PRELIMINARY
STORMWATER MANAGEMENT PLAN

DAIN WEST

CITY OF WELLAND

Prepared for:

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   Erosion & Sediment Control Guidelines for Hamilton Harbour Watershed and Region of Hamilton-Wentworth (April 1994)

2. Stormwater Management Planning and Design Manual
   Ontario Ministry of the Environment (March 2003)

3. Stormwater Quality Best Management Practices
   Ontario Ministry of Environment and Energy (June 1991)

4. MTO Drainage Management Technical Guidelines
   Ontario Ministry of Transportation (November 1989)

EXECUTIVE SUMMARY

Upper Canada Planning & Engineering Ltd. (Upper Canada Consultants) has been retained by 555 Canal Bank Developments GP Inc. to prepare a Preliminary Stormwater Management Plan in support of the draft plan of subdivision application for the 74.7 hectare development known as Dain West, located on the former John Deere site in the City of Welland.

Stormwater quality improvements are to be provided to MECP Enhanced levels (80% TSS Removal) for stormwater discharging from the site into the Welland Recreational Canal to allow for the Environmental Compliance Approval review to be completed through the Transfer of Review process. Stormwater Quantity controls are not considered necessary for the development.

To provide the required MECP Enhanced quality improvement levels (80 % TSS Removal) prior to discharge into the Welland Recreational Canal, a stormwater management wet pond facility is proposed.

Based on the findings of this study, the following conclusions are offered:

- Infiltration techniques are not suitable for this site as the primary control facility due to the site size and soil conditions.
- Roof water leaders shall discharge to grade to enhance the future infiltration levels.
- A wet pond shall be constructed on this site to provide water quality controls.
- Various lot level and vegetative stormwater management practices can be implemented to enhance stormwater quality.
- This report was prepared in accordance with the provincial guidelines contained in “Stormwater Management Planning and Design Manual, March 2003".

The above conclusions lead to the following recommendations:

- That the stormwater management criteria established in this report be accepted.
- That a wet pond shall be constructed to provide stormwater quality control to the Welland Recreational Canal.
- That additional lot level controls and vegetative stormwater management practices as described in this report be implemented.
- That sediment and erosion controls during construction as described in this report be implemented.

PRELIMINARY
STORMWATER MANAGEMENT PLAN

DAIN WEST

CITY OF WELLAND

1.0 INTRODUCTION

1.1 Study Area

The proposed development area of Dain West is located within the southern section of the City of Welland known as Dain City, on the lands of the former John Deere facility. As shown on the Site Location Plan (Figure 1), the site is bounded by the Welland Recreational Canal on the west, St. Clair Drive on the south, the existing Gio Rail tracks to the east, and located south of Highway 58A. The study area includes the site proper and the existing wooded area located within the southeast portion of the subject lands.

1.2 Objectives

The objectives of this study are as follows:

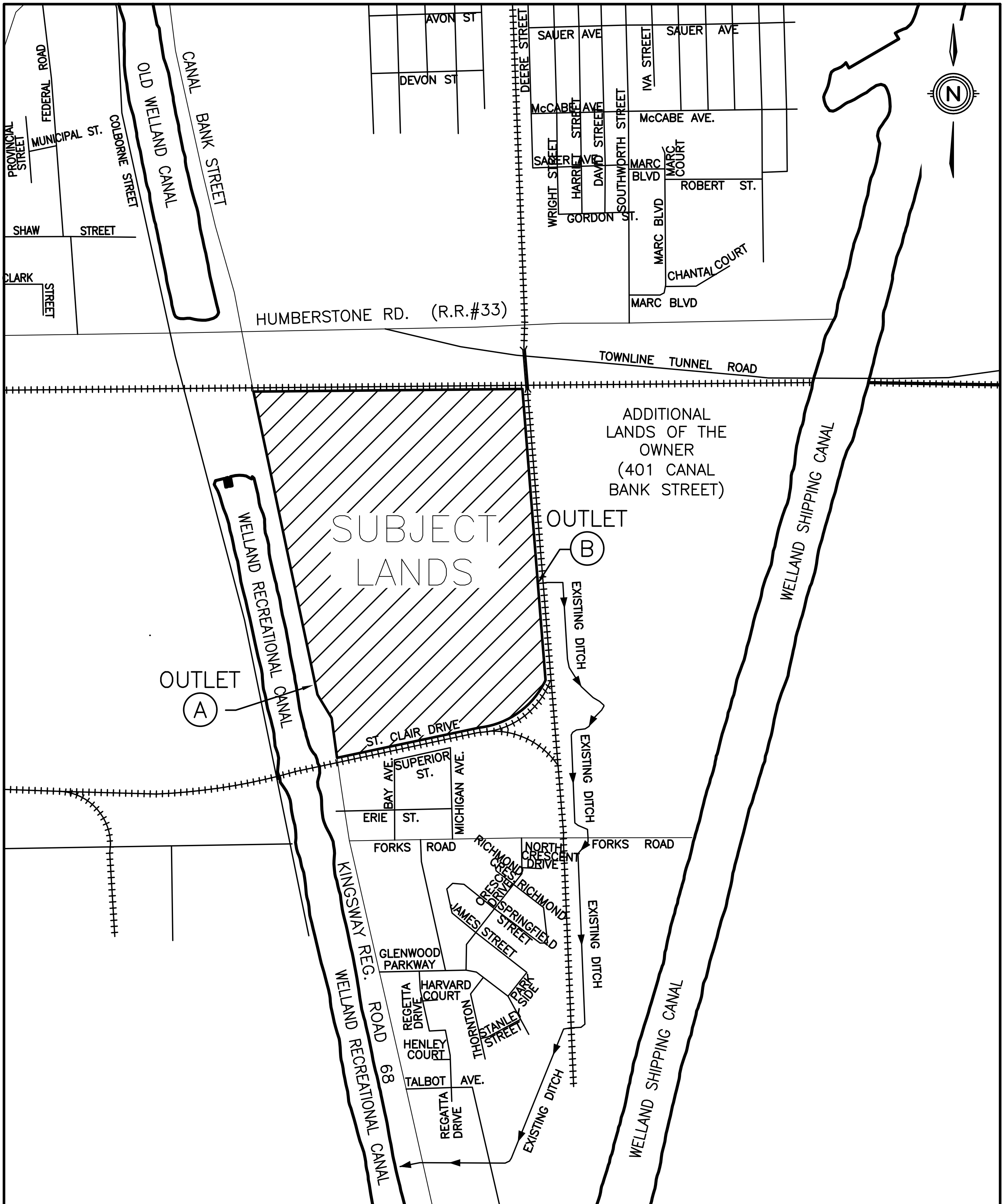
a. Establish criteria for the management of stormwater discharging from this site.

b. Determine the impact of development on the peak flow from this site.

c. Investigate alternatives for controlling the quality of stormwater runoff from this site.

d. Recommend a comprehensive plan for the management of stormwater runoff during and after construction.

e. Determine the land use requirements for the draft plan of subdivision.



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DAIN WEST

CITY OF WELLAND SITE LOCATION PLAN

DATE	2020–08–19
SCALE	N.T.S.
REF No.	**0585**
DWG No.	**FIGURE 1**

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1.3 Existing and Future Conditions

Existing Conditions

The existing drainage patterns for the subject lands convey stormwater flows overland to two outlets:

- Outlet A, the Welland Recreational Canal, via a series of existing culverts crossing Canal Bank Street; and,

- Outlet B, the eastern limit of the site draining by sheet and ditch flow to the existing Gio Rail lands through an existing culvert crossing. This area ultimately drains through an existing drainage system to the Welland Recreational Canal at a culvert located approximately 1.3 km south of the southern limit of the subject lands.

The native soils in the area consist of mainly silty clays. Review of the Ontario Institute of Pedology *"Soils of the Regional Municipality of Niagara Soil – Report Survey 60, 1989"* indicate that this soil type is classified as imperfectly drained by the Soil Conservation Service (SCS) classification method and is considered Hydrologic Soil Group CD.

Future Conditions

The proposed development of Dain West shall be predominantly a residential development consisting of approximately 780 residential units, a 4.06 hectare mixed use block, a 2.33 hectare school block, and associated park land and open space to the balance of the area.

The site shall be provided with full municipal services including sanitary sewers, storm sewers, watermains and urban roadways with asphalt pavement, catch basins and concrete curbs and gutters.

2.0 STORMWATER MANAGEMENT CRITERIA

New developments are required to provide stormwater management according to provincial and municipal policies including:

- Stormwater Quality Guidelines for New Development (MOEE/MNR, May 1991).
- Stormwater Management Planning and Design Manual (MOE, March 2003)

Based on policies from the City of Welland, Regional Municipality of Niagara, Niagara Peninsula Conservation Authority (NPCA), and the Ministry of Environment, Conservation and Parks (MECP) the following site specific considerations were identified:

- The receiving watercourse (Welland Recreational Canal) has been classified as Important Fish Habitat (Type 2) by the Ministry of Natural Resources. Based on this fish habitat classification, the corresponding minimum MECP level of protection for new developments in this watershed will be *Normal* (70% TSS removal).
- NPCA policy requires that all stormwater from new developments in Niagara are treated to a minium of Normal (70% TSS removal).
- Stormwater **quantity** controls and downstream erosion protection are not considered necessary for stormwater discharging directly to the Welland Recreational Canal (Outlet A).
- The receiving drainage system downstream of the Gio Rail culvert crossing at the eastern extent of the subject lands (Outlet B) contains lands that would be negatively impacted by an increase in peak stormwater flows.

Based on the above policies and site specific considerations, the following stormwater management criteria have been established for this site.

- Stormwater **quality** controls are to be provided for stormwater flows generated within the proposed development to a minimum of *Normal* Protection levels in accordance to MECP guidelines.
- Stormwater **quantity** controls and downstream erosion protection are **not** considered necessary for stormwater flows discharging directly to the Welland Recreational Canal (Outlet A). Therefore, the 25mm and 5 year design storm event shall only be considered when determining the extended detention volume for **quality** control and for sizing of the sediment forebay in accordance to MECP guidelines.
- Stormwater **quantity** controls will only be required **if** peak stormwater flows discharging easterly to the existing Gio Rail culvert crossing (Outlet B) exceed existing levels.

3.0 STORMWATER ANALYSIS

Stormwater for the existing and proposed conditions was estimated using the MIDUSS computer modelling program. This program was selected because it is applicable to both urban and rural drainage areas like the study area. It is relatively easy to use and modify for the future drainage conditions and control facilities. It readily allows for design storm hyetographs for the various return periods being investigated.

3.1 Design Storms

Design storm hyetographs for the storm system design uses a Chicago distribution based on the City of Welland Intensity-Duration-Frequency (IDF) curves. A hyetographs for the 5 year event was developed using a 4 hour Chicago distribution. The 25mm design storm event parameters were derived using the IDF curve and a 4 hour Chicago distribution. Table 1 summarizes the rainfall data applied in the stormwater modelling.

Table 1. Rainfall Data

Design Storm (Return Period)	Chicago Distribution Parameters			Duration (minutes)
	a	b	c	
25mm	510.00	5.70	0.800	240
5 Year	830.00	7.30	0.777	240

$$RainfallIntensity\ (mm/hr) = \frac{a}{(t_d + b)^c}$$

t_d = *Time of concentration/duration*

3.2 Existing Conditions

The existing drainage areas for the existing stormwater outlets shown in Figure 2 were assessed based on existing parameters shown in Table 2 and Table 3

3.3 Future Conditions

The stormwater management plan was assessed using the development conditions shown in Figure 3. It is proposed to use an urban storm sewer system to collect stormwater up to the 5 year design storm event and convey it to a central Stormwater Management Facility prior to discharge directly to the Welland Recreational Canal. Stormwater generated in excess of the 5 year design storm event shall be conveyed westerly overland, within the roadways, directly to the Welland Recreational Canal.

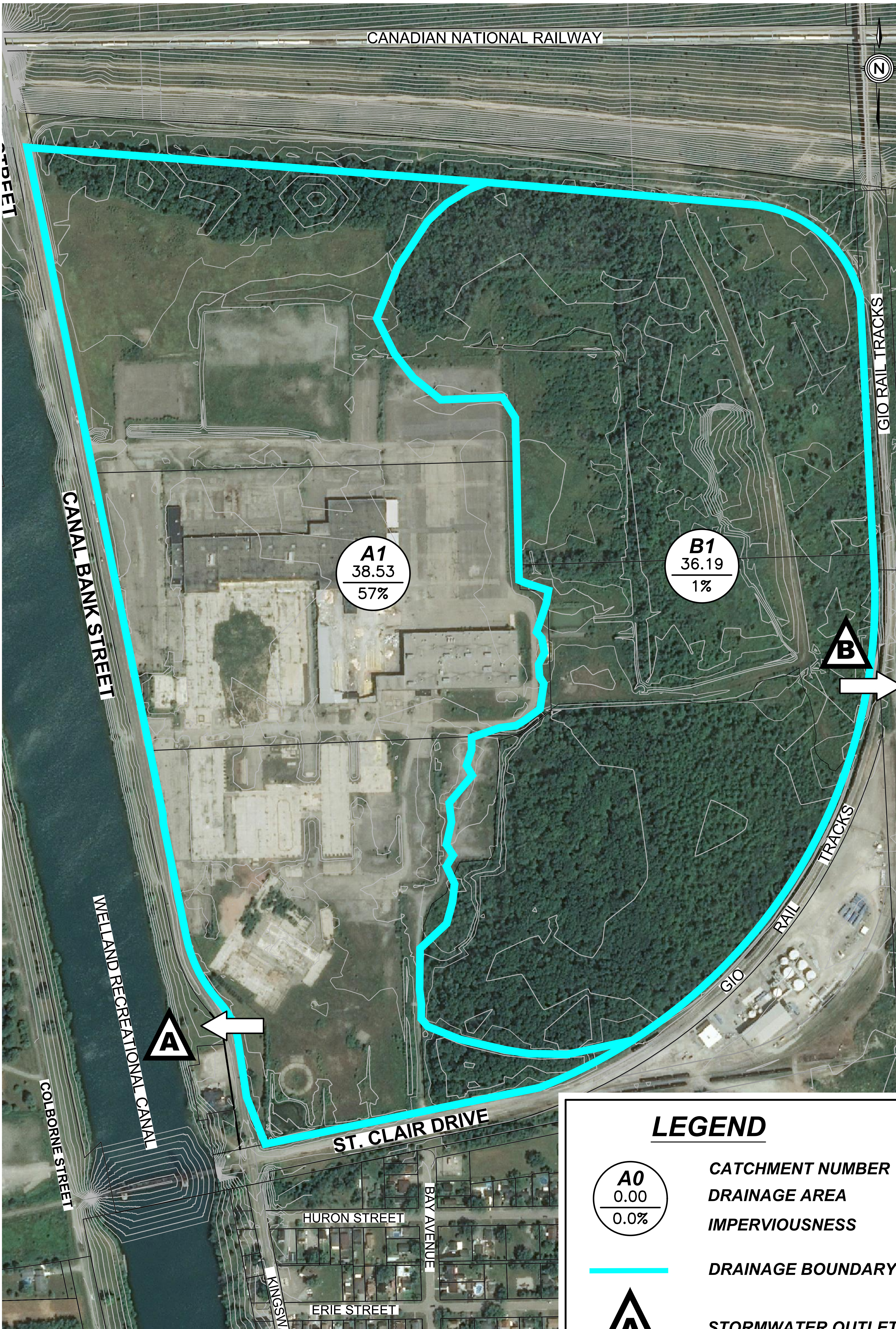
A minimum percent impervious value of 0.2% has been used within the MIDUSS model to avoid computational errors known to occur with an impervious value of 0%.

Table 2. Existing and Future Hydrologic Parameters - Outlet A								
Area No.	**Area (ha)**	**Length (m)**	**Slope (%)**	**Manning -"n"**		**Soil Type**	**SCS CN**	**Percent Impervious**
				Perv	**Imperv**			
Existing Conditions								
A1	38.53	507	1.0%	0.25	0.015	CD	77	57%
	38.53	**TOTAL** - Existing Conditions						
Future Conditions								
A10	4.43	172	0.5%	0.25	0.015	CD	77	5%
A20	6.98	216	0.5%	0.25	0.015	CD	77	5%
A21	37.78	502	1.0%	0.25	0.015	CD	77	65%
A22	6.18	203	1.0%	0.25	0.015	CD	77	50%
A23	2.24	122	1.0%	0.25	0.015	CD	77	0.2%
A30	1.96	114	0.5%	0.25	0.015	CD	77	5%
	59.57	**TOTAL** - Future Conditions						

Table 3. Existing and Future Hydrologic Parameters - Outlet B								
Area No.	**Area (ha)**	**Length (m)**	**Slope (%)**	**Manning -"n"**		**Soil Type**	**SCS CN**	**Percent Impervious**
				Perv	**Imperv**			
Existing Conditions								
B1	36.19	491	0.5%	0.25	0.015	CD	77	1%
	36.19	**TOTAL** - Existing Conditions						
Future Conditions								
B10	16.89	336	0.5%	0.25	0.015	CD	77	1%
	16.89	**TOTAL** - Future Conditions						

As shown in Table 3, the overall drainage area to Outlet B has decreased under the proposed site conditions.

The development of the site will cut off the northern portion of the drainage area contributing to Outlet B, which currently consists of solely open space with existing drainage ditches which serve only to convey the stormwater flows to the existing Gio Rail culvert crossing. The reduction in drainage area will result in a decrease in ponding at the Gio Rail culvert inlet and is expected to improve the existing drainage conditions within the downstream drainage system. Therefore, stormwater quantity controls are not required for stormwater discharging to the existing Gio Rail culvert crossing (Outlet B).



LEGEND

A0 / 0.00 / 0.0%	CATCHMENT NUMBER DRAINAGE AREA IMPERVIOUSNESS
(cyan line)	DRAINAGE BOUNDARY
A (triangle)	STORMWATER OUTLET

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EXISTING STORM DRAINAGE AREAS

DATE	2020–08–18
SCALE	1:4000 m
REF No.	0585
DWG No.	FIGURE 2

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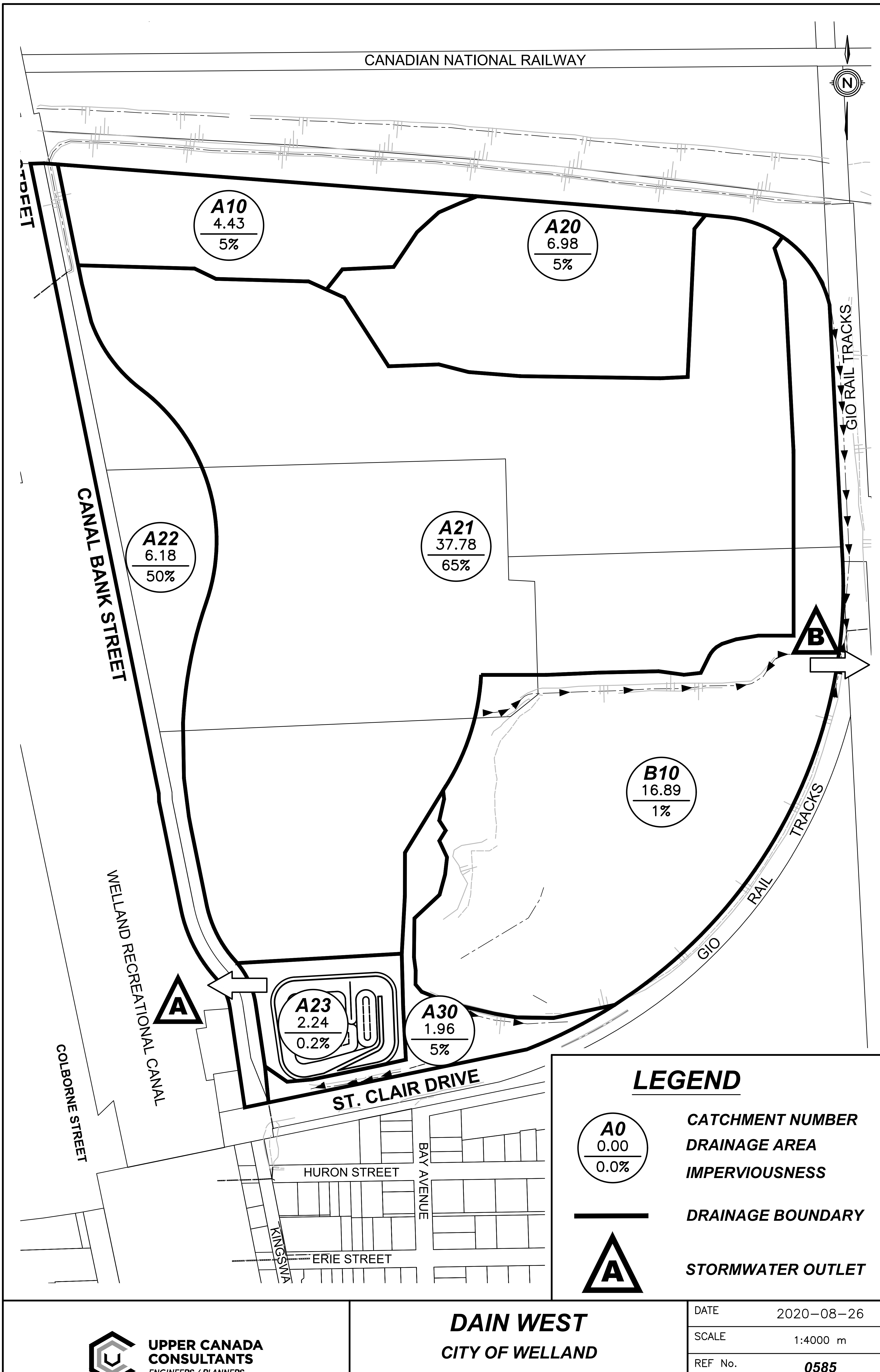

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FUTURE STORM DRAINAGE AREAS

DATE	2020–08–26
SCALE	1:4000 m
REF No.	0585
DWG No.	FIGURE 3

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4.0 STORMWATER MANAGEMENT ALTERNATIVES

4.1 Screening of Stormwater Management Alternatives

A variety of stormwater management alternatives are available to control the quantity and quality of stormwater, most of which are described in the Stormwater Management Planning and Design Manual (MOE, March 2003). Alternatives for this site were considered in the following broad categories: lot level, vegetative, infiltration and surface storage controls. An evaluation of the individual alternatives is provided in Table 4 with comments on the effectiveness and applicability to this site.

a. Lot Level Controls

Lot level controls are not generally suitable as the primary control facility for quality control. They are generally used to enhance stormwater quality levels in conjunction with other types of control facilities. Where soils are suitable, infiltration techniques can be very effective in providing quantity and quality control.

b. Vegetative Alternatives

Vegetative stormwater management practices are generally not suitable as the primary control facility for quantity or quality controls. They are generally used to reduce the rate of stormwater and to enhance stormwater quality in conjunction with other types of control facilities.

c. Infiltration Alternatives

Where soils are suitable, infiltration alternatives can be very effective in providing both quality and quantity controls. However, economics generally limit the use of these techniques to relatively small sites (<1.5 ha). The soils on this site are predominantly clay with infiltration rates of less than 12 mm/hr. Infiltration alternatives may provide some quality benefits, however, due to the low infiltration rates and large development site, infiltration alternatives are not considered feasible for the primary control facilities.

d. Surface Storage

Surface storage techniques can be very effective in providing both quality and quantity control. Wetlands are generally the most efficient method of water quality control, however require more attention to maintenance than a wet pond and the 53.18 ha drainage area will generate sufficient stormwater to maintain permanent a wet pool. Therefore, a wet pond is recommended for the stormwater management facility to provide quality control.

e. End-of-pipe Alternatives

End-of-pipe techniques can be effective in providing quality control. Oil/grit separators are effective for water quality control, but are limited to small drainage areas.

4.2 Selection of Stormwater Management Alternatives

Stormwater management alternatives were screened based on technical effectiveness, physical suitability for this site, and their ability to meet the stormwater management criteria established for this site. The following stormwater management alternatives are recommended for implementation on this site:

a. **Lot grading** to be kept as flat as practical in order to slow down stormwater and encourage infiltration.

b. **Roof water leaders** to be discharged to the ground surface in order to slow down stormwater and encourage infiltration.

c. **Grassed swales** to be used to collect and convey rear lot drainage where possible between units.

d. **A wet pond** to provide stormwater quality control for frequent storms discharging to Outlet A.

Table 4. Evaluation of Stormwater Management Practices								
Dain West	**Criteria for Implementation of Stormwater Management Practices (SWMP)**					**Technical Effectiveness (10 high)**	**Recommend Implementation Yes / No**	**Comments**
	Topography	**Soils**	**Bedrock**	**Groundwater**	**Area**			
Site Conditions	***Variable 1.5 - 6%***	***Clay <12mm/hr***	***At Considerable Depth***	***At Considerable Depth***	***±53.18 ha***			
Lot Level Controls								
Lot Grading	<5%	nlc	nlc	nlc	nlc	2	Yes	Quality/quantity benefits
Roof Leaders to Surface	nlc	nlc	nlc	nlc	nlc	2	Yes	Quality/quantity benefits
Roof Ldrs.to Soakaway Pits	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 0.5 ha	6	No	Quality/quantity benefits
Sump Pump Fdtn. Drains	nlc	nlc	nlc	nlc	nlc	2	No	Unsuitable site soil conditions
Vegetative								
Grassed Swales	< 5 %	nlc	nlc	nlc	nlc	7	Yes	Quality/quantity benefits
Filter Strips(Veg. Buffer)	< 10 %	nlc	nlc	>.5m Below Bottom	< 2 ha	5	No	Unsuitable site conditions
Infiltration								
Infiltration Basins	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 5 ha	2	No	Unsuitable site soil conditions
Infiltration Trench	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 2 ha	4	No	Quality/quantity benefits
Rear Yard Infiltration	< 2.0 %	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 0.5 ha	7	No	Unsuitable site soil conditions
Perforated Pipes	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	nlc	4	No	Unsuitable site soil conditions
Pervious Catch basins	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	nlc	3	No	Unsuitable site soil conditions
Sand Filters	nlc	nlc	nlc	>.5m Below Bottom	< 5 ha	5	No	High maintenance/poor aesthetics
Surface Storage								
Dry Detention Facility	nlc	nlc	nlc	nlc	> 5 ha	7	No	Less effective than wet facilities
Wet Ponds	nlc	nlc	nlc	nlc	> 5 ha	10	Yes	Greater volume of storage required
Wet Lands	nlc	nlc	nlc	nlc	> 5 ha	9	No	Very effective quality control
Other								
Oil/Grit Separator	nlc	nlc	nlc	nlc	< 2.7 ha	8	No	Effective quality control

Reference : Stormwater Management Planning and Design Manual - 2003

nlc - No Limiting Criteria

5.0 STORMWATER MANAGEMENT PLAN

A MIDUSS model was created to assess future peak flows and stormwater volumes generated by the proposed subdivision. The stormwater management wet pond facility was sized according to MECP Guidelines (MOE, March 2003) as follows:

5.1 Wet Pond Facility

Water Quality

The stormwater drainage outlet for the proposed development is the Welland Recreational Canal, where *Normal* protection is recommended in accordance with MECP requirements. The proposed wet pond facility will be designed to provide *Enhanced* protection (80% TSS Removal) to allow for the Environmental Compliance Approval review to be completed through the Transfer of Review process. Based on Table 3.2 of SWMP & Design Manual, the *Enhanced* water quality storage requirement for wet pond facilities in a development with 53% overall impervious area is approximately 185 m^3/ha. A corresponding drainage area of approximately 53.18 hectares (A20, A21, A22, and A23) was used to determine the quality control sizing requirements.

Table 5. Stormwater Quality Volume Calculations	
Total Water Quality Volume = 53.18 ha x 185 m^3/ha = 9,838 m^3	Reference: Table 3.2, SWMP & Design Manual (MOE 2003)
Permanent Pool Volume = 53.18 ha x 145 m^3/ha = 7,711 m^3	**Active Pool Volume** = 53.18 ha x 40 m^3/ha = 2,127 m^3

Erosion Control

Using the MIDUSS hydrological model, the stormwater volume from the 25mm - 4 hour design storm event for 53.18 hectares is 6,390 m^3. The following table shows the stormwater storage volumes required using both the water quality and erosion control guidelines.

Table 6. Stormwater Quality Volume Requirements	
A. Permanent Pool Volume	7,711 m^3
B. Extended Detention Volume	2,127 m^3
C. Stormwater Volume from 25mm - 4 hour rainfall event	6,390 m^3
D. Maximum Extended Detention Volume (greater of B & C)	6,390 m^3
Total Quality and Extended Detention Volume (A+D)	14,101 m^3

Preliminary conceptual design has been undertaken, however detailed engineering will be required as part of the overall design, a two stage outlet control structure for the pond is proposed. The first stage of control consists of an orifice to detain the extended detention volume and release it slowly over an extended period of time. The second stage of control is provided by a ditch inlet catch basin and outlet pipe which provides an outlet for flows exceeding the extended detention volume.

The bottom elevation of the facility permanent pool is 172.50 and the permanent pool water level is 174.50, providing a permanent pool depth of 2.0 m of approximately 7,873 m^3, which is greater than the required volume of 7,711 m^3. Based on the configuration of the proposed wet pond, it was determined that a 200mm diameter reverse slope outlet pipe would be required to provide approximately 63.6 hours of detention for the extended detention volume of storage. The rim elevation for the ditch inlet chamber is proposed at 176.00 and will provide a maximum extended detention volume of 12,588 m^3 which is greater than the required 6,390 m^3 shown in Table 7. A 525mm diameter outflow orifice from the pond outlet/ditch inlet structure shall control the total stormwater flows discharging from the facility to the Welland Recreational Canal. During major storm events, the stormwater shall surcharge from the internal storm sewer system and travel westerly overland within the proposed roadways to discharge directly to the Welland Recreational Canal.

A sediment forebay has been included in this stormwater management wet pond facility to minimize the transport of heavy sediment from the storm sewer outlet throughout the facility and to localize maintenance activities. Calculations for the forebay sizing are shown in Table 7 in accordance with MECP Guidelines.

Table 7. Stormwater Management Facility North Forebay Sizing

a) Forebay Settling Length (MOE SWMP&D, Equation 4.5)

$$Settling\ Length = \sqrt{\frac{r * Qp}{Vs}}$$

r =	7.1	:1	(Length:Width Ratio)
Q_p =	0.064	m^3/s	(25mm Storm Pond Discharge)
V_s =	0.0003	m/s	(Settling Velocity)

Settling Length = **39.04 m**

b) Dispersion Length (MOE SWMP&D, Equation 4.6)

$$Dispersion\ Length = \frac{8\ Q}{D\ V_f}$$

Q =	4.745	m^3/s	(5 Yr Stm Sew Design Inflow)
D =	1.60	m	(Depth of Forebay)
V_f =	0.5	m/s	(Desired Velocity)

Dispersion Length = **47.45 m**

c) Minimum Forebay Deep Zone Bottom Width (MOE SWMP&D, Equation 4.7)

$$Width = \frac{Dispersion\ Length}{8}$$

Minimum Forebay Length from Equations 3.3 and 3.4

47.45 m (minimum required length)

Width = **5.93 m** (minimum required width)

d) Average Velocity of Flow

$$Average\ Velocity = \frac{Q}{A}$$

Q =	2.004	m^3/s	(Storm Sewer Quality Design Inflow)
A =	24.00	m^2	(Cross Sectional Area)
D =	1.60	m	(Depth of Forebay)
W =	7.00	m	(Proposed Bottom Width)
SS =	5	:1	(Side slopes - minimum)

Average Velocity = **0.08 m/s**

Is this Acceptable? **Yes** (Maximum velocity of flow = 0.15 m/s)

e) Cleanout Frequency

Is this Acceptable? **Yes**

L =	50.0	m	(Proposed Bottom Length)
ASL =	1.8	m^3/ha	(Annual Sediment Loading)
A =	53.18	ha	(Drainage Area)
FRC =	80	%	(Facility Removal Efficiency)
FV =	1494.4	m^3	(Forebay Volume)

Cleanout Frequency = **12.5 years**

Is this Acceptable? **Yes** (10 year minimum cleanout frequency)

Based on the MIDUSS model, Table 8 shows a maximum wet pond elevation of 175.99 m and an active storage volume of 12,464 m^3 for the 5 year design storm event.

Table 8. Proposed Wet Pond Facility Characteristics

Design Storm (Return Period)	Peak Flows (m^3/s)		Ponding Depth (m)	Maximum Elevation (m)	Maximum Volume (m^3)
	Inflow	Outflow			
25mm	2.004	0.064	0.70	175.20	5,204
5 Year	4.745	0.101	1.49	175.99	12,464

5.2 Stormwater Management Facility Maintenance

Maintenance is a necessary and important aspect of urban stormwater quality and quantity measures such as wet ponds. Many pollutants (ie. nutrients, metals, bacteria, etc.) bind to sediment and therefore removal of sediment on a scheduled basis is required.

The wet pond for this development may be subjected to infrequent wetting and deposition of sediments as a result of infrequent high intensity storm events. The purpose of the facility is to reduce suspended solids loading on the receiving waterways and minimize potential downstream erosion. For the initial operation period of the stormwater management facility, the required frequency of maintenance is not definitively known and many of the maintenance tasks will be performed on a 'as required' basis. For example, during the home construction phase of the development there will be a greater potential for increased maintenance frequency, which depends on the effectiveness of sediment and erosion control techniques employed.

Inspections of the facilities will indicate whether or not maintenance is required. Inspections should be made after every significant storm during the first two years of operation or until all development is completed to ensure the facility is functioning properly. This may translate into an average of six inspections per year. Once all building activity is finalized, inspections will be performed annually.

The following points should be addressed during inspections of the facility.

a) Standing water above the outlet structure bottom a few days or more after a storm may indicate a blockage in the outlet or orifice. The blockage may be caused by trash or sediment and a visual inspection would be required to determine the cause.

b) The vegetation around the pond should be inspected to ensure its function and aesthetics. Visual inspections will indicate whether replacement of plantings is required. A decline in vegetation habitat may indicate that other aspects of the facility are operating improperly, such as the detention times may be inadequate or excessive.

c) The accumulation of sediment and debris at the inlet or around the high water line of the facility should be inspected. This will indicate the need for sediment removal or debris clean up.

d) The facility has been created by excavating a detention volume. The integrity of the embankment should be periodically checked to ensure that it remains stable and the side slopes have not sloughed.

Grass cutting is a maintenance activity that is done solely for aesthetic purposes. It is recommended that grass cutting be limited to the upper embankment areas. It should be noted that municipal by-laws may require regular grass maintenance for weed control.

Trash removal is an integral part of maintenance. Annual cleanup, usually in the spring, is a minimum requirement. After this, trash removal is performed as required based on observation of trash build-up during inspections.

To ensure long term effectiveness, the sediment that accumulates in the forebay area should be removed periodically. Upon full build-out of the development, the sediment forebay is expected to require clean-out approximately every 10.9 years per Table 7. During construction, increased sediment loading is to be expected and will require annual inspection and clean-out. For sediment removal operations, typical grading/excavating equipment should be used to remove sediment from detention areas. Care should be taken to ensure that limited damage occurs to existing vegetation and habitat.

5.3 Existing Slough Forest Flows (A20)

As shown in Figure 3, drainage area A20 consists of the eastern portion of the Slough Forest within Block 73, along the northern limit of the subject lands. This drainage area contains the extreme upstream portions of the existing drainage ditches which have been cut off as a result of the proposed development. The existing topography of the area generally slopes southerly to the existing drainage ditch flowing west to east within Block 73, approximately 15m north of the rear lot lines of Blocks 27, 33, and 39.

It is proposed to construct a ditch inlet structure in the open space between Blocks 33 and 39 to capture the peak stormwater flows from A20 and convey them to the proposed wet pond facility through the internal storm sewer system. The proposed ditch inlet structure shall be constructed with a rim elevation of 176.44m to capture the peak stormwater flows within the existing ditch. The internal storm sewers shall be sized to convey stormwater generated up to the 5 year design storm event. For the major storm events (up to the 100 year design storm event), ponding within the existing drainage ditch is expected. As shown in the MIDUSS output found in Appendix C, a maximum water surface elevation of 176.93m is expected during the 100 year design storm event based on the existing topography of the drainage area. The top of the existing ditch bank has a minimum elevation of approximately 177.12m on the south side of the ditch. Therefore, there is adequate volume within the existing drainage ditch to contain the peak 100 year flows without impacting the units backing onto Block 73.

6.0 SEDIMENT AND EROSION CONTROL

Sediment and erosion controls are required during all construction phases of this development to limit the transport of sediment into downstream watercourses. Proposed sediment and erosion controls will be provided as part of the final design and will include:

- Silt control fencing to minimize the transport of sediment offsite from the construction process.
- Straw bale filters in accordance with MNR/MECP guidelines.
- Re-vegetate disturbed areas as soon as possible after grading works have been completed.

7.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the findings of this study, the following conclusions are offered:

- Infiltration techniques are not suitable for this site as the primary control facility due to the site size and soil conditions.
- Roof water leaders shall discharge to grade to enhance the future infiltration levels.
- A wet pond shall be constructed on this site to provide water quality controls.
- Various lot level and vegetative stormwater management practices can be implemented to enhance stormwater quality.
- This report was prepared in accordance with the provincial guidelines contained in "Stormwater Management Planning and Design Manual, March 2003".

The above conclusions lead to the following recommendations:

- That the stormwater management criteria established in this report be accepted.
- That a wet pond shall be constructed to provide stormwater quality control to Outlet A.
- Neither quantity or quality controls are considered necessary to Outlet B due to the overall reduction in stormwater drainage area.
- That additional lot level controls and vegetative stormwater management practices as described previously in this report be implemented.
- That sediment and erosion controls during construction as described in this report be implemented.

Prepared By:

Brendan Kapteyn, E.I.T.

Reviewed By:

Adam Keane, P.Eng.

APPENDICES

APPENDIX A

Stormwater Management Facilities Calculations

Upper Canada Consultants
3-30 HANNOVER DRIVE
St. Catharines, Ontario L2W 1A3
PROJECT NAME: **Dain West**
PROJECT NO.: **0585**

PROPOSED WETPOND CALCULATIONS

Quality Requirements
Drainage Area (ha) = 53.18
Enhanced@53% (m3/ha) = 185
Perm Pool (m3/ha) = 145
Perm Pool Vol (m3) = 7,711
Required Vol (m3) 9,838
25mm MECP (m3) 6,390
Perm. Pool Elev. = 174.50 m

Quality Orifice
Diameter (m) = 0.200
Cd = 0.63
Invert (m) = 174.50

Ditch Inlet Weir
Length (m) = 0.60
Grate Slope (X:1) = 4
Inlet Elevation (m) = 176.00

Outflow Pipe Orifice
Diameter (m) = 0.525
Cd = 0.63
Invert (m) = 174.50
Overt (m) = 175.03

MOE Equation 4.10 Drawdown Coefficient 'C2' = 2,513
MOE Equation 4.10 Drawdown Coefficient 'C3' = 6,498
MOE Equation 4.10 Drawdown Time (h) = **63.6**

Elevation	Increment Depth (m)	Active Depth (m)	Surface Area (m2)	Average Surface Area (m2)	Increment Volume (m3)	Permanent Volume (m3)	Active Volume (m3)	Quality Orifice (m3/s)	Ditch Inlet (m3/s)	Max Pipe Orifice (m3/s)	Total Outflow (m3/s)	Average Discharge (m3/s)	Side Slope (H:V)
172.50		-2.00	2,724			0							
	1.00			3,310.02	3,310.02								5:1
173.50		-1.00	3,896			3,310							
	1.00			4,562.99	4,562.99								5:1
174.50		0.00	5,230			**7,873**							
	0.00												5:1
174.50		0.00	6,496				0	0.000	0.000	0.000	0.000		
	0.50			7,101.39	3,550.69							0.027	5:1
175.00		0.50	7,706				3,551	0.053	0.000	0.141	0.053		
	0.50			8,409.79	4,204.90							0.067	5:1
175.50		1.00	9,113				7,756	0.082	0.000	0.487	0.082		
	0.50			9,664.80	4,832.40							0.092	5:1
176.00		**1.50**	**10,216**				**12,588**	**0.102**	**0.000**	**0.648**	0.102		
	0.50			10,792.34	5,396.17							0.222	5:1
176.50		2.00	11,368				17,984	0.120	0.362	0.776	0.481		
	0.50			11,893.23	5,946.62							0.684	5:1
177.00		2.50	12,418				23,931	0.135	1.023	0.886	0.886		
	0.50			12,960.79	6,480.39							0.935	5:1
177.50		3.00	13,503				30,411	0.148	1.880	0.984	0.984		

Notes

1. Quality Orifice flow is the orifice controlling for the 24 hour detention period and uses an orifice formula.
2. Pipe Orifice flow is calcuated using an orifice formula on the pipe from the ditch inlet to the outlet and uses the total head on the orifice.
3. Overflow Weir flow is calculated using a trapezondial weir to convey outflow for less frequent storms through the embankment with an emergency spillway.
4. Total Outflow is calculated by adding the Overflow Spillway with the lowest of Quality Orifice plus Ditch Inlet or Max Pipe Orifice.

APPENDIX B

Future Drainage Analysis Output Files

```
      Output File (4.7) SWM25M.OUT   opened 2020-08-17  14:19
      Units used are defined by G =    9.810
         144   288    10.000        are MAXDT MAXHYD & DTMIN values
      Licensee: UPPER CANADA CONSULTANTS
 35   COMMENT
     3     line(s) of comment
      JOHN DEERE, CITY OF WELLAND
      STORMWATER MANAGEMENT PLAN
      POST DEVELOPMENT CONDITIONS WITH STORMWATER MANAGEMENT
 14   START
     1     1=Zero; 2=Define
 35   COMMENT
     1     line(s) of comment
      25mm MOE EROSION CONTROL DESIGN STORM
  2   STORM
         1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
    510.000     Coefficient  a
      5.700     Constant  b    (min)
       .800     Exponent  c
       .450     Fraction to peak  r
    240.000     Duration ó 1440 min
              24.961 mm     Total depth
  3   IMPERVIOUS
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .015     Manning "n"
     98.000     SCS Curve No or C
       .100     Ia/S Coefficient
       .518     Initial Abstraction
 35   COMMENT
     1     line(s) of comment
      DAIN WEST TO PROPOSED SWM FACILITY
  4   CATCHMENT
     20.000     ID No.ó 99999
      6.980     Area in hectares
    216.000     Length (PERV) metres
       .500     Gradient (%)
      5.000     Per cent Impervious
    216.000     Length (IMPERV)
       .000     %Imp. with Zero Dpth
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .250     Manning "n"
     77.000     SCS Curve No or C
       .100     Ia/S Coefficient
      7.587     Initial Abstraction
         1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
           .033       .000       .000       .000 c.m/s
           .130       .802       .163     C perv/imperv/total
 15   ADD RUNOFF
           .033       .033       .000       .000 c.m/s
  4   CATCHMENT
     21.000     ID No.ó 99999
     37.780     Area in hectares
    502.000     Length (PERV) metres
      1.000     Gradient (%)
     65.000     Per cent Impervious
    502.000     Length (IMPERV)
       .000     %Imp. with Zero Dpth
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .250     Manning "n"
     77.000     SCS Curve No or C
       .100     Ia/S Coefficient
      7.587     Initial Abstraction
         1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
          1.676       .033       .000       .000 c.m/s
           .130       .802       .566     C perv/imperv/total
 15   ADD RUNOFF
          1.676      1.708       .000       .000 c.m/s
  4   CATCHMENT
     22.000     ID No.ó 99999
      6.180     Area in hectares
    203.000     Length (PERV) metres
      1.000     Gradient (%)
     50.000     Per cent Impervious
    203.000     Length (IMPERV)
       .000     %Imp. with Zero Dpth
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .250     Manning "n"
     77.000     SCS Curve No or C
       .100     Ia/S Coefficient
      7.587     Initial Abstraction
         1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
           .295      1.708       .000       .000 c.m/s
           .130       .805       .467     C perv/imperv/total
 15   ADD RUNOFF
           .295      2.003       .000       .000 c.m/s
  4   CATCHMENT
     23.000     ID No.ó 99999
      2.240     Area in hectares
    122.000     Length (PERV) metres
       .500     Gradient (%)
       .200     Per cent Impervious
    122.000     Length (IMPERV)
       .000     %Imp. with Zero Dpth
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .250     Manning "n"
     77.000     SCS Curve No or C
       .100     Ia/S Coefficient
      7.587     Initial Abstraction
         1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
           .005      2.003       .000       .000 c.m/s
           .130       .806       .131     C perv/imperv/total
 15   ADD RUNOFF
           .005      2.004       .000       .000 c.m/s
 27   HYDROGRAPH DISPLAY
     5     is # of Hyeto/Hydrograph chosen
      Volume  =  .6414066E+04 c.m
 10   POND
     7 Depth - Discharge - Volume sets
      174.500        .000          .0
      175.000       .0530      3551.0
      175.500       .0820      7756.0
      176.000        .102     12588.0
      176.500        .481     17984.0
      177.000        .886     23931.0
      177.500        .984     30411.0
      Peak Outflow    =       .064 c.m/s
      Maximum Depth   =   175.197 metres
      Maximum Storage =     5204. c.m
           .005      2.004       .064       .000 c.m/s
 16   NEXT LINK
           .005       .064       .064       .000 c.m/s
 14   START
     1     1=Zero; 2=Define
 35   COMMENT
     1     line(s) of comment
      5 YEAR DESIGN STORM - MINOR SYSTEM SIZING STORM
  2   STORM
         1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
    830.000     Coefficient  a
      7.300     Constant  b    (min)
       .777     Exponent  c
       .450     Fraction to peak  r
    240.000     Duration ó 1440 min
              45.874 mm     Total depth
  3   IMPERVIOUS
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .015     Manning "n"
     98.000     SCS Curve No or C
       .100     Ia/S Coefficient
       .518     Initial Abstraction
 35   COMMENT
     1     line(s) of comment
      DAIN WEST TO PROPOSED SWM FACILITY
  4   CATCHMENT
     20.000     ID No.ó 99999
      6.980     Area in hectares
    216.000     Length (PERV) metres
       .500     Gradient (%)
      5.000     Per cent Impervious
    216.000     Length (IMPERV)
       .000     %Imp. with Zero Dpth
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .250     Manning "n"
     77.000     SCS Curve No or C
       .100     Ia/S Coefficient
      7.587     Initial Abstraction
         1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
           .079       .000       .000       .000 c.m/s
           .280       .883       .310     C perv/imperv/total
 15   ADD RUNOFF
           .079       .079       .000       .000 c.m/s
  4   CATCHMENT
     21.000     ID No.ó 99999
     37.780     Area in hectares
    502.000     Length (PERV) metres
      1.000     Gradient (%)
     65.000     Per cent Impervious
    502.000     Length (IMPERV)
       .000     %Imp. with Zero Dpth
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .250     Manning "n"
     77.000     SCS Curve No or C
       .100     Ia/S Coefficient
      7.587     Initial Abstraction
         1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
          4.128       .079       .000       .000 c.m/s
           .280       .885       .673     C perv/imperv/total
 15   ADD RUNOFF
          4.128      4.203       .000       .000 c.m/s
  4   CATCHMENT
     22.000     ID No.ó 99999
      6.180     Area in hectares
    203.000     Length (PERV) metres
      1.000     Gradient (%)
     50.000     Per cent Impervious
    203.000     Length (IMPERV)
       .000     %Imp. with Zero Dpth
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .250     Manning "n"
     77.000     SCS Curve No or C
       .100     Ia/S Coefficient
      7.587     Initial Abstraction
         1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
           .534      4.203       .000       .000 c.m/s
           .280       .879       .580     C perv/imperv/total
 15   ADD RUNOFF
           .534      4.736       .000       .000 c.m/s
  4   CATCHMENT
     23.000     ID No.ó 99999
      2.240     Area in hectares
    122.000     Length (PERV) metres
       .500     Gradient (%)
       .200     Per cent Impervious
    122.000     Length (IMPERV)
       .000     %Imp. with Zero Dpth
         1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
       .250     Manning "n"
     77.000     SCS Curve No or C
       .100     Ia/S Coefficient
      7.587     Initial Abstraction
         1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
           .033      4.736       .000       .000 c.m/s
           .280       .872       .281     C perv/imperv/total
```

```
15     ADD RUNOFF
              .033      4.745       .000       .000 c.m/s
27     HYDROGRAPH DISPLAY
      5     is # of Hyeto/Hydrograph chosen
       Volume  =  .1457114E+05 c.m
10     POND
      7 Depth - Discharge - Volume sets
       174.500        .000          .0
       175.000       .0530      3551.0
       175.500       .0820      7756.0
       176.000        .102     12588.0
       176.500        .481     17984.0
       177.000        .886     23931.0
       177.500        .984     30411.0
       Peak Outflow    =      .101 c.m/s
       Maximum Depth   =   175.987 metres
       Maximum Storage =    12464. c.m
              .033      4.745       .101       .000 c.m/s
16     NEXT LINK
              .033       .101       .101       .000 c.m/s
14     START
      1     1=Zero; 2=Define
```

APPENDIX C

100 Year Drainage Analysis Output Files (A20)

```
       Output File (4.7) SWM100.OUT   opened 2020-08-14  11:39
       Units used are defined by G =    9.810
          144   288    10.000        are MAXDT MAXHYD & DTMIN values
       Licensee: UPPER CANADA CONSULTANTS
35     COMMENT
      3     line(s) of comment
       DAIN WEST, CITY OF WELLAND
       STORMWATER MANAGEMENT PLAN
       EXISTING SLOUGH FOREST FLOWS
14     START
      1     1=Zero; 2=Define
35     COMMENT
      1     line(s) of comment
       100-YEAR DESIGN STORM EVENT
 2     STORM
           1     1=Chicago;2=Huff;3=User;4=Cdn1hr;5=Historic
    1020.000     Coefficient  a
       4.700     Constant  b    (min)
        .731     Exponent  c
        .450     Fraction to peak  r
     240.000     Duration ó 1440 min
              73.203 mm     Total depth
 3     IMPERVIOUS
           1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
        .015     Manning "n"
      98.000     SCS Curve No or C
        .100     Ia/S Coefficient
        .518     Initial Abstraction
35     COMMENT
      1     line(s) of comment
       DRAINAGE AREA A20
 4     CATCHMENT
      20.000     ID No.ó 99999
       6.980     Area in hectares
     216.000     Length (PERV) metres
        .500     Gradient (%)
       5.000     Per cent Impervious
     216.000     Length (IMPERV)
        .000     %Imp. with Zero Dpth
           1     Option 1=SCS CN/C; 2=Horton; 3=Green-Ampt; 4=Repeat
        .250     Manning "n"
      77.000     SCS Curve No or C
        .100     Ia/S Coefficient
       7.587     Initial Abstraction
           1     Option 1=Trianglr; 2=Rectanglr; 3=SWM HYD; 4=Lin. Reserv
              .244       .000       .000       .000 c.m/s
              .416       .923       .441     C perv/imperv/total
15     ADD RUNOFF
              .244       .244       .000       .000 c.m/s
10     POND
      7 Depth - Discharge - Volume sets
       176.400        .000          .0
       176.600      .00100        11.5
       176.800       .0920       127.5
       177.000        .259       514.2
       177.200        .391      1365.6
       177.400        .391      3406.0
       177.600        .391      8140.9
       Peak Outflow    =      .199 c.m/s
       Maximum Depth   =   176.928 metres
       Maximum Storage =      375. c.m
              .244       .244       .199       .000 c.m/s
16     NEXT LINK
              .244       .199       .199       .000 c.m/s
14     START
      1     1=Zero; 2=Define
```