STORMWATER MANAGEMENT PLAN

RIVERFRONT (PHASE 1)

CITY OF NIAGARA FALLS

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REFERENCES

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

2. Wetland Water Balance Risk Evaluation
   Toronto and Region Conservation Authority (November 2017)

STORMWATER MANAGEMENT PLAN

RIVERFRONT (PHASE 1)

CITY OF NIAGARA FALLS

1.0 INTRODUCTION

1.1 Study Area

The proposed residential development of Riverfront is located at the City of Niagara Falls, within the Thundering Waters Secondary Plan area. As shown on the enclosed Site Location Plan (Figure 1), the subject lands are bound to the south and west by the Chippawa Parkway, situated south of the existing CP Rail tracks and west of Stanley Avenue.

The subject lands, now known as Riverfront Phase 1, were previously identified as Block 12 in the Approved Draft Plan of Subdivision for the Riverfront Communities Subdivision. The Stormwater Management Plan has been prepared to assess existing and future stormwater conditions to establish the property requirements for the proposed Stormwater Management Facility in support of the Submission for Draft Plan of the Vacant Land Condominium Approval.

1.2 Objectives

The objectives of this study are as follows:

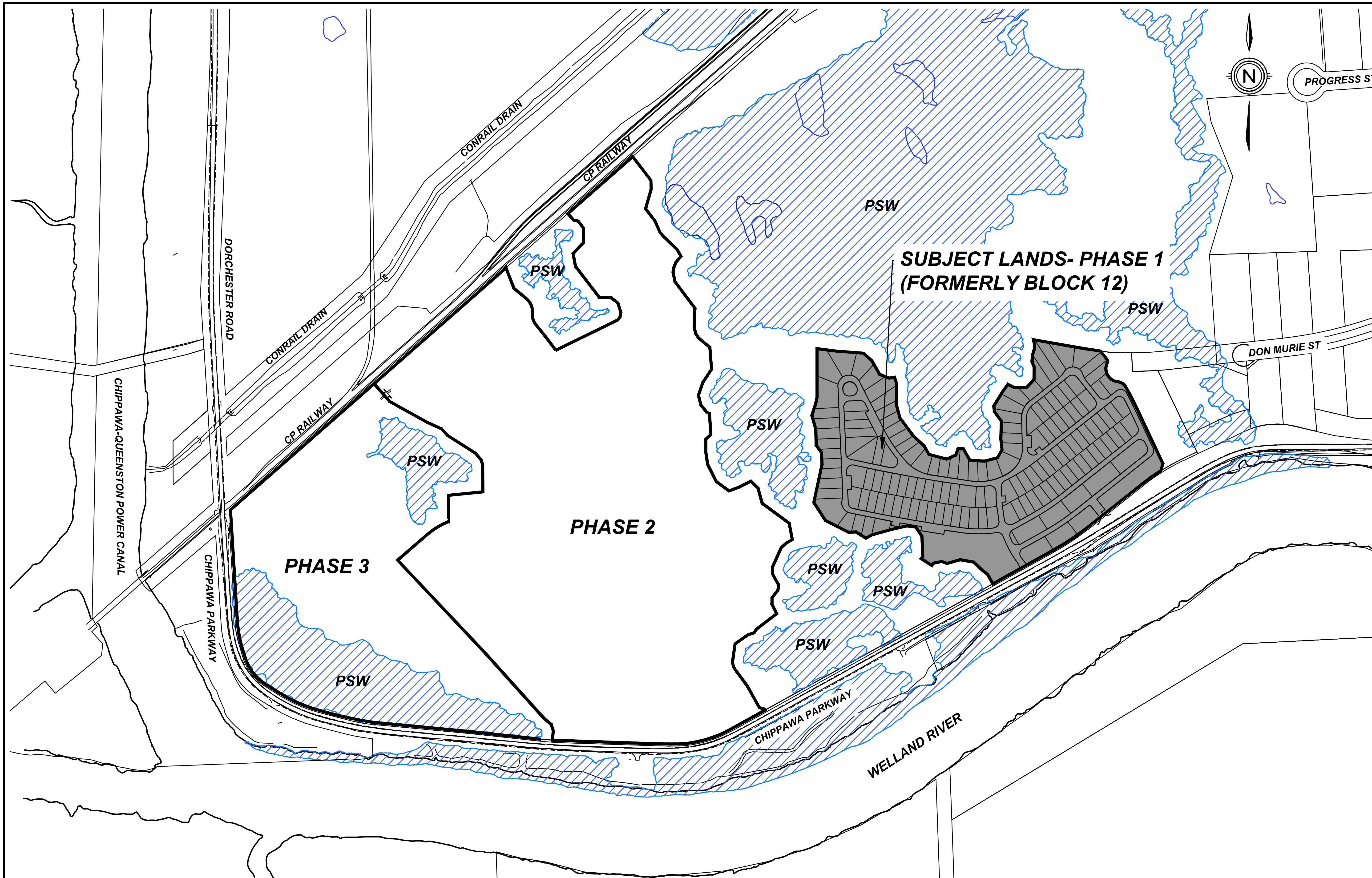
1. Establish specific criteria for the management of stormwater from Phase 1;

2. Determine the impact of development on the stormwater peak flow & volume of flows from Phase 1 and external drainage areas;

3. Investigate alternatives for controlling the quality of stormwater discharging from Phase 1; and,

4. Establish the property requirements for the Stormwater Management Facility for the Draft Plan of Vacant Land Condominium for Phase 1.

Figure 1. Site Location Plan



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SITE LOCATION PLAN

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1.3 Existing & Proposed Conditions

a) <u>Existing Conditions</u>

The subject lands and external drainage areas are currently vacant, comprising of predominantly open space separated by areas of dense vegetation. The existing stormwater flows are conveyed overland through existing ditches, ultimately outletting to the Welland River.

The subject lands presently convey stormwater overland to three separate outlets. Figure 2 shows the existing catchment areas and drainage paths within the overall Riverfront Submission Area. As shown in this Figure, the Phase 1 lands convey existing stormwater flows to the Welland River through three separate catchments:

A. Catchment Area A1 which includes the northeast end of Phase 1, flows easterly to the Welland River through an existing culvert crossing on Chippawa Parkway;

B. Catchment Area B1 which flows Southerly to the existing ditch present along the north side of Chippawa Parkway, outletting to the Welland River through a separate existing culvert crossing, and;

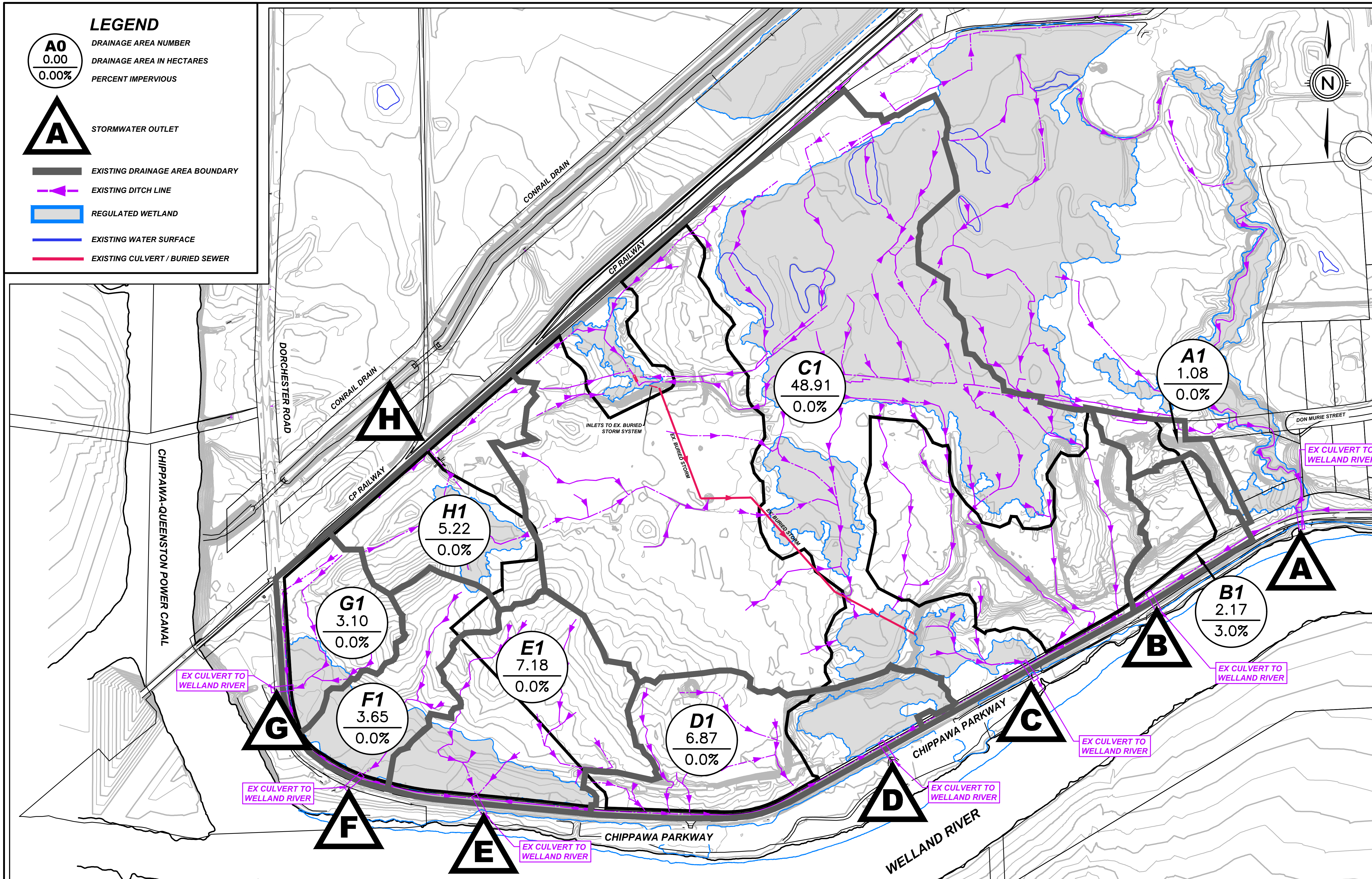
C. Catchment Area C1 which flows westerly and southerly to the existing ditch present along the north side of Chippawa Parkway, outletting to the Welland River through a third existing culvert crossing.

The soil in the subject lands consist mainly of silty clay/clayey silt fill and is classified in the Soil Conservation Service (SCS) classification method as belonging to hydrologic soil group C.

b) <u>Proposed Conditions</u>

The subject lands are approximately 10.38 hectares and comprises of approximately 145 single detached and 68 townhouse dwellings. The subject lands will be developed with full urban services including sanitary and storm sewers, watermains, private asphalt roads with concrete curb and gutters.

Figure 2. Existing Stormwater Drainage Area Plan



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EXISTING STORM DRAINAGE AREA PLAN

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2.0 STORMWATER MANAGEMENT CRITERIA

New developments are required to provide stormwater management in accordance with provincial and municipal policies including:

- Stormwater Quality Guidelines for New Development (MECP/MNRF, May 1991)
- Stormwater Management Planning and Design Manual (MECP, March 2003)

The development area outlets to the Welland River. This drainage system has been identified as Type 2 fish habitat. Based on this classification, the corresponding MECP level of Protection for stormwater management quality practices necessary is Normal (70% TSS Removal). However, as per the comments received by the Niagara Region, Enhanced Protection (80% TSS Removal) is required prior to discharging to the Welland River.

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

a. Stormwater **quality** controls are to be provided for the more frequent storm events to provide Enhanced Protection (80% TSS Removal) in accordance with MECP guidelines.

b. Erosion control is not required for the Welland River or Chippawa-Queenston Power Canal. However, for new outlets to existing ditches, erosion controls are to be provided in accordance with MECP guidelines. The guidelines require an extended detention volume for 24 hours.

c. Quantity controls are not required as the subject lands will outlet to the Welland River, where water levels are controlled by the Niagara River and Chippawa-Queenston Power Canal.

3.0 STORMWATER ANALYSIS

Since stormwater quantity controls are not required for the subject lands. future stormwater flows are modelled using the PCSWMM computer modelling program for the purposes of sizing sediment forebays and determining stormwater quality volumes **only**.

This program was selected because it is applicable to an urban drainage area like the study area, it is relatively easy to use and modify for the proposed drainage conditions and control facilities, and it readily allows for the use of design storm hyetographs for the various return periods being investigated.

3.1 Design Storms

The 5-year design storm hyetograph was developed using a 4 hour Chicago distribution based on the City of Niagara Falls Intensity-Duration-Frequency (IDF) curves. The 25mm design storm IDF curve parameters were derived using a 4-hour Chicago distribution. Table 1 summarizes the rainfall data used in this study.

Table 1. Rainfall Data			
Design Storm (Return Period)	**Chicago Distribution Parameters**		
	a	**b**	**c**
25mm	512.000	6.00	0.800
5 Year	719.500	6.34	0.7687

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

3.2 Future Conditions

It is proposed to convey future stormwater flows from the subject lands to Welland River through a proposed box culvert. An overall imperviousness value of 57.1% has been assumed for the site, 45% for the proposed stormwater management wet pond block area to account for the permanent pool levels in the proposed facility and 0% for the external drainage areas. The imperviousness value of 57.1% within the subject lands was determined by converting from a runoff coefficient of 0.60.

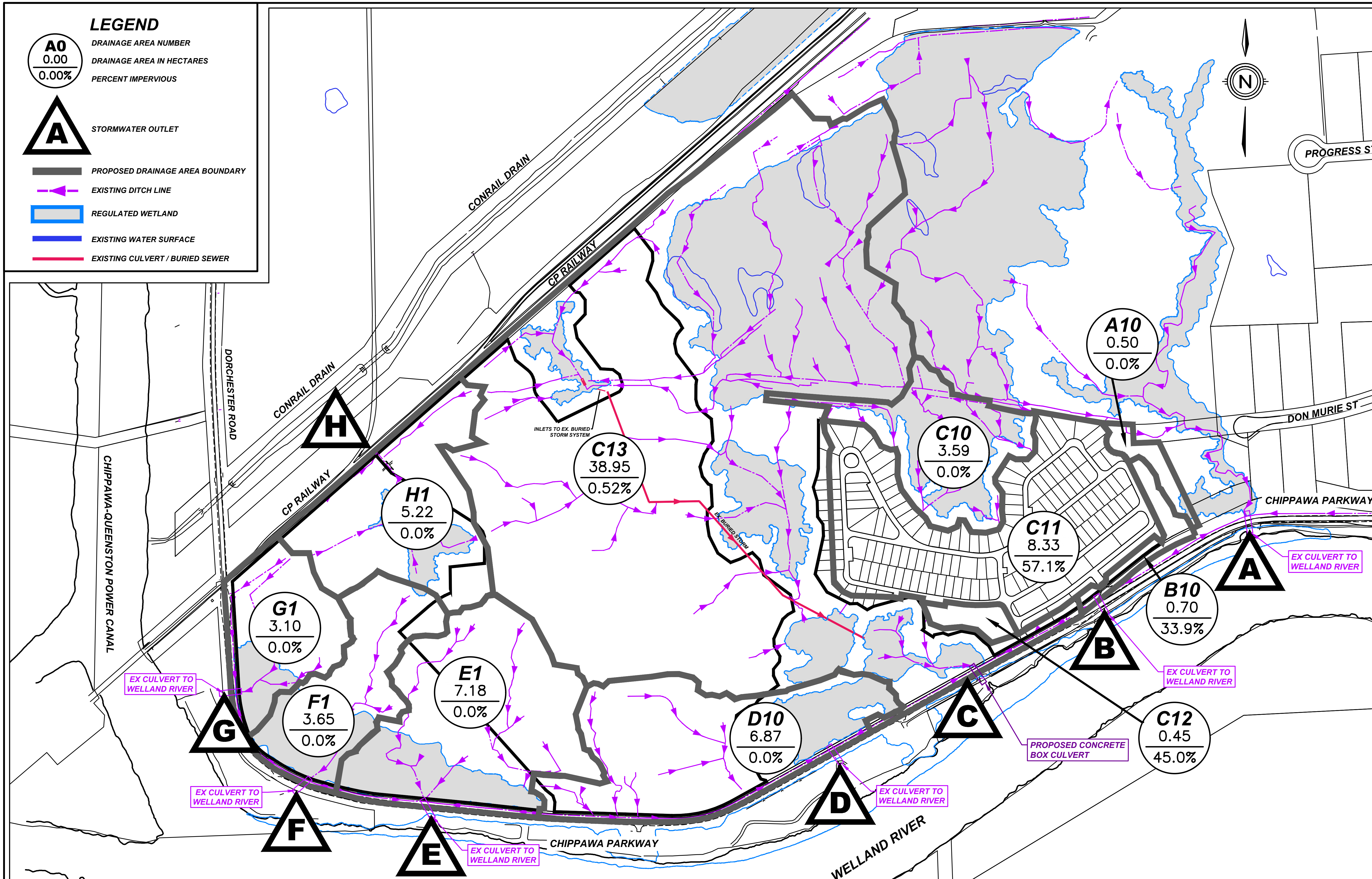
Figure 3 shows the proposed drainage areas for phase 1 lands. Input parameters for the computer model for proposed development conditions are shown in Table 2.

Table 2. Hydrologic Parameters for Future Conditions – SWM Pond					
Area No.	**Area (ha)**	**Length (m)**	**Slope (%)**	**SCS CN**	**Percent Impervious**
C10	8.34	52	0.5	80	57.1%
C11	3.59	236	1.0	74	0.0%
C12	0.45	54	20.0	74	45.0%
	12.38	**Total Area**			

As shown in Figure 3, the rear yard areas from the western limits of the subject lands will contribute future stormwater flows to the adjacent Provincially Significant Wetlands through Catchment Area C13, which will also discharge to the Welland River at Outlet C.

The detailed PCSWMM modelling output files have been enclosed in Appendix B for reference.

Figure 3. Proposed Stormwater Drainage Area Plan (Phase 1)



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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 quality of stormwater, most of which are described in the Stormwater Management Planning and Design Manual (MECP, March 2003). Alternatives for the proposed and ultimate developments were considered in the following broad categories: lot level, vegetative, infiltration, and end-of-pipe controls. General comments on each category are provided below. Individual alternatives for the proposed development are listed in Table 3 with comments on their effectiveness and applicability to the proposed outlet.

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 in conjunction with other types of control facilities.

b) Vegetative Alternatives

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

c) Infiltration Alternatives

Where soils are suitable, infiltration techniques can be very effective in providing quantity and quality control. However, the very small amount of surface area on this site dedicated to permeable surfaces such as greenspace and landscaping make this an impractical option. Therefore, infiltration techniques will not be considered for this development.

d) End-of-Pipe Alternatives

Surface storage techniques can be very effective in providing quality and quantity control. Wet facilities are effective practices for stormwater quality control for large drainage areas (>5ha).

Table 3. Evaluation of Stormwater Management Practices

Riverfront (Phase 1)	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 to 3%*	*Clayey Silt ±15mm/hr*	*At Considerable Depth*	*At Considerable Depth*	*± 12.83ha*			
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	Unsuitable site conditions
Sump Pump Fdtn. Drains	nlc	nlc	nlc	nlc	nlc	2	Yes	Suitable site 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 conditions
Infiltration Trench	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 2 ha	4	No	Unsuitable site conditions
Rear Yard Infiltration	< 2.0 %	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	< 0.5 ha	7	No	Unsuitable site conditions
Perforated Pipes	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	nlc	4	No	Unsuitable site conditions
Pervious Catch basins	nlc	loam, infiltr. > 15 mm/hr	>1m Below Bottom	>1m Below Bottom	nlc	3	No	Unsuitable site conditions
Sand Filters	nlc	nlc	nlc	>.5m Below Bottom	< 5 ha	5	No	High maintenance/poor aesthetics
Surface Storage								
Dry Ponds	nlc	nlc	nlc	nlc	> 5 ha	7	No	No quality control
Wet Ponds	nlc	nlc	nlc	nlc	> 5 ha	9	Yes	Very effective quality control
Wetlands	nlc	nlc	nlc	nlc	> 5 ha	6	No	Very effective quality control
Other								
Oil/Grit Separator	nlc	nlc	nlc	nlc	<5 ha	3	No	Limited benefit/area too large

Reference: Stormwater Management Planning and Design Manual - 2003
nlc - No Limiting Criteria

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 proposed and future development areas. The following stormwater management alternatives are recommended for implementation on the proposed development:

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

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

- **Grassed swales** to be used to collect rear lot drainage. Grassed swales tend to filter sediments and slow down the rate of stormwater.

- A **wet pond facility** to be constructed to provide stormwater quality enhancement.

5.0 STORMWATER MANAGEMENT PLAN

5.1 Proposed Stormwater Management Facility - Phase 1

5.1.1 Stormwater Quality

Based on Table 3.2 of SWMP & Design Manual, the water quality storage requirement is approximately 195 m^3/ha for *Enhanced* protection for developments with 57.1% impervious areas. The proposed stormwater management facility will be required to provide stormwater quality improvements for a future drainage area of 8.34 hectares. The storage volumes required for this proposed facility are shown in Table 4.

Table 4. Stormwater Quality Volume Calculations

Total Water Quality Volume = 8.34 ha x 195 m^3/ha = 1,626 m^3	Reference: Table 3.2, SWMP & Design Manual (MECP 2003)
Permanent Pool Volume = 8.34 ha x 155 m^3/ha = 1,293 m^3	**Extended Detention Volume** = 8.34 ha x 40 m^3/ha = 334 m^3

Table 5 below summarizes the stormwater volume requirements to provide quality improvements to MECP Normal levels. The 25mm design storm volume was calculated in the PCSWMM model for future conditions.

Table 5. Stormwater Quality Volume Requirements		
A.	Permanent Pool Volume	1,293 m^3
B.	Extended Detention Volume	334 m^3
C.	Stormwater Volume from 25mm – 4 hour Rainfall Event	1,369 m^3
D.	Required Extended Detention Volume (Greater of B & C)	1,369 m^3
	Total Quality and Extended Detention Volume (A + D)	**2,662 m^3**

5.1.2 Stormwater Management Facility Configuration

It is proposed to construct a stormwater management wet pond facility with a controlled outlet. The outlet consists of a reverse slope pipe acting as a tubular control orifice providing the required quality and erosion controls connected to a manhole with an outlet pipe and an emergency spillway which will provide an outlet for greater storm events.

The proposed bottom elevation of the facility is 169.80 m, and the permanent pool water level is 171.60 m for a permanent pool depth of 1.80 m. The configuration of the facility provides 1,380 m^3 of permanent pool volume, which is more than the required 1,293 m^3. The proposed top of pond is at an elevation of 172.60m, providing a total active storage volume of 2,116 m^3.

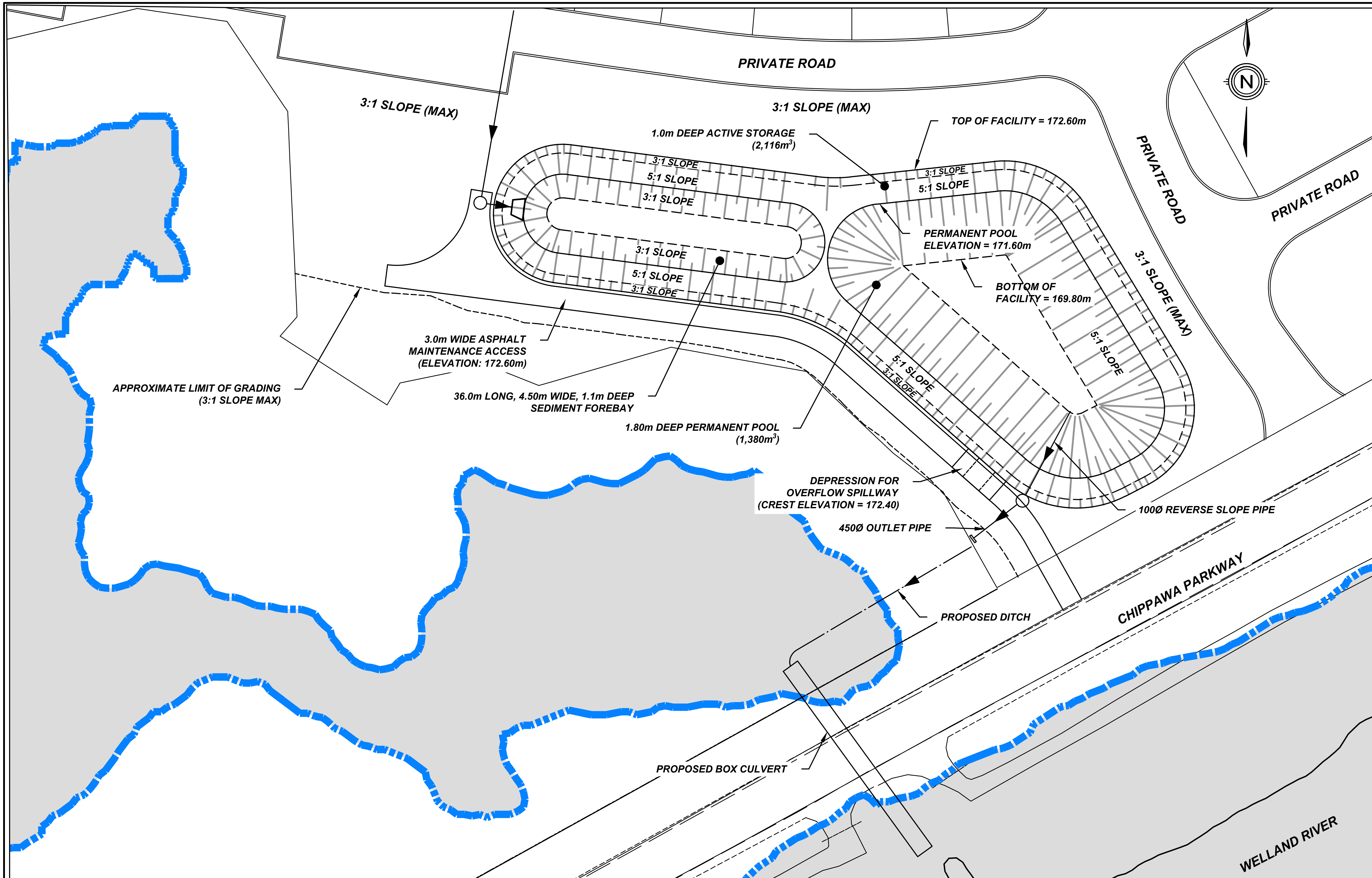
Based on the proposed configuration of the proposed facility it was determined that a 100mm diameter reverse slope pipe with an invert of 171.60 m can provide 46 hours of detention with the emergency spillway being constructed at an elevation of 172.40m; which is greater than the minimum drawdown time of 24 hours. This configuration will provide an extended detention volume of 1,606 m^3, which is greater than the volume of 1,369 m^3 specified in Table 5.

Stage-storage-discharge calculations have been prepared for this facility and are included in Appendix A for reference.

Major overland flows from the subject lands will be directed to the SWM facility, which will ultimately outlet to the Welland River.

A sediment forebay was designed to minimize the transport of heavy sediment through the facility to the Welland River and to localize future maintenance activities. Calculations for the forebay sizing follow MECP Guidelines and are shown in Appendix A.

Figure 4. Stormwater Management Pond



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STORMWATER MANAGEMENT POND

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Table 6. SWM Facility - MECP Quality and Erosion Requirements Comparison		
SWM Facility Characteristic	**MECP Requirement**	**Provided by SWM Facility**
Permanent Pool Volume (m^3) - *minimum*	1,293	1,380
Extended Detention Volume (m^3) - *minimum*	1,369	1,606
Total Quality + Detention Storage (m^3) - *minimum*	2,662	2,986
Facility Drawdown Time (hours) - *minimum*	24	46
Forebay Length (m) - *minimum*	20.66	36
Forebay Width (m) - *minimum*	2.58	4.50
Average Forebay Velocity (m/s) - *maximum*	0.15	0.06
Cleanout Frequency (years) - *minimum*	10	10.1

As shown in Table 6, the configuration of the proposed stormwater management facility satisfies the quality and erosion control requirements outlined by the MECP for the subject lands.

Table 7. Stormwater Management Wet Pond Facility Characteristics				
Design Storm (Return Period)	**Peak Flows (m^3/s)**		**Maximum Elevation (m)**	**Maximum Volume (m^3)**
	Inflow	**Outflow**		
25 mm	0.544	0.016	172.17	1,117
5 Year	0.941	0.078	172.45	1805

As shown in Table 7, the proposed stormwater management facility has adequate storage capacity to detain future 25mm and 5year design storm flows to provide the required quality and erosion controls.

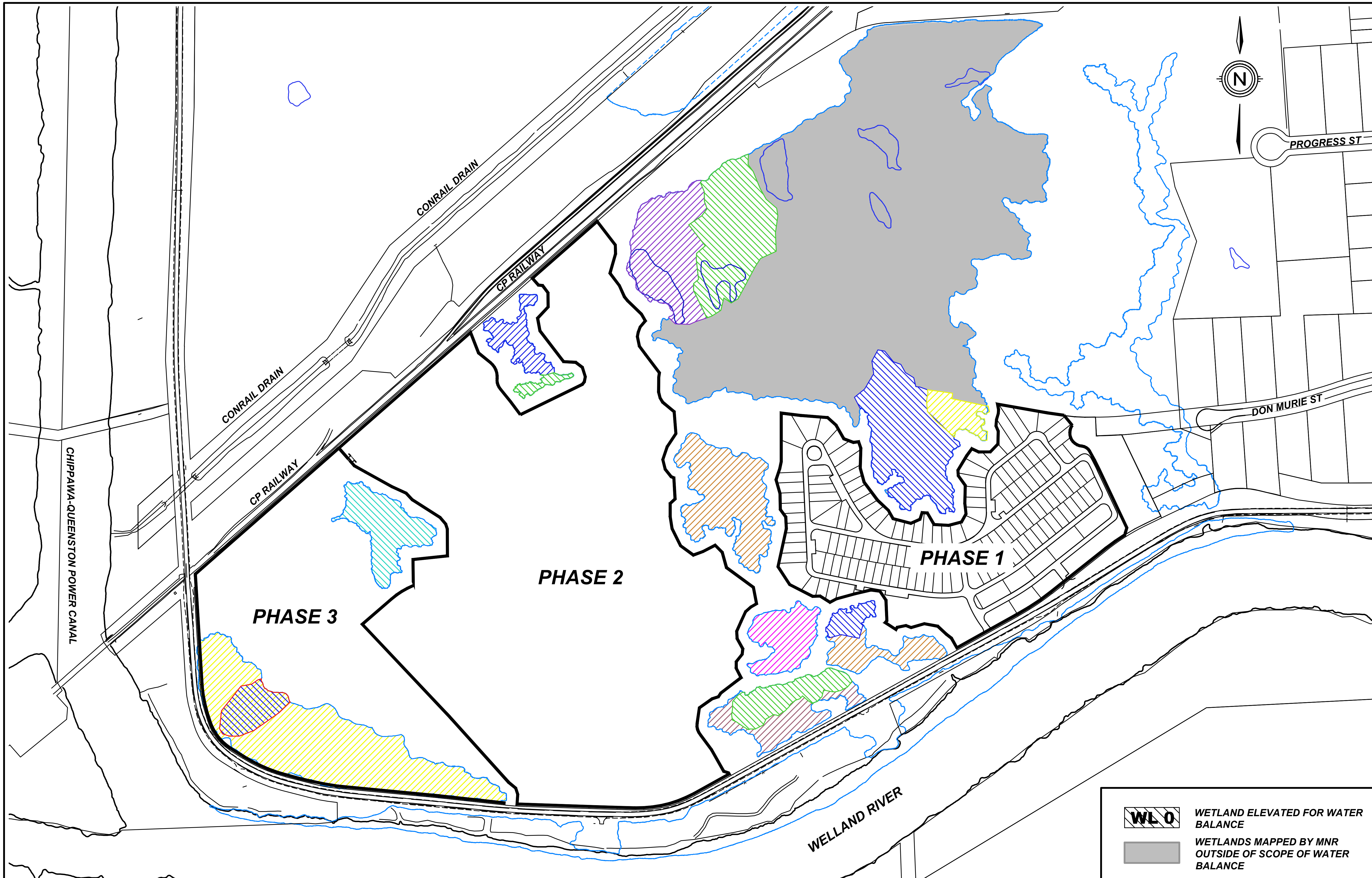
5.2 Preliminary Wetland Assessment

The Conditions of Draft Plan of Subdivision Approval for the Riverfront Subdivision requires a Feature Based Water Balance be submitted prior to final approval and registration of the Subdivision. The existing Wetlands location on the subject area is shown on Figure 5.

For the purposes of the proposed Draft Plan of Vacant Land Condo Application for Phase1, a preliminary assessment of the existing and future drainage areas contributing to the existing wetlands has been prepared.

The existing and proposed (Phase 1 development) drainage area plans for wetlands and schematics are shown on Figures 6, 7, 8 and 9.

Figure 5. Existing Wetland Location Plan



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EXISTING WETLAND LOCATION PLAN

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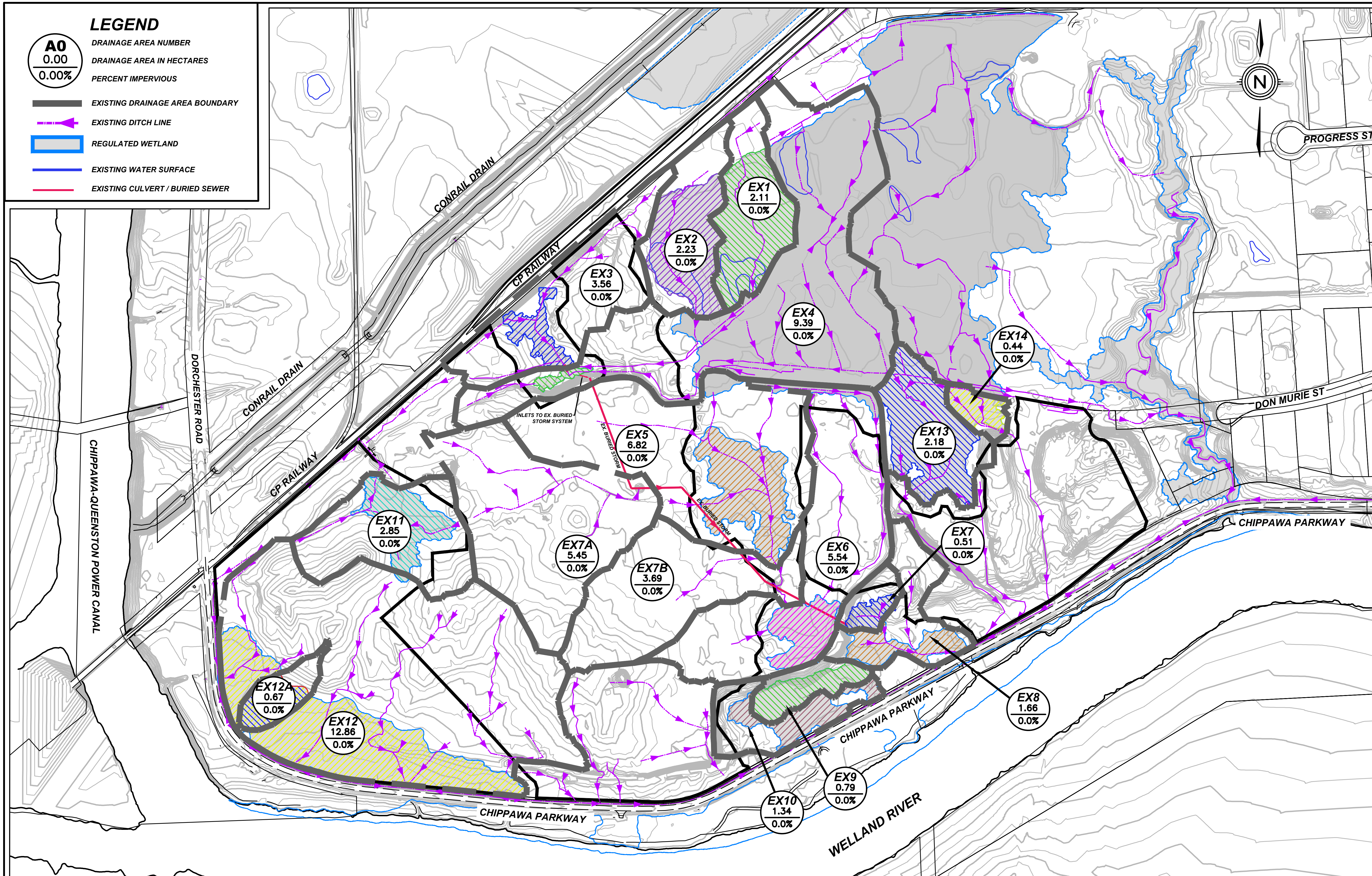
Figure 6. Existing Wetland Drainage Area Plan



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EXISTING WETLAND DRAINAGE AREA PLAN

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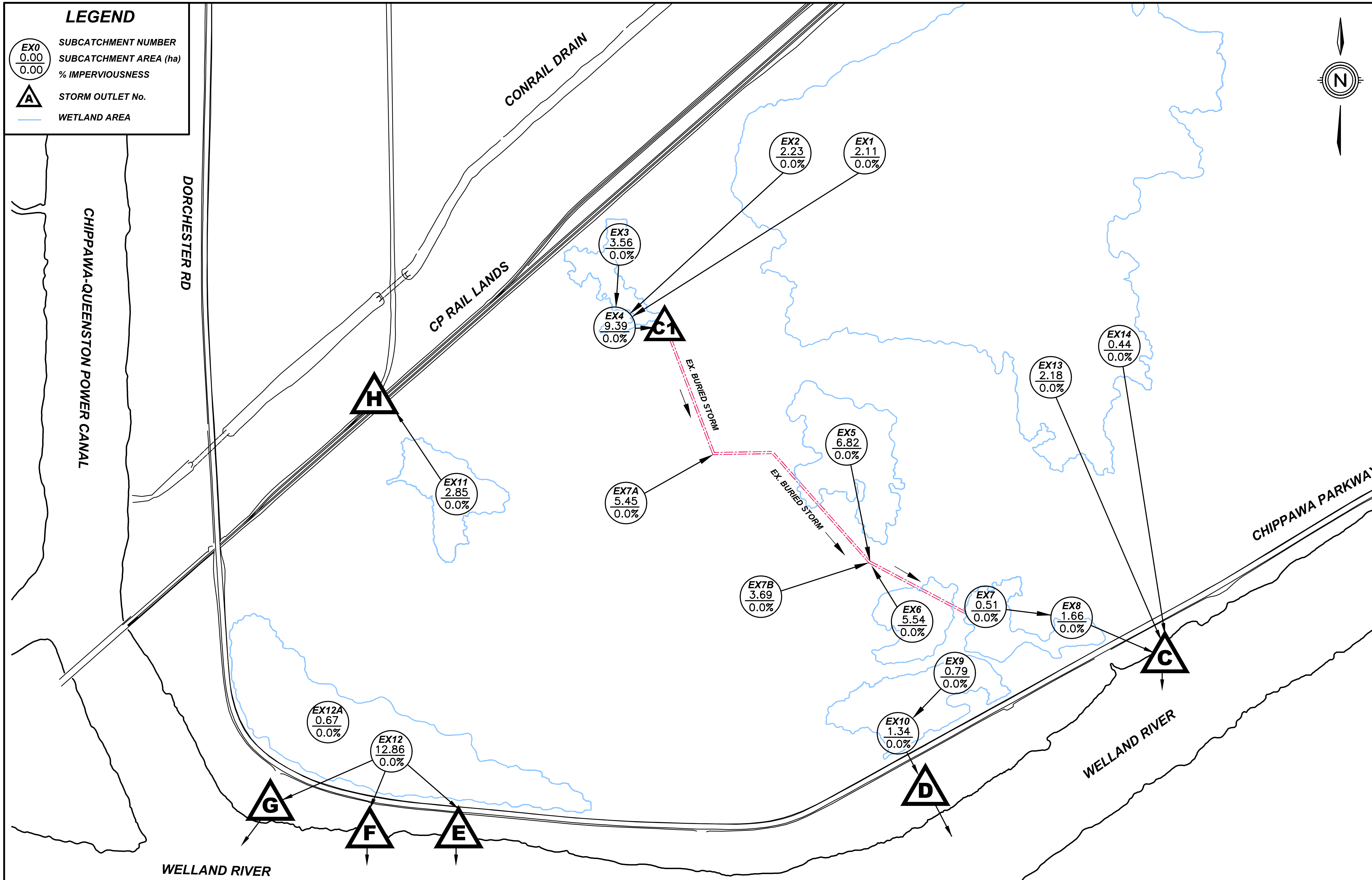
Figure 7. Schematic of Existing Wetland Drainage Area Plan



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SCHEMATIC OF EXISTING WETLAND DRAINAGE AREA PLAN

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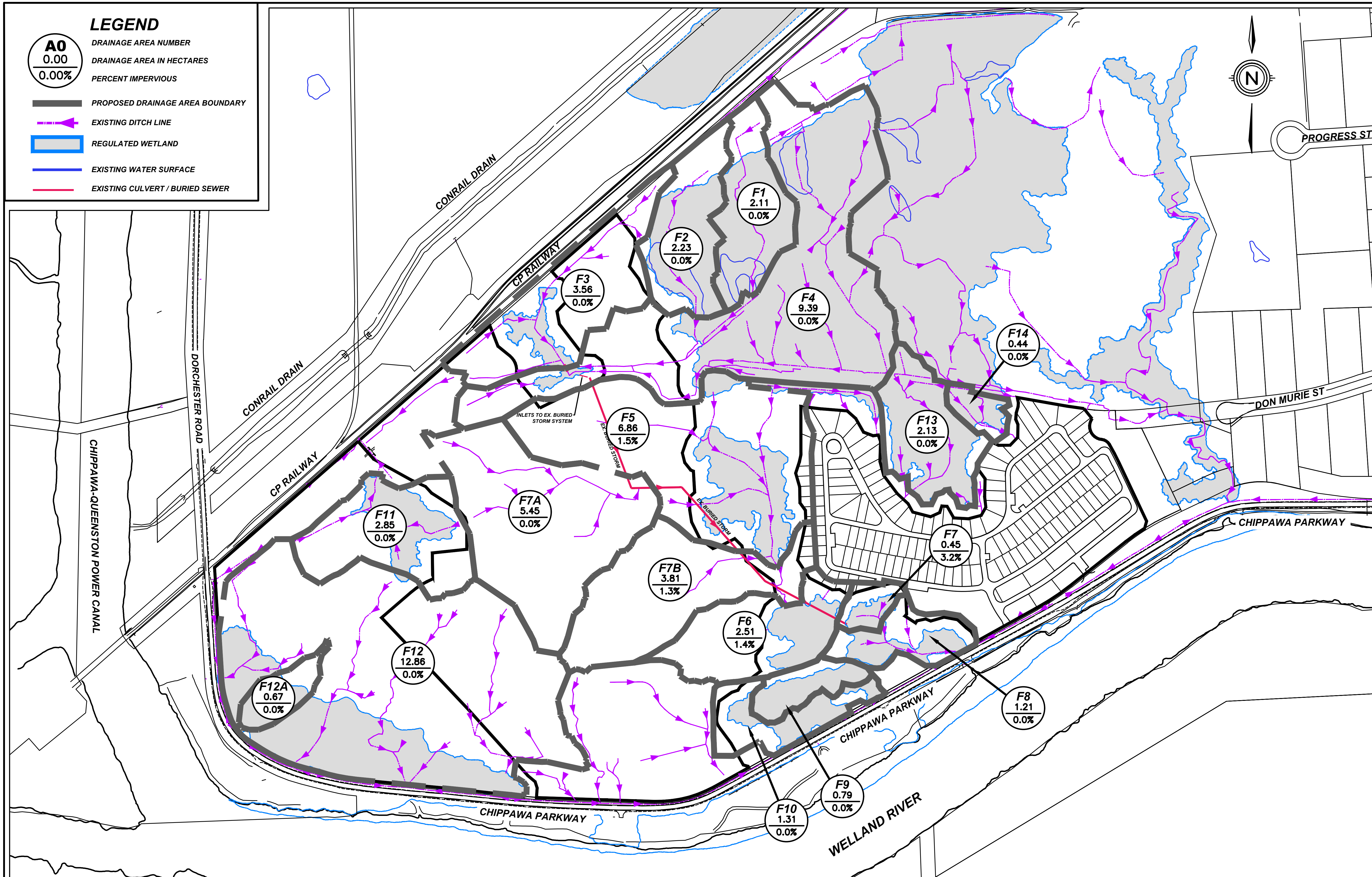
Figure 8. Proposed Wetland Drainage Area Plan (Phase 1)



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PROPOSED WETLAND DRAINAGE AREA PLAN-PHASE 1

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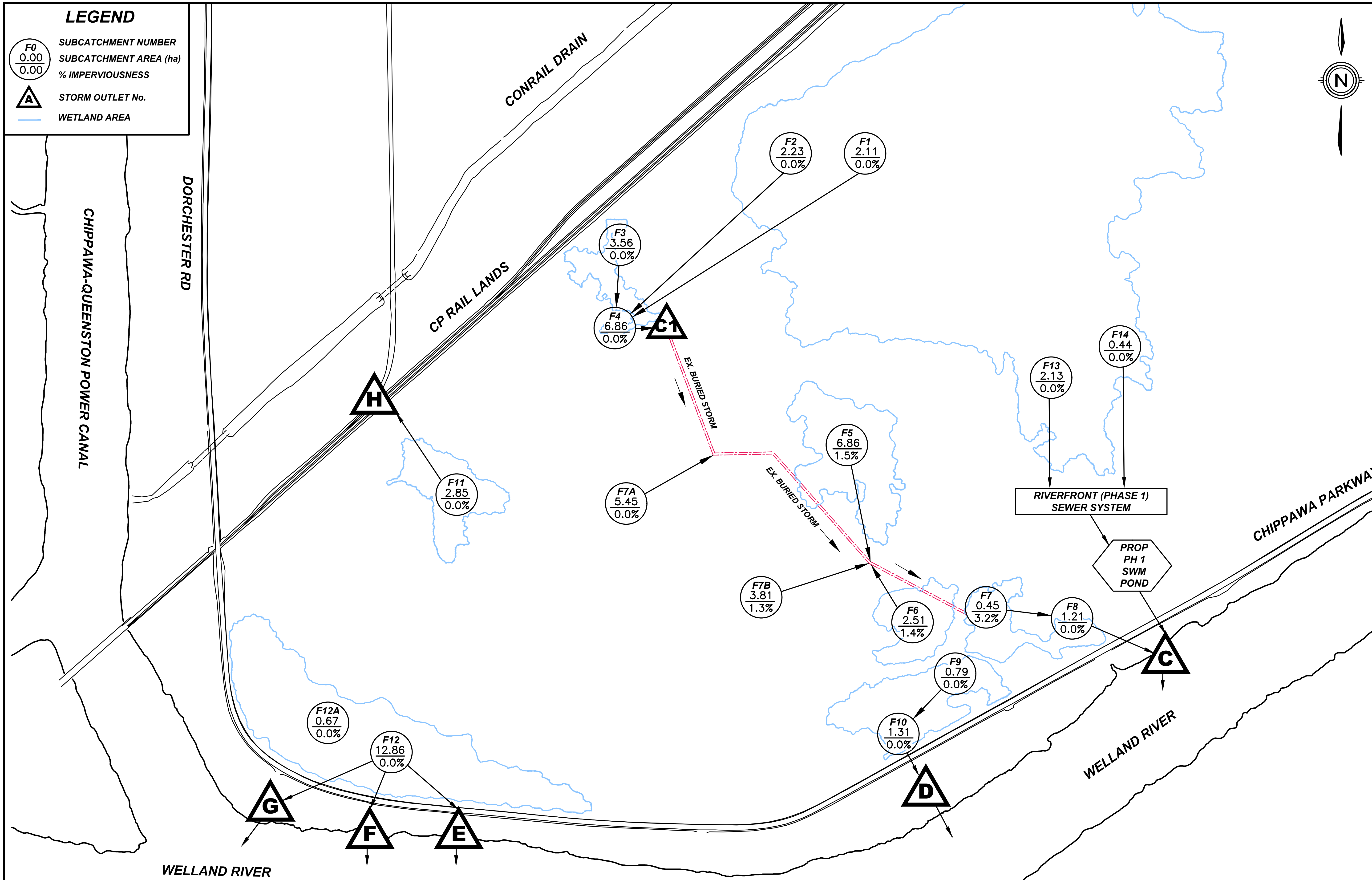
Figure 9. Schematic of Proposed Wetland Drainage Area Plan (Phase 1)



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SCHEMATIC OF PROPOSED WETLAND DRAINAGE AREA PLAN - PHASE 1

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Table 8 summarizes the existing and future drainage areas for each wetland, and changes to the total drainage area and impervious cover score in future condition.

Table 8. Wetlands Comparison (Phase 1 development)

Wetland ID	Change in Drainage Area			Change in Impervious Score	
	Existing	Proposed	Change (%)	Existing	Proposed
WL 1	2.11	2.11	0.0	0.0	0.0
WL 2	2.23	2.23	0.0	0.0	0.0
WL 3	3.56	3.56	0.0	0.0	0.0
WL 4	17.29	17.29	0.0	0.0	0.0
WL 5	6.82	6.86	0.58	0.0	1.5
WL 6	5.54	2.51	54.7	0.0	1.4
WL 7	22.01	19.08	13.3	0.0	1.1
WL 8	23.67	20.29	14.3	0.0	1.0
WL 9	0.79	0.79	0.0	0.0	0.0
WL 10	2.13	2.10	1.4	0.0	0.0
WL 11	2.85	2.85	0.0	0.0	0.0
WL 12	12.86	12.86	0.0	0.0	0.0
WL 12A	0.67	0.67	0.0	0.0	0.0
WL 13	2.18	2.13	2.3	0.0	0.0
WL 14	0.44	0.44	0.0	0.0	0.0

As shown in Table 8 and Figure 8, only the adjacent wetlands (WL5, WL6, WL7, WL8, WL13 and WL14) may be impacted by the development of Phase 1.

Impervious Cover Scores for all the wetlands are within 10%. Also, the changes in Drainage Area for all wetlands other than WL6, WL7 and WL8 are within 10%, with WL7 and WL8 being close to the 10% threshold. Therefore, these are considered of Low hydrological Impact per the TRCA Wetland Risk Assessment protocol.

To clear the Conditions of Draft Plan of Subdivision Approval for Phase 1, a detailed Feature Based Water Balance will be submitted addressing the impacts of the overall Riverfront Subdivision. If it is determined that additional future flows are required to support the hydrological function of any adjacent wetlands, Phase 2 and 3 will be modified to ensure adequate flows are conveyed to each wetland.

Therefore, there is expected to be no negative impact on the hydrological function of the adjacent wetlands as a result of the 15m wetland buffer proposed for Phase 1.

5.3 Ultimate Conditions

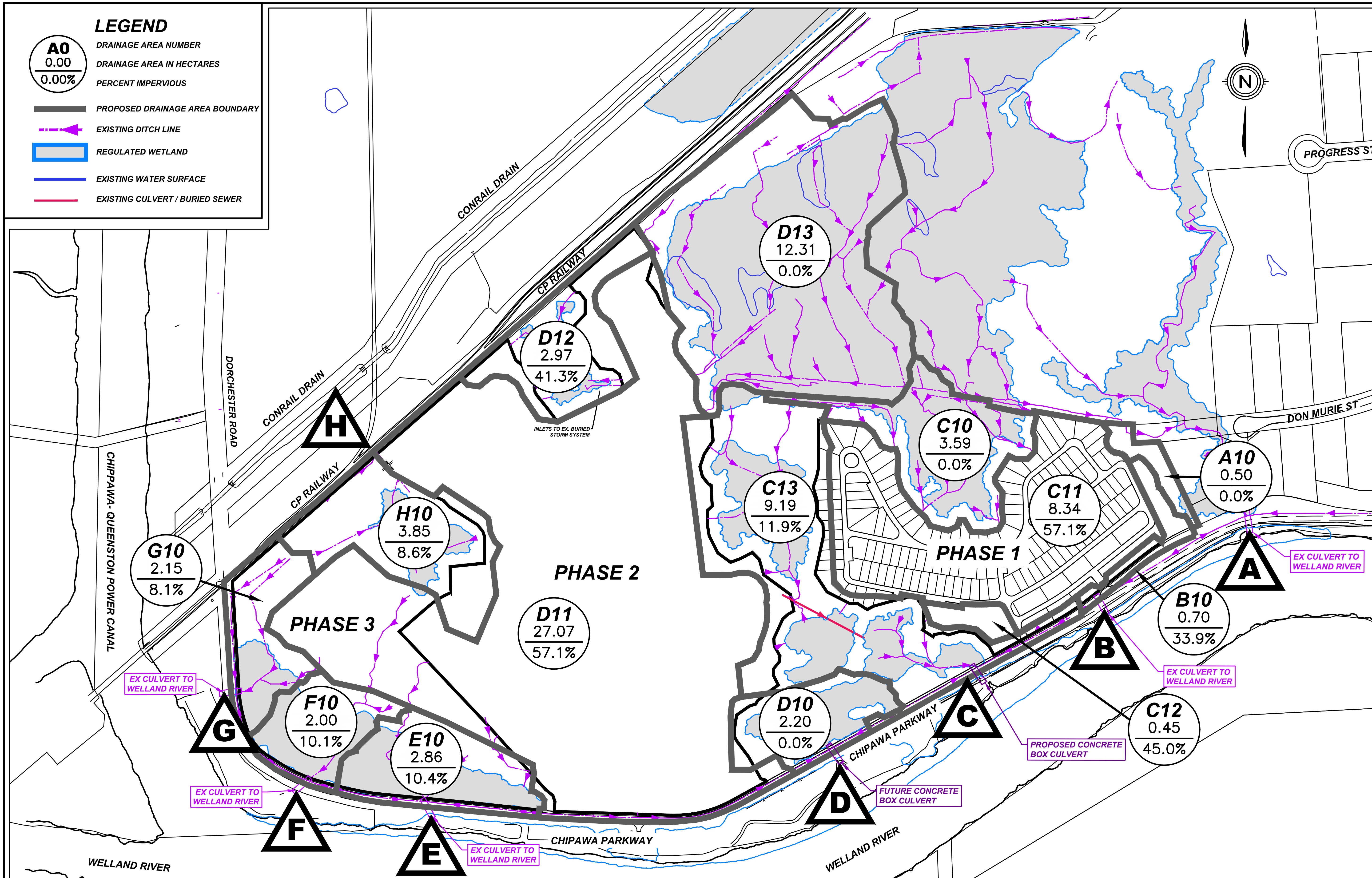
A conceptual Ultimate Storm Drainage Area Plan and Schematic have been prepared as Figure 10 and 11 to demonstrate how ultimate stormwater flows will conceptually be managed upon full Build-out of Riverfront Phases 1 to 3.

It is proposed to construct a second stormwater management facility within Phase 2, which will be sized to provide quality controls for both Phases 2 and 3, prior to discharging to the Welland River through a proposed concrete box culvert.

The size and location of the future SWM facility and box culvert will be determined as part of future Planning Act applications for the Phase 2 lands.

As previously stated, the future drainage areas contributing to the Phase 2 Stormwater Management Pond can be modified to convey additional flows to the adjacent wetlands, if determined to be required by the detailed Feature Based Water Balance.

Figure 10. Ultimate Storm Drainage Area Plan



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ULTIMATE STORM DRAINAGE AREA PLAN

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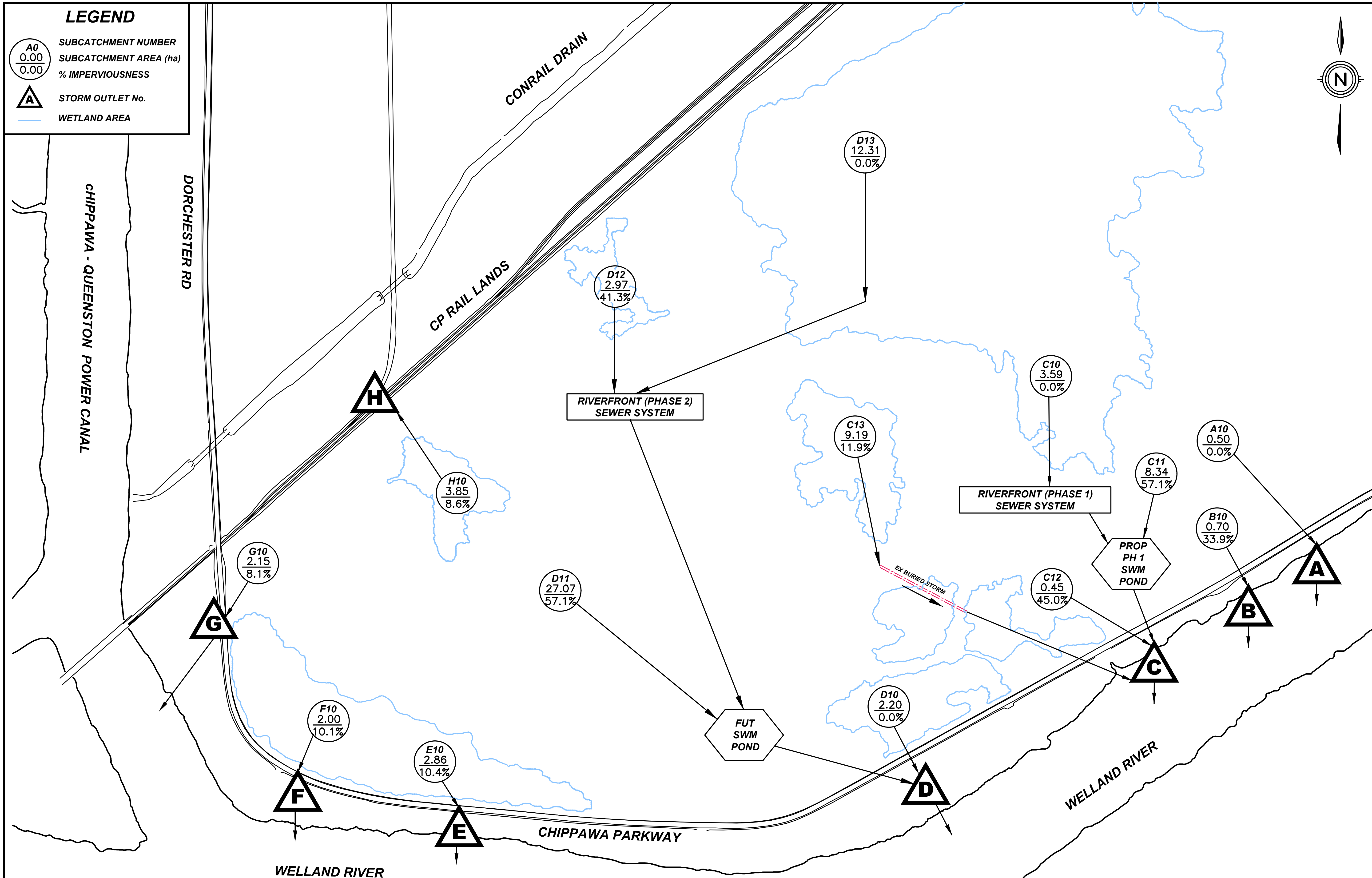
Figure 11. Schematic of Ultimate Storm Drainage Area Plan



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SCHEMATIC OF ULTIMATE STORM DRAINAGE AREA PLAN

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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 Welland River.

The following additional erosion and sediment controls will also be implemented during construction:

- Install silt control fencing along the limits of construction where overland flows will flow beyond the limits of the development or into downstream watercourse.

- Re-vegetate disturbed areas as soon as possible after grading works have been completed.

- Lot grading and siltation controls plans will be provided with sediment and erosion control measures to the appropriate agencies for approval during the final design stage.

- The stormwater management facility be cleaned after construction prior to assumption by municipality.

7.0 STORMWATER MANAGEMENT FACILITY MAINTENANCE

7.1 Wet Pond Facility

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

The wet pond for this development is subject to frequent wetting and deposition of sediments as a result of frequent low intensity storm events. The purpose of the wet pond is to improve post development sediment and contaminant loadings by detaining the 'first flush' flow for a 24-hour period. 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 an '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 wet pond 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 wet pond is functioning properly. This may translate into an average of six inspections per year. Once all building activity is finalized, inspections shall be performed annually. The following points should be addressed during inspections of the facility:

a) Standing water above the inlet storm sewer invert a day or more after a storm may indicate a blockage in the reverse slope pipe 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 wet pond should be inspected to ensure its function and aesthetics. Visual inspections will indicate whether replacement of plantings are required. A decline in vegetation habitat may indicate that other aspects of the constructed wet pond are operating improperly, such as the detention times may be inadequate or excessive.

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

d) The wet pond has been created by excavating a detention area. The integrity of the embankments should be periodically checked to ensure that it remains watertight 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 eliminated. It should be noted that municipal by-laws may require regular grass maintenance for weed control.

Trash removal is an integral part of maintenance and an annual clean-up, usually in the spring, is a minimum requirement. After this, trash removal is performed as required basis 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 to ensure that sediment in not deposited throughout the facility. For sediment removal operations, typical grading/excavating equipment should be used to remove sediment from the inlet forebay and detention areas. Care should be taken to ensure that limited damage occurs to existing vegetation and habitat.

Generally, the sediment which is removed from the detention pond will not be contaminated to the point that it would be classified as hazardous waste. However, the sediment should be tested to determine the disposal options.

8.0 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 low soil infiltration rates and the large drainage area for this development.
- Roof water leaders shall discharge to grade.
- The proposed stormwater management wet pond facility will provide the required stormwater quality control and erosion controls to the proposed development.
- Various lot level 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 stormwater management wet pond facility be constructed to provide stormwater quality protection to MECP *Enhanced* Protection levels.
- That additional lot level controls and vegetative stormwater management practices as described previously in this report be implemented.
- That sediment and erosion controls be implemented during construction as described in this report.

Yours very truly,
Prepared By:

Anu Jacob, E.I.T.

Reviewed By:

Brendan Kapteyn, P.Eng.

APPENDICES

APPENDIX A

Stormwater Management Facility Calculations

APPENDIX B

PCSWMM Model Output Files

Development Conditions with SWM
25mm Storm Event

```
EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.3)
------------------------------------------------------------
*************
Element Count
*************
Number of rain gages ...... 3
Number of subcatchments ... 3
Number of nodes ........... 3
Number of links ........... 3
Number of pollutants ...... 0
Number of land uses ....... 0
****************
Raingage Summary
****************
                                                     Data       Recording
Name                 Data Source                     Type       Interval
------------------------------------------------------------------------
25mm_storm           25mm_storm                      VOLUME       5 min.
5-year               5-year                          VOLUME       5 min.
********************
Subcatchment Summary
********************
Name                       Area     Width   %Imperv    %Slope Rain Gage            Outlet
-----------------------------------------------------------------------------------------------------------
S1                         0.45     54.00     45.00   20.0000 25mm_storm           POND
S2                         8.35    236.00     57.10    1.0000 25mm_storm           POND
S5                         3.59     52.00      0.00    0.5500 25mm_storm           S2
************
Node Summary
************
                                          Invert      Max.    Ponded    External
Name                 Type                  Elev.     Depth      Area    Inflow
-------------------------------------------------------------------------------
J1                   JUNCTION             171.30      1.28       0.0
OF1                  OUTFALL              171.35      0.45       0.0
POND                 STORAGE              171.60      1.00       0.0
************
Link Summary
************
Name             From Node        To Node          Type            Length    %Slope Roughness
---------------------------------------------------------------------------------------------
C2               J1               OF1              CONDUIT           26.0    0.9616    0.0150
ORIFICE_PIPE     POND             J1               ORIFICE
SPILLWAY         POND             OF1              WEIR
*********************
Cross Section Summary
*********************                                  Full     Full     Hyd.     Max.   No. of     Full
Conduit          Shape                  Depth     Area     Rad.    Width  Barrels     Flow
---------------------------------------------------------------------------------------
C2               CIRCULAR                0.45     0.16     0.11     0.45        1     0.24
****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... KINWAVE
Starting Date ............ 06/20/2023 00:00:00
Ending Date .............. 06/22/2023 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:05:00
Routing Time Step ........ 5.00 sec
**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         0.310        25.038
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.167        13.484
Surface Runoff ...........         0.135        10.900
Final Storage ............         0.009         0.711
Continuity Error (%) .....        -0.228
**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.135         1.350
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.130         1.303
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.005         0.047
Continuity Error (%) .....         0.000
********************************
Highest Flow Instability Indexes
********************************
All links are stable.
*************************
Routing Time Step Summary
*************************
Minimum Time Step           :     5.00 sec
Average Time Step           :     5.00 sec
Maximum Time Step           :     5.00 sec
% of Time in Steady State   :     0.00
Average Iterations per Step :     1.00
% of Steps Not Converging   :     0.00
```

Subcatchment Runoff Summary

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Imperv Runoff mm	Perv Runoff mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff CMS	Runoff Coeff
S1	25.04	0.00	0.00	10.11	11.30	3.12	14.42	0.06	0.04	0.576
S2	25.04	0.39	0.00	9.60	15.40	0.83	15.40	1.29	0.50	0.606
S5	25.04	0.00	0.00	22.92	0.00	0.91	0.91	0.03	0.00	0.037

Node Depth Summary

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min	Reported Max Depth Meters
J1	JUNCTION	0.35	0.38	171.68	0 04:21	0.38
OF1	OUTFALL	0.05	0.08	171.43	0 04:21	0.08
POND	STORAGE	0.22	0.57	172.17	0 04:21	0.57

Node Inflow Summary

Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Flow Balance Error Percent
J1	JUNCTION	0.000	0.016	0 04:21	0	1.3	0.000
OF1	OUTFALL	0.000	0.016	0 04:21	0	1.3	0.000
POND	STORAGE	0.544	0.544	0 01:25	1.35	1.35	-0.000

Node Flooding Summary

No nodes were flooded.

Storage Volume Summary

Storage Unit	Average Volume 1000 m³	Avg Pcnt Full	Evap Pcnt Loss	Exfil Pcnt Loss	Maximum Volume 1000 m³	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CMS
POND	0.412	18.9	0.0	0.0	1.117	51.2	0 04:21	0.016

Outfall Loading Summary

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
OF1	99.01	0.008	0.016	1.303
System	99.01	0.008	0.016	1.303

Link Flow Summary

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
C2	CONDUIT	0.016	0 04:21	0.86	0.07	0.17
ORIFICE_PIPE	ORIFICE	0.016	0 04:21			0.00
SPILLWAY	WEIR	0.000	0 00:00			0.00

Conduit Surcharge Summary

No conduits were surcharged.

Analysis begun on: Thu Sep 14 11:03:01 2023
Analysis ended on: Thu Sep 14 11:03:01 2023
Total elapsed time: < 1 sec

5 year Storm Event

```
  EPA STORM WATER MANAGEMENT MODEL - VERSION 5.2 (Build 5.2.3)
------------------------------------------------------------
*************
Element Count
*************
Number of rain gages ...... 3
Number of subcatchments ... 3
Number of nodes ........... 3
Number of links ........... 3
Number of pollutants ...... 0
Number of land uses ....... 0
****************
Raingage Summary
****************
                                                   Data       Recording
Name                Data Source                    Type       Interval
------------------------------------------------------------------------
25mm_storm          25mm_storm                     VOLUME       5 min.
5-year              5-year                         VOLUME       5 min.
********************
Subcatchment Summary
********************
Name                       Area     Width   %Imperv    %Slope Rain Gage            Outlet
-----------------------------------------------------------------------------------------------------------
S1                         0.45     54.00     45.00   20.0000 5-year               POND
S2                         8.35    236.00     57.10    1.0000 5-year               POND
S5                         3.59     52.00      0.00    0.5500 5-year               S2
************
Node Summary
************
                                         Invert      Max.    Ponded    External
Name                Type                  Elev.     Depth      Area    Inflow
-------------------------------------------------------------------------------
J1                  JUNCTION             171.30      1.28       0.0
OF1                 OUTFALL              171.35      0.45       0.0
POND                STORAGE              171.60      1.00       0.0
************
Link Summary
************
Name             From Node        To Node          Type            Length    %Slope Roughness
---------------------------------------------------------------------------------------------
C2               J1               OF1              CONDUIT           26.0    0.9616    0.0150
ORIFICE_PIPE     POND             J1               ORIFICE
SPILLWAY         POND             OF1              WEIR
*********************
Cross Section Summary
*********************
                                     Full     Full     Hyd.     Max.   No. of     Full
Conduit          Shape              Depth     Area     Rad.    Width  Barrels     Flow
---------------------------------------------------------------------------------------
C2               CIRCULAR            0.45     0.16     0.11     0.45        1     0.24
****************
Analysis Options
****************
Flow Units ............... CMS
Process Models:
  Rainfall/Runoff ........ YES
  RDII ................... NO
  Snowmelt ............... NO
  Groundwater ............ NO
  Flow Routing ........... YES
  Ponding Allowed ........ YES
  Water Quality .......... NO
Infiltration Method ...... CURVE_NUMBER
Flow Routing Method ...... KINWAVE
Starting Date ............ 06/20/2023 00:00:00
Ending Date .............. 06/22/2023 00:00:00
Antecedent Dry Days ...... 0.0
Report Time Step ......... 00:01:00
Wet Time Step ............ 00:05:00
Dry Time Step ............ 00:05:00
Routing Time Step ........ 5.00 sec
**************************        Volume         Depth
Runoff Quantity Continuity     hectare-m            mm
**************************     ---------       -------
Total Precipitation ......         0.517        41.758
Evaporation Loss .........         0.000         0.000
Infiltration Loss ........         0.257        20.773
Surface Runoff ...........         0.252        20.359
Final Storage ............         0.009         0.718
Continuity Error (%) .....        -0.220
**************************        Volume        Volume
Flow Routing Continuity        hectare-m      10^6 ltr
**************************     ---------     ---------
Dry Weather Inflow .......         0.000         0.000
Wet Weather Inflow .......         0.252         2.521
Groundwater Inflow .......         0.000         0.000
RDII Inflow ..............         0.000         0.000
External Inflow ..........         0.000         0.000
External Outflow .........         0.242         2.425
Flooding Loss ............         0.000         0.000
Evaporation Loss .........         0.000         0.000
Exfiltration Loss ........         0.000         0.000
Initial Stored Volume ....         0.000         0.000
Final Stored Volume ......         0.010         0.097
Continuity Error (%) .....         0.000
********************************
Highest Flow Instability Indexes
********************************
All links are stable.
*************************
Routing Time Step Summary
*************************
Minimum Time Step           :      5.00 sec
Average Time Step           :      5.00 sec
Maximum Time Step           :      5.00 sec
% of Time in Steady State   :      0.00
Average Iterations per Step :      1.00
% of Steps Not Converging   :      0.00
```

****
Subcatchment Runoff Summary
****

Subcatchment	Total Precip mm	Total Runon mm	Total Evap mm	Total Infil mm	Imperv Runoff mm	Perv Runoff mm	Total Runoff mm	Total Runoff 10^6 ltr	Peak Runoff CMS	Runoff Coeff
S1	41.76	0.00	0.00	14.25	18.82	8.20	27.02	0.12	0.07	0.647
S2	41.76	2.08	0.00	14.67	28.77	3.63	28.77	2.40	0.87	0.656
S5	41.76	0.00	0.00	35.75	0.00	4.84	4.84	0.17	0.01	0.116

****
Node Depth Summary
****

Node	Type	Average Depth Meters	Maximum Depth Meters	Maximum HGL Meters	Time of Max Occurrence days hr:min	Reported Max Depth Meters
J1	JUNCTION	0.36	0.39	171.69	0 03:28	0.39
OF1	OUTFALL	0.06	0.09	171.44	0 03:28	0.09
POND	STORAGE	0.40	0.85	172.45	0 03:28	0.85

****
Node Inflow Summary
****

Node	Type	Maximum Lateral Inflow CMS	Maximum Total Inflow CMS	Time of Max Occurrence days hr:min	Lateral Inflow Volume 10^6 ltr	Total Inflow Volume 10^6 ltr	Flow Balance Error Percent
J1	JUNCTION	0.000	0.020	0 03:28	0	2.02	0.000
OF1	OUTFALL	0.000	0.078	0 03:28	0	2.42	0.000
POND	STORAGE	0.941	0.941	0 01:25	2.52	2.52	-0.000

****
Node Flooding Summary
****

No nodes were flooded.

****
Storage Volume Summary
****

Storage Unit	Average Volume 1000 m³	Avg Pcnt Full	Evap Pcnt Loss	Exfil Pcnt Loss	Maximum Volume 1000 m³	Max Pcnt Full	Time of Max Occurrence days hr:min	Maximum Outflow CMS
POND	0.782	35.8	0.0	0.0	1.805	82.7	0 03:28	0.078

****
Outfall Loading Summary
****

Outfall Node	Flow Freq Pcnt	Avg Flow CMS	Max Flow CMS	Total Volume 10^6 ltr
OF1	99.32	0.014	0.078	2.425
System	99.32	0.014	0.078	2.425

****
Link Flow Summary
****

Link	Type	Maximum |Flow| CMS	Time of Max Occurrence days hr:min	Maximum |Veloc| m/sec	Max/ Full Flow	Max/ Full Depth
C2	CONDUIT	0.020	0 03:28	0.92	0.08	0.19
ORIFICE_PIPE	ORIFICE	0.020	0 03:28			0.00
SPILLWAY	WEIR	0.058	0 03:28			0.00

****
Conduit Surcharge Summary
****

No conduits were surcharged.
Analysis begun on: Thu Sep 14 13:43:30 2023
Analysis ended on: Thu Sep 14 13:43:30 2023
Total elapsed time: < 1 sec