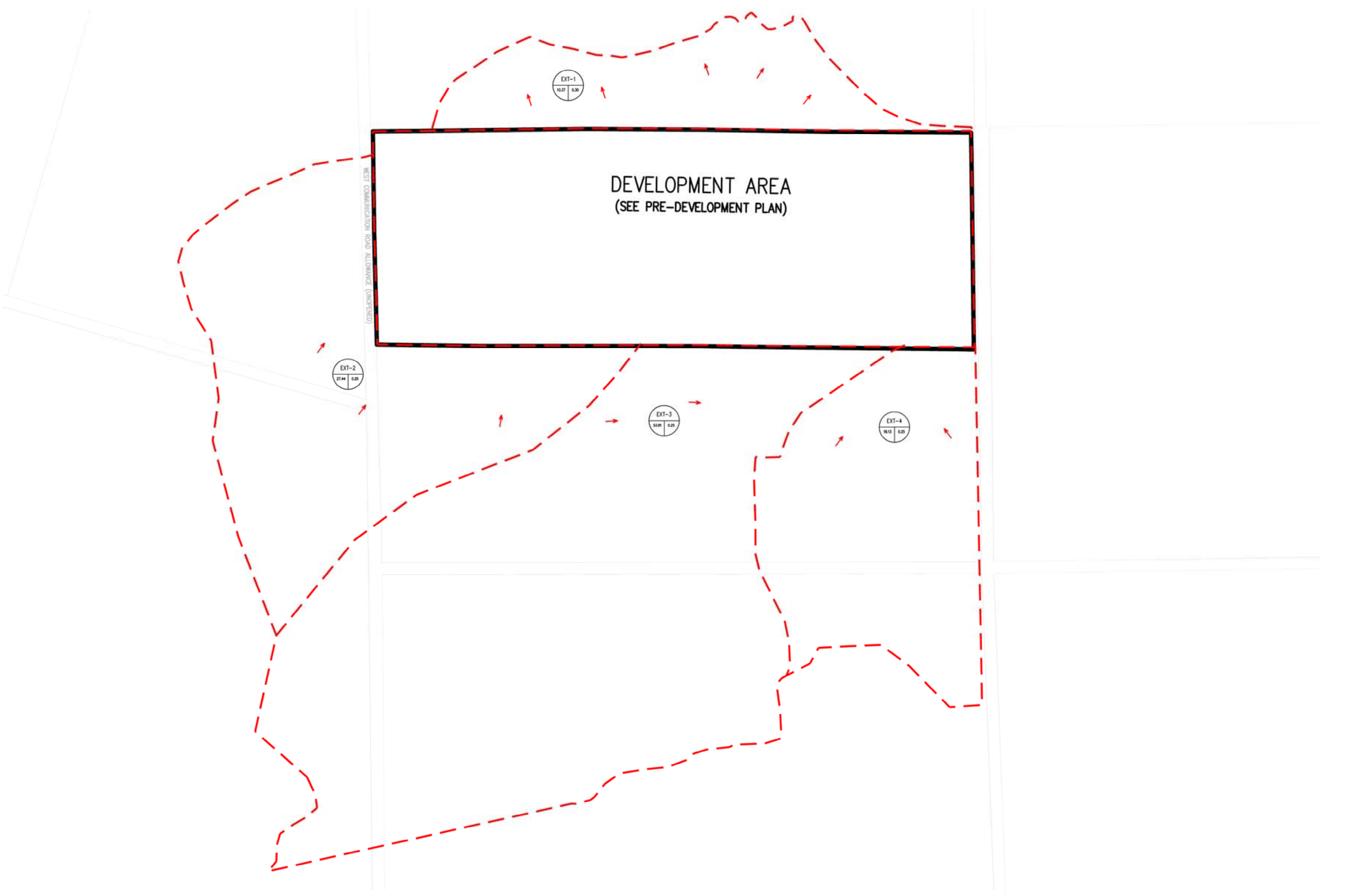
LEGEND:



DRAINAGE BOUNDARY

DRAINAGE DIRECTION

TOTAL SITE = 37.99± ha



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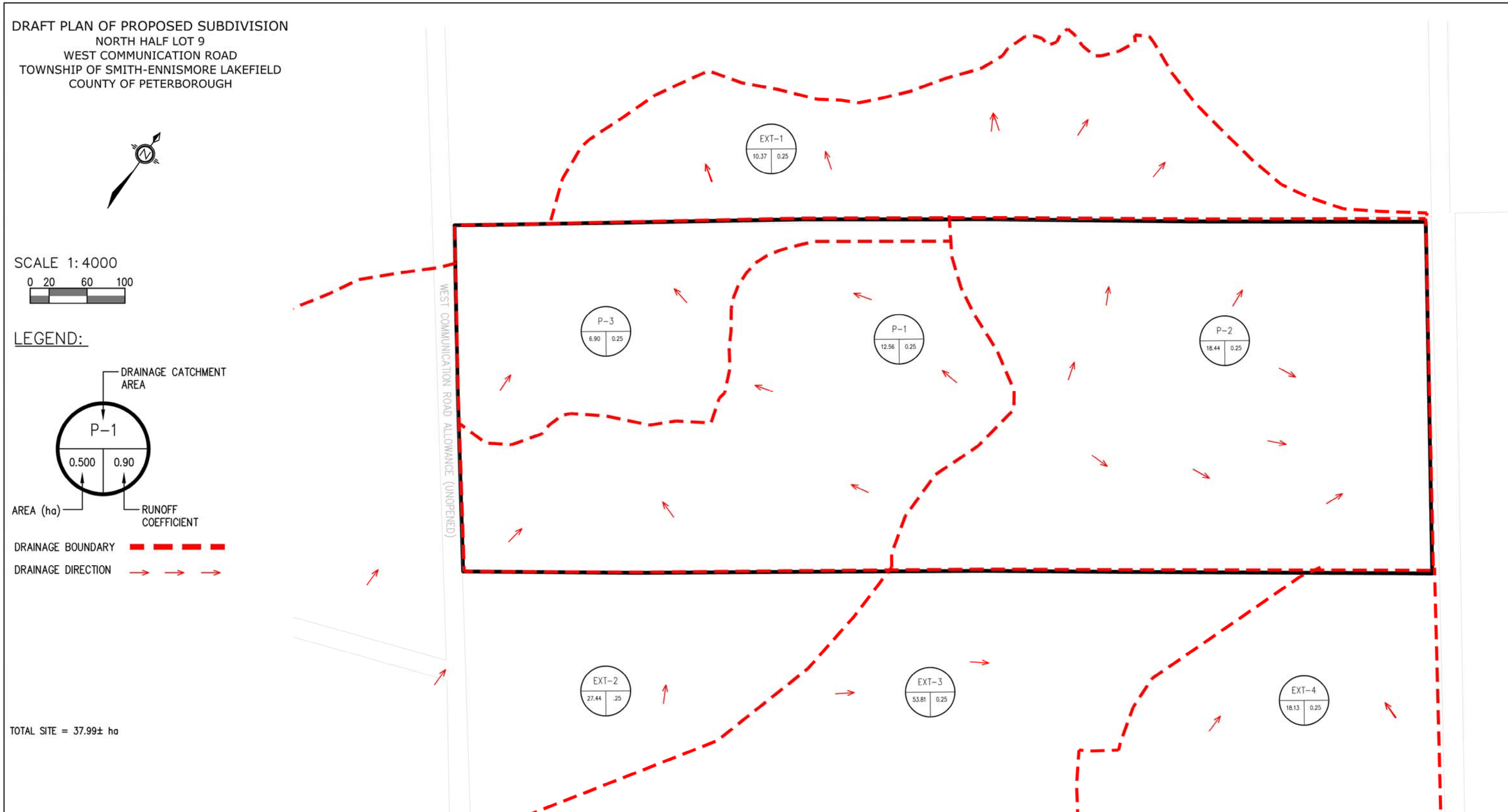
DESIGNED: B. DOBRI	TOWNSHIP OF SMITH-ENNISMORE-LAKEFIELD	DATE: MARCH, 2017
DRAWN: J. WHALEN		PROJECT: P11-896
CHECKED: B. DOBRI		CAD FILE: P11-896
APPROVED: B. DOBRI	CATCHMENT DRAINAGE AREA PLAN	
SCALE: HORZ. 1:7000		DRAWING: FIGURE 2



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APPROVED:	B. DOBRI
SCALE:	HORZ. 1: 4000

TOWNSHIP OF SMITH-ENNISMORE-LAKEFIELD

PRE DEVELOPMENT PLAN

DATE:	MARCH, 2017
PROJECT:	P11-896
CAD FILE:	P11-896
DRAWING:	FIGURE 3

The Post-Development Plan, Figure No. 4, illustrates the proposed conditions. Seven (7) drainage catchment areas are identified. The catchment areas are described in Section 3 of the report.

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TOWNSHIP OF SMITH-ENNISMORE-LAKEFIELD

POST DEVELOPMENT PLAN

DATE:	MARCH, 2017
PROJECT:	P11-896
CAD FILE:	P11-896
DRAWING:	FIGURE 4

3.0: Stormwater Management

3.0 Stormwater Management

The following were used in the stormwater management analysis:

1. Peterborough IDF rainfall Data

return	a	b	c
2	662	7.5	0.79
5	1098	10.1	0.83
10	1560	13.0	0.86
25	2010	14.0	0.88
50	2200	14.6	0.87
100	2507	14.8	0.88

$I = a / (Tc + b)^c$

2. Airport Formula, when runoff coefficient C is less than 0.4

$T_c = (3.26(1.1\text{-}C)L^{0.5} / sw^{0.33}$

Where L = drainage length (m)
C = runoff coefficient
Sw = slope (%)
T_c = time of concentration, minutes

3. Calculate Tc using the Bransby Williams equation $Tc = 0.057\ L\ sw^{0.2}\ A^{0.1}$, when C is greater than 0.40.

Where L = catchment length (m)
Sw = catchment slope (%)
A = catchment area (ha).

4. Rational Method

$Q = CiA/360$

Where C = runoff coefficient
i = rainfall intensity mm/hr.
A = area (hectares)
Q = peak discharge cms

5. C = 0.25 pre-development, proposed landscaped areas
0.95 for buildings and asphalt
0.70 for gravel areas.

6. Each lot - Building area 250 m^2
- Height area 90 m^2

Roadway - Asphalt 7 m wide
- Gravel Shoulder 1.5 m wide (each side)

7. Ministry of Environment - Stormwater Management Planning and Design Manual, 2003.

8. Low Impact Development Stormwater Management Planning and Design Guide prepared by Credit Valley Conservation and Toronto and Region Conservation.

9. Ministry of Transportation Drainage Management Manual.

Any land development project will alter the runoff characteristics of the site. Normal stormwater management practice is to provide both stormwater quality and stormwater quantity controls for a new land development project. The documents referenced also outline various techniques to address stormwater management controls. The types of controls selected are dependent on the site conditions.

STORMWATER QUALITY CONTROLS

The immediate effects that the development will have on the quality of stormwater runoff is directly associated with the construction activities, while long term effects will be associated with the winter maintenance operations, where sand and salt on the roadway, parking lot and vehicles will be transported to the drainage ditch. The level of protection to be provided is determined by the sensitivity of the aquatic habitat which may be impacted by the discharge. The three (3) levels of protection are:

- ‘Enhanced Protection’ where habitat is very sensitive to sediment and siltation
- ‘Normal Protection’ where conditions for enhanced protection don’t exist
- ‘Basic Protection’ where habitat is not sensitive to stormwater impacts.

Temporary stormwater quality controls during construction typically include:

- the construction of temporary sediment control ponds (large sites)
- the installation of silt fences along property boundaries or around earth stockpiles
- the installation of rock check dams or straw bales within swales or drainage channels
- the installation of a mud mat at the road entrance.

For this development a “normal protection” level is suitable (Refer to Figure 5). Light duty silt fence will be installed along the construction limits as noted on the plan and around any material stockpiles. The silt fence will be installed in accordance with OPSD 219.110. Once new vegetation is established over the disturbed areas, the silt fence will be removed.

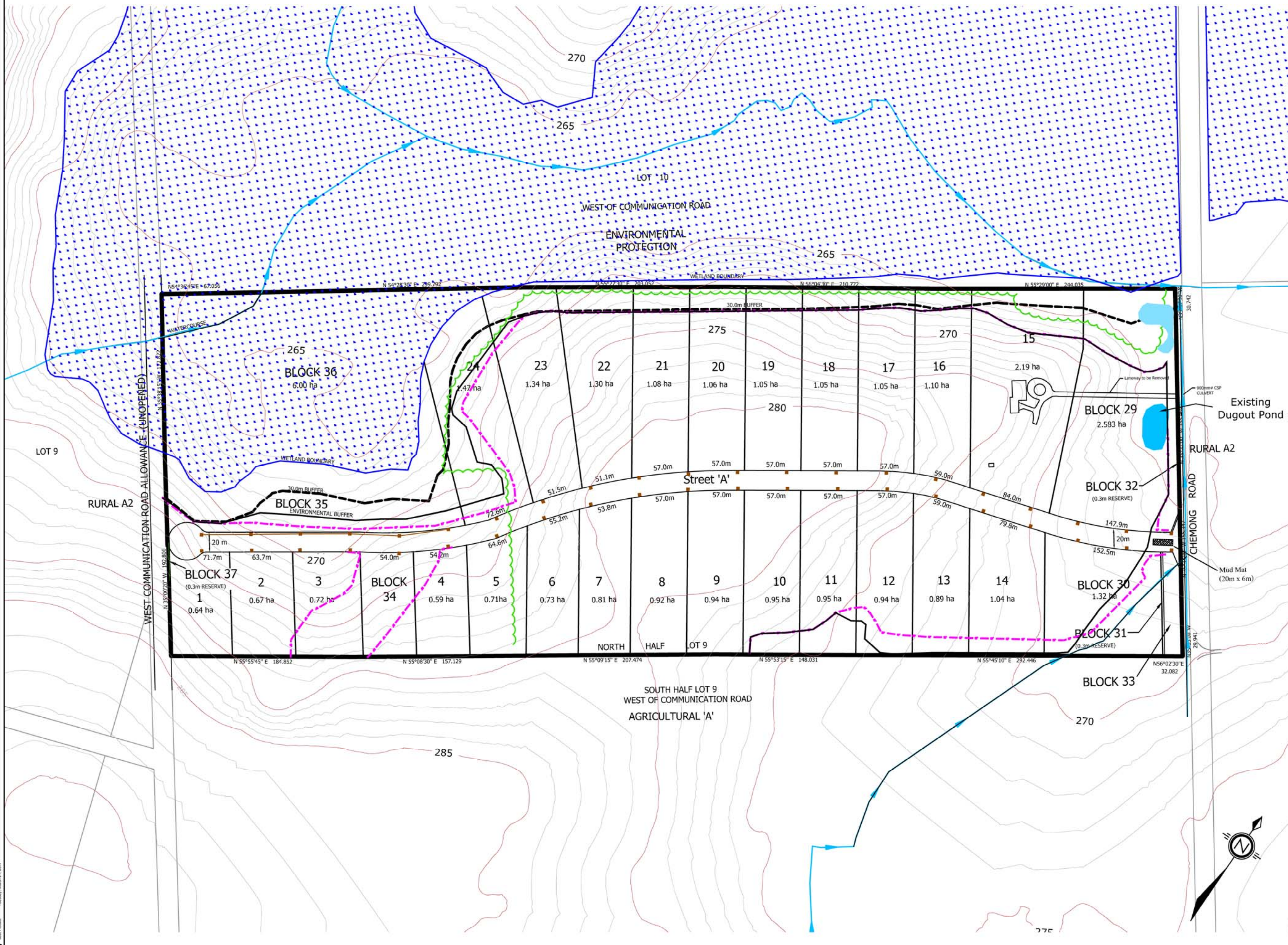
Mud mats are also recommended at entrance roadways (refer to Figure 6). The mud mat is to be a minimum 6 m wide x 20 m long x 0.5 m deep, consisting of 100-150 mm rip-rap, complete with filter cloth.

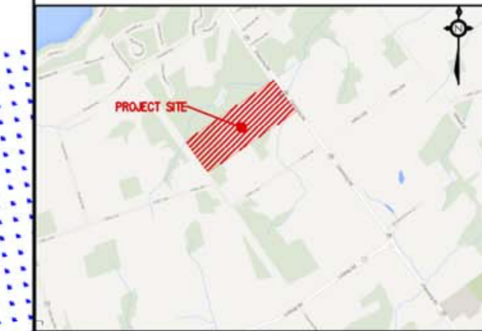
In addition, rock check dams or straw bale check dams in accordance with OPSD’s will be installed in the road ditches, placed at 50 m ± intervals.

Permanent stormwater quality controls which are typically implemented are:

- Lot Level Controls

    - reduce grade to promote infiltration
    - rear yard ponding areas or soak-away pits
    - infiltration trenches
    - grassed swales





KEY PLAN N.T.S.

DRAFT PLAN OF PROPOSED SUBDIVISION
NORTH HALF LOT 9
WEST COMMUNICATION ROAD
TOWNSHIP OF SMITH-ENNISMORE LAKEFIELD
COUNTY OF PETERBOROUGH

EROSION AND SEDIMENT CONTROL PLAN

LEGEND:

EXISTING
- TEMPORARY BENCHMARK
- TREE LINE
- GRAVEL
- BITUM. GRANULAR SEALING
- POST AND WIRE FENCE
- 201.87 EX. GRADE ELEVATION

PROPOSED
- CENTRELINE OF DITCH / SWALE
- SILT FENCE AS PER OPSD 219.110
- CHECK DAM

SCALE 1:1750

0 10 30 50

NOTES:

DRAWINGS ARE NOT TO BE SCALED.

MEASUREMENTS ARE IN METRE / MILLIMETRES UNLESS OTHERWISE SHOWN.

TOPOGRAPHIC SURVEY COMPLETED BY TED VAN LANKVELD ONTARIO LAND SURVEYORS ON APRIL 18, 2012.

CONTOURS SHOWN ARE AT 0.50m INTERVAL.

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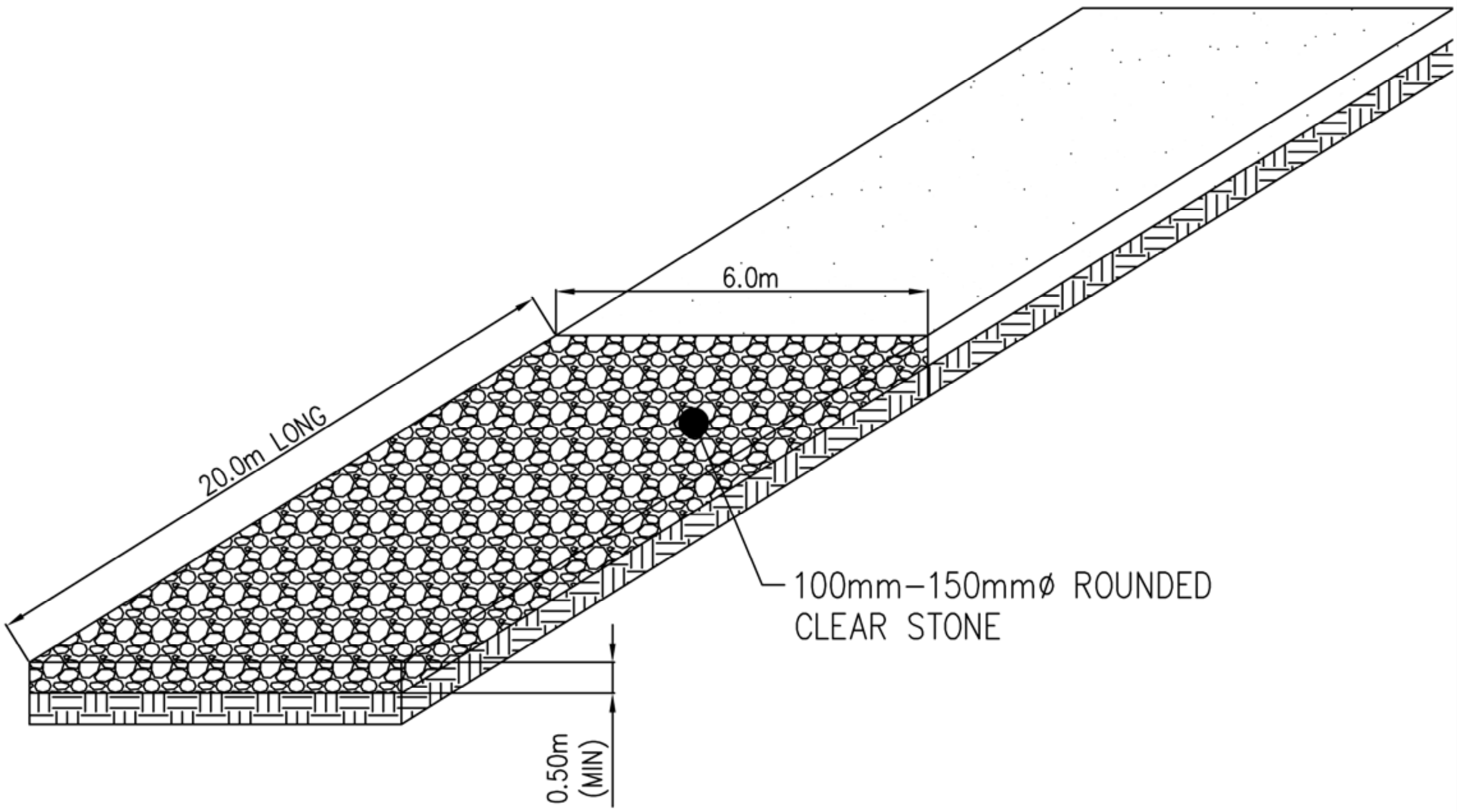
LICENSED PROFESSIONAL ENGINEER
BRUNO DOBRI
PROVINCE OF ONTARIO

No.	DESCRIPTION	DATE	BY	APR.
5				
4				
3				
2			D.W.	B. D.

Designed By:	Drawn By:	Checked By:
	J. WHALEN	B. DOBRI

Project No.:	Date:
P11-896	March, 2017

Drawing Name:	Drawing No.:
P11-896-E&S PLAN-March2017.dwg	FIGURE 5



NOTE:
SHALL BE INSTALLED PRIOR TO CONSTRUCTION AND SHALL BE MAINTAINED THROUGHOUT ENTIRE CONSTRUCTION PERIOD.

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TEMPORARY MUD MAT	PROJECT NO. P11-896	DATE: MARCH 2017
	SCALE: NOT TO SCALE	DRAWING NO. FIGURE 6

- pervious pipe systems
- vegetated filter strips
- stream and valley corridor buffer strips.

- End-of-Pipe Controls

  - wet ponds
  - dry ponds
  - wetlands
  - infiltration basins
  - quality control structure.

The topography, soil type, bedrock elevation, water table elevation and the catchment area are all factors which must be considered in determining the appropriate stormwater controls implemented.

Passive measures will be utilized using swales, and if soils are suitable soak-away pits from the homes. Natural vegetation buffers will also provide stormwater management quality controls.

STORMWATER QUANTITY CONTROLS

In general, any development will affect the generation of runoff in terms of expected flowrate and total runoff volume. Typically the peak post-development discharge rates cannot exceed the peak pre-development discharge rates, ensuring that the development does not negatively impact downstream lands. Temporary surface storage facilities include parking lot storage, building rooftop storage, or stormwater management ponds. Sub-surface storage in large structures or oversized pipes is also possible, but more costly.

Stormwater conveyance will need to be addressed at the detailed design stage. All newly constructed ditches/swales must be designed to convey the expected peak discharge. The capacities of any existing swales/ditches will also be checked to confirm that they will also convey the expected peak flow. Maximum velocities in grassed swales or ditches where the grass is well established and the soils are easily eroded is 1.2 m/s. Where this velocity is exceeded, the ditch/swale will need to be rip-rapped complete with filter fabric (see excerpt from the Municipal Works Design Manual in the Appendix).

PRE-DEVELOPMENT CALCULATIONS

Catchment Area ‘P1’ - 12.56 hectares - Drainage Toward Wetland to Northwest

$L = (A/1.5)^{1/2} = 289.4$ metres
Sw = 6.86%
C = 0.25

T_c = 24.9 minutes

A = 12.56 hectares

P1 Area - The peak discharge from the entire catchment is tabulated below.

Event	i pre	Q (cms)
5 Year	57.4	0.505
10 Year	68.4	0.602
25 Year	80.1	0.705
50 Year	89.8	0.789
100 Year	98.2	0.863

P1 Area - The peak discharge from each of the sub-catchment areas is tabulated below.

Event	Qt	Q1a	Q1b	Q1c
5 Year	0.505	0.239	0.049	0.217
10 Year	0.602	0.285	0.058	0.259
25 Year	0.705	0.334	0.068	0.303
50 Year	0.789	0.374	0.076	0.339
100 Year	0.863	0.409	0.084	0.371

Catchment Area ‘P2' - 18.44 hectares - Drainage Toward the North and East

$L = (A/1.5)^{1/2} = 350.65$ metres
Sw = 5.70%
C = 0.25

T_c = 29.22 minutes

A = 18.44 hectares

P2 Area - The peak discharge from the entire catchment is tabulated below.

Event	i pre	Q (cms)
5 Year	52.1	0.673
10 Year	62.4	0.806
25 Year	73.1	0.943
50 Year	82.1	1.059
100 Year	89.7	1.158

P2 Area - The peak discharge from each of the sub-catchment areas is tabulated below.

Event	Qt	Q2a	Q2b	Q2c
5 Year	0.673	0.280	0.033	0.359
10 Year	0.806	0.335	0.040	0.430
25 Year	0.943	0.393	0.047	0.504
50 Year	1.059	0.441	0.052	0.566
100 Year	1.158	0.482	0.057	0.618

POST DEVELOPMENT CALCULATIONS

Calculate runoff coefficient 'C' for area P1a (9 homes, Lots 1-9)

Surface	Area (m^2)	C	Area 'C"
Grass	55,240	0.25	13,810
Building	2,250	0.95	2,137.5
Pavement	810	0.95	769.5
TOTAL	**58,300**		**16,717**

Weighted C = 0.29

P1a Calculations

Tc = 19.7 minutes

Event	i post	Q (cms)
5 Year	65.7	0.307
10 Year	77.8	0.364
25 Year	91.0	0.426
50 Year	101.6	0.476
100 Year	111.2	0.521

Under Post-Development conditions, the peak discharge for P1a will increase by approximately 30%.

Calculate runoff coefficient ’C’ for area P1b (ROW)

Surface	Area (m²)	C	Area ‘C”
Grass	6,050	0.25	1,512.5
Gravel	1,815	0.70	1,270.5
Pavement	4,235	0.95	4,023.3
TOTAL	**12,100**		**6,806.3**

Weighted C = 0.56

<u>P1b Calculations</u>

Tc = 10 minutes (minimum)

Event	i post	Q (cms)
5 Year	91.0	0.173
10 Year	105.2	0.201
25 Year	122.6	0.234
50 Year	135.6	0.258
100 Year	148.6	0.283

Under Post-Development conditions, the peak discharge for P1b will increase by more than 3 times. This increase is due to the impervious roadway/driveway construction.

Calculate runoff coefficient 'C' for area P1c (5 homes - Lots 10-14)

Surface	Area (m^2)	C	Area 'C"
Grass	53,500	0.25	13,375
Building	1,250	0.95	1,187.5
Pavement	450	0.95	427.5
TOTAL	55,200		14,990

Weighted C = 0.27

P1c Calculations

Tc = 19.8 minutes

Event	i post	Q (cms)
5 Year	65.5	0.275
10 Year	77.6	0.326
25 Year	90.8	0.381
50 Year	101.4	0.426
100 Year	110.9	0.466

Under Post-Development conditions, the peak discharge for P1c will increase by approximately 25%.

Calculate runoff coefficient ’C’ for area P2a (5 homes - Lots 20-24)

Surface	Area (m^2)	C	Area ‘C”
Grass	75,100	0.25	18,785
Building	1,250	0.95	1,187.5
Pavement	450	0.95	427.5
TOTAL	**76,800**		**20,390**

Weighted C = 0.27

<u>P2a Calculations</u>

Tc = 23.0 minutes

Event	i post	Q (cms)
5 Year	60.1	0.343
10 Year	71.5	0.408
25 Year	83.7	0.478
50 Year	93.7	0.535
100 Year	102.5	0.585

Under Post-Development conditions, the peak discharge for P2a will increase by nearly 25%.

Calculate runoff coefficient 'C' for area P2b (ROW)

Surface	Area (m^2)	C	Area 'C"
Grass	4,550	0.25	1,137.5
Gravel	1,365	0.70	955.5
Pavement	3,185	0.95	3,025.8
TOTAL	**9,100**		**5,118.8**

Weighted C = 0.56

<u>P2b Calculations</u>

Tc = 10 minutes (minumum)

Event	i post	Q (cms)
5 Year	91.0	0.130
10 Year	105.2	0.151
25 Year	122.6	0.176
50 Year	135.6	0.194
100 Year	148.6	0.213

Under Post-Development conditions, the peak discharge for P2b will increase by nearly 4 times. This increase is due to the impervious roadway and driveway construction.

Calculate runoff coefficient 'C' for area P2c (5 homes - Lots 15-19)

Surface	Area (m^2)	C	Area 'C"
Grass	96,800	0.25	24,200
Building	1,250	0.95	1,187.5
Pavement	450	0.95	427.5
TOTAL	**98,500**		**25,815**

Weighted C = 0.26

<u>P2c Calculations</u>

Tc = 24.6 minutes

Event	i post	Q (cms)
5 Year	57.8	0.418
10 Year	68.9	0.498
25 Year	80.7	0.583
50 Year	90.4	0.653
100 Year	98.8	0.714

Under Post-Development conditions, the peak discharge for P2c will increase by approximately 15%.

P3 Calculations (Undisturbed Area)

Tc = 28.9 minutes

Event	i post	Q (cms)
5 Year	52.5	0.306
10 Year	62.9	0.367
25 Year	73.6	0.429
50 Year	82.7	0.482
100 Year	90.4	0.527

Under Post-Development conditions, the peak discharge for P3 will not increase, since the area will remain undisturbed.

PERMANENT STORMWATER MANAGEMENT CONTROL

The Hydrogeological & Site Servicing Study completed by Oakridge Environmental Ltd. determined that the percolation rate of the native soils ranged from 8-20 min/cm (30-75 mm/hr. The water table is also deep. The site conditions are suitable for infiltration systems such as soak-away pits.

The construction of soak-away pits to capture the runoff from the proposed building roof area for each lot is recommended (refer to Figure 7. From the Ontario Building Code, the rainfall data for Peterborough used for design purposes is a 28 mm rainfall for a 15 minute event and 85 mm rainfall over a 24 hour period. Allowing for a capture and infiltration of 25 mm over a 24 hour period, a 1.5 m x 12 m x 1.2 m storm trench would suffice. 50mm clear stone has a 40% void volume and the trench could store 8.64 cu. m of runoff. Using a soils percolation rate of 30 mm/hr, 12.96 cu m of runoff would infiltrate (1.5 x 12 x 0.03 x 24=12.96). The total storage and infiltration over 24 hours is 21.6 cu. m.

Runoff from the building roof is 20.19 cu m(0.085 x 250 x 0.95=20.19).
Note: That using the higher soils percolation rate of 75 mm/hr, the soils are capable of infiltrating 32.4 cu. m of runoff).

DRAFT PLAN OF PROPOSED SUBDIVISION
NORTH HALF LOT 9
WEST COMMUNICATION ROAD
TOWNSHIP OF SMITH-ENNISMORE LAKEFIELD
COUNTY OF PETERBOROUGH

SCALE 1: 4000

0 20 60 100

LEGEND:

- SUBJECT PROPERTY
- PROPOSED LOT LINES
- SWALE
- CONCEPTUAL DRILLED WELL LOCATION
- CONCEPTUAL FULLY RAISED CONVENTIONAL SEWAGE SYSTEM BASED ON 3000 L/DAY
- CONCEPTUAL RESIDENCE
- INFILTRATION TRENCH (TYPICAL 1.5m X 12m X 1.2m DEEP)

TOTAL SITE = 37.99± ha

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SCALE:	HORZ. 1: 4000

TOWNSHIP OF SMITH-ENNISMORE-LAKEFIELD

GENERAL OVERALL LOT LAYOUT PLAN

DATE:	MARCH, 2017
PROJECT:	P11-896
CAD FILE:	P11-896
DRAWING:	FIGURE 7

Constructing an infiltration trench on 23 lots (existing lot #15 to remain as is) will capture an infiltration of 50.5 cu. m of stormwater runoff over a 24 hour period.

The 23 lots total an area of 21.95 hectares (excluding existing lot # 15). The calculated runoff coefficient for the lot is C=0.28. With an 85mm rainfall event, the total runoff from the lots is 5 224 cubic metres and the infiltration trench will capture approximately 10% of the total runoff (Pre-development total runoff is 4 664 cu. m, c=0.25).

The stormwater runoff in the road right-of-way (Area P1b), will be captured in an infiltration area adjacent the road and the wetland buffer area.

Constructing a 120 metre long and 7 metre wide and 0.3 metre deep depressed area will capture 252 cu. m of runoff. Discharge will be over a flow spreader into the wetland buffer area. It will capture the flow from a 37.2 mm rainfall (12100 x 37.2 x 0.56=252).
During a 24 hour period the area will infiltrate 604.8 cu. m of runoff (120 x 7 x 0.03 x 24=604.8).

With storage, 856.8 cu. m of runoff will be captured over a 24 hour period. This is equivalent to capturing a 126 mm over 24 hour rainfall event. During a minor storm event there will not be any runoff into the wetland. Runoff during a major storm event will be substantially reduced from an uncontrolled condition.

Storm	T	Qp	Discharge Volume (cu. m)
5-YR	10	0.173	103.8
100-YR	10	0.283	169.8

Catchment 2-b will not be constructed with any stormwater quantity controls and catchment 1-b will be controlled with essentially 0 runoff, and 100% infiltration.
Both Stormwater Management quality and quantity control will need to be determined for the two (2) commercial lots during the site plan application.

Maximum velocities in grassed swales or ditches where grass is well established and the solids are easily eroded is 1.2 m/s. Where this velocity is exceeded, the ditch/swale will need to be rip-rapped c/w filter fabric (see excerpt in appendices).

4.0: Conclusions and Recommendations

4.0 Conclusions and Recommendations

Based on this analysis, we make the following conclusions and recommendations:

1. All erosion and sedimentation measures should be installed in accordance with Sections B and C of “Guidelines on Erosion and Sedimentation Control for Urban Construction Sites”, published by the Government of Ontario (MNR, MOE, MMA, MTO, Conservation Authorities, Municipal Engineers Association and the Urban Development Institute).

2. Contractor to follow best management practices (ie. fuelling and cleaning of equipment is not to be carried out near swales and ditches).

3. Disturbed areas are to be kept to a minimum and should be stabilized as soon a possible.

4. A silt fence barrier should be installed around the perimeter of all material stockpiles. The stockpiles should be seeded to establish a temporary vegetative cover if necessary.

5. The installation of a light duty silt fence along the property boundary prior to commencing major construction activities is recommended.

6. An inspection and maintenance schedule of all erosion and sedimentation measurers should be established and adhered to.

7. Install mud mat at entrance.

8. Install rock check dams/straw bales within road ditches and major drainage swales.

9. Permanent quality control for the site will be accomplished by passive measures.

10. The soak-away pits on each of the lots and the infiltration basin adjacent the wetland area will reduce the peak discharge from the development and provide Stormwater Management quantity controls.

Respectfully submitted.

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Appendix

Design Chart 1.07: Runoff Coefficients (Continued)

- Rural

Land Use & Topography[3]	Soil Texture		
	Open Sand Loam	Loam or Silt Loam	Clay Loam or Clay
CULTIVATED Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	0.22 0.30 0.40	0.35 0.45 0.65	0.55 0.60 0.70
PASTURE Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	0.10 0.15 0.22	0.28 0.35 0.40	0.40 0.45 0.55
WOODLAND OR CUTOVER Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	0.08 0.12 0.18	0.25 0.30 0.35	0.35 0.42 0.52
BARE ROCK	COVERAGE[3]		
	30%	50%	70%
Flat 0 - 5% Slopes Rolling 5 - 10% Slopes Hilly 10- 30% Slopes	0.40 0.50 0.55	0.55 0.65 0.70	0.75 0.80 0.85
LAKES AND WETLANDS	0.05		

2 Terrain Slopes

3 Interpolate for other values of % imperviousness

Sources: American Society of Civil Engineers - ASCE (1960)
U.S. Department of Agriculture (1972)

Recent studies have indicated that for these minimum flows the effect of pipe size is negligible. Therefore, these minimum grades for partially full pipe are not effected by minimum pipe size used.

d) Calculate the velocity of flow in the partially full sewer using Values of Hydraulic Elements of Circular Sections for Various Depths of Flow - Figures 1.3.2 and 1.3.5. See Section 1.3.6 for examples.

1.2.4 Maximum Velocities and Grades

1.2.4.1 Sewers

Little is known about the desirable maximum grades which should be permitted in sewers. Due to the possibility of erosion of the invert, if abrasive material is carried in the pipe, maximum velocities are usually limited to:

Sanitary sewers 3 to 4.6 m/s
Storm sewers 4.6 to 6 m/s

The grades which will produce these maximum velocities are shown on Figure 1.2.6.

1.2.4.2 Open Channels

The maximum velocities normally permitted in channels where no special provision is made for erosion protection, are as follows:

Soil Type	Maximum Permissible Velocities - m/sec
Fine sand	0.76
Fine gravel	1.5
Course gravel	1.8
Sandy loam	0.76
Silty loam	0.9

Ordinary firm loam	1.1
Stiff clay	1.5
Shales and hardpan	1.8

Where grass is well established, permissible velocities are:

Easily eroded soils	1.2 m/sec
Erosion resistant soils	1.5 m/sec

1.3 DESIGN OF SANITARY SEWERS

1.3.1 Introduction

Sanitary sewage is defined as a combination of (a) the liquid wastes conducted away from residences, commercial buildings and institutions and (b) the liquid wastes from industrial developments and (c) such ground, surface and storm water as may be admitted to or finds its way into the sanitary sewers. The allowance of water into sanitary sewers which does not contain objectionable impurities should not be permitted and such prohibition should be strictly enforced.

The flow rate of sewage, for which sewer capacity is to be provided, is determined from careful considerations of the present and probable future quantities of domestic sewage, commercial and industrial wastes, ground - water infiltration and any other unavoidable contributions.

A sanitary sewer has two main functions; namely (a) to carry the peak discharge for which it is designed and (b) to transport suspended solids so that deposits in the sewer are kept to a minimum - all to a satisfactory point for treatment or ultimate disposal. It is obviously essential that the sewers have adequate capacity for the peak flow and that they function at minimum flow without nuisance.