Ontario

Ministry of Transportation

DRAINAGE, HYDROLOGY, STORMWATER MANAGEMENT AND FLOODPLAIN HYDRAULICS

Preliminary Design Report

407 Transitway from Jane Street to Kennedy Road

Delcan

TRANSPORTATION • INFORMATION TECHNOLOGY • WATER

Project No: GWP 252-96-00

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1. INTRODUCTION

1.1. Background and Project Description

Delcan Corporation (Delcan) was retained by the Ontario Ministry of Transportation (MTO) to prepare a Drainage, Hydrology, Stormwater Management and Floodplain Hydraulics Preliminary Design Report in support of an Environmental Progress Report (EPR) for the proposed 407 Transitway (407 TWY) between Jane Street and Kennedy Road, a total distance of approximately 28km.

The study area extends east to west along 407 Express Toll Route (407 ETR) from Kennedy Road in the Town of Markham to Jane Street in the City of Vaughan. The study area is located in the City of Vaughan, Town of Richmond Hill and Town of Markham in the Region of York. The proposed 407 Transitway (407 TWY) corridor through the study area is predominantly located in an urban environment passing through rolling terrain with large grassed areas on both north and south sides and its median. Refer to **Figure 1.1** for the study area.

This report has been prepared to document the proposed drainage plan, stormwater management and water crossings for the 407 TWY. The report also provides a framework for establishing design guidelines to be used during the detail design of the transitway.

1.2. Objectives and Scope of Work

The objectives of the study were to:

- develop a drainage and stormwater management plan for the proposed 407 TWY that minimizes impact on the existing watercourses and drainage system;
- undertake a hydraulic analysis of the proposed water crossings; and
- provide mitigation measures where necessary.

The study activities included:

- hydrologic analysis to assess any negative impacts on the existing watercourses;

- identifying possible measures to minimize stormwater runoff impacts to fisheries, surface water, groundwater and wetlands;
- calculation of stormwater storage volumes where needed to provide quantity and/or quality control;
- updating existing HEC-RAS models provided by TRCA to establish base models that could be used to assess the impact of the proposed 407 TWY;
- hydraulic analysis of proposed 407 TWY structures; and
- updating existing floodplain mapping received from TRCA to include the proposed 407 TWY.

1.3. Report Organization

This report is divided into six (8) chapters and several appendices.

Chapter 1 provides project background information, a brief overview of the project and its objectives.

Chapter 2 describes the existing environment for the proposed transitway, surface water drainage, major creek systems and soils.

Chapter 3 presents the pre-development hydrologic analysis of the study area.

Chapter 4 discusses the post-development hydrologic analysis.

Chapter 5 presents the stormwater management strategies for the proposed stations and parking lots.

Chapter 6 includes the hydraulic analysis of the proposed water crossings and describes the HEC-RAS modeling approach for each crossing.

Chapter 7 presents considerations for detailed design.

Chapter 8 identifies reports, design manuals, standards and guidelines that were referred to during preparation of this report.

The appendices include Visual OttHYMO model output tables for the pre-development, post-development condition with SWMFs and without SWMFs, the preliminary location and footprint of stormwater management ponds, HEC-RAS analysis for each crossing and hydrologic modeling of proposed 407 TWY facilities (workyards, parking lots, stations).

2. EXISTING ENVIRONMENT CHARACTERIZATION

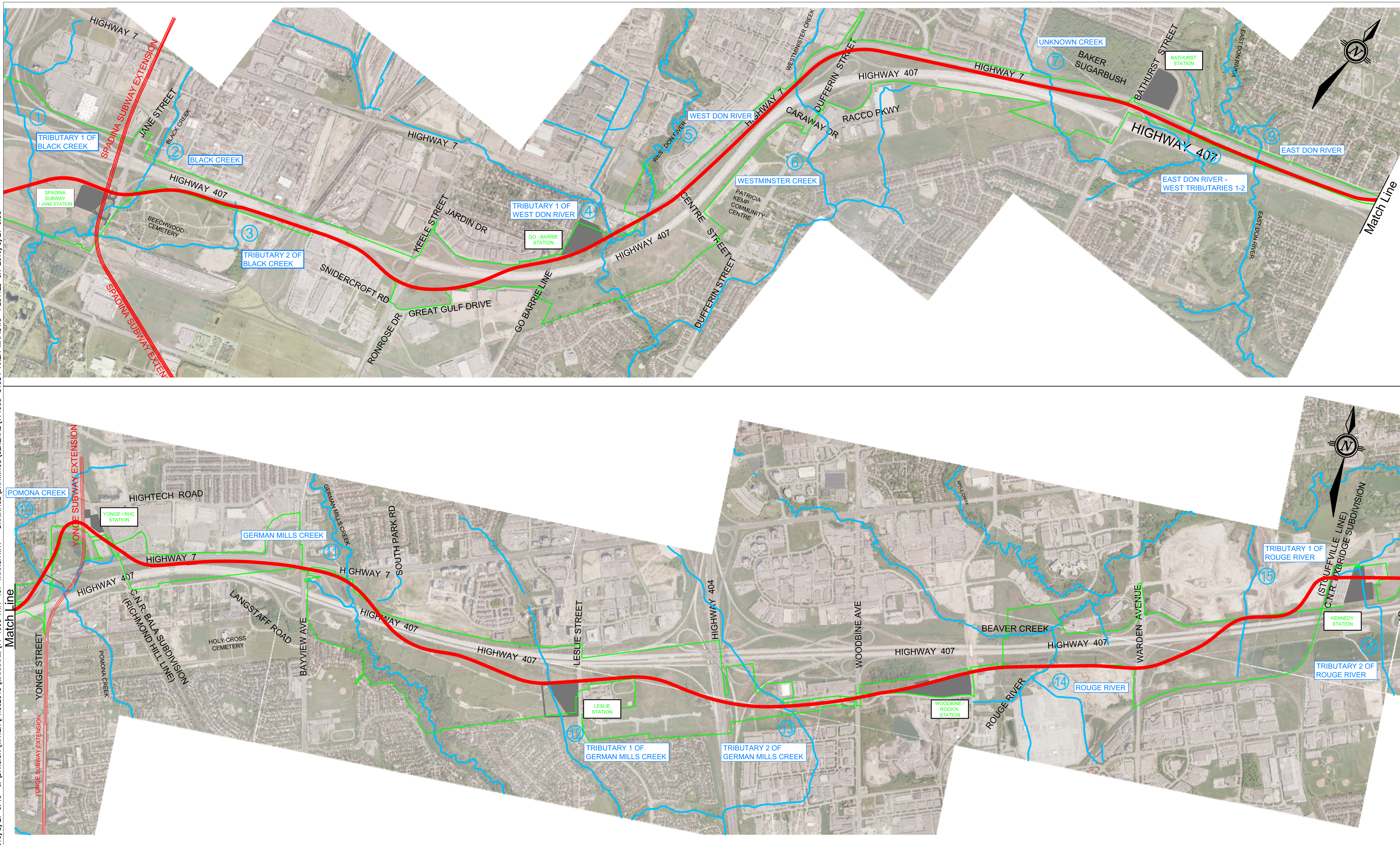
2.1. Surface Water Drainage

The proposed alignment of the 407 TWY closely follows the existing 407 ETR. The 407 ETR has been used in the following sections as a baseline reference in the discussion of existing conditions.

The existing drainage system along 407 ETR consists of open ditches, culverts and storm sewers. The 407 ETR is crowned such that 1 lane in each direction plus the paved median shoulder typically drains toward the median with the rest of the lanes draining towards the outside of the highway. Drainage along the centre median is provided by a system of storm sewers/culverts and/or ditch inlet catchbasins that outlet either directly to the transverse drainage crossings or to the outside ditches and ponds. The drainage along the outside edge of the highway varies. At some locations there is a curb or concrete barrier wall. Surface runoff from the outside lanes, speed change lanes and paved shoulder drains toward the curb/concrete barrier wall and is picked up by catchbasins that outlet into a storm sewer system or directly into the adjacent roadside ditch. At other locations, the road has a "rural' type cross section and the highway runoff flows across the shoulder and directly into the ditch.

2.2. Major Creek Systems

The study area crosses three (3) major watersheds governed by the Toronto and Region Conservation Authority (TRCA) - the Humber River, Don River (West and East Don River), and Rouge River. Within the above-mentioned watersheds, 16 (sixteen) watercourses cross the proposed alignment of 407 TWY as described in **Table 2.1** (refer to **Figure 1.1** for location of each creek):



HIGHWAY 7
SPADINA SUBWAY EXTENSION
JANE STREET
BLACK CREEK
TRIBUTARY 1 OF BLACK CREEK
BLACK CREEK
SPADINA SUBWAY / JANE STATION
HIGHWAY 407
BEECHWOOD CEMETERY
TRIBUTARY 2 OF BLACK CREEK
SNIDERCROFT RD
RONROSE DR
GREAT GULF DRIVE
KEELE STREET
JARDIN DR
TRIBUTARY 1 OF WEST DON RIVER
GO - BARRIE STATION
GO BARRIE LINE
WEST DON RIVER
WEST DON RIVER
WESTMINSTER CREEK
WESTMINSTER CREEK
CENTRE STREET
PATRICIA KEMP COMMUNITY CENTRE
DUFFERIN STREET
CARAWAY DR
RACCO PKWY
UNKNOWN CREEK
BAKER SUGARBUSH
BATHURST STREET
BATHURST STATION
EAST DON RIVER
EAST DON RIVER
EAST DON RIVER - WEST TRIBUTARIES 1-2
Match Line
POMONA CREEK
YONGE SUBWAY EXTENSION
YONGE / RHC STATION
HIGHTECH ROAD
GERMAN MILLS CREEK
SOUTH PARK RD
YONGE STREET
POMONA CREEK
C.N.R. BALA SUBDIVISION (RICHMOND HILL LINE)
LANGSTAFF ROAD
HOLY CROSS CEMETERY
BAYVIEW AVE
LESLIE STREET
LESLIE STATION
TRIBUTARY 1 OF GERMAN MILLS CREEK
HIGHWAY 404
TRIBUTARY 2 OF GERMAN MILLS CREEK
WOODBINE AVE
WOODBINE / RODICK STATION
ROUGE RIVER
ROUGE RIVER
BEAVER CREEK
WARDEN AVENUE
TRIBUTARY 1 OF ROUGE RIVER
C.N.R. UXBRIDGE SUBDIVISION (STOUFFVILLE LINE)
KENNEDY STATION
TRIBUTARY 2 OF ROUGE RIVER
KENNEDY ROAD
1
2
3
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500m
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ACAD2008 2010/8/27 9:46 J:\DIVISION\WATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY - DRAINAGE\DRAWINGS\GENERAL\TT4003-STUDY AREA MAP.DWG PLOTTED ON 2010/8/27 9:55

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HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

Figure 1.1: STUDY AREA MAP

Table 2.1. Summary of water crossings

Ref. No	Name	Location	
1	Tributary 1 of Black Creek	East of Hwy 400	Humber River
2	Black Creek	East of Jane Street	
3	Tributary 2 of Black Creek	East of Jane Street	
4	Tributary 1 of West Don River	East of GO Barrie Line	Don River
5	West Don River	West of Centre Street	
6	Westminster Creek	West of Dufferin Street and Hwy 7	
7	Tributary to East Don River (Baker Sugarbush)	West of Bathurst Street	
8	East Don River- west tributaries 1-2	East of Bathurst	
9	East Don River	West of Yonge Street	
10	Pamona Creek	West of CNR Bala	
11	German Mills Creek	West of Bayview Street &Hwy 407	
12	Tributary 1 of German Mills Creek	West of Leslie Street	
13	Tributary 2 of German Mills Creek	Hwy 404/Hwy 407	
14	Rouge River	West of Warden Ave.	Rouge River
15	Tributary 1 of Rouge River	East of Warden Ave.	
16	Tributary 2 of Rouge River	West of Kennedy Road	

The proposed transitway is located in the upstream areas of the watersheds. Locally, watercourse slopes are generally less than 1%. The general direction of drainage is from the north side of 407 ETR, south and east towards Lake Ontario. There is one exception (Rouge River - Creek

Ref#14), where the drainage flows easterly and from south to north. The environmental issues and mitigation measures at these watercourses were detailed as part of the planning, engineering and construction of 407 ETR. Upstream of 407 ETR, the watershed areas extend as far north as the Oak Ridges Moraine. All of the watersheds have both urban and rural components and peak flows are expected to be quite variable from one watershed to another.

The TRCA has actively studied the water surface profiles and design flow rates of the major creeks and this information has been obtained to be used as part of the design guidelines for the future detailed design. It is expected that future development and urbanization will affect the peak flows in the major creeks. As the TRCA actively manages flood control and peak flow mitigation measures in the various watersheds, they are the best source for design flow information for the major creek crossings.

2.3. Existing Ponds

The 407 ETR corridor has a total of 21 stormwater management facilities with an average depth of 1.0m. Their location and IDs are listed in **Table 2.2** shown in **Appendix A**.

2.4. Soils

The study area lies within the physiographic region known as the Iroquois Plain (*Physiography of Southern Ontario, Chapman and Putnam, 1984*). The area is characterized by clay and till plains with drumlins and areas of silty lacustrine deposits. Report No. 23 of the Ontario Soil Survey (*Soil Survey of Ontario County, 1960*) shows that the soil types mainly consist of loam or clay loam with a section of sandy loam.

Minimum soil percolation rates as shown in *Table 4.4,* from *MOEE, 2003* are 15 mm/h for loam, 25 mm/h for sandy loam, 60 mm/h for loamy sand and 210 mm/h for sand. The minimum recommended percolation rate for infiltration type water quality treatment facilities is 60 mm/h. While actual infiltration rates are not available for the soils within the right-of-way of the 407 TWY, it would appear that infiltration type treatment would only be feasible in locations where the native soil is a sand and perhaps within the sandy loam area. The typical clay loam and loam

soils within the study area would be unsuitable for infiltration type treatment of storm water runoff.

2.5. Meteorology

The rainfall events that have been analyzed for each watershed were taken from the TRCA hydrologic model. They correspond to the City of Toronto Pearson historical data. These hyetographs have been used to assess the pre-development and post-development conditions for the 407 TWY and the upstream catchment areas. The return periods for each storm analyzed are 2-year, 5-year, 10-year, 25-year, 50-year, 100-year and the Tegional event. The distribution varies from watershed to watershed as per TRCA's modeling studies. For further details refer to Hydrologic Modeling included in Chapter 3&4 of this report.

3. HYDROLOGIC ANALYSIS – PRE-DEVELOPMENT CONDITION

Hydrologic maps (refer to **Figures 3.1, 3.2** and **3.3** included in **Appendix A**) and models, as well as flow information for each watershed were provided by TRCA for the purpose of this study. The models were analyzed and where necessary, subwatersheds upstream of the proposed transitway were extracted from the model to simplify the analysis. For the purpose of this analysis hydrologic reference points (HRPs) have been identified for comparative analysis. (Note: some HRPs coincide with nodes in the TRCA's models).

3.1. Humber River Watershed

The hydrologic model and map for Humber River watershed - *Humber River Watershed Hydrology Update, Nov 2002* prepared by Aquafor Beech Limited for TRCA were provided by TRCA (refer to **Figure 3.1**, **Appendix A**). The original hydrologic model (provided in INTERHYMO) was converted into Visual OttHYMO Version 2.3.1. All input parameters were used as per the original model including rainfall events. Design storm events included the 2-year up to 100-year and the Regional event. For the purpose of this study Black Creek subwatersheds 46.00, 46.10 and 46.20 have been used in the analysis.

The proposed 407 TWY at the western limit of this study crosses the Black Creek subwatershed. Three (3) HRPs have been identified as HRP 46.20 for the longer eastern area, HRP 46.10 for the western area and HRP 46.00 is at the junction just downstream of 46.10 and 46.20. The subwatershed is delineated in the south by the CN rail tracks just south of the 407 ETR. The watercourses join together at the CN rail tracks and the total area draining into the existing culverts (2@3x3.5m oval culverts) under the CN tracks has been estimated as 1422ha. Refer to **Figure 3.4** in **Appendix A** for details.

Pre-development peak flows were calculated using the original model areas provided by TRCA. Subsequently, the areas representing the proposed transitway were subdivided from the original area in order to provide representative flow targets for both pre-development and post-development scenarios. Pre-development simulation results are shown in **Table 3.1**. **The Visual**

OttHYMO Modelling Schematics-1 included in **Appendix A** illustrates pre-development condition scenario.

There are two existing 407 ETR stormwater management ponds in this area named SP3 and SP4 respectively (refer to **Figure 3.4, Detail 1**). These ponds were not included in the models provided by TRCA and were not analyzed for this study.

3.2. Don River Watershed

The hydrologic model and map for Don River Watershed were provided by TRCA. For the purpose of this study, the hydrologic model has been extracted to include only the relevant subwatersheds for the present study as shown in **Figure 3.5** in **Appendix A**:

- subwatershed 6 – catchment area of Creek Ref # 4
- subwatersheds 1, 2, 3, 4, and 5 – catchment area of Creek Ref # 5
- subwatersheds 8A and 8B – catchment area of Creek Ref # 6
- subwatershed 24 – catchment area of Creek Ref # 7 and 8
- subwatersheds 17, 18, 19, 20, 21, 22 and 23 – catchment area of Creek Ref # 9
- subwatershed 26 – catchment area of Creek Ref # 10
- subwatersheds 29 and 30 – catchment area of Creek Ref # 11
- subwatershed 31– catchment area of Creek Ref # 12 and Creek Ref # 13

3.2.1. West Don River

The West Don River catchments 5, 6 and 8A join just upstream of the existing 407 ETR which is located downstream of the proposed 407 TWY. Catchment area 5 includes tributary area IDs 1 to 4. The total upstream drainage area is approximately 4247ha. HRP 7.1, 7.2 and 9.3 have been identified as points of reference for the analysis. **Figure 3.5** in **Appendix A** shows the catchment areas upstream of the proposed 407 TWY and downstream to the HRPs.

Pre-development peak flows were calculated using the original TRCA model. The model was provided in Visual OttHYMO and no conversion was necessary. The areas representing the proposed transitway were subdivided from the original area in order to provide representative flow targets for both the pre-development and post-development scenarios. Simulation results are shown in **Table 3.2. Visual OttHYMO Modelling Schematics-2** included in **Appendix A** illustrates pre-development condition scenario for West Don River.

There are four existing 407 ETR stormwater management ponds (D1, D2, D3 and D4) in this area. Refer to **Figure 3.6, Details 1** to **3**. These ponds were not included in the models provided by TRCA and were not analyzed for this study.

3.2.2. East Don River

The East Don tributary area is shown in **Figure 3.5** in **Appendix A** and is comprised of Area IDs 17 to 24 and 26. HRPs 23.1, 26 and 49.2 have been identified as points of reference for the analysis. The HRPs are located just downstream of the proposed crossings and were used for the comparative analysis.

The proposed 407 TWY bisects Area 24 and crosses Area 23 at its southern limits. Area 24 is mostly developed with residential neighborhoods and commercial.

The Pomona Creek is represented by Area 26 in the Don River OttHYMO model.

Pre-development peak flows were calculated using the original TRCA models. The areas representing the proposed transitway were subdivided from the original areas and simulation results are shown in **Table 3.2. Visual OttHYMO Modelling Schematics-3** included in **Appendix A** illustrates pre-development condition scenario.

There are three existing 407 ETR stormwater management ponds (D5 to D7) in the area between Keele Street and Bayview Avenue, as well as another existing pond, outside the 407 ETR right-of-way (refer to **Figure 3.6, Details 3** and **4** and **Figure 3.7, Detail 5, in Appendix A**). These ponds were not included in the models provided by TRCA and were not analyzed for this study.

German Mills Creek

The German Mills Creek is also a tributary of the East Don River and is comprised of Area IDs 29 and 30 with a total of 1,904ha draining to HRP 30.1 located downstream of the proposed 407 TWY. Area ID 31 with a drainage area1381ha is an eastern tributary of the German Mills watershed and joins the main creek just upstream of HRP 32.2, at HRP 31, identified as points of references for the analysis.

Pre-development peak flows were calculated using the original TRCA models. The areas representing the proposed transitway were subdivided from the original area and simulation results are shown in **Table 3.2. Visual OttHYMO Modelling Schematics-3** included in **Appendix A** illustrates pre-development condition scenario.

Within the German Mills Creek watershed there are eight (8) existing ETR stormwater management ponds (Pond ID-existing, D9A, D10, D1 to D5), refer to **Details 5 to 7** in **Figure 3.7, Appendix A**. The existing ponds were not included in the models provided by TRCA and were not modeled for this study.

3.3. Rouge River

The hydrologic model and map for the Rouge River watershed were provided by TRCA. The existing OttHYMO hydrologic model and map for the Rouge River watershed was obtained from TRCA and there was no need for conversion.

The relevant subwatersheds for the present study as shown in **Figure 3.8** in **Appendix A** are 318, 319, 320, 322, 323, 340 and 350.

The subwatersheds ID between Woodbine Avenue and Warden Avenue are 322, 323, 340 and 350 in the model with a total tributary area of approximately 867ha. The area between Warden Avenue and the CN rail tracks is contained within subwatershed area 319 with a total area of 288ha. Refer to **Figure 3.8** in **Appendix A**.

Area ID 318 also drains north towards the main Rouge from the CN rail tracks to a high point just east of Kennedy Road.

Within the aforementioned subwatersheds there are five (5) existing 407 ETR stormwater management ponds (Pond D4, R1, R2, R3 and R4). The existing ponds were not included in the existing OttHYMO model provided by TRCA and were not analyzed for this study.

HRPs 826, 827, 828 and 833 have been identified as points of reference for the analysis. In addition, a new HRP – 9024 was introduced for comparative analysis for Area ID 319. Area ID 319 has been subdivided in two areas representing the areas north and south of the newly constructed Enterprise Boulevard.

Pre-development peak flows were calculated using the original TRCA model. The areas representing the proposed transitway were subdivided from the original area in order to provide representative flow targets for both the pre-development and post-development scenarios. Simulation results are shown in **Table 3.3. Visual OttHYMO Modelling Shematics-4** included in **Appendix A** illustrates the pre-development condition scenario.

Table 3.1 HUMBER RIVER (BLACK CREEK) - Pre-development peak flows (m^3/s) at downstream HRPs

Return Period	BLACK CREEK		
	HRP 46.10	HRP 46.20	HRP 46.00
Area (ha)	356.28	1066.18	1422.46
2-yr	5.30	25.16	30.46
5-yr	8.63	36.98	44.90
10-yr	11.56	44.40	54.74
25-yr	14.73	56.73	70.20
50-yr	23.00	65.67	82.03
100-yr	28.52	74.71	93.96
Regional	40.61	123.70	163.69

Table 3.2 DON RIVER - Pre-Development peak flows (m^3/s) at downstream HRPs

Return Period	WEST DON RIVER			EAST DON RIVER			EAST DON - GERMAN MILLS CREEK		
	HRP 7.1	HRP 7.2	HRP 9.3	HRP 23.1	HRP 26	HRP 49.2	HRP 30.1	HRP 31	HRP 32.2
Area (ha)	5004.66	4625.83	5657.46	3649.31	699.30	4887.33	1903.65	1380.46	3284.11
2-yr	19.96	22.63	25.70	13.25	16.50	25.21	26.48	34.75	61.43
5-yr	28.04	31.47	36.28	19.57	24.21	38.18	45.56	52.44	95.65
10-yr	34.70	39.47	45.46	24.52	34.52	52.70	60.87	64.42	121.26
25-yr	46.65	62.56	62.70	31.97	43.92	66.99	87.05	89.90	179.16
50-yr	56.41	82.29	79.21	39.47	45.84	73.28	106.85	104.49	202.57
100-yr	67.80	123.61	97.92	47.16	52.44	85.56	132.48	119.45	242.45
Regional	323.68	349.39	385.89	176.60	77.73	238.38	196.57	147.22	343.27

Table 3.3 ROUGE RIVER - Pre-Development peak flows (m^3/s) at downstream HRPs

Return Period	ROUGE RIVER				
	HRP 826	HRP 827	HRP 828	HRP 9024	HRP 833
Area (ha)	1244.12	1654.12	1682.41	174.70	6633.86
2-yr	23.77	32.60	31.32	2.32	31.69
5-yr	31.61	43.31	42.01	3.14	45.97
10-yr	35.93	49.28	47.96	3.59	53.94
25-yr	41.37	56.73	55.40	4.16	63.92
50-yr	45.16	61.72	60.32	4.52	69.99
100-yr	49.08	67.48	64.24	4.92	77.45
Regional	100.63	130.60	132.16	9.93	272.40

4. HYDROLOGIC ANALYSIS – POST-DEVELOPMENT CONDITION

The Visual OttHYMO simulation modeling software was used for the hydrologic analysis. The STANDHYD component was used for the transitway areas and the change from existing conditions to the transitway scenario was modeled by increasing the imperviousness input variable (all transitway areas were estimated 90% impervious and 90% connected to be conservative).

The preliminary plan and profile of 407 TWY were used to delineate transitway drainage sub-areas. A Visual OttHYMO model was created for both post-development uncontrolled and post-development controlled scenarios. The main objective of this exercise was to obtain volumetric requirements at the local level for quantity control as per TRCA requirements. Results are shown in **Appendix A.**

4.1. Humber River (Black Creek)

The proposed transitway drainage areas are shown in **Figure 3.4**, **Detail 1**. Increases in runoff peak flows due to the construction of the transitway were estimated and compared to the pre-development peak flows at the HRPs identified in the previous chapter. **Table 3.4** shows the percent increase without stormwater management measures.

HRP 46.20

Transitway subarea IDs 2 and 3 (0.42ha) will be draining to a low point under Jane Street just north of the proposed TTC subway (Spadina Subway Extension). There is a proposed channel realignment by the TTC that will allow a connection through a proposed bio-detention swale just south of the 407 TWY.

Transitway subarea ID 4 (1.32ha) will drain towards a proposed enhanced grassed swale and discharge into the east side of the Black Creek via rock flow check and grassed swales.

HRP 46.10

Proposed subarea ID 1 (1.2ha) will be conveyed via a swale to a proposed SWM facility on the east side of Creek Reference#1 that will also treat the runoff from the proposed transitway facilities (parking lot, work yard, station).

Existing 407 ETR ponds SP3 and SP4 cannot be used as outlets because they are located at a higher elevation as shown in **Figure 3.4 – Detail 1** in **Appendix A**.

According to the modeling results included in **Table 3.4** the increase in peak flows at the above mentioned HRPs is minimal (0.1% - 0.3%) and this does not warrant the use of quantity control facilities.

HRP 46.00 is the junction between 46.10 and 46.20 and **Hydrograph-1** included in **Appendix A** shows the comparison for the 100-yr hydrograph in the pre-development and post-development conditions at this HRP. **Visual OttHYMO Modelling Schematics-5** included in **Appendix A** illustrates the post-development condition scenario for Black Creek.

A stormwater management strategy is discussed in Chapter 5.

4.2. Don River

4.2.1. West Don River

The proposed transitway drainage areas for the West Don River are shown on **Details 1** to **3** in **Figure 3.6** in **Appendix A**. Increases in runoff peak flows due to the construction of the transitway were estimated and compared to the pre-development peak flows using the HRPs 7.1, 7.2 and 9.3 identified in the previous chapter. **Table 3.5** shows the percent increase without stormwater management measures.

HRP 7.1

Within subwatershed 7 of the West Don River hydrologic model, a total area of 3.7ha represented by transitway sub-area IDs 71 to 73 will drain towards Keele Street. The proposed 407 TWY

goes underground at Keele Street and there is little opportunity to convey the 407 TWY flows into the 407 ETR ROW. Therefore east of the eastbound ramp, an existing swale that appears to enter the municipal system could potentially be used as an outlet. For this outlet, controlling post-development to pre-development runoff rates is proposed (refer to **Table 3.6**, **Appendix A** for pond details).

Sub-area IDs 83 and 84 of the proposed 407 TWY, will drain toward 407 ETR ponds D2 and D3, however, the proposed embankments of the 407 TWY encroaches in the existing ponds. These two ponds need to be re-designed and reconstructed to allow the construction of the 407 TWY.

HRP 7.2

Transitway sun-area IDs 74 to 77, 61, 62 and area 51 will drain to a low point at the GO-Barrie CN proposed platform and then conveyed to the existing 407 ETR SWM pond D1. The adequacy of this pond will be assessed during detailed design. Should the existing pond not have enough capacity there are other alternatives including enhanced swales that could be implemented.

HRP 9.3

Transitway sub-area IDs 85, 86 and 241 will drain towards 407 ETR pond D4. The adequacy of this pond will be assessed during detailed design.

According to the modeling results included in **Table 3.5** the increase in peak flows at the above mentioned HRPs is minimal (0.1% - 0.6%) and this does not warrant the use of quantity control facilities.

HRP 9.3 is the junction between 7.1 and 7.2 and **Hydrograph-2** included in **Appendix A** shows the comparison for the 100-yr hydrograph in the pre-development and post-development conditions at this HRP. **Visual OttHYMO Modelling Schematics-6** included in **Appendix A** illustrates the post-development condition scenario for West Don River.

A stormwater management strategy is discussed in Chapter 5.

4.2.2.East Don River

The proposed drainage areas for the East Don River are shown in **Figure 3.6 Details 3** and **4** and **Figure 3.7 Detail 5** in **Appendix A**. Increases in runoff peak flows due to the construction of the transitway were estimated and compared to the pre-development peak flows using the HRPs 23.1, 26 and 49.2 identified in the previous chapter. **Table 3.5** shows the percent increase without stormwater management measures.

HRP 23.1

Transitway sub-area ID 242 is tributary of existing pond D5 and transitway sub-area ID 243 is tributary to existing 407 ETR pond D6. The adequacy of these ponds will be assessed during detailed design.

Transitway sub-area IDs 244, 232, 233 and 234 are proposed to drain to enhanced grassed swales as shown in **Figure 3.6, Appendix A**.

From upstream catchment area 26, transitway sub-area IDs 262 and 2644 will be diverted towards upstream catchment area 23.

HRP 26 and HRP 49.2

Within upstream catchment area 26, transitway sub-area IDs 265 to 269 represent the underground section of the proposed 407 TWY. A joint strategy should be developed between the proposed Yonge Subway Extension and the 407 design team at detail design stage.

According to the modeling results included in **Table 3.5** the increase in peak flows at the above mentioned HRPs is minimal (0.1% - 0.6%) and this does not warrant the use of quantity control facilities. HRP 49.2 is the junction between HRP 23.1 and HRP 26. **Hydrograph-3** included in **Appendix A** shows the comparison for the 100-yr hydrographs for HRP 49.2 in the pre-development and post-development conditions. **Visual OttHYMO Modelling Schematics-7** included in **Appendix A** illustrates the post-development condition scenario for East Don River.

German Mills Creek

The proposed transitway drainage areas for the German Mills Creek are shown in **Figure 3.7 Details 5 to 7** in **Appendix A**. Increases in runoff peak flows due to the construction of the transitway were estimated and compared to the pre-development peak flows using HRPs 30.1, 31 and 32.2 identified in the previous chapter. **Table 3.5** shows the percent increase without stormwater management measures.

HRP 30.1

Transitway sub-area IDs 301, 302, 303 will drain towards Creek Ref#11 through enhanced grassed swales.

HRP 31

Transitway sub-area IDs 310 and 311 drain to Creek Reference 12. Transitway sub-areas 312 and 313 drain to an enhanced grassed swales and then to existing 407 ETR Pond 1. Transitway sub-area 314 drain to 407 ETR Pond 3 and subarea IDs 315 to 317 will drain to an enhanced grassed The adequacy of Pond 1 will be assessed during detailed design.

According to the modeling results included in **Table 3.5** the increase in peak flows at the above mentioned HRPs is minimal (0.1% - 0.2%) and this does not warrant the use of quantity control facilities.

HRP 32.2 is the junction between HRP 30.1 and HRP 31. **Hydrograph-3** included in **Appendix A** shows the comparison for the 100-yr hydrograph for HRP 32.2 in the pre-development and post-development conditions. **Visual OttHYMO Modelling Schematics-8** included in **Appendix A** illustrates the post-development condition scenario for East Don - German Mills.

A stormwater management strategy is discussed in Chapter 5.

4.3. Rouge River

The proposed transitway drainage areas are shown in **Figure 3.9 Detail 1**to **3, Appendix A**. Increases in runoff peak flows due to the construction of the transitway were estimated and compared to the pre-development peak flows using HRPs 826, 827, 828 and 9024 identified in the previous chapter. **Table 3.6** shows the percent increase without stormwater management measures.

HRP 827

Transitway sub-area IDs 10, 20 and 30 (2.23ha) will drain to Creek Reference#14, (low point located at Rodick Road, just north of the proposed Woodbine station).

Transitway sub-area IDs 40 to 70 will drain towards existing 407 ETR Pond R3. The adequacy of this pond will be assessed during detailed design.

HRP 9024

Transitway sub-area IDs 80 and 90 will drain to a municipal system on Enterprise Blvd. The development underway will provide an outlet to the Rouge River.

According to the modeling results included in **Table 3.6** the increase in peak flows at the above mentioned HRPs is minimal (0.2% - 0.7%) and this does not warrant the use of quantity control facilities.

HRP 833 is the junction between HRP 828 and 9024. **Hydrograph-5** included in **Appendix C** shows the comparison for the 100-yr hydrographs for HRP 833 in the pre-development and post-development conditions. **Visual OttHYMO Modelling Schematics-9** included in **Appendix C** illustrates the post-development condition scenario for Rouge River.

A stormwater management strategy is discussed in Chapter 5.

Table 3.4 HUMBER RIVER (BLACK CREEK) - Post-development peak flows (m^3/s) at downstream HRPs

Return Period	BLACK CREEK								
	HRP 46.10			HRP 46.20			HRP 46.00		
	Pre-Dev	Post no SWMM	% increase	Pre-Dev	Post no SWMM	% increase	Pre-Dev	Post no SWMM	% increase
Area (ha)	356.28	356.28		1066.18	1066.18		1422.46	1422.46	
2-yr	5.30	5.31	0.3%	25.16	25.19	0.1%	30.46	30.50	0.1%
5-yr	8.63	8.63	0.1%	36.98	37.02	0.1%	44.90	44.95	0.1%
10-yr	11.56	11.57	0.1%	44.40	44.42	0.1%	54.74	54.80	0.1%
25-yr	14.73	14.75	0.1%	56.73	56.75	0.0%	70.20	70.23	0.0%
50-yr	23.00	23.01	0.0%	65.67	65.70	0.0%	82.03	82.06	0.0%
100-yr	28.52	28.54	0.1%	74.71	74.73	0.0%	93.96	93.98	0.0%
Regional	40.61	40.64	0.1%	123.70	123.74	0.0%	163.69	163.76	0.0%

Table 3.5 DON RIVER - Post-development peak flows (m^3/s) at downstream HRPs

Return Period	WEST DON RIVER														
	HRP 7.1					HRP 7.2					HRP 9.3				
	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase
Area (ha)	5004.66	5005.97		5005.97		4625.83	4627.12				5657.46	5657.56		5657.56	
2-yr	19.96	19.98	0.1%	19.98	0.0%	22.63	22.64	0.0%	--	--	25.70	25.70	0.0%	25.700	0.0%
5-yr	28.04	28.06	0.1%	28.06	0.0%	31.47	31.49	0.0%	--	--	36.28	36.30	0.0%	36.296	0.0%
10-yr	34.70	34.72	0.1%	34.72	0.0%	39.47	39.49	0.0%	--	--	45.46	45.23	-0.5%	45.231	-0.5%
25-yr	46.65	46.68	0.1%	46.68	0.0%	62.56	62.57	0.0%	--	--	62.70	62.68	0.0%	62.678	0.0%
50-yr	56.41	56.41	0.0%	56.41	0.0%	82.29	81.64	-0.8%	--	--	79.21	79.23	0.0%	79.234	0.0%
100-yr	67.80	67.84	0.1%	67.84	0.0%	123.61	124.31	0.6%	--	--	97.92	98.05	0.1%	98.036	0.1%
Regional	323.68	323.61	0.0%	--	--	349.39	348.93	-0.1%	--	--	385.89	385.73	0.0%	--	--

Return Period	EAST DON RIVER														
	HRP 23.1					HRP 26					HRP 49.2				
	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase
Area (ha)	3649.31	3649.94				699.3	697.76				4887.33	4886.54			
2-yr	13.25	13.27	0.2%	--	--	16.50	16.47	-0.2%	--	--	25.21	25.30	0.3%	--	--
5-yr	19.57	19.59	0.1%	--	--	24.21	24.14	-0.3%	--	--	38.18	38.26	0.2%	--	--
10-yr	24.52	24.54	0.1%	--	--	34.52	34.42	-0.3%	--	--	52.70	52.76	0.1%	--	--
25-yr	31.97	32.00	0.1%	--	--	43.92	43.78	-0.3%	--	--	66.99	67.02	0.0%	--	--
50-yr	39.47	39.49	0.1%	--	--	45.84	45.85	0.0%	--	--	73.28	73.34	0.1%	--	--
100-yr	47.16	47.19	0.1%	--	--	52.44	52.43	0.0%	--	--	85.56	85.56	0.0%	--	--
Regional	176.60	176.61	0.0%	--	--	77.73	77.52	-0.3%	--	--	238.38	238.46	0.0%	--	--

Return Period	GERMAN MILLS CREEK														
	HRP 30.1					HRP 31					HRP 32.2				
	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase
Area (ha)	1903.65	1904.04				1380.46	1380.76					3284.8			
2-yr	26.48	26.29	-0.7%	--	--	34.75	34.76	0.0%	--	--	61.43	61.53	0.2%	--	--
5-yr	45.56	45.56	0.0%	--	--	52.44	52.42	0.0%	--	--	95.65	95.57	-0.1%	--	--
10-yr	60.87	60.83	-0.1%	--	--	64.42	64.38	-0.1%	--	--	121.26	120.72	-0.4%	--	--
25-yr	87.05	87.15	0.1%	--	--	89.90	89.84	-0.1%	--	--	179.16	178.86	-0.2%	--	--
50-yr	106.85	106.94	0.1%	--	--	104.49	104.41	-0.1%	--	--	202.57	202.82	0.1%	--	--
100-yr	132.48	132.42	0.0%	--	--	119.45	119.35	-0.1%	--	--	242.45	242.52	0.0%	--	--
Regional	196.57	196.61	0.0%	--	--	147.22	147.25	0.0%	--	--	343.27	343.36	0.0%	--	--

Table 3.6 ROUGE RIVER - Post-development peak flows (m^3/s) at downstream HRPs

Return Period	BEAVER CREEK									
	HRP 826					HRP 827				
	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase
Area (ha)	1244.12	1243.99				1654.12	1654.72			
2-yr	23.77	23.83	0.3%	--	--	32.60	32.72	0.4%	--	--
5-yr	31.61	31.68	0.2%	--	--	43.31	43.47	0.4%	--	--
10-yr	35.93	36.02	0.2%	--	--	49.28	49.46	0.4%	--	--
25-yr	41.37	41.47	0.2%	--	--	56.73	56.93	0.4%	--	--
50-yr	45.16	45.27	0.2%	--	--	61.72	61.93	0.4%	--	--
100-yr	49.08	49.20	0.2%	--	--	67.48	67.72	0.4%	--	--
Regional	100.63	100.73	0.1%	--	--	130.60	130.79	0.1%	--	--

Return Period	MIDDLE ROUGE									
	HRP 828					HRP 9024 (for Area 319-Enterprise)				
	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase
Area (ha)	1682.41	1682.85	1682.85			174.70	174.25			
2-yr	31.32	31.45	0.4%	--	--	2.32	2.34	0.7%	--	--
5-yr	42.01	42.17	0.4%	--	--	3.14	3.15	0.5%	--	--
10-yr	47.96	48.15	0.4%	--	--	3.59	3.61	0.4%	--	--
25-yr	55.40	55.60	0.4%	--	--	4.16	4.18	0.3%	--	--
50-yr	60.32	60.54	0.4%	--	--	4.52	4.53	0.3%	--	--
100-yr	64.24	64.46	0.3%	--	--	4.92	4.93	0.2%	--	--
Regional	132.16	132.35	0.1%	--	--	9.93	9.89	-0.5%	--	--

Return Period	BEAVER CREEK and MIDDLE ROUGE				
	HRP 833				
	Pre-Dev	Post no SWMM	% increase	Post with SWMM	% increase
Area (ha)	6633.86	6633.86			
2-yr	31.69	31.72	0.1%	--	--
5-yr	45.97	46.00	0.1%	--	--
10-yr	53.94	53.98	0.1%	--	--
25-yr	63.92	63.95	0.0%	--	--
50-yr	69.99	70.01	0.0%	--	--
100-yr	77.45	77.48	0.0%	--	--
Regional	272.40	272.45	0.0%	--	--

5. STORMWATER MANAGEMENT

5.1. Stormwater Management Criteria

Stormwater management criteria developed by the TRCA are described as follows:

Table 5.1 - Stormwater Management Criteria

Quantity Control	Control post-development peak flows to pre-development levels for all storms up to and including the 100-year storm
Quality Control	Enhanced protection (Level-1) is required for the Don River and Rouge River - Use criteria defined in *Table 3.2* of the Stormwater Management Planning and Design Manual (MOE, 2003) to determine the minimum permanent pool size for end of pipe facilities
Erosion Control	25mm event or as approved by the Authority
Water balance	Pre-development rate of infiltration should be maintained through one or a combination of on-site measures to the extent possible Site water balance following new development shall resemble pre-development conditions to the extent possible

The Ministry of the Environment document *Stormwater Management Planning and Design Manual (MOE, 2003)* provides guidance for the design of stormwater management facilities (SWM). Table 3.2 of this manual has been used to establish volumetric requirements for the level of protection required.

Developing a stormwater management strategy involves reviewing and evaluating alternative approaches to stormwater management to meet the above criteria. The recommended SWM Plans, are based on sound engineering, environmental, social and economic considerations.
The alternative approaches that were considered for the 407 TWY are passive stormwater management practices (SWMPs) that rely on gravity and include:

- Extended detention wet ponds
- Extended detention dry ponds
- Grassed Swales
- Conveyance Ditches

- Filter strips

The proposed 407 TWY will be located mostly in grassed areas. As a result of the introduction of impervious area within the ROW, volumes of runoff and local peak flows will likely increase. There may also be water quality impacts in the form of increased erosion, contaminants such as rubber and oil, and increased runoff temperature due to warming from the pavement/surface treatment structure.

Mitigation of potential impacts will be provided through the use of conveyance and end-of-pipe control measures such as grassed swales and wet ponds. Through the preliminary design process it has been determined that there are opportunities to drain the proposed 407 TWY runoff to existing swales within the 407 ETR ROW and treat the extra runoff using some of the existing downstream SWM infrastructure. Where the existing 407 ETR infrastructure cannot be used, new facilities will be provided.

5.2. Proposed Stormwater Management Strategy

The following sections describe the criteria and post-development strategy for drainage and stormwater management (SWM) within the ROW. Additional hydrologic and hydraulic analyses will be required during the detailed design stage to confirm the type and extent of the stormwater management works.

The objective of the SWM plan is to establish an environmentally sensitive plan for the SWM needs. The plan recognizes that an ecosystem approach must be followed whether the proposed Transitway passes through a watershed or subwatershed. The relationship between hydrologic and hydraulic regimes and the aquatic and terrestrial environments associated with the drainage plan must be considered.

5.2.1. Stormwater Management Ponds

Extended detention wet ponds are the most reliable end-of-pipe stormwater management facility in terms of pollutant removal. This type of facility consists of a permanent pool with extended

detention above the permanent pool level that is used during a storm event. Treatment occurs via sedimentation.

There are 21 existing stormwater management ponds in the 407 ETR corridor and a number of these will receive flow from the 407 TWY through the existing conveyance swales. Subsequent detailed studies will be required to determine existing pond capacities at the time of construction to accommodate the flow from the proposed 407 TWY. Retrofitting or other measures will be needed to provide the required level of control.

A number of these enhanced swales are proposed as shown in **Figures 3.4** to **3.9** in **Appendix C**.

5.2.2. Grassed swales

Grassed swales can be used to deal with quality and quantity control of runoff. Grassed swales would generally be suitable where SWM ponds are not used or where there is no extra capacity available with the existing ponds.

A literature review of highway runoff water quality (*MTO 1992*) shows that grasses swales of at least 60m in length are effective in reducing pollutant levels in highway runoff. Grasses swales need to be vegetated with a relatively flat gradient and a flat bottom to minimize flow velocity, maximize contact between the runoff and the vegetation and maximize sedimentation.

The effectiveness of grassed swales in terms of quality control depends on the flow depth, therefore the lower the depth the more effective the swale is for quality control. The majority of the existing side slopes are 3:1; however, these could also be retrofitted to meet the storage requirements. Velocities not exceeding 0.5m/s with a depth of flow of 0.25m are desirable according to *MOE Stormwater Management Planning and Design Manual (March 2003).*

5.2.3. Enhanced Grassed Swales

Permanent rock flow checks along the swale can be used to promote infiltration of stormwater and settling of pollutants. The flow checks can also provide some storage volumes to assist with quantity control. Flow checks reduce the effective slope of the swale and the ponding behind the flow check provides time for sedimentation and enhances the water quality treatment provided by

a standard grassed swale. Where the swale slope is too steep, small drop structures or short steep sections with rip rap can be used to flatten the swale. Refer to **Figures 3.4** to **3.9**, in **Appendix A** for proposed enhance grassed swale locations.

As per MTO design requirements (*MTO, January 2008*), the conveyance ditches (and grassed swales) are typically designed to convey the Minor System Flow (10-year) with the water level in the swale at or below the subgrade elevation. During the the Major System Flows (100-year), the flow spread should not extend onto either the shoulder or the travelled lane.

5.3. Proposed 407 TWY Stations, Parking Lots and Work Yards

Preliminary Visual OttHYMO models for the pre-development and post-development conditions were developed for five (5) 407 TWY facilities (stations, parking lots and workyards) located within the project limits and they are as follows:

- Jane Station – located west of Jane Street, south of the proposed 407 TWY
- Go Barrie Station – located just east of Go Barrie Line and north of the proposed 407 TWY
- Bathurst Station – located east of Bathurst Street and north of the proposed 407 TWY
- Leslie Station – located just west of Leslie Street and south of the proposed 407 TWY
- Woodbine Station – located east of Woodbine Station and south of the proposed 407 TWY

In the pre-development condition the stations were modeled as NASHYDs, using the same input parameters as in the TRCA model. The same approach was taken in areas where TRCA used STANDHYDs because the area allocated for the station is currently undeveloped.

In the post-development condition, the stations were modeled as STNDHYDs assuming they are 90% impervious and 90% connected (conservative approach). On-site stormwater quantity and quality controls are required at each of these locations due to the relatively large impervious areas associated with the stations, parking lots and work yards. Stormwater management criteria for these areas depend on the receiving watercourse and typically requires the control of post-development peak flow rates to pre-development levels for storm events from the 2-yr to the 100- yr, including water quality control. An end-of-pipe stormwater management pond is the

most appropriate stormwater management treatment due to the large drainage areas and the high level of imperviousness.

Figures 5.1 to **5.5** included in **Appendix B** show the location and footprint of the proposed stormwater management ponds that were preliminary designed to determine volumetric requirements for the proposed facilities (also refer to **Tables 5.1** to **5.5,** in **Appendix B)**. Tables with Design Parameters for each pond (SWMF-1 to SWMF-7) are included in **Appendix B**, as well as **Visual OttHYMO Modelling Schematics-10 to 12** for the pre-development and post-development hydrologic modeling for each station within each major watershed.

6. HYDRAULIC ANALYIS OF PROPOSED WATER CROSSINGS

The proposed 407 TWY crosses sixteen (16) creeks within three major watersheds. From west to east, they are the Humber River, Don River and Rouge River watersheds. The majority of the creeks are crossed by the existing Highway 7 and 407 ETR in close proximity to the proposed 407 TWY. Refer to **Figure 1.1** for the location of crossings.

The crossings within each watershed are as follows:

- Creek Ref 1, 2, 3 - Black Creek Subwatershed
- Creek Ref 4, 5, 6 - West Don River Subwatershed
- Creek Ref 7 through 13 - East Don River Subwatershed
- Creek Ref 14, 15, 16 - Rouge River Watershed
-

Table 6.1 provides a description of each crossing and the required analysis.

6.1. Methodology

TRCA maintains and updates hydraulic models in digital form as HEC-RAS (River Analysis System) models in the area of this study. The existing HEC-RAS models were obtained from TRCA for the above noted watersheds. Existing models were available for the major creeks as mentioned in **Table 6.1**. The input required to run the model includes cross-sectional elevation information determined by topographical survey or contour mapping. In addition to the HEC RAS model, the TRCA also maintains digital floodplain mapping that shows the limits of the regional flood levels within the major river systems. The floodplain mapping includes contour lines and existing topographical information. Digital floodplain mapping files were also obtained from TRCA to be used in the analysis. Refer to **Figures 6.2** to **6.6** in **Appendix C** for the existing floodplain mapping details.

A detailed survey was obtained from J.D. Barnes for the proposed 407 TWY alignment that included existing topographical information. This survey was compared to the contour line

mapping by TRCA to confirm crossing information in the model. A 3D surface was developed using Civil 3D Autodesk software with the TRCA mapping and the latest survey.

The proposed 407 TWY was overlaid on top of the existing floodplain mapping to determine existing cross-section information that needed to be updated and the location of new cross sections required to fully represent the proposed crossings. Simply adding existing condition cross-sections to a HEC-RAS model can result in changes to the simulated flood levels. The HEC-RAS model was first updated with new cross sections from the Civil 3D surface. These cross-sections were located to fit the proposed bridges or culverts as per model requirements. The updated model was used as the base model for the analysis and is called for the purposes of this report "*New Existing Model*".

Table 6.1. Summary of Water Crossings

Ref. No	Name	Location		NOTES
1	Tributary 1 of Black Creek	East of Hwy 400	Humber River	No floodplain mapping available - hydraulic analysis done with new HEC-RAS model
2	Black Creek	East of Jane Street		HEC-RAS model available from TRCA - analysis done by updating model
3	Tributary 2 of Black Creek	East of Jane Street		No analysis required, no upstream drainage areas, tributary is located downstream of TWY
4	Tributary 1 of West Don River	East of GO Barrie Line	Don River	HEC-RAS model available from TRCA - analysis done by upgrading West Don Basin 6
5	West Don River	West of Centre Street		HEC-RAS model available from TRCA - analysis done by updating - West Don Basin 5
6	Westminster Creek	West of Dufferin Street and Hwy 7		No HEC-RAS model available; flow through channel determined using West Don-Basin 5's Overflow - flows have been diverted towards the West Don - hydraulic analysis done with new HEC-RAS model
7	East Don Trib.	West of Bathurst		No models available, flows from Visual OttHYMO;
8	East Don River-west tributaries 1-2	East of Bathurst		No analysis required, 407 TWY alignment located above existing crossing; and above pond D5 – re-grading of pond is feasible during detailed design
9	East Don River	West of Yonge Street		No analysis required, 407 TWY alignment located above existing crossing
10	Pamona Creek	West of CNR Bala		No analysis required, 407 TWY alignment located above existing crossing
11	German Mills Creek	West of Bayview Street &Hwy 407		HEC RAS model available from TRCA - analysis done by updating model
12	Tributary 1 of German Mills Creek	West of Leslie Street		No floodplain mapping available, no models, flows calculated using Visual OttHYMO; analysis done using new HEC-RAS model
13	Tributary 2 of German Mills Creek	Hwy 404/Hwy 407		No floodplain mapping available - Creek has been enclosed; No analysis needed; grading details will be provided during detailed design and SWM analysis
14	Rouge River	West of Warden Ave.	Rouge River	Obsolete floodplain mapping available, no HEC available; analysis done using new HEC-RAS model created to simulate prop. bridge; flows taken from Beaver Creek HEC-RAS model (outlet SWMF 1323)
15	Tributary 1 of Rouge River	East of Warden Ave.		No analysis required, 407TWY alignment located above existing crossing
16	Trib.2 of Rouge	West of Kennedy Rd.		No analysis required, 407TWY align located above existing crossing

As per **Table 6.1**, there is a number crossings where analysis is not required because the alignment is well above the river in which case the proposed alignment is distant from the floodplain and/or above the 407 ETR or Highway 7 crossings.

Where the floodplain mapping and HEC-RAS models were not available from TRCA, new HEC-RAS models for existing and proposed conditions were developed using the existing survey data. Information and characteristics including flows used in the existing and proposed HEC-RAS model for each creek are provided in the following subchapters.

A detailed analysis of each water crossing is provided in subsequent sections of this report. The objective was to maintain water levels as per existing conditions. Where impacts were shown in the results, a number of iterations were conducted to determine the benefit of increasing bridge spans against the improvement in water levels. Differences in water levels have been recorded with recommendations regarding improvement to proposed structures to be addressed at the detailed design stage.

All the models developed can be used during subsequent design to plot the existing and proposed regional floodwater surface elevations. It is expected that cut/fill analyses will be required in a number of crossings during detailed design.

6.2. Hydraulic Design Standards

For this study, the following standards have been used from the MTO Drainage Manual (Jan 2008):

Standard WC-1: Design Flows (Bridges and Culverts)

- Road classification – freeway; Design flow – 100-year; check flow for scour 130% of 100-yr

Standard WC-2 – Freeboard and Clearance at Bridge Crossings

- The minimum freeboard is measured vertically from the High Water Level for the Design Flow (100-yr WL) to the edge of the travelled lane; the freeboard at bridge crossings shall be greater than or equal to 1m for freeways.
- The clearance is measured vertically from the High Water Level of the Design Flow to the lowest point on the soffit; the clearance for freeways shall be greater than or equal to 1m.
- Zero clearance is required for the regulatory flow.

6.3. Hydraulic Analysis

6.3.1. Tributary 1 of Black Creek (Creek Ref # 1)

Both, floodplain mapping and HEC-RAS model were not available from TRCA for this crossing. A new HEC-RAS model that includes 6 (six) sections was developed for existing and proposed conditions. The proposed bridge geometry was taken from the most up-to-date vertical alignment (July 5, 2010). The proposed floodplain mapping for this crossing is shown in **Figure 6.7, Appendix C. Figure 6.7-1,** in **Appendix C** shows the HEC-RAS sections used in the model and the regional water levels upstream and downstream of the proposed bridge.

The hydraulic model started approximately 200m below the transitway using the critical depth as starting water elevation. It is recommended that during detailed design the HEC-RAS model be updated with the proposed work for the TTC Spadina Subway Extension.

Existing and proposed Regional storm water levels for all sections are presented in **Table 6.3**

Table 6.3. Existing and Proposed Regional Water Levels - Creek Ref # 1

HEC-RAS Station	Water Level (m)	
	Existing Condition	Proposed Condition
200	188.37	188.38
180	188.36	188.35
150 – Bridge	--	55m span
140	188.34	188.34
100	188.24	188.24
80	187.44	187.44
60	186.07	186.07

The proposed bridge structure is 55m span, 13m wide with a minimum weir flow elevation of 190.48m.

The proposed 407 TWY HEC-RAS modeling shows that a minimal increase (~10mm) in water level is expected immediately upstream of the proposed structure and the bridge conveys the Regional storm without overtopping the road.

Storm profiles used in the HEC-RAS model include the 2-year to 100-year events, as well as the Regional event. **Table 6.2** in **Appendix C** shows water elevation results for all return periods analyzed, freeboard and clearance for the 100-year storm.

6.3.2. Black Creek (Creek Ref # 2)

Both the existing HEC-RAS model and floodplain mapping were available from TRCA. The model is included in the CD ROM in **Appendix C**. The hydraulic model was updated as follows:

- proposed 407 TWY structure (ST 46.096) modeled as a bridge with 4 piers;
- roadway/deck geometry modeled using latest profile of 407 TWY (July 5, 2010);

- new sections (ST 46.095 and ST 46.098) added in the model; and
- TRCA's sections 46.10 and 46.09 updated.

The existing floodplain mapping is shown in **Figure 6.2, Appendix C**. The proposed floodplain mapping illustrating the 407 TWY alignment, proposed bridge and new/ updated sections is shown in **Figure 6.8, Appendix C. Figure 6.8-1** in **Appendix C** shows the HEC-RAS sections used in the model and the regional water levels upstream and downstream of the proposed bridge.

Existing and proposed water levels for the Regional storm event for the section of the creek that has been impacted by the proposed transitway are presented in **Table 6.4.**

Table 6.4 Existing and Proposed Regional Water Levels - Creek Ref # 2

HEC-RAS Station	Water Level (m)			Notes
	Existing Condition		Proposed Condition	
	TRCA	New Existing		
46.142	200.36	200.36	200.37	Same section as existing
46.141	198.79	198.99	199	Same section as existing
46.14	198.84	199.04	199.04	Same section as existing
46.132	198.73	198.97	198.97	Same section as existing
46.131	198.60	197.92	198.93	Same section as existing
46.13	198.66	198.96	198.97	Same section as existing
46.122	198.67	198.97	198.98	Same section as existing
46.121	198.65	198.95	198.97	Same section as existing
46.12	198.66	198.95	198.97	Same section as existing
46.11	198.16	198.50	198.53	Same section as existing
46.10	194.64	195.66	195.68	Section updated
46.098	--	195.89	195.91	New section
46.096	--	--	60m span bridge	407 TWY new bridge
46.095	--	195.88	195.88	New section

HEC-RAS Station	Water Level (m)			Notes
	Existing Condition		Proposed Condition	
	TRCA	New Existing		
46.09	194.33	195.88	195.88	Section updated
46.082	194.34	195.81	195.81	Same section as existing
46.081	191.82	191.82	191.82	Same section as existing

The proposed structure is a bridge with a span of 60m, 13m wide and the minimum weir flow elevation 196.0m.

The impact shown by the results (20 to 30 mm increase) can be considered minimal and increased water levels are observed within the MTO right of way. No impacts are expected upstream of 407 ETR and/or downstream of Jane Street due to the construction of the proposed structure. The bridge conveys the Regional storm without overtopping the road.

It was found that there are discrepancies between the water levels reported in the TRCA floodplain mapping drawing and those given by the HEC-RAS model. The table above was developed using the model results.

Storm profiles used in the HEC-RAS model include the 2-year to 100-year events, as well as the Regional event. **Table 6.2** in **Appendix C** shows water elevation results for all return periods analyzed, freeboard and clearance for the 100-year storm.

6.3.3 Tributary 2 of Black Creek (Creek Ref # 3)

Tributary 2 is connected to the north side of 407 ETR via an existing culvert. It appears to collect overflow drainage from an area just upstream of 407 ETR right of way and/or slope drainage from the westbound 407 ETR embankment. On the downstream side, south of 407 ETR, this

tributary is a straight channel showing signs of intermittent flows. The existing culvert will not require extension because the proposed transitway will sit well above it on the embankment. No analysis is required for this creek. According to TRCA mapping, the watercourse does not have upstream drainage areas beyond 407 ETR.

6.3.4 Tributary 1 of West Don River (Creek Ref # 4)

Both the existing HEC-RAS model and floodplain mapping for this creek were available from TRCA. The model is included in CD ROM in **Appendix C**. The hydraulic model was updated as follows:

- proposed 407 TWY structure (ST 6.0155) modeled as a 70m span bridge;
- roadway/deck geometry modeled using latest profile of 407 TWY (July 5, 2010);
- new section (ST 6.012) downstream of proposed bridge added in the model; and
- TRCA section 6.01 updated.

The existing floodplain mapping is shown in **Figure 6.3** in **Appendix C**. The proposed floodplain mapping illustrating the 407 TWY alignment, proposed bridge and new/ updated sections is shown in **Figure 6.9, Appendix C. Figure 6.9-1** in **Appendix C** shows the HEC-RAS sections used in the model and the regional water levels upstream and downstream of the proposed bridge.

Existing and proposed water levels for the regional storm event for the section of the creek that has been impacted by the proposed transitway are presented in **Table 6.5.**

Table 6.5. Existing and Proposed Regional Water Levels - Creek Ref # 4

HEC-RAS Stations	Water Level (m)			Notes
	Existing Condition		Proposed Condition	
	TRCA	New Existing		
6.19	190.72	190.72	190.72	No modification
6.18	190.25	190.25	190.25	No modification
6.17	190.25	190.25	190.26	No modification
6.16 - 6.15	190.26	190.25	190.26	No modification
6.14 - 6.11	190.25	190.24	190.25	No modification
6.10 - 6.09	190.24	190.24	190.25	No modification
6.08	190.22	190.22	190.23	No modification
6.071 - 6.02	190.20	190.20	190.21	No modification
6.0155	--		Bridge	New 407 TWY bridge – 70m span
6.012	--	190.20	190.20	New section added for 407 TWY
6.01 - 6.00	190.20	190.20	190.20	Sections updated

The proposed structure is a bridge with a span of 70m, 1.23m deck, 13m wide and the minimum weir flow elevation 190.25m.

Analysis results show that impact to regional water levels is minimal. The proposed bridge will require further analysis during the detail design stage. It is recommended for this area that the transitway be constructed with a combination of vertical retaining walls and piers to eliminate the loss of storage due to embankments encroaching onto the floodplain. There is an existing culvert between cross-sections 6.11 and 6.10 in the HEC-RAS model from TRCA. When more details are known about the layout and arrangement of the parking lot during detail design, it may be possible to replace this culvert to further minimize impacts in the upstream reaches.

Storm profiles used in the HEC-RAS model include the 2-year to 100-year events, as well as the Regional event. **Table 6.2** in **Appendix C** shows water elevation results for all return periods analyzed, freeboard and clearance for the 100-year storm.

6.3.5 West Don River (Creek Ref # 5)

Both the existing HEC-RAS model and floodplain mapping of this creek were available from TRCA. The model is included in CD ROM in **Appendix C**. The hydraulic model was updated as follows:

- proposed 407 TWY structure (ST 5.0575) modeled as a 80m span bridge and 1.23m deck thickness;
- roadway/deck geometry modeled using latest profile of 407 TWY (July 5, 2010);
- Section 5.05 and 5.06 from TRCA model/map deleted;
- New section (ST 5.05) added in the model/map; and
- TRCA ST 5.04, 5.03, 5.01 updated.

The existing floodplain mapping is shown in **Figure 6.3** in **Appendix C**. The proposed floodplain mapping illustrating the 407 TWY alignment, proposed bridge and new/ updated sections is shown in **Figure 6.9, Appendix C. Figure 6.9-2** in **Appendix C** shows the HEC-RAS sections used in the model and the regional water levels upstream and downstream of the proposed bridge.

Existing and proposed water levels for the Regional storm event for the section of the creek that has been impacted by the proposed transitway are presented in **Table 6.6**.

Table 6.6 Existing and Proposed Regional Water Levels - Creek Ref # 5

HEC-RAS Stations	Water Levels (m)			Notes
	Existing Condition		Proposed Condition	
	TRCA	New Existing		
5.064	191.20	191.20	191.20	No modifications
5.063	191.13	191.14	191.14	No modifications
5.062	190.69	190.31	190.31	No modifications
5.061	190.74	190.37	190.37	No modifications
5.06	190.77	--	--	Section deleted
5.059	--	190.44	190.44	New section added for 407 TWY
5.058	--	190.37	190.38	New section added
5.0575	--	--	Bridge	New 407 TWY bridge – 80m span
5.05	190.64	190.40	190.35	New section added
5.04	190.30	190.39	190.39	Section updated
5.03	190.46	190.42	190.42	Section updated
5.02	190.29	190.26	190.26	No modifications
5.01	190.22	190.22	190.22	No modifications
5.00	190.20	190.20	190.20	No modifications

The proposed structure is a bridge with a span of 80m, 1.23m deck, 13m wide and the minimum weir flow elevation 190.95m.

Analysis results show that there is no impact on regional water levels. The changes in water levels within the bridge cross-sections 5.058 and 5.05 may indicate a hydraulic jump; this however does not impact any property or result in damage to property. The proposed bridge will require further analysis during the detail design stage. Just like in the previous crossing, it is recommended for this area that the transitway be constructed with a combination of vertical

retaining walls and/or piers to eliminate the loss of storage due to embankments encroaching onto the floodplain.

Storm profiles used in the HEC-RAS model include the 2-year to 100-year events, as well as the Regional event. **Table 6.2** in **Appendix C** shows water elevation results for all return periods analyzed, freeboard and clearance for the 100-year storm.

6.3.6 Westminister Creek (Creek Ref # 6)

The HEC-RAS model for this creek is included in the West Don River-Basin 5 HEC-RAS model received from TRCA. The model has been analyzed and it appears that the creek has been diverted and it flows towards West Don River through a 3.75m x 2.5m box culvert, 805m long (minimum weir flow elevation 201.0m) from south of Connie Crescent and west of Hwy 7 to south-west of N Rivermede Rd & Audia Ct. intersection (culvert/ diversion tunnel confirmed on site). However, the model results indicate that the flows generated by the 2-yr, 10-yr, 25-yr and 50-yr rainfall events are entirely conveyed through the culvert, whereas the 100-yr and the Regional events theoretically may overflow. For the purpose of this analysis it is assumed that the 100 -yr and regional event flows will overflow and be conveyed through the proposed transitway.

The proposed floodplain mapping is included in **Figure 6.10, Appendix C**. **Figure 6.10-1** in **Appendix C** shows the HEC-RAS sections used in the model and the Regional water levels upstream and downstream of the proposed bridge.

The HEC-RAS model for the existing and proposed conditions of this crossing includes four (4) sections and it started approximately 25m below the transitway using the critical depth as the starting water elevation.

Existing and proposed Regional storm water levels for all sections are presented in **Table 6.7**

Table 6.7. Existing and Proposed Regional Water levels - Creek Ref # 6

HEC-RAS Stations	Water Level (m)	
	Existing Condition	Proposed Condition
200	199.64	199.78
180	199.63	199.62
Bridge	--	10m span
160	199.47	199.42
140	199.25	199.25

The proposed structure is modeled as a bridge with a span of 10m, 13m wide and the minimum weir flow elevation 200.95m.

It should be noted that although there is a small increase in the proposed upstream water level (~1mm) there is no road overtopping during the regional event and the flow is contained in the channel and MTO property. No impacts are expected for upstream properties.

Storm profiles used in the HEC-RAS model include the 2-year to 100-year events, as well as the Regional event. **Table 6.2** in **Appendix C** shows water elevation results for all return periods analyzed, freeboard and clearance for the 100-year storm.

6.3.7 Baker Sugarbush – East Don Tributary (Creek Ref # 7)

There is no HEC-RAS model or floodplain mapping available from TRCA for this creek. A preliminary hydraulic analysis suggests that the existing culvert on Highway 7, upstream of 407 TWY, a 4.84m x 2m box culvert is oversized. The upstream drainage area is a residential subdivision with a stormwater management pond and a large trapezoidal grass channel that flows

into the existing structure The downstream channel flows towards Bathurst Street via swales and culverts and finally to the East Don River. It is possible that the oversized culvert has been designed for animal passage; a strategy should be developed during detailed design stages to mitigate the impacts to the existing crossing.

A considerable amount of grading will be required in this area to allow animal passage and drainage. A storm pipe is proposed to pick up the flows downstream of the existing culvert on Hwy 7 and convey them to pond D5, just west of Bathurst. Refer to **Figure 6.11** in **Appendix C** for details.

6.3.8 East Don River – Tributaries 1-2 (Creek Ref # 8)

There is no HEC-RAS model or floodplain mapping for this tributary from TRCA. There appears to be two tributaries that join at an existing online pond situated just south of an existing culvert under Highway 7. See **Figure 6.12** in **Appendix C** for details.

No HEC-RAS analysis is required for this creek since the proposed 407 TWY alignment is located above the existing crossing and above SWMF D5, however, the existing pond will need to be re-graded and retrofitted to allow for the proposed 407 TWY embankment construction. Due to the grade difference between the proposed transitway and the bottom of the valley, a bridge is proposed for this crossing. The bridge layout should be investigated to minimize large amounts of fill over the embankment. A cut and fill analysis should be performed during detail design for this crossing.

6.3.9 East Don River (Creek Ref # 9)

Both the existing HEC-RAS model and floodplain mapping of this creek were available from TRCA. **Figure 6.5** shows the existing floodplain mapping from TRCA. No analysis is required for this creek since the proposed 407 TWY alignment is located above the existing crossing. No hydraulic impacts are expected due to the transitway crossing of this watercourse with no piers or abutments proposed within the floodplain.

Table 6.2 in **Appendix C** shows water levels downstream of Hwy 7 culvert on Station 23.15, East Don, Basin 23 TRCA HEC model.

6.3.10 Pomona Creek (Creek Ref # 10)

No HEC RAS model or floodplain mapping were available from TRCA. The existing model starts well downstream of the proposed alignment. The area has been fully urbanized. No analysis is required for this creek since the proposed 407 TWY alignment is located above the existing culvert at Yonge Street and will completely span the watercourse.

6.3.11 German Mills Creek (Creek Ref # 11)

Both the existing HEC-RAS model and floodplain mapping of this creek were available from TRCA. The model is included in the CD ROM in **Appendix C**. The hydraulic model was updated as follows:

- proposed 407 TWY structure (ST 30.0628) modeled as a 50m span bridge;
- roadway/deck geometry modeled using latest profile of 407 TWY (July 5, 2010);
- Section ST 30.063 from TRCA's model/map updated;
- New section ST 30.0625 added downstream of the proposed bridge in the model/map;

The existing floodplain mapping is shown in **Figure 6.6, Appendix C** and the proposed floodplain mapping illustrating the 407 TWY alignment, proposed bridge and new/ updated sections is shown in is shown in **Figure 6.13, Appendix C**. **Figure 6.13-1** in **Appendix C** shows the HEC-RAS sections used in the model and the Regional water levels upstream and downstream of the proposed bridge.

Existing and proposed water levels for the regional storm event for the section of the creek that has been impacted by the proposed transitway are presented in **Table 6.8.**

Table 6.8. Existing and Proposed Regional Water Levels - Creek Ref # 11

HEC-RAS Stations	Water Level (m)			Notes
	Existing Condition		Proposed Condition	
	TRCA	New Existing		
30.064	193.41	193.41	193.41	Same section as existing
30.063	191.98	192.28	192.47	Section updated
30.0628	--	--	50m span bridge	407 TWY new bridge
30.0625	--	191.65	191.67	New section
30.062	191.44	191.44	191.44	Same section as existing

The proposed structure is a bridge with a span of 50m, 17m wide and the minimum weir flow elevation of 196.0 m.

The proposed arrangement does not impact upstream or downstream properties and the proposed bridge conveys the Regional storm without overtopping the road. The proposed transitway is located between Hwy 7 and 407 ETR and the only increase in water level is located just upstream of the proposed crossing. The water level returns to existing conditions at the downstream side of Hwy 7. A number of larger bridge sizes were modeled to assess the benefit of increasing spans, however, the water levels between the crossing and Hwy 7 do not decrease with larger spans. Increasing the bridge span to further reduce the proposed water level is not warranted.

Storm profiles used in the HEC-RAS model include the 2-year to 100-year events, as well as the Regional event. **Table 6.2** in **Appendix C** shows water elevation results for all return periods analyzed, freeboard and clearance for the 100-year storm.

6.3.12 Tributary 1 of German Mills Creek (Creek Ref # 12)

Both, floodplain mapping and HEC-RAS model were not available from TRCA for this crossing. A new HEC-RAS model that includes 6 (six) sections was developed for existing and proposed conditions. The proposed bridge geometry was taken from the most up-to-date vertical alignment.

The proposed floodplain mapping for this crossing is shown in **Figure 6.14** in **Appendix C. Figure 6.14-1** in **Appendix C** shows the HEC-RAS sections used in the model and the regional water levels upstream and downstream of the proposed bridge.

The hydraulic model started approximately 150m below the transitway using the critical depth as starting water elevation. Existing and proposed regional water levels for all sections are presented in **Table 6.9**.

Table 6.9. Existing and Proposed Regional Water Levels - Creek Ref # 12

HEC-RAS Stations	Water Level (m)	
	Existing Condition	Proposed Condition
200	181.05	181.05
140	180.79	180.91
Bridge	--	37m span
120	180.48	180.45
100	179.82	179.82
80	179.48	179.48
60	178.22	178.22

The proposed structure is a bridge with a span of 37m, 17.8m long and the minimum weir flow elevation 180.5m.

The proposed 407 TWY HEC-RAS modeling shows that a 0.12 m increase in water level is expected immediately upstream of the proposed structure, however the proposed bridge conveys the Regional storm without overtopping the road. Due to the vertical alignment of the proposed transitway there is minimum clearance for the 100 year event and during the Regional storm the water levels are very close to the proposed bridge deck elevation. The upstream drainage area has been urbanized and a naturalized channel upstream of 407 ETR acts as a conveyance system. The water level returns to existing conditions approximately 60m upstream of the proposed crossing. There is no developable land located between the crossing and the upstream 407 ETR and the increase in the Regional storm flood level is within MTO ROW.

Storm profiles used in the HEC-RAS model include the 2-year to 100-year events, as well as the Regional event. **Table 6.2** in **Appendix C** shows water elevation results for all return periods analyzed, freeboard and clearance for the 100-year storm.

It should be noted that the HEC-RAS model for East Don River provided by TRCA includes a section of this creek; however, the model starts approximately 500m downstream of 407 TWY (approximately 180 m north of Green Lane crossing). Consideration should be given during detail design stage to extend the existing HEC-RAS model from TRCA to include the proposed transitway crossing as well.

6.3.13 Tributary 2 of German Mills Creek (Creek Ref # 13)

No floodplain mapping is available for this tributary of German Mills Creek. The watercourse has been completely enclosed through this area and a hydraulic analysis is not required.

6.3.14 Rouge River (Creek Ref # 14)

Although floodplain mapping has been produced by TRCA, there is no HEC-RAS model available for this creek. It is understood that TRCA is currently updating both the floodplain mapping and model due to recent development application by Hydro One south of the 407 ETR and the proposed transitway. The existing floodplain is wide and covers a large floodway. As can be seen in the aerial photography the channel just upstream of 407 ETR has been realigned, however this topography is not yet available. For the purposes of this analysis, the original topography was used keeping in consideration that there should not be changes to water levels upstream or downstream.

The proposed floodplain mapping for this crossing is shown in **Figure 6.15, Appendix C**. **Figure 6.15-1** in **Appendix C** shows the HEC-RAS sections used in the model and the Regional water levels upstream and downstream of the proposed bridge.

A new HEC-RAS model that includes four (4) sections was developed for the existing and proposed conditions. The hydraulic model started approximately 20m below the transitway, using the critical depth as starting water elevation.

Existing and proposed regional storm water levels for all sections are presented in **Table 6.10.**

Table 6.10. Existing and Proposed Regional Water Levels - Creek Ref # 14

HEC-RAS Stations	Water Level (m)	
	Existing Condition	Proposed Condition
300	179.39	179.41
260	179.39	179.40
250	--	Bridge 83m span
240	179.39	179.38
200	179.38	179.38

The proposed structure is a bridge with a span of 83m, 14.6m wide and the minimum weir flow elevation of 181.3m.

The analysis shows minimal increase in water levels (~1mm) and the proposed structure conveys the Regional storm without overtopping the road. It is recommended that the floodplain mapping and hydraulic analysis for the proposed crossing be updated during the detailed design stage.

Storm profiles used in the HEC-RAS model include the 2-year to 100-year events, as well as the Regional event. **Table 6.2** in **Appendix C** shows water elevation results for all return periods analyzed, freeboard and clearance for the 100-year storm.

6.3.15 Tributary 1 of Rouge River (Creek Ref # 15)

No analysis is required for this creek since the proposed 407 TWY alignment is located above the existing crossing. The transitway will completely span the watercourse at this location. The regional water level just downstream of the 407 ETR has been estimated at 176.5m.

6.3.16 Tributary 2 of Rouge River (Creek Ref # 16)

No analysis is required for this creek since the proposed 407 TWY alignment is located above the existing crossing. The transitway will completely span the watercourse at this location.

7. CONSIDERATIONS FOR DETAIL DESIGN

The following have been identified and restated here for ease of reference:

1. Confirm that proposed channel realignment by TTC will take place to allow connection from 407 TWY areas ID 2 and 3 (0.43ha) through a proposed bio-detention swale (cross-reference Chapter 4.1, HRP 46.20).

2. Redesign and reconstruct 407 ETR ponds D2 and D3 that are in the way of the proposed 407 TWY alignment (cross-reference Chapter 4.2, HRP 7.1).

3. Assess the adequacy of 407 ETR Pond D1 as an outlet for 407 TWY area IDs 74 to 77, 61, 62 and 51 (cross-reference Chapter 4.2, HRP 7.2).

4. Assess the adequacy of 407 ETR Pond D4 as an outlet for 407 TWY area IDs 85, 86 and 241 (cross-reference Chapter 4.2, HRP 9.3).

5. Assess the adequacy of 407 ETR Pond D5 as an outlet for 407 TWY sub-area 242 (cross-reference Chapter 4.2.2, HRP 23.1).

6. Assess the adequacy of 407 ETR Pond D6 as an outlet for 407 TWY sub-area 243 (cross-reference Chapter 4.2.2, HRP 23.1).

7. Update the HEC-RAS model developed for the Tributary 1 of Black Creek (Creek Ref#1) to take into account the proposed work for the TTC Spadina Subway Extension (Cross-reference Chapter 6.3.1).

8. Examine the feasibility of upsizing the existing culvert between channel cross-sections 6.11 and 6.10 in the HEC-RAS model from TRCA for Don River to further minimize the impacts on the upstream reaches (cross-reference Chapter 6.3.4).

9. The grading plans for the stations are not available. Given their close proximity to watercourses, grading plans are required to confirm the constructability of the ponds, to avoid encroachment

into the floodplains and to ensure that the ponds are set high enough to avoid back-water effects from the watercourses into the ponds (refer to Figures 5.1 to 5.5).

10. A tributary bypass channel is required at the Woodbine station due to site constraints (refer to **Figure 5.5**, **Appendix B**).

11. At the West Don River, several crossings are proposed in an area that is currently considered to be in the floodplain. To minimize encroachment of the 407 TWY into the floodplain, the construction of vertical walls or elevated structures should be considered (refer to **Fig. 6.9**, **Appendix C**)

12. A creek re-alignment west of Leslie Station (Creek Ref#12) may be required to minimize the risk of flooding of the Station if changes to the 407 TWY alignment are not possible (refer to **Fig. 6.14**, **Appendix C**).

13. The culvert under Highway 7 west of Bathurst (Creek Ref #7) appears to be significantly over-sized based on flow calculations; it may be sized as an animal passage. If this is the case, the current alignment of the 407 TWY will cut off animal passage; alternate access may be required (refer to Fig. **6.11**, **Appendix C**).

8. REFERENCES

The following documents were used in preparation for this report:

- Contract drawings for 407 ETR received from MTO
- Hydrologic maps and models and floodline mapping for Humber River, Don River and Rouge River watersheds available from TRCA
- Physiography of Southern Ontario, Chapman and Putnam, 1984
- Report No. 23 of the Ontario Soil Survey (Soil Survey of Ontario County, 1960)
- 407 Transitway Assessment of Crossings, Geomorphology report, JTB Environmental Systems Inc., received June 7, 2010
- Humber River Watershed - Hydrology Update, prepared by Aquafor Beech Limted for TRCA, November 2002
- Stormwater management Planning and Design Manual, Ministry of the Environment, March 2003
- Highway Drainage Design Standards, Ministry of Transportation, January 2008
- Highway Runoff Quality Review, MTO 1992, Research and Development Branch, Ontario, Ministry of Transportation, Downsview, ON

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APPENDIX A

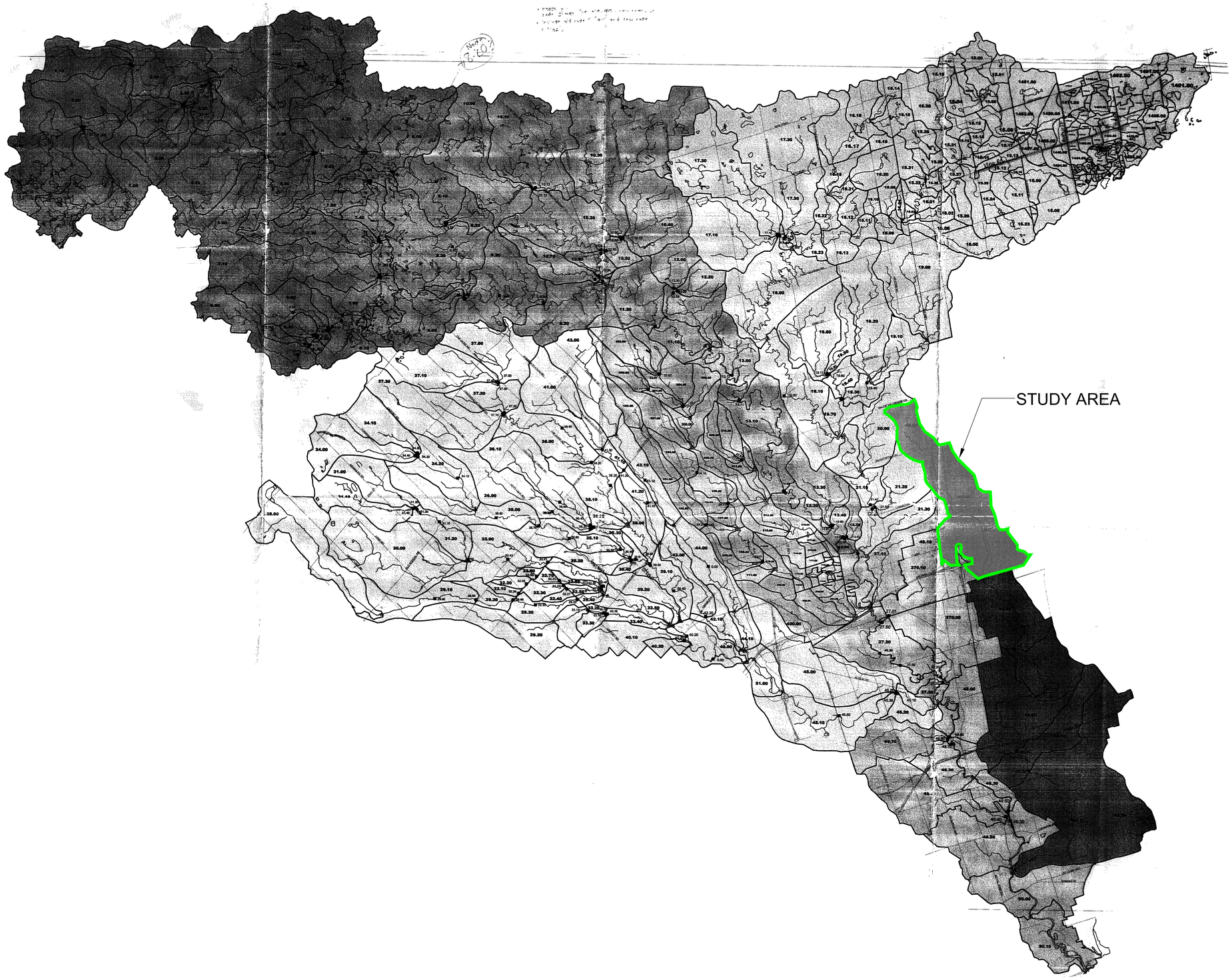
HYDROLOGIC ANALYSIS

Table 2.2 - Existing 407 ETR Ponds

Pond ID	Design ID	Location	Area (ha)	Depth (m)	Volume (m^3)
E-66.9.O.JA	SP3	407EB W of Jane	0.21	1.05	2,211.30
E-67.7.O.JA	SP4	407EB E of Jane	0.08	1.56	1,263.60
E-71.1-407	D1	407EB E of Keele	0.04	0.50	209.00
W-72.6.O.7E	D3	407WB W of Dufferin	0.47	0.85	4,033.25
W-72.0.CE	D2	407WB E of Centre	0.16	0.81	1,305.72
E-73.5-407	D4	407EB E of Dufferin	1.38	0.90	12,393.00
E-75.5-407	D5	407EB W of Bathurst	0.64	1.04	6,612.84
W-76.0.O.7E	D6	407WB E of Bathurst	0.14	1.07	1,444.50
E-76.8.O.YO	D7	407EB W of Yonge St	0.05	0.68	306.00
E-79.9-407	exist.	407EB W of German Mills	0.11	1.10	1,155.00
E-80.1-407	D9A	Bayview NB - 407EB	0.05	0.72	324.00
E-81.4-407	D10	407EB E of German Mills	0.05	1.54	693.00
E-81.8.O.LE	POND1	407EB E of Leslie	0.20	1.08	2,160.00
E-404-407	POND2	407EB - 404SB	0.24	1.18	2,888.64
W-82.8-407	POND3	407WB E of Hwy 404	0.05	0.80	3,600.00
E-83.4-407	POND4	407EB W of Woodbine	0.23	1.00	2,300.00
W-84.1-407	R1	407WB E of Woodbine	0.13	1.00	1,320.00
E-85.0-407	R2	407EB W of Warden	0.08	1.00	825.00
E-82.5-407	POND5	404NB to 407EW	0.31	1.00	3,125.00
E-85.2-407	R3	407E W of Warden	0.16	1.00	1,600.00
W-88.0-407	R4	407W - E of Kennedy	0.64	0.70	4,510.80

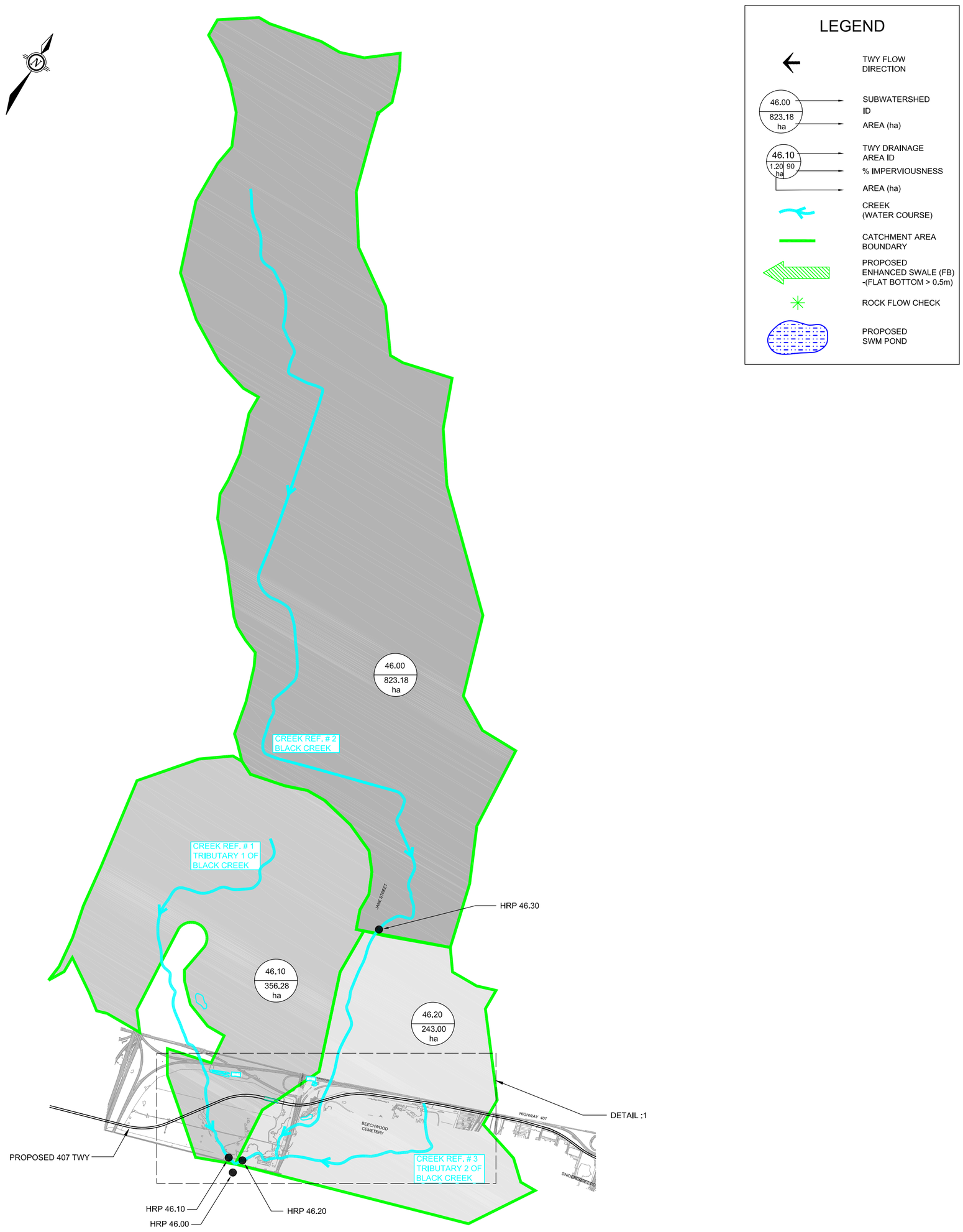
NOTE: All facilities are wet ponds

HYDROLOGIC ANALYSIS
HUMBER RIVER – Black Creek

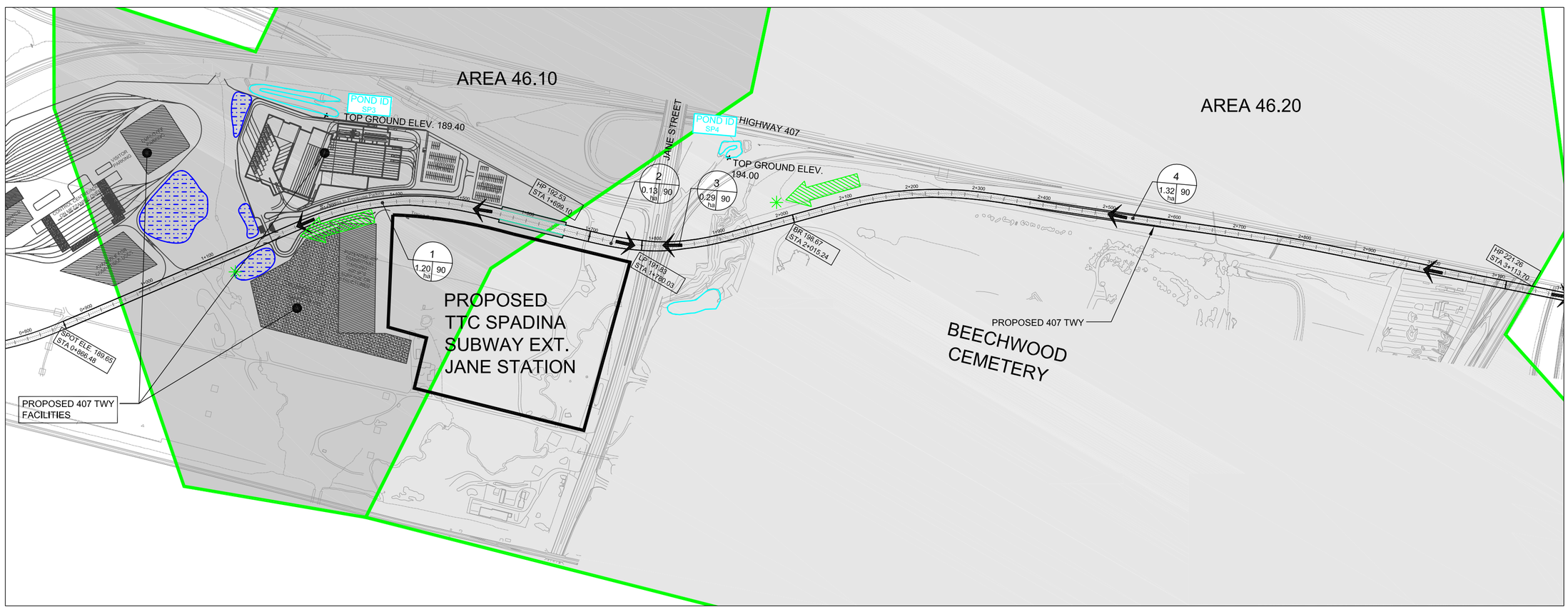


	DATE: AUGUST, 2010 SCALE: N.T.S.	Ontario	Delcan 625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400	HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT FIGURE 3.1: HUMBER RIVER WATERSHED

J:\DIVISION\VATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY - DRAINAGE\DRAWINGS\FLOODPLAINMAPPING\SUBVATERSHEDS\TT4003-HUMJDENJRDUGE-VATERSHEDS.DWG



SCALE 1:20,000



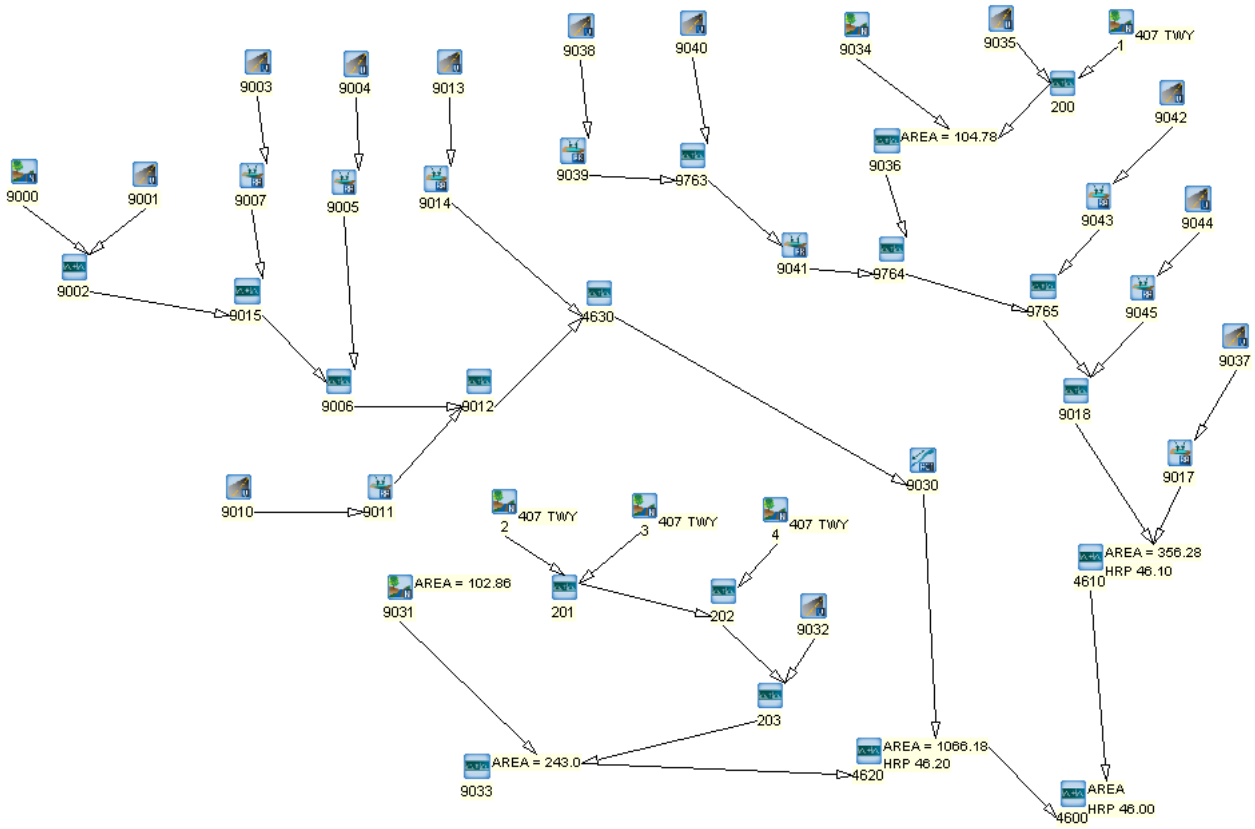
DETAIL :1

SCALE 1:5000

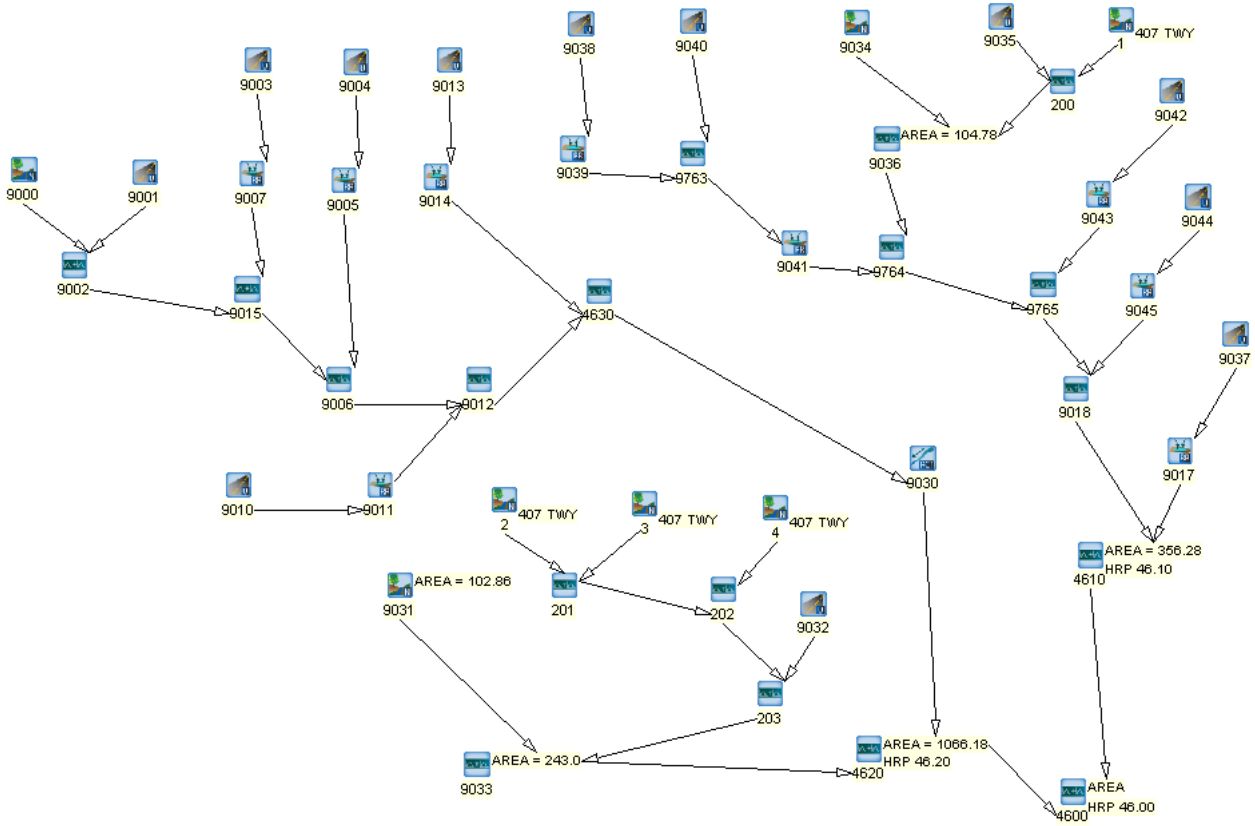
DATE:	AUGUST, 2010	Ontario	Delcan TRANSPORTATION • INFRASTRUCTURE TECHNOLOGY • WATER	625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400
SCALE:	AS SHOWN			HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT FIGURE 3.4: BLACK CREEK SUBWATERSHED - DRAINAGE AREA MAP

J:\DIVISION\WATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY - DRAINAGE\DRAWINGS\FLOODPLAINMAPPING\SUBWATERSHEDS\TT4003-HUM-DA.DWG

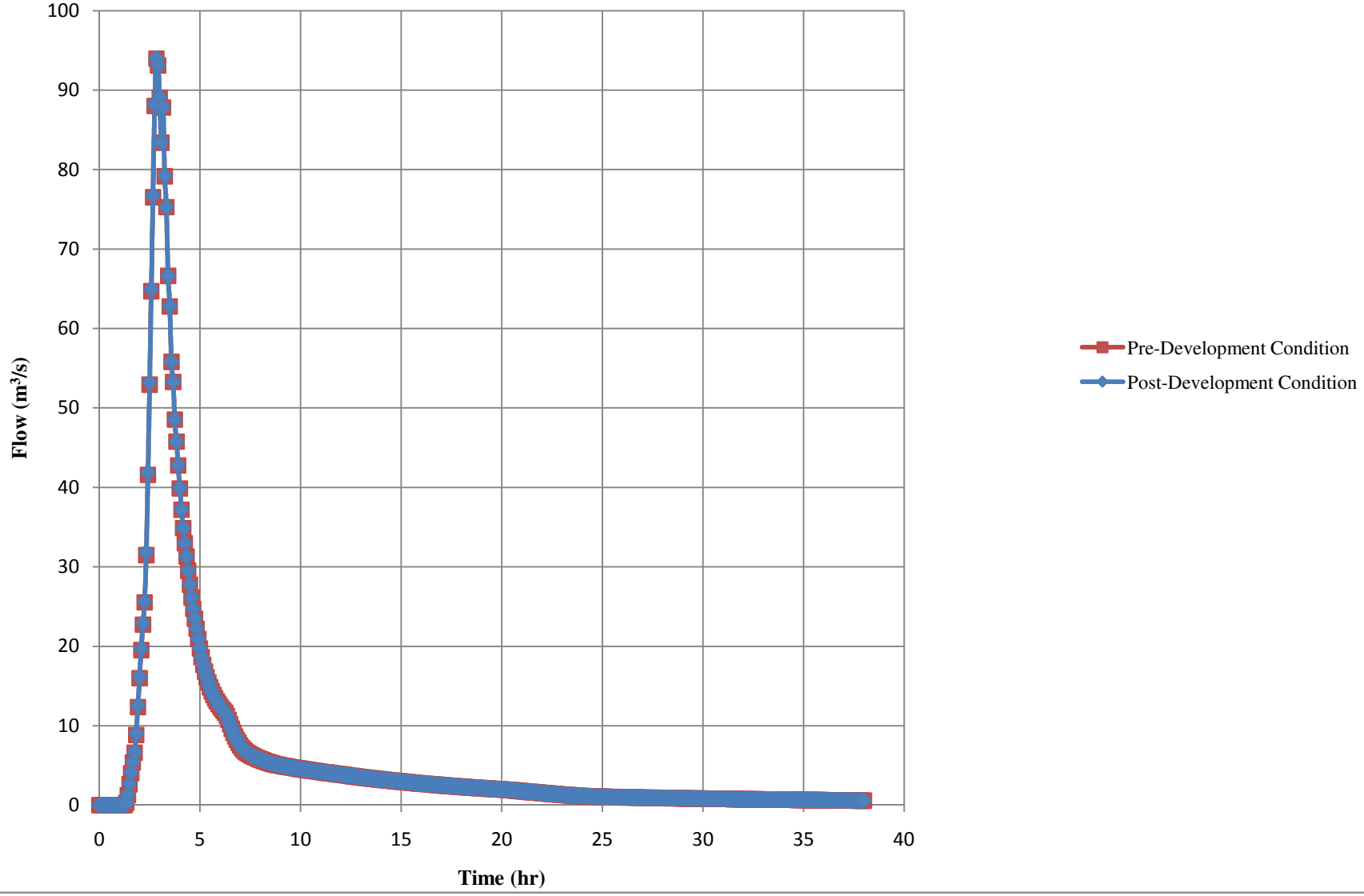
Visual OttHYMO Modelling Schematics – 1: HUMBER RIVER (Black Creek) – Pre – Development Condition Scenario



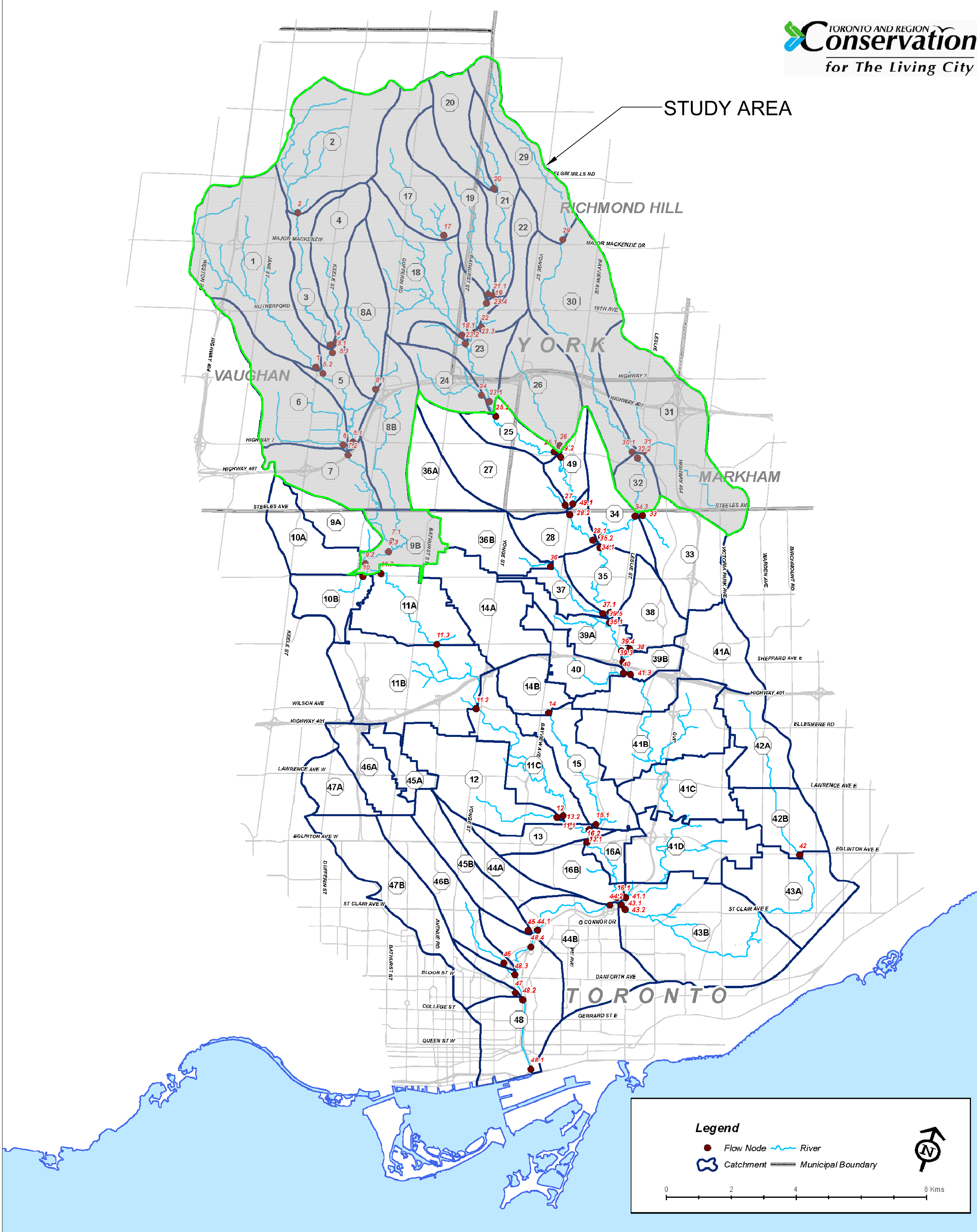
Visual OttHYMO Modelling Schematics – 5: HUMBER RIVER (Black Creek) – Post – Development Condition Scenario



Hydrograph 1: HRP 46.00 (100- yr event)



HYDROLOGIC ANALYSIS
DON RIVER



J:\DIVISION\WATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY - DRAINAGE\DRAWINGS\FLOODPLAINMAPPING\SUBWATERSHEDS\TT4003-HUM,DON,ROUGE-WATERSHEDS.DWG

DATE:	AUGUST, 2010	Ontario	Delcan	625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400
SCALE:	N.T.S.			

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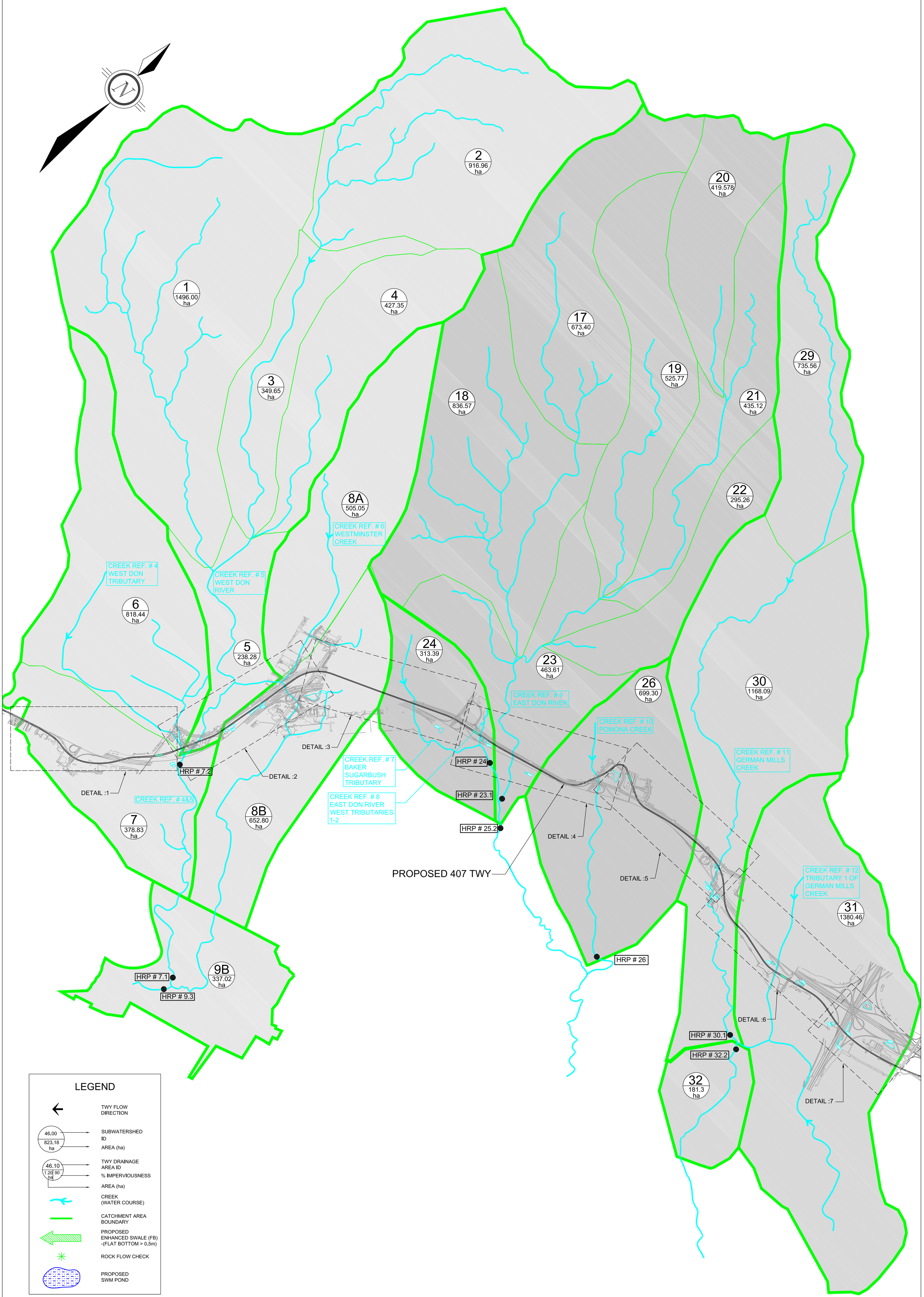
FIGURE 3.2: DON RIVER WATERSHED



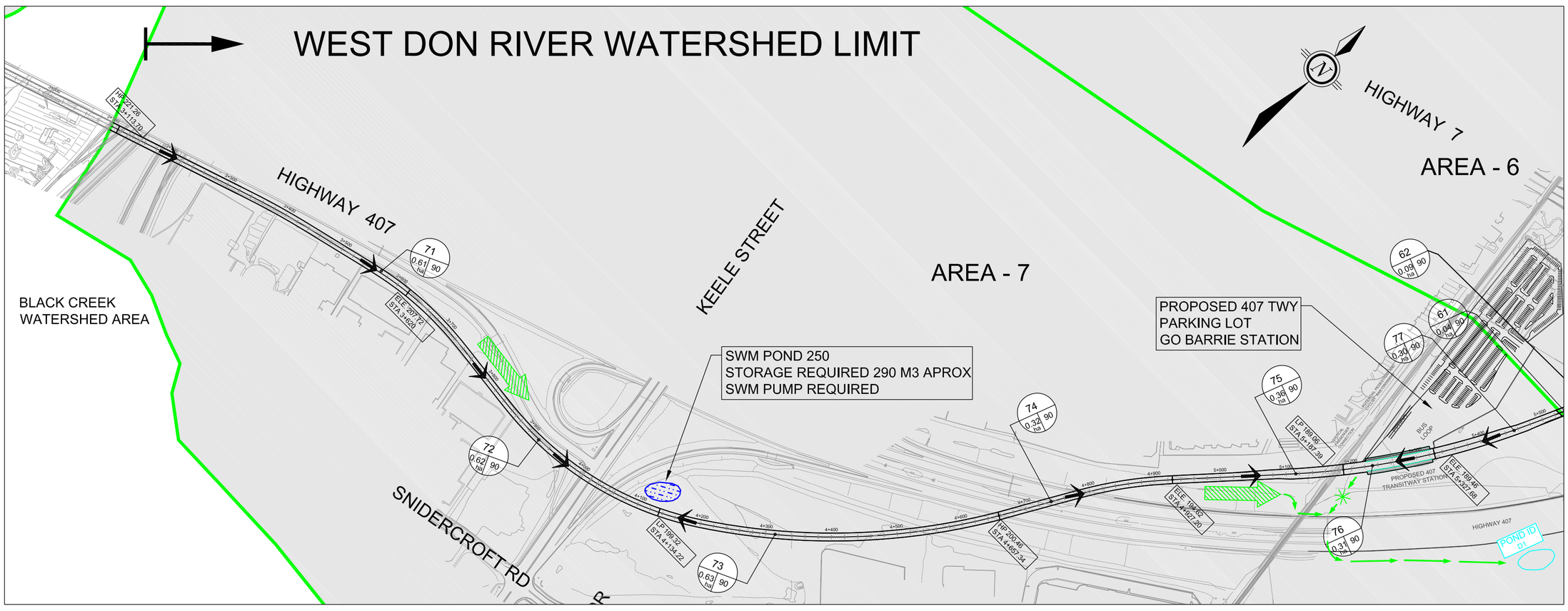
LEGEND

- TWY FLOW DIRECTION
- 46.00 / 823.18 ha — SUBWATERSHED ID; AREA (ha)
- 46.10 / 1.20 ha / 90 — TWY DRAINAGE AREA ID; % IMPERVIOUSNESS; AREA (ha)
- CREEK (WATER COURSE)
- CATCHMENT AREA BOUNDARY
- PROPOSED ENHANCED SWALE (FB) -(FLAT BOTTOM > 0.5m)
- ROCK FLOW CHECK
- PROPOSED SWM POND

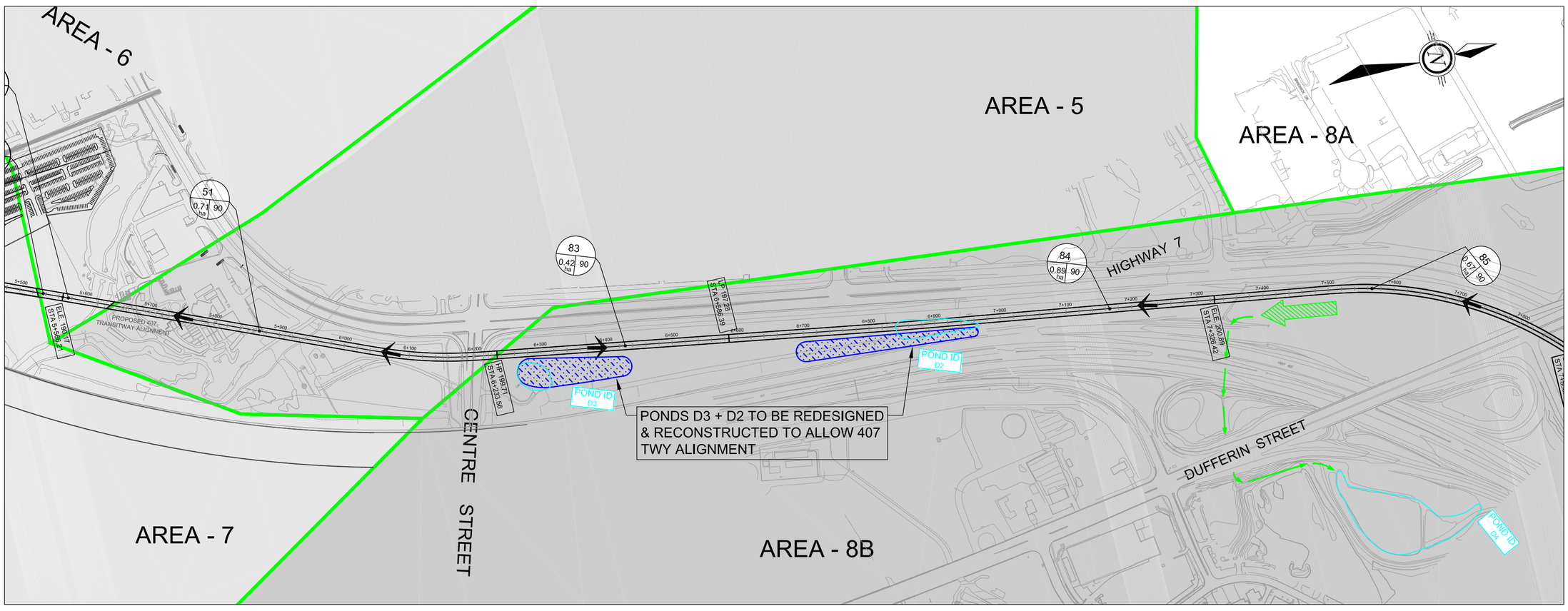
J:\DIVISION\WATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY - DRAINAGE\DRAWINGS\FLOODPLAINMAPPING\SUBWATERSHEDS\TT4003-DON-DA.DWG

DATE:	AUGUST, 2010	Ontario	Delcan TRANSPORTATION • INFRASTRUCTURE TECHNOLOGY • WATER	625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400
SCALE:	1: 25,000			HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT FIGURE 3.5: DON RIVER WATERSHED - DRAINAGE AREA MAP

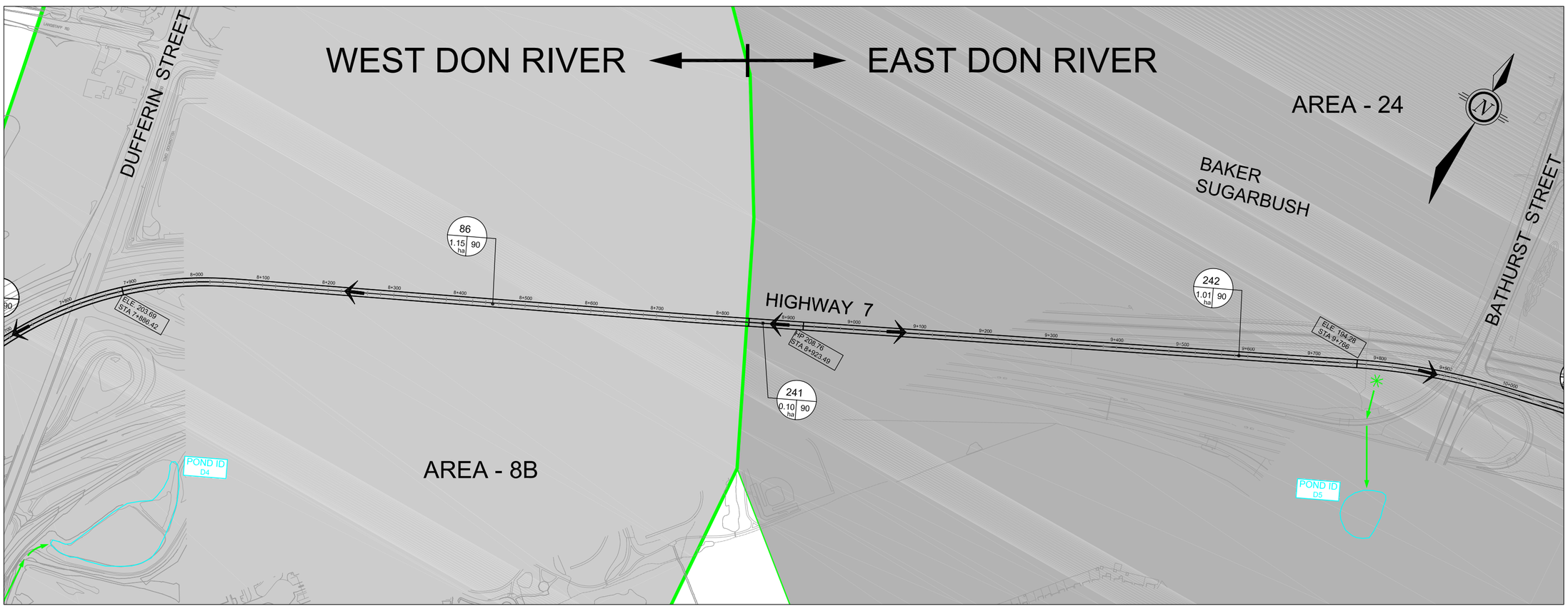
DETAIL :1



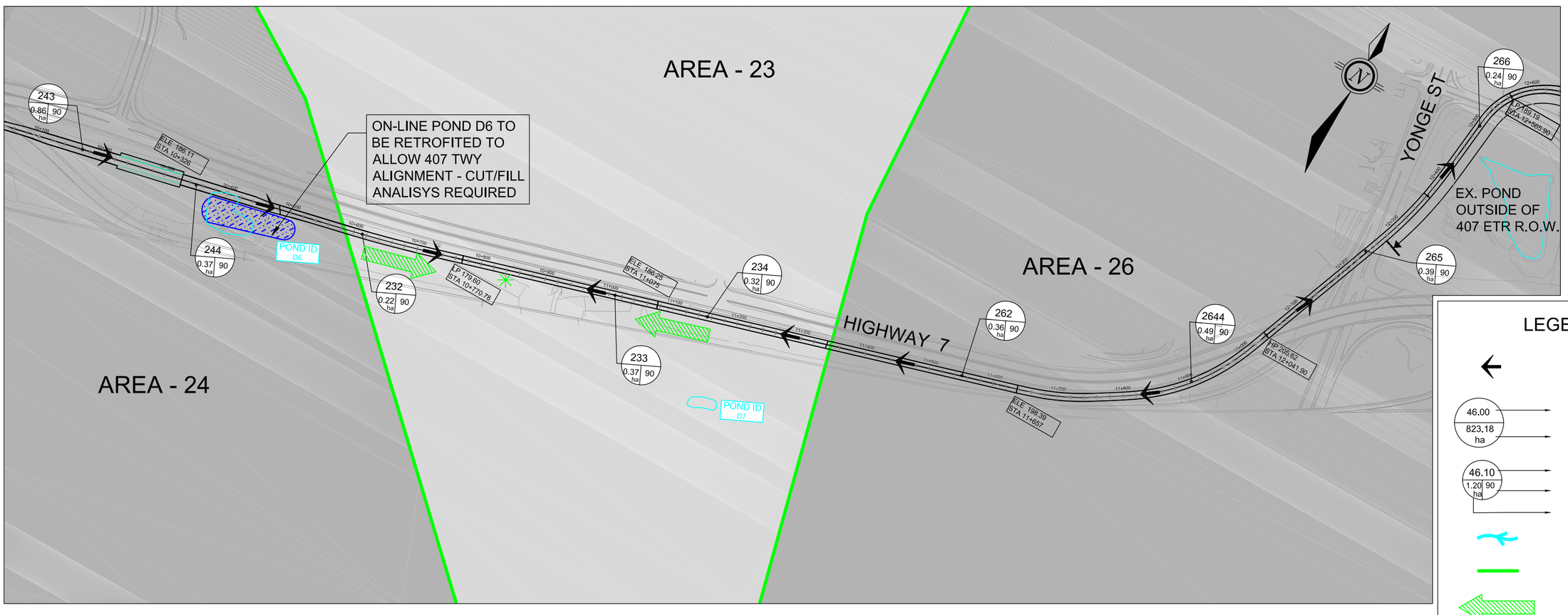
DETAIL :2



DETAIL :3



DETAIL :4



LEGEND

- TWY FLOW DIRECTION
- 46.00 / 823.18 ha — SUBWATERSHED ID / AREA (ha)
- 46.10 / 1.20 ha / 90 — TWY DRAINAGE AREA ID / % IMPERVIOUSNESS / AREA (ha)
- CREEK (WATER COURSE)
- CATCHMENT AREA BOUNDARY
- PROPOSED ENHANCED SWALE (FB) -(FLAT BOTTOM > 0.5m)
- ROCK FLOW CHECK
- PROPOSED SWM POND

DATE:	AUGUST, 2010
SCALE:	1:5000

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FIGURE 3.6: DON RIVER WATERSHED - DRAINAGE AREA MAP DETAIL & STORMWATER STRATEGY

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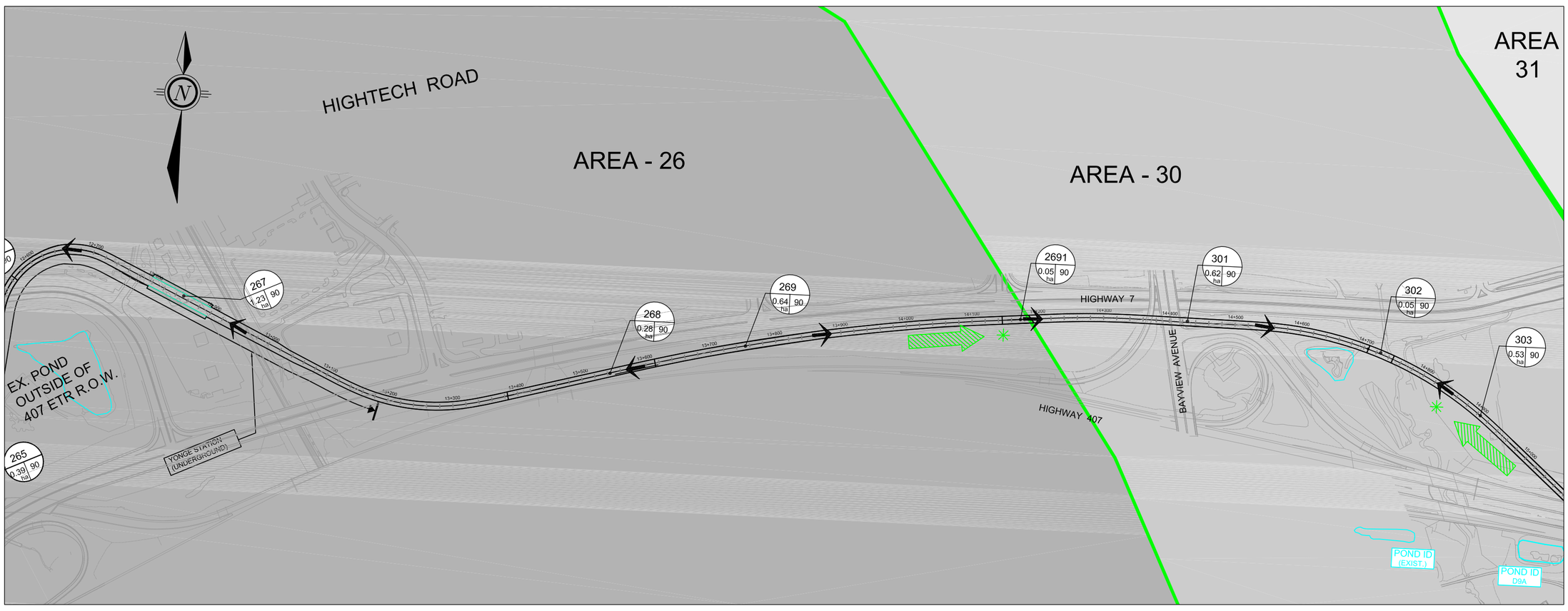
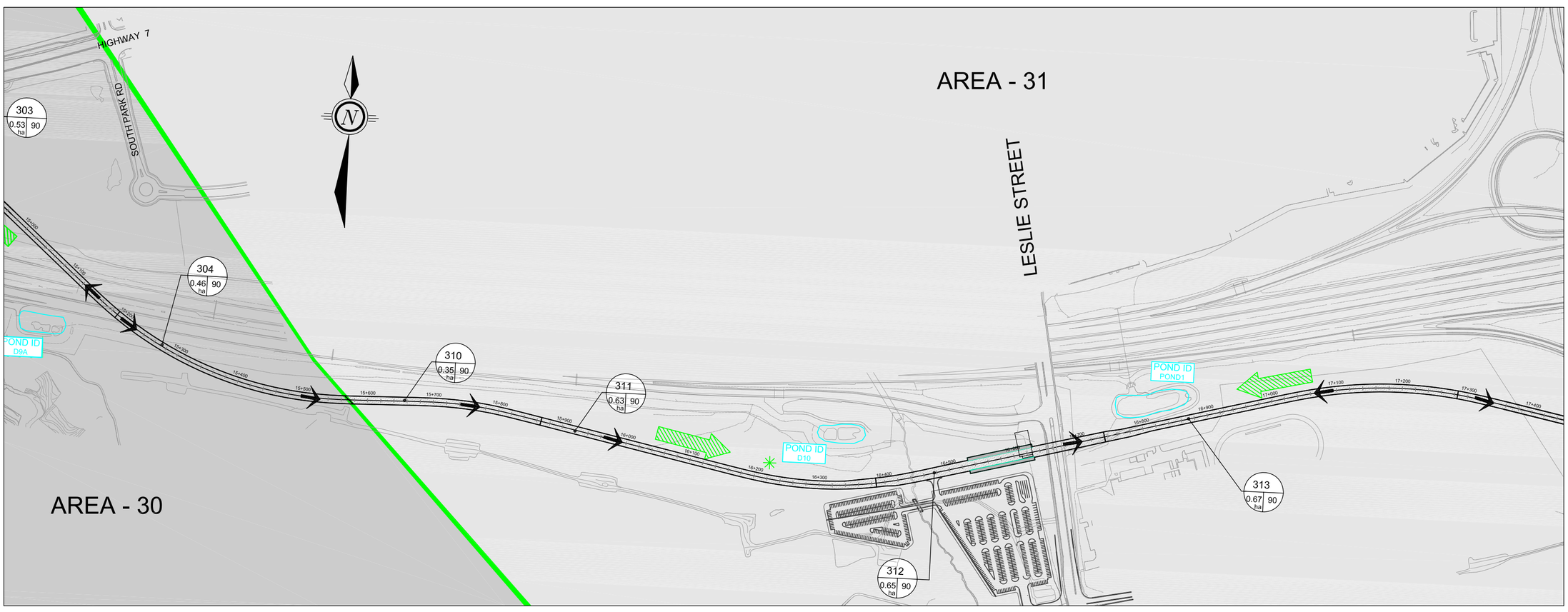
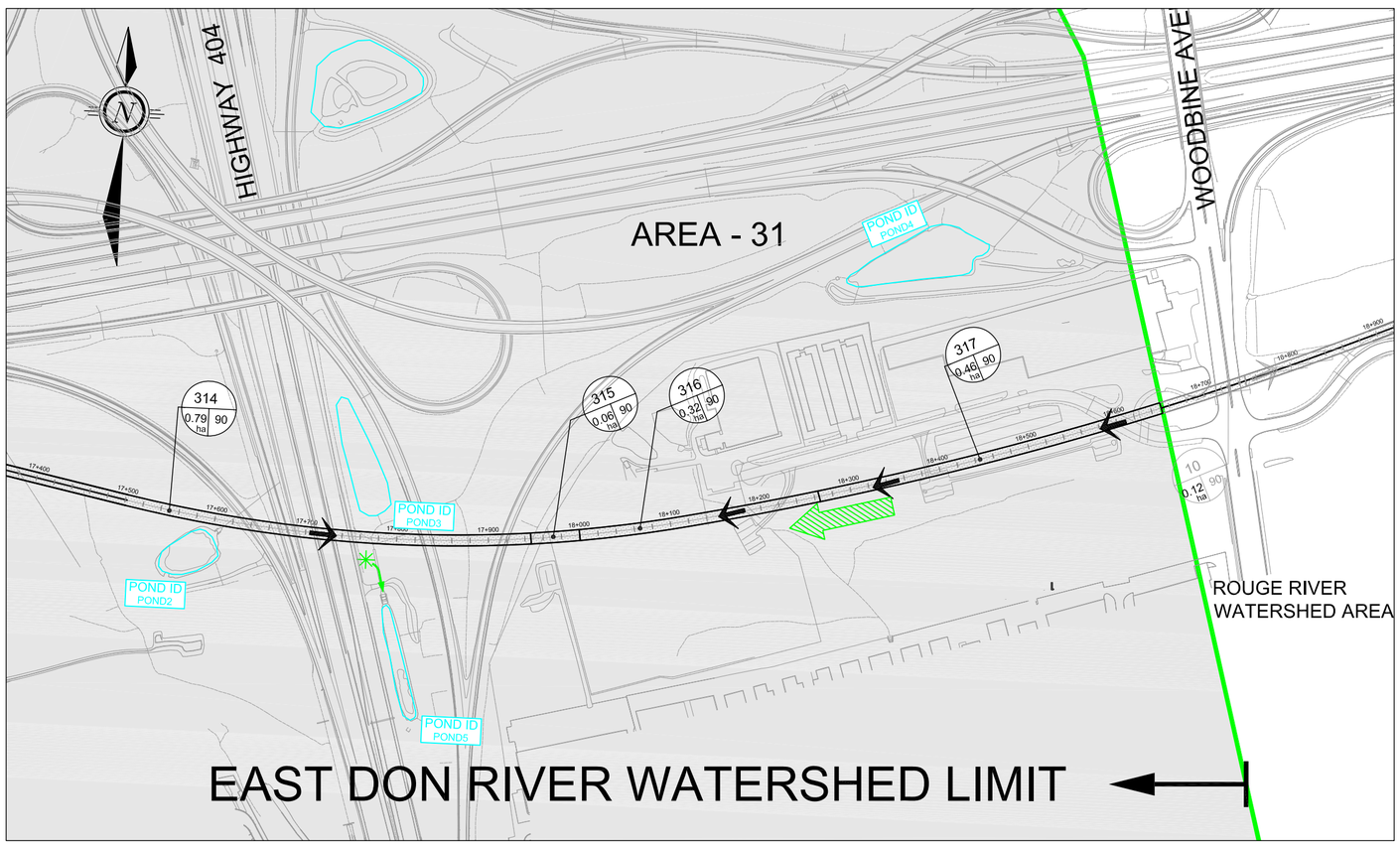


DETAIL :5



DETAIL :6



DETAIL :7

LEGEND

- TWY FLOW DIRECTION
- 46.00 / 823.18 ha — SUBWATERSHED ID / AREA (ha)
- 46.10 / 1.20 ha 90 — TWY DRAINAGE AREA ID / % IMPERVIOUSNESS / AREA (ha)
- CREEK (WATER COURSE)
- CATCHMENT AREA BOUNDARY
- PROPOSED ENHANCED SWALE (FB) -(FLAT BOTTOM > 0.5m)
- ROCK FLOW CHECK
- PROPOSED SWM POND

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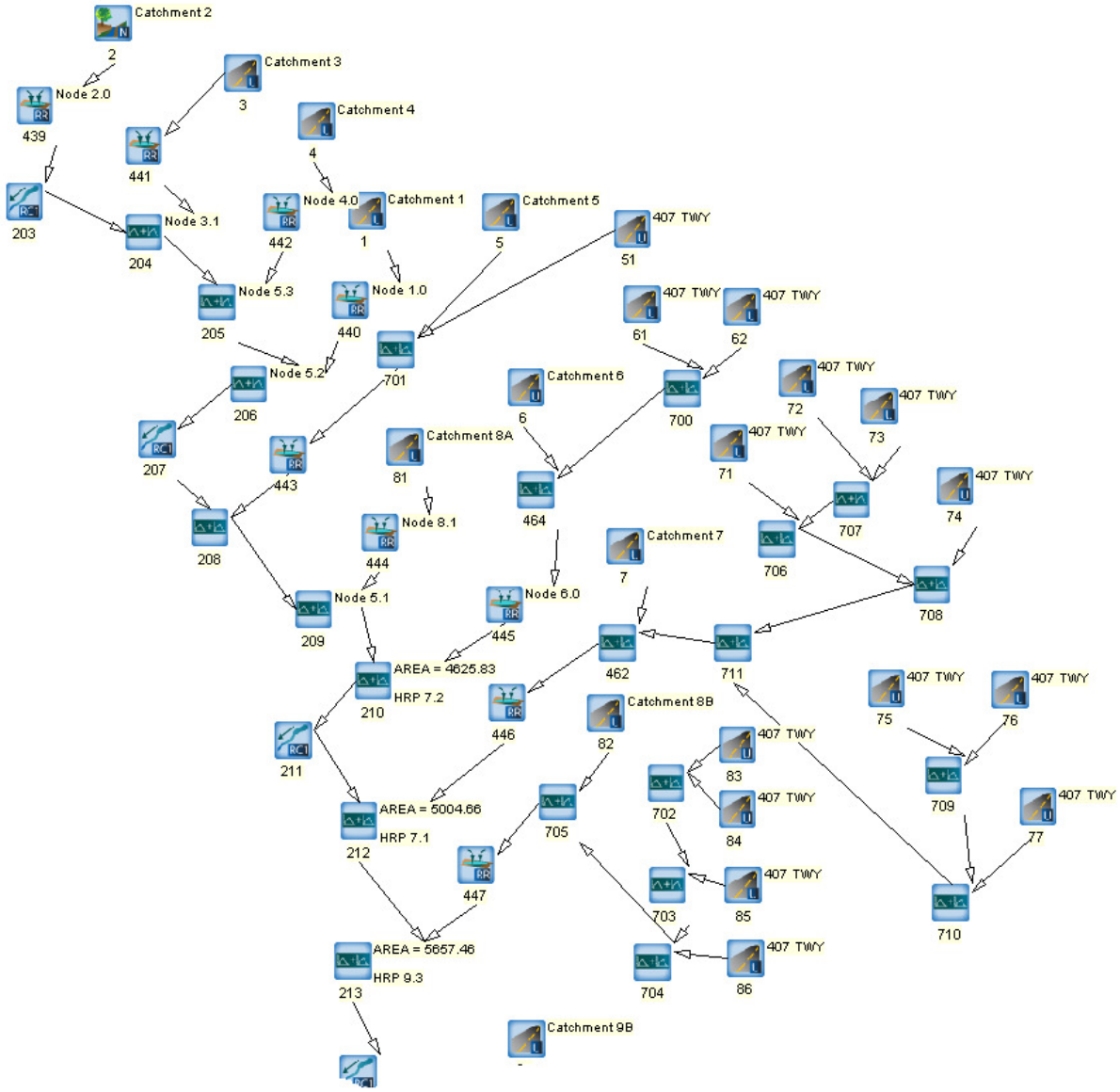
SCALE:	1:5000			

HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

FIGURE 3.7: DON RIVER WATERSHED - DRAINAGE AREA MAP DETAIL & STORMWATER STRATEGY

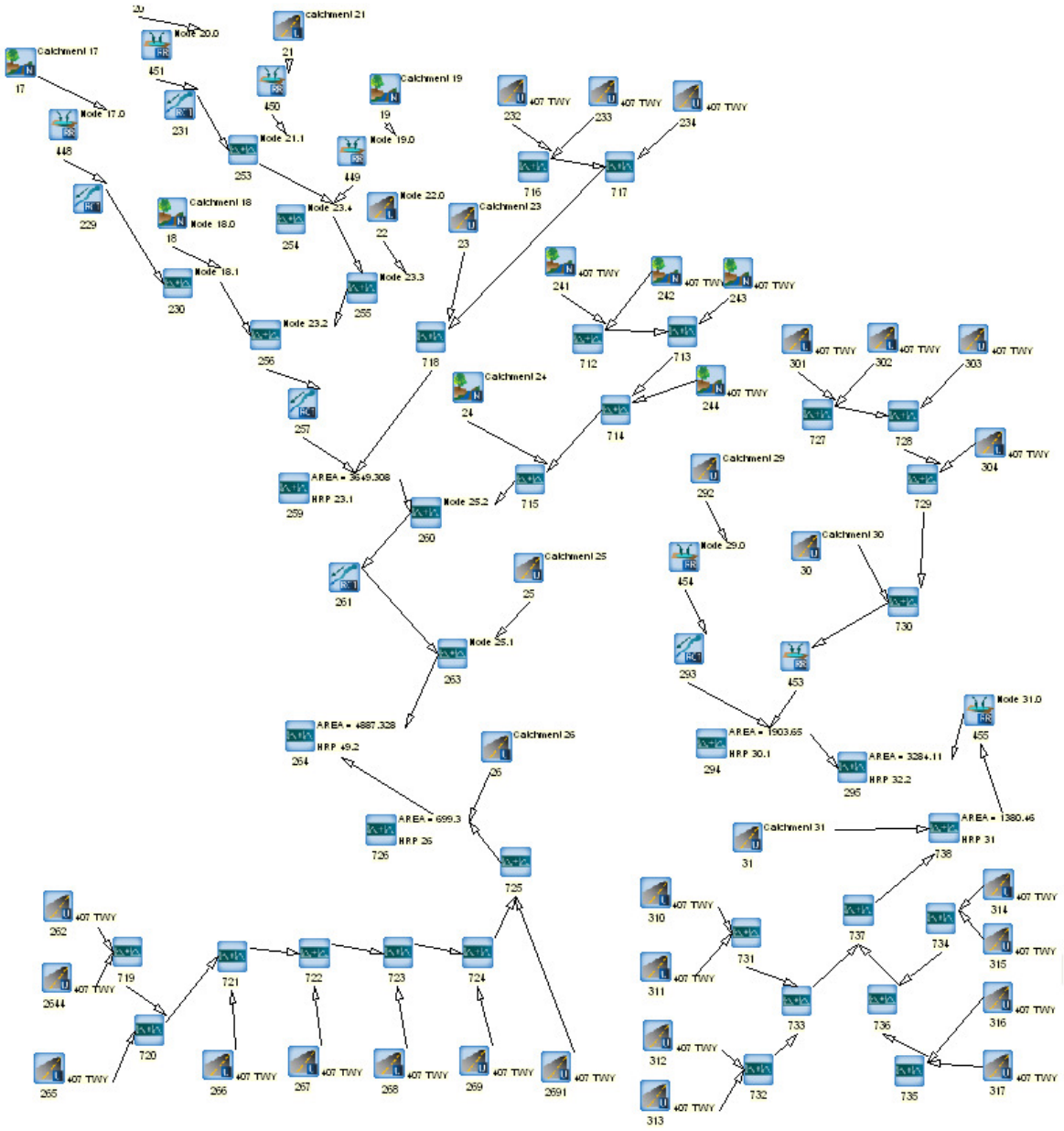
Visual OttHYMO Modelling Schematics – 2: WEST DON RIVER

Pre – Development Condition Scenario



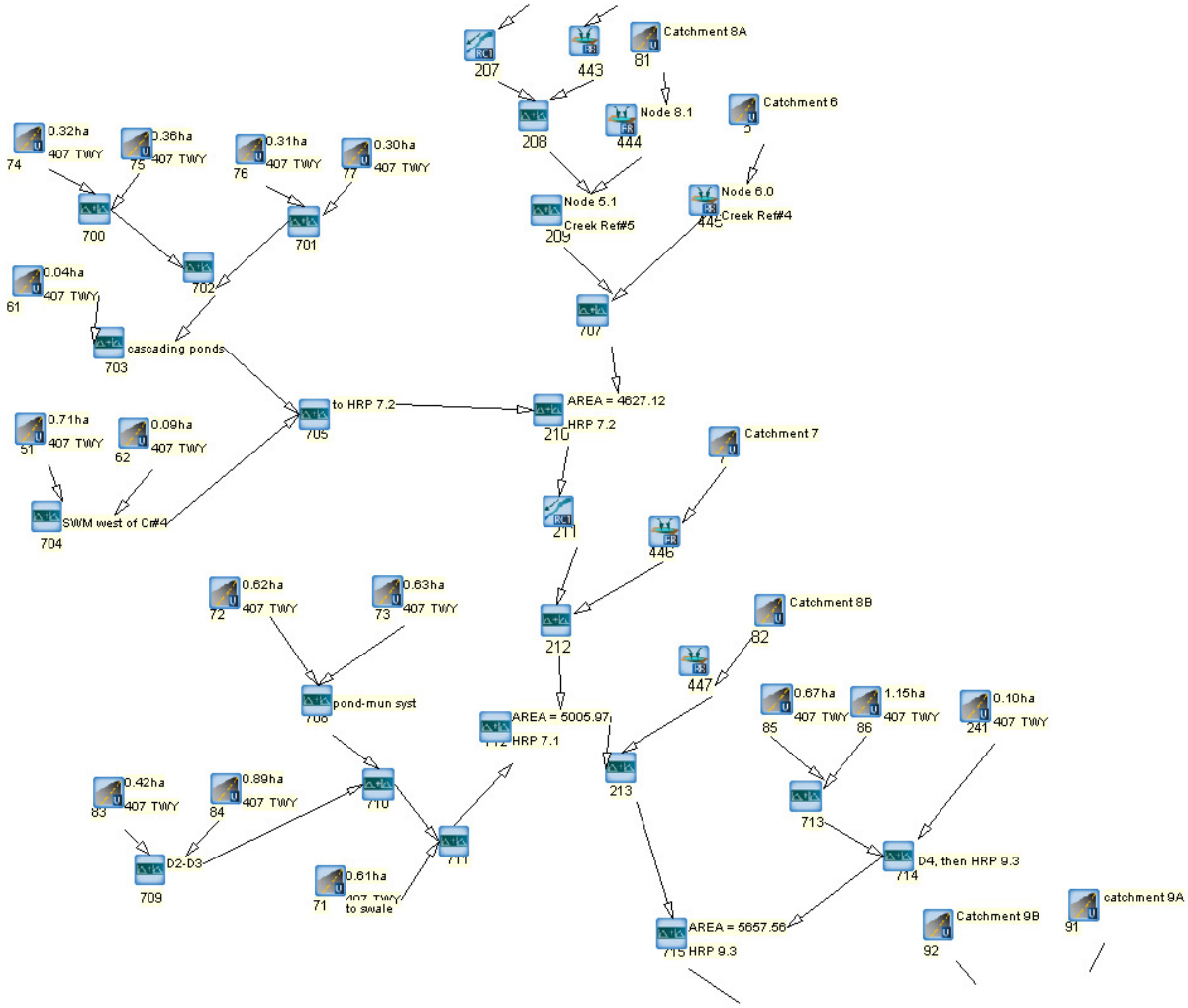
Visual OttHYMO Modelling Schematics – 3: EAST DON RIVER

Pre – Development Condition Scenario



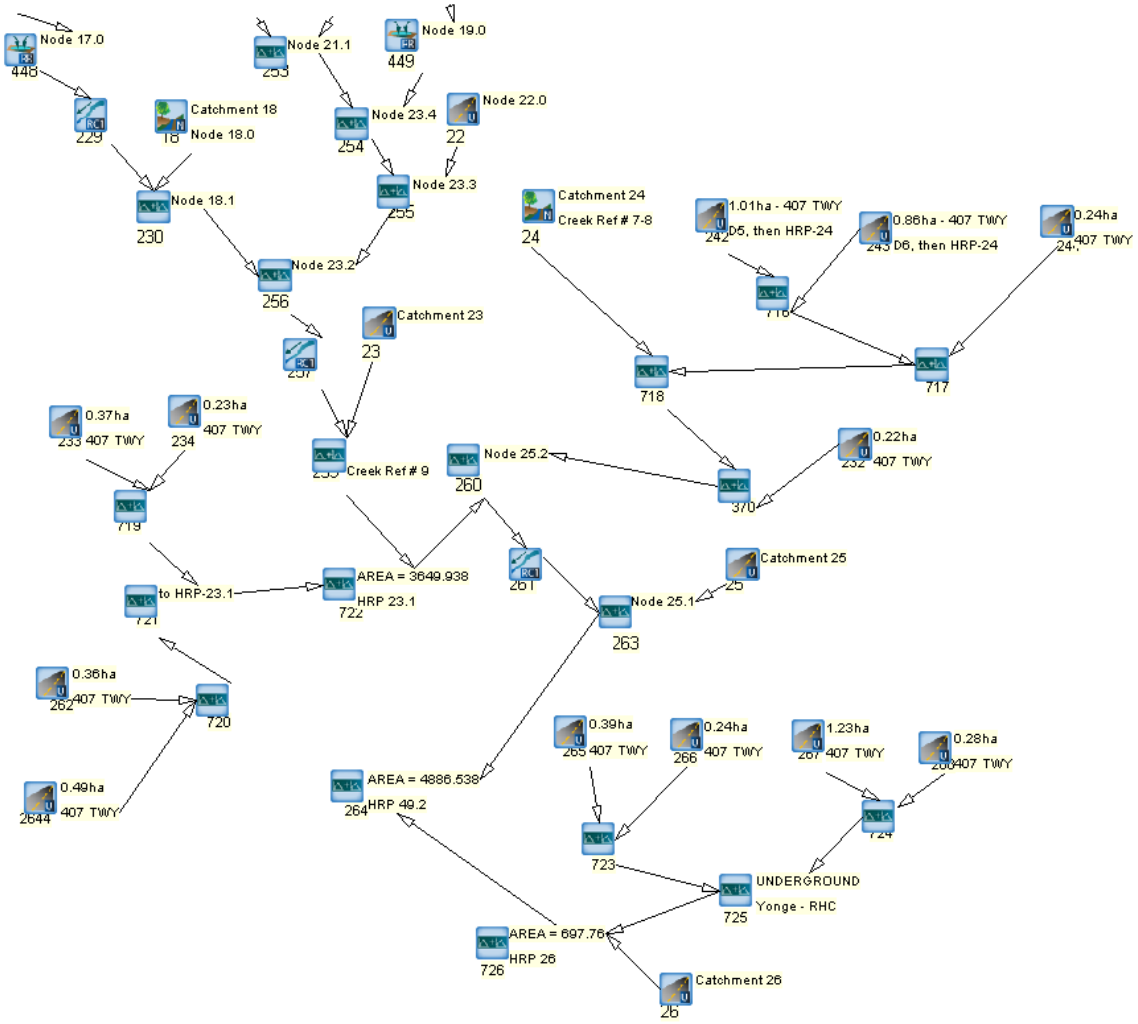
Visual OttHYMO Modelling Schematics – 6: DON RIVER (West Don)

Post – Development Condition Scenario



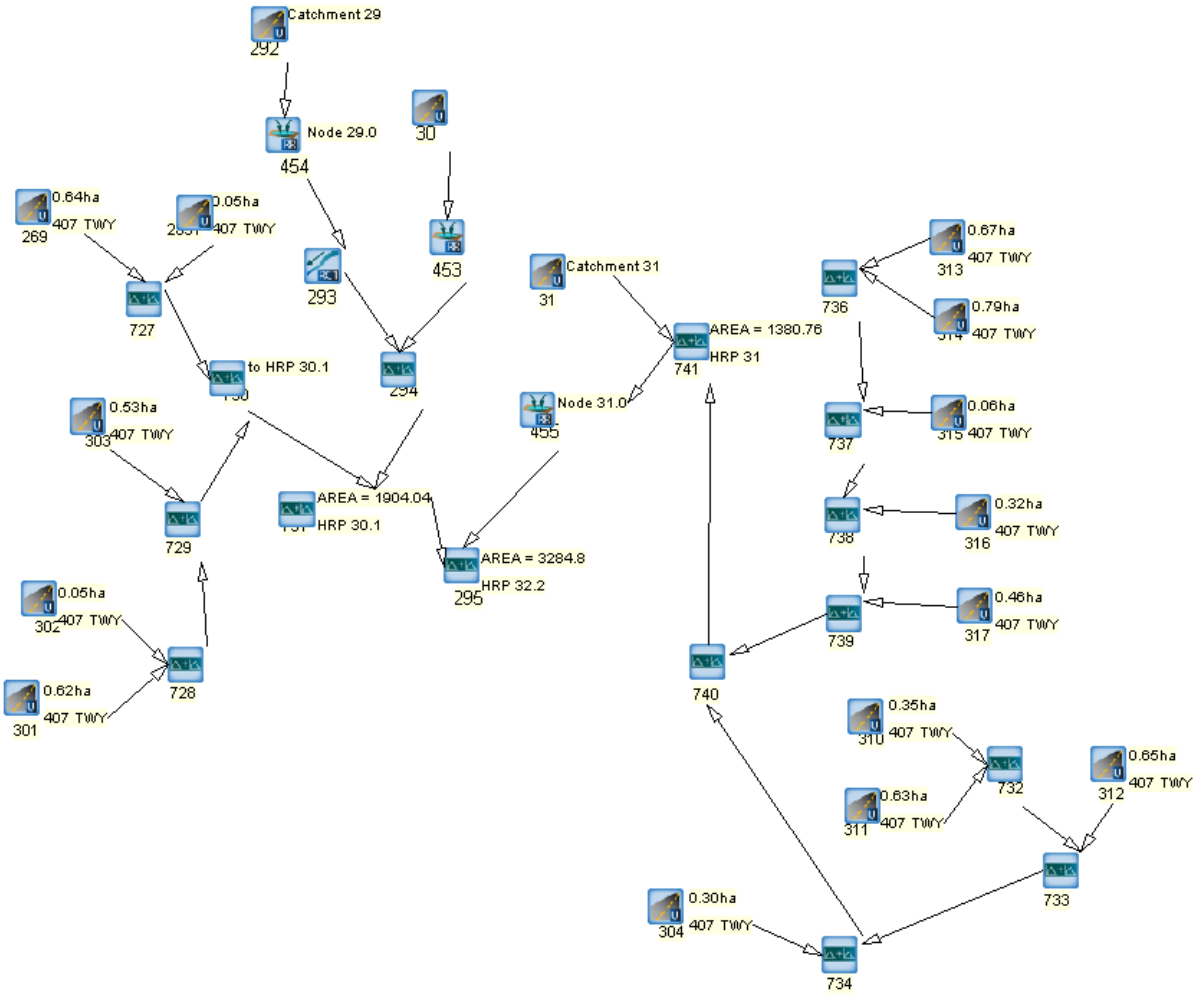
Visual OttHYMO Modelling Schematics – 7: DON RIVER (East Don)

Post – Development Condition Scenario

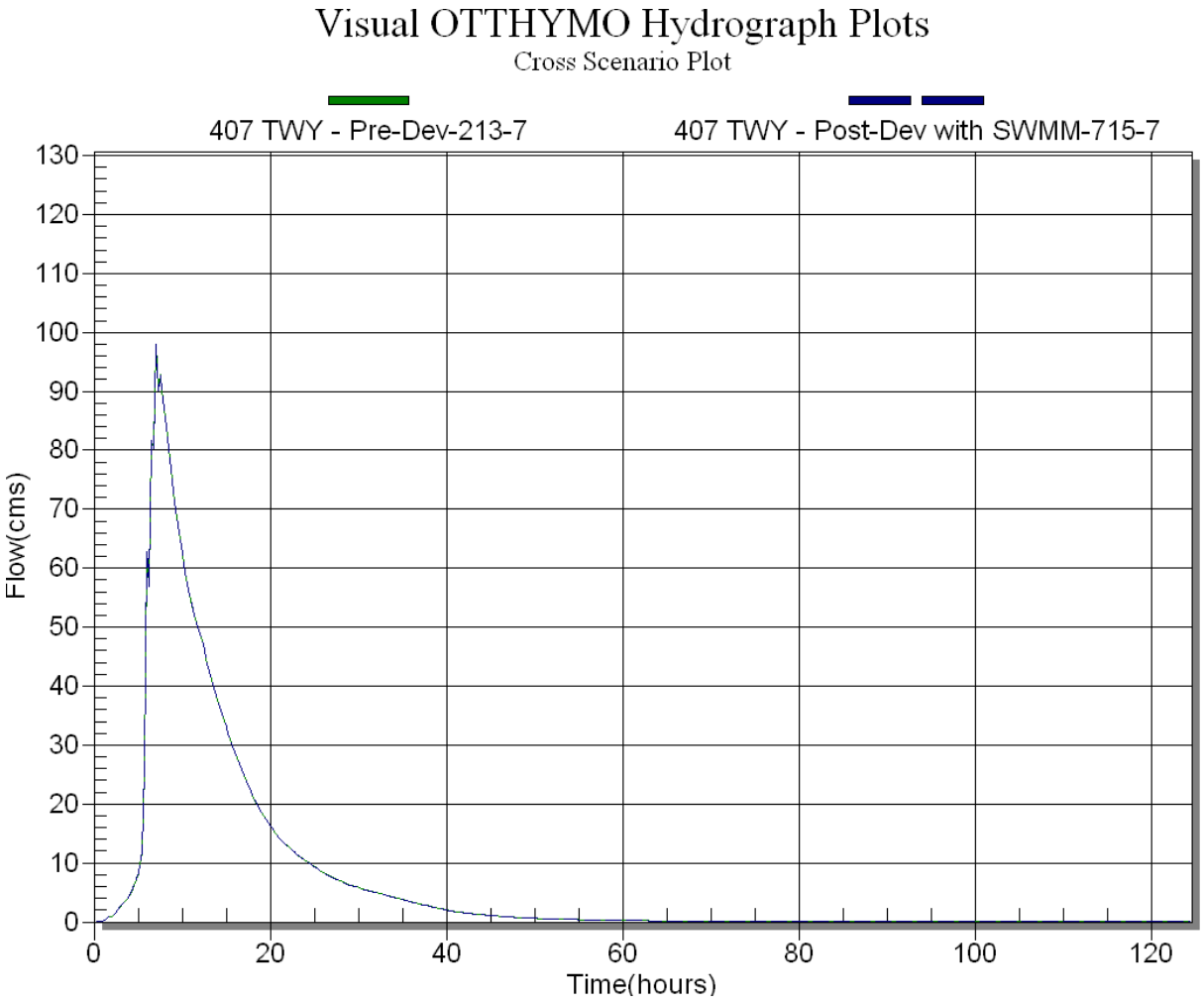


Visual OttHYMO Modelling Schematics – 8: DON RIVER (German Mills)

Post – Development Condition Scenario



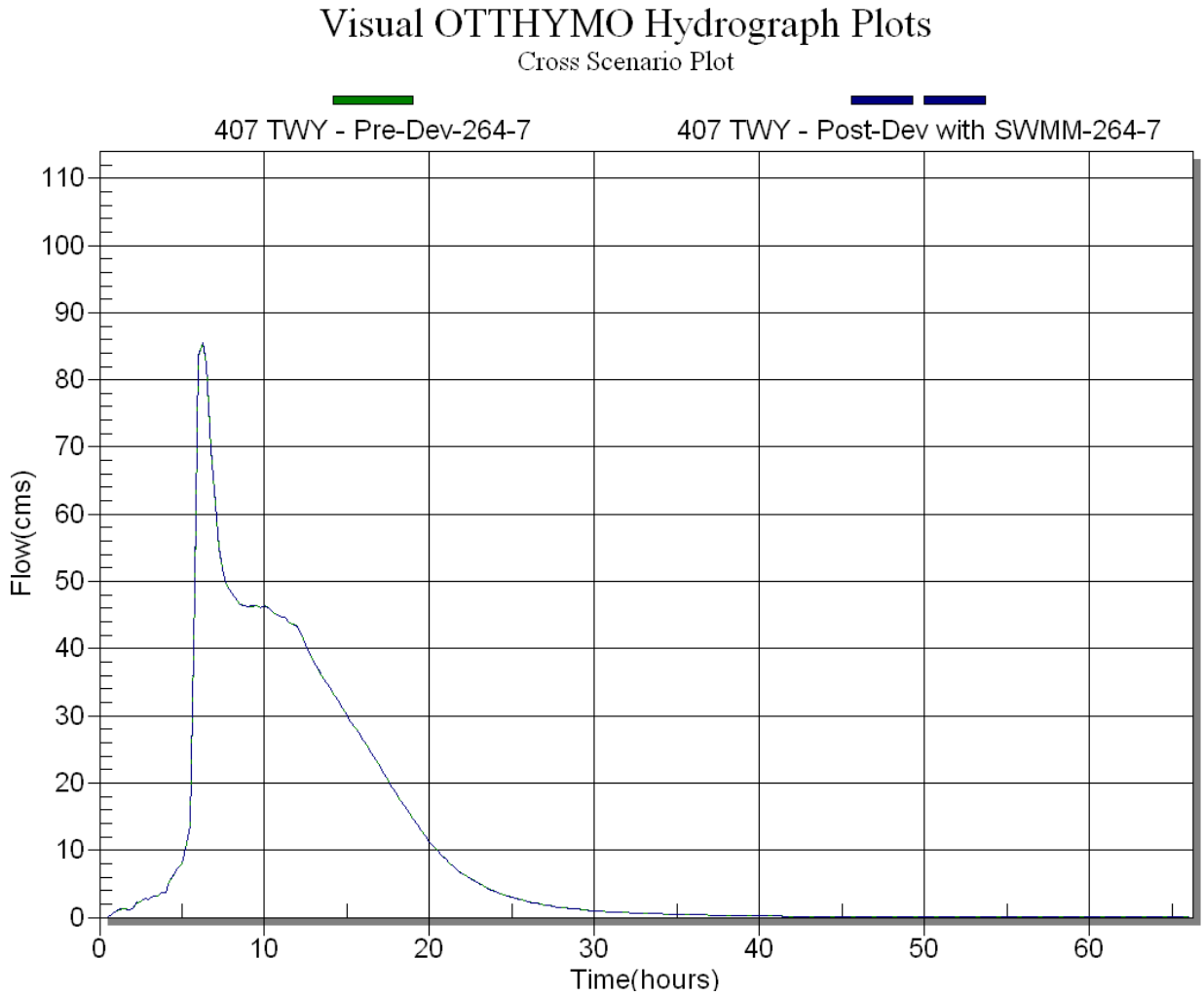
Hydrograph 2: HRP 9.3 (100 – yr event)



NOTES: HRP 9.3 ID 213 – Pre-Development Condition

ID 715 – Post-Development Condition

Hydrograph 3: HRP 49.2 (100 – yr event)



Hydrograph 4: HRP 32.2 (100 – yr event)

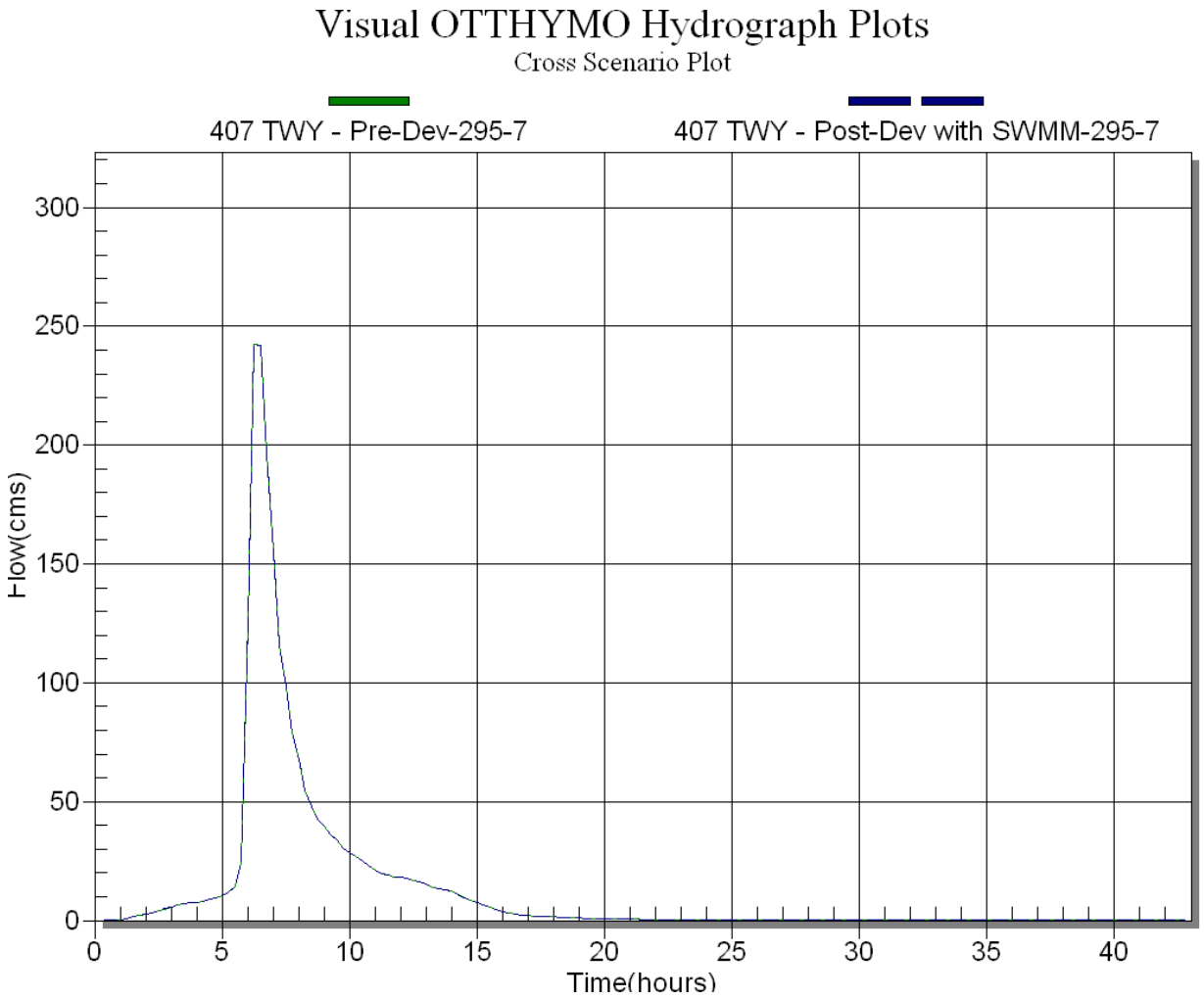
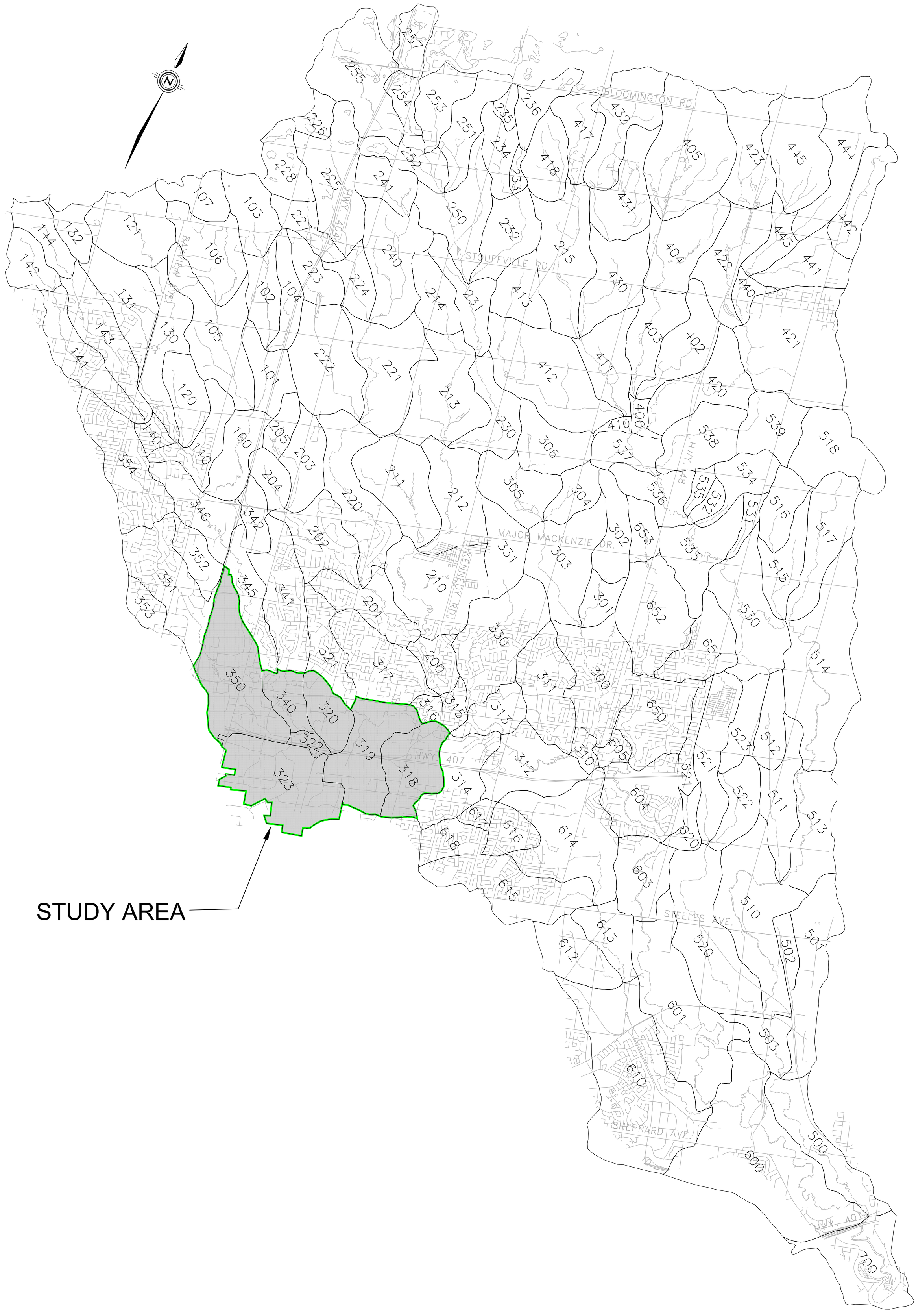


Table 3.7 Proposed SWM facility - West Don River Watershed

Return Period	Pre-Dev peak flows (m^3/s)	Post-Dev release rates (m^3/s)	Storage required (ha.m)
Contributory Area IDs 72&73 (A=1.25ha)			
2-yr	0.07	0.00	0.04
5-yr	0.09	0.10	0.042
10-yr	0.11	0.12	0.0485
25-yr	0.14	0.14	0.0484
50-yr	0.16	0.16	0.0531
100-yr	0.18	0.18	0.0579

HYDROLOGIC ANALYSIS
ROUGE RIVER



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SCALE:	N.T.S.			

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FIGURE 3.3: ROUGE RIVER WATERSHED

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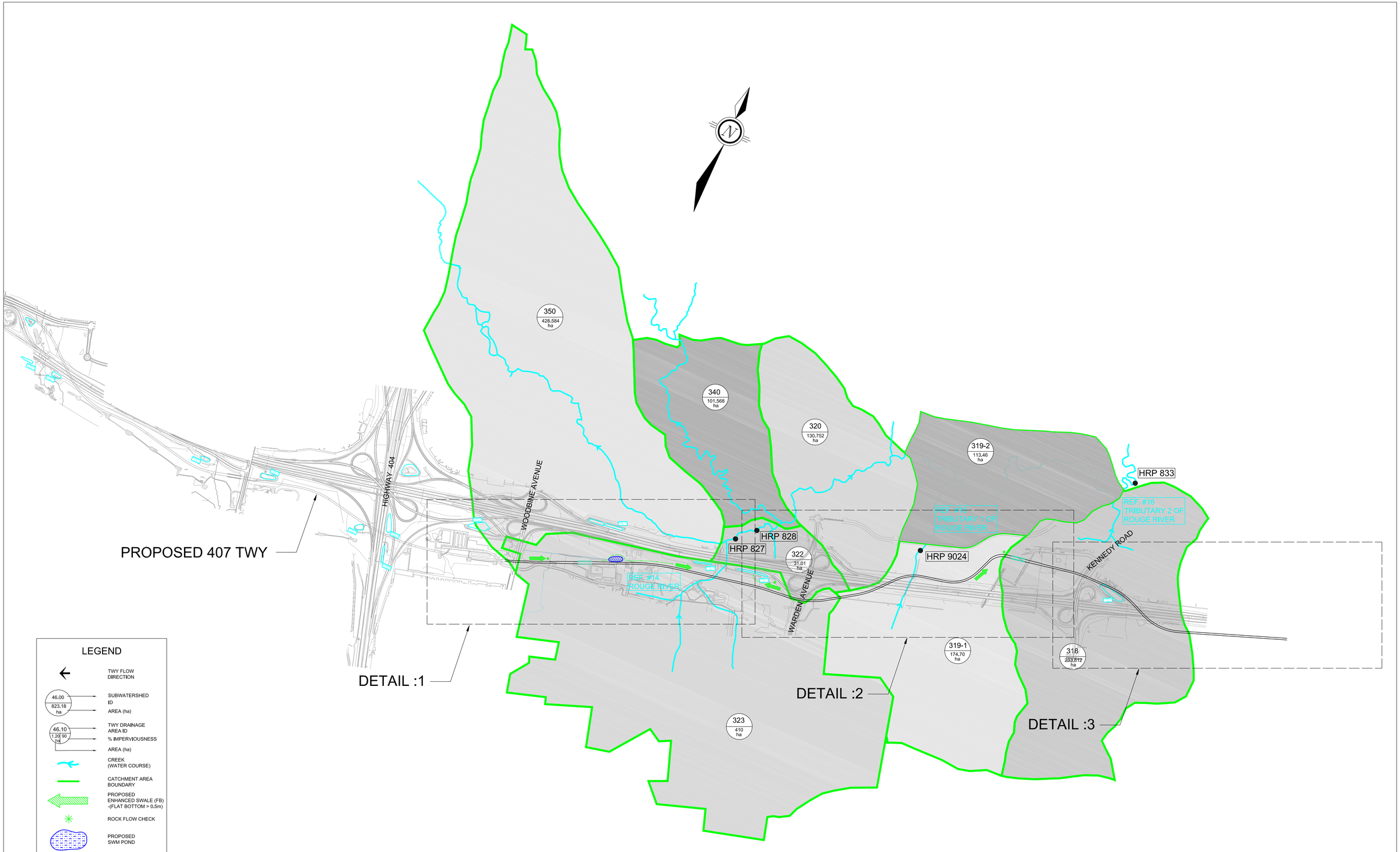

J:\DIVISION\WATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY - DRAINAGE\DRAWINGS\FLOODPLAINMAPPING\SUBWATERSHEETS\TT4003-ROUGE-DA.DWG

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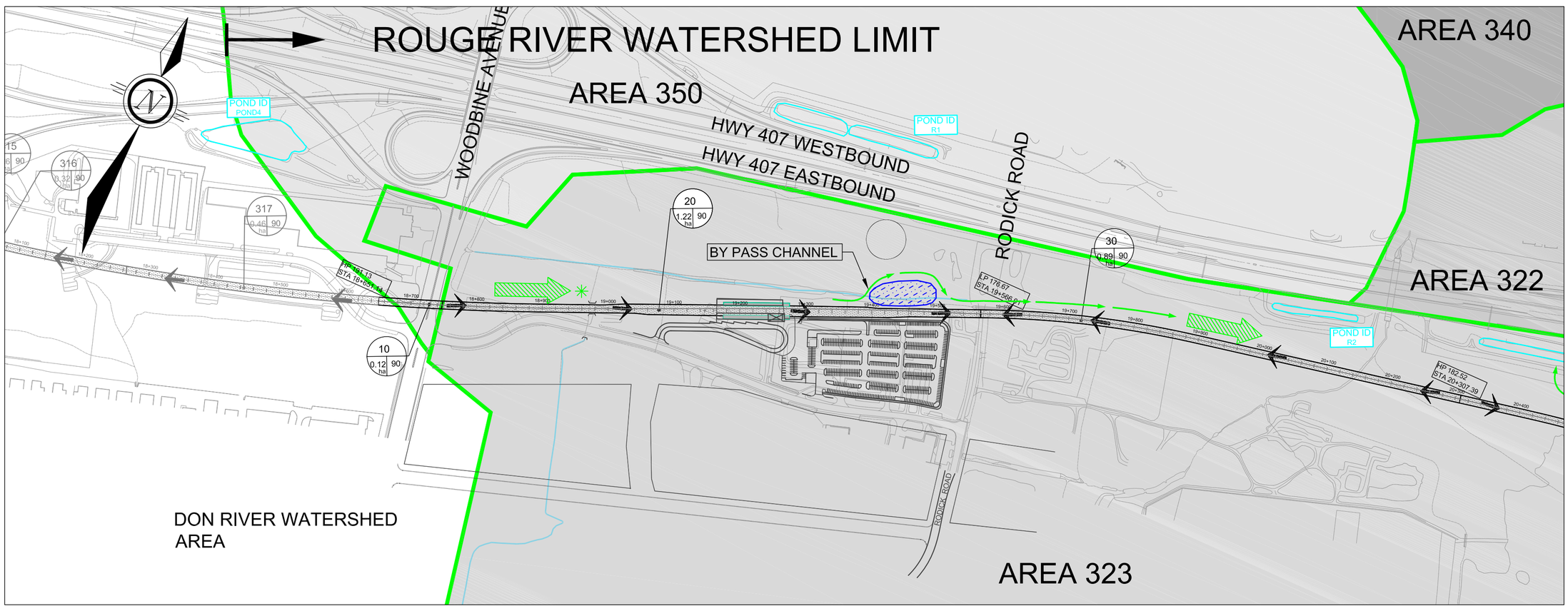
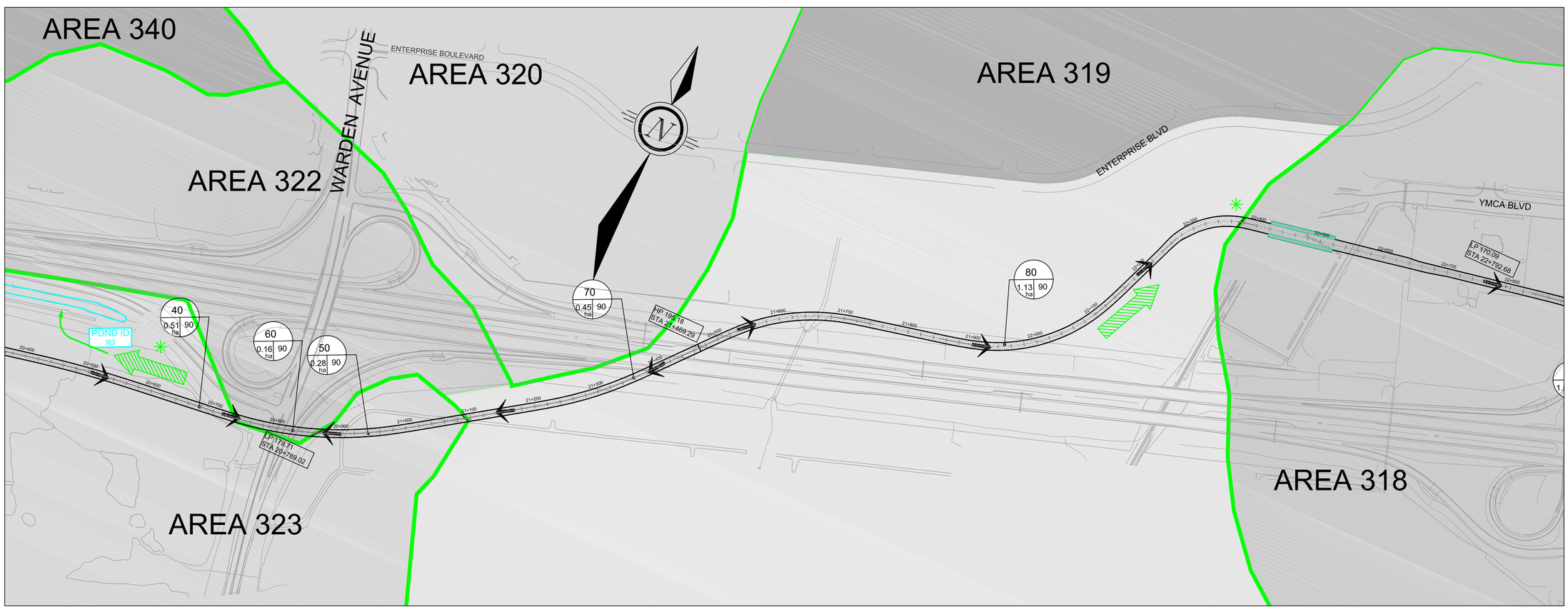
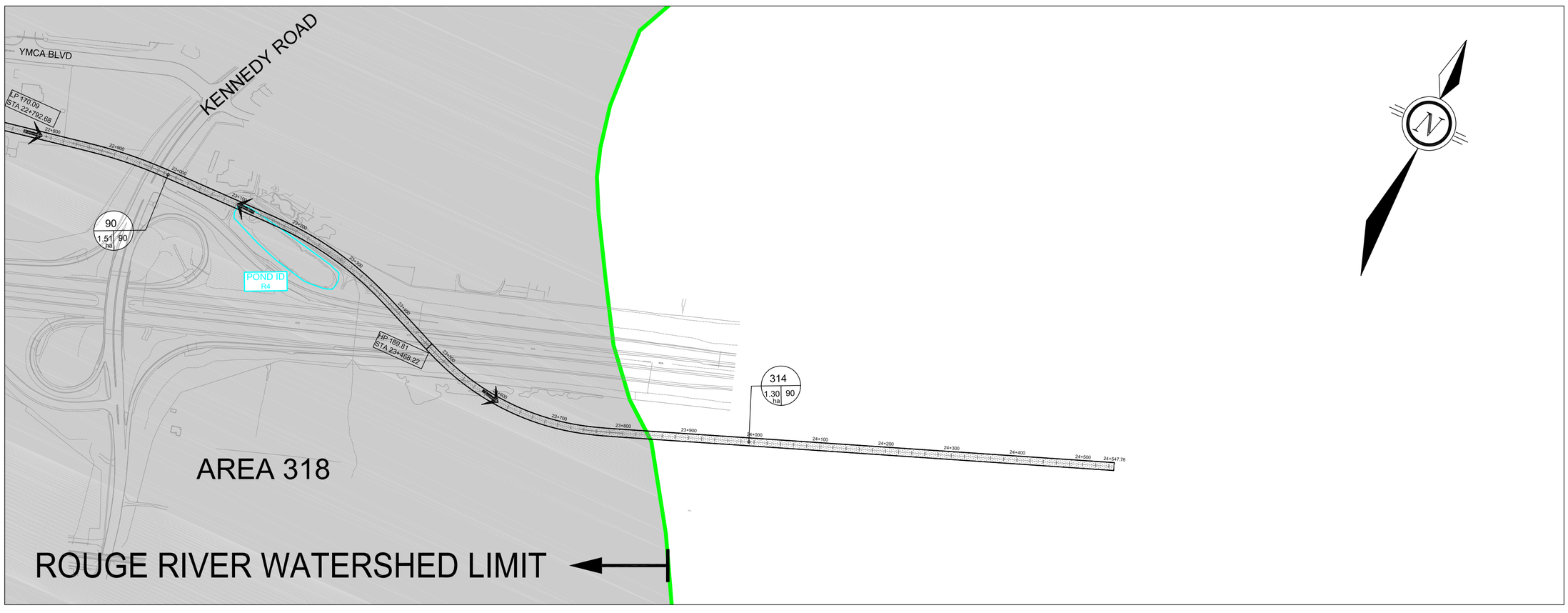
	SCALE: 1: 12,500			FIGURE 3.8: ROUGE RIVER WATERSHED - DRAINAGE AREA MAP



DETAIL :1



DETAIL :2



DETAIL :3

LEGEND

- TWY FLOW DIRECTION
- SUBWATERSHED ID (46.00 / 823.18 ha) — AREA (ha)
- TWY DRAINAGE AREA ID (46.10 / 1.20 ha / 90) — % IMPERVIOUSNESS — AREA (ha)
- CREEK (WATER COURSE)
- CATCHMENT AREA BOUNDARY
- PROPOSED ENHANCED SWALE (FB) -(FLAT BOTTOM > 0.5m)
- ROCK FLOW CHECK
- PROPOSED SWM POND

DATE:	AUGUST, 2010
SCALE:	1: 5,000

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FIGURE 3.9: ROUGE RIVER WATERSHED - DRAINAGE AREA MAP DETAIL & STORMWATER STRATEGY

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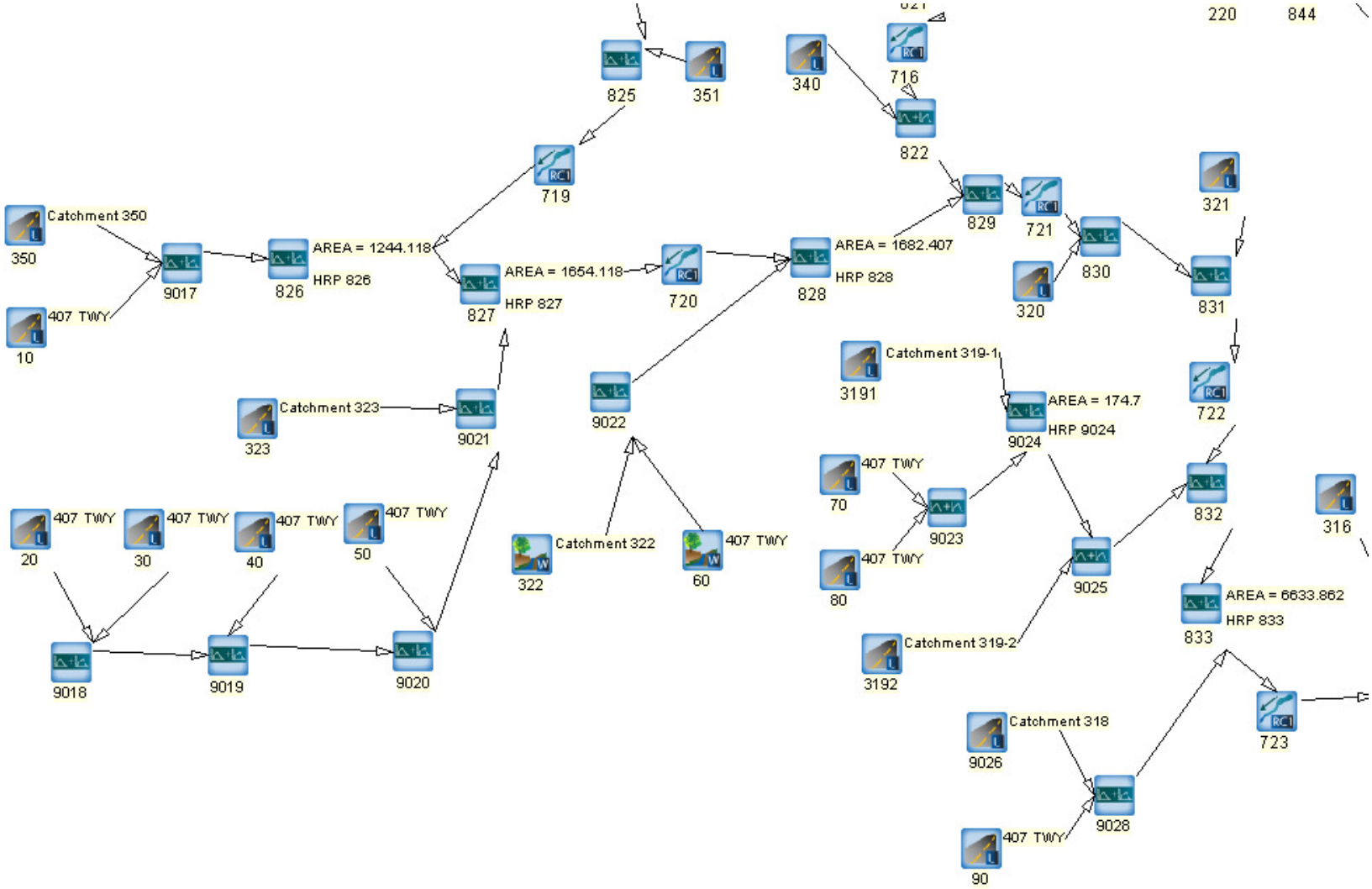
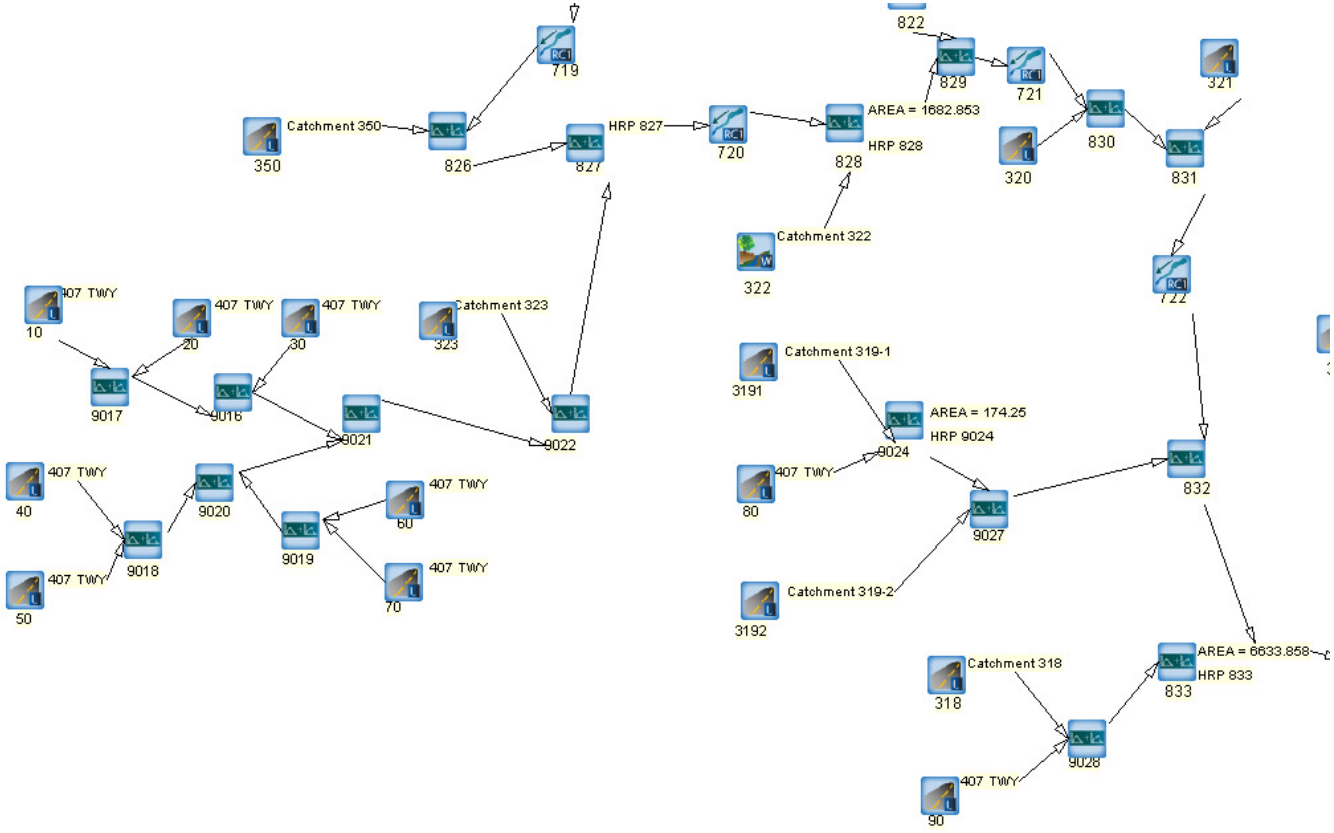
Visual OttHYMO Modelling Schematics – 4: ROUGE RIVER

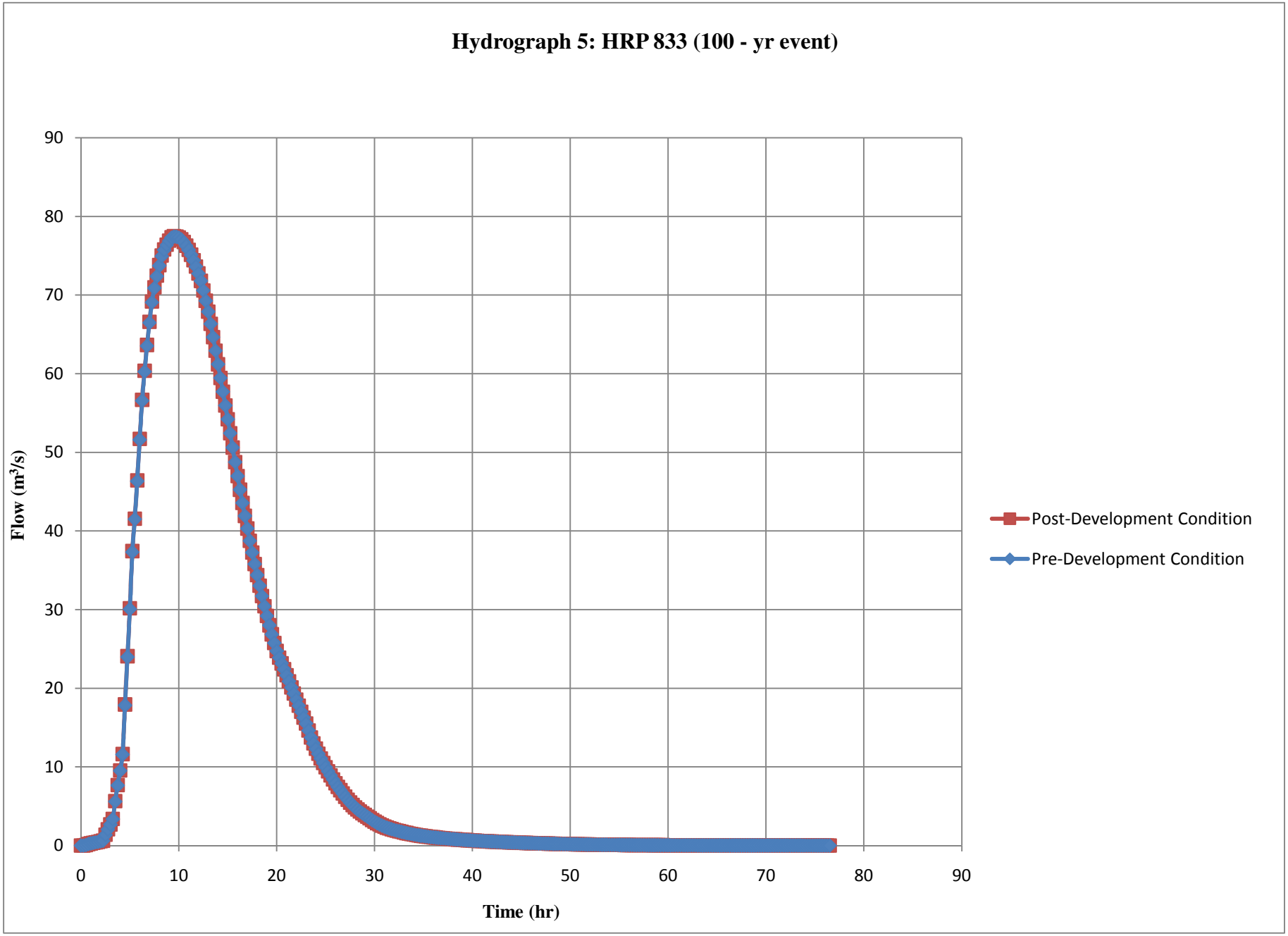
Pre – Development Condition Scenario



Visual OttHYMO Modelling Schematics – 9: ROUGE RIVER

Post – Development Condition Scenario



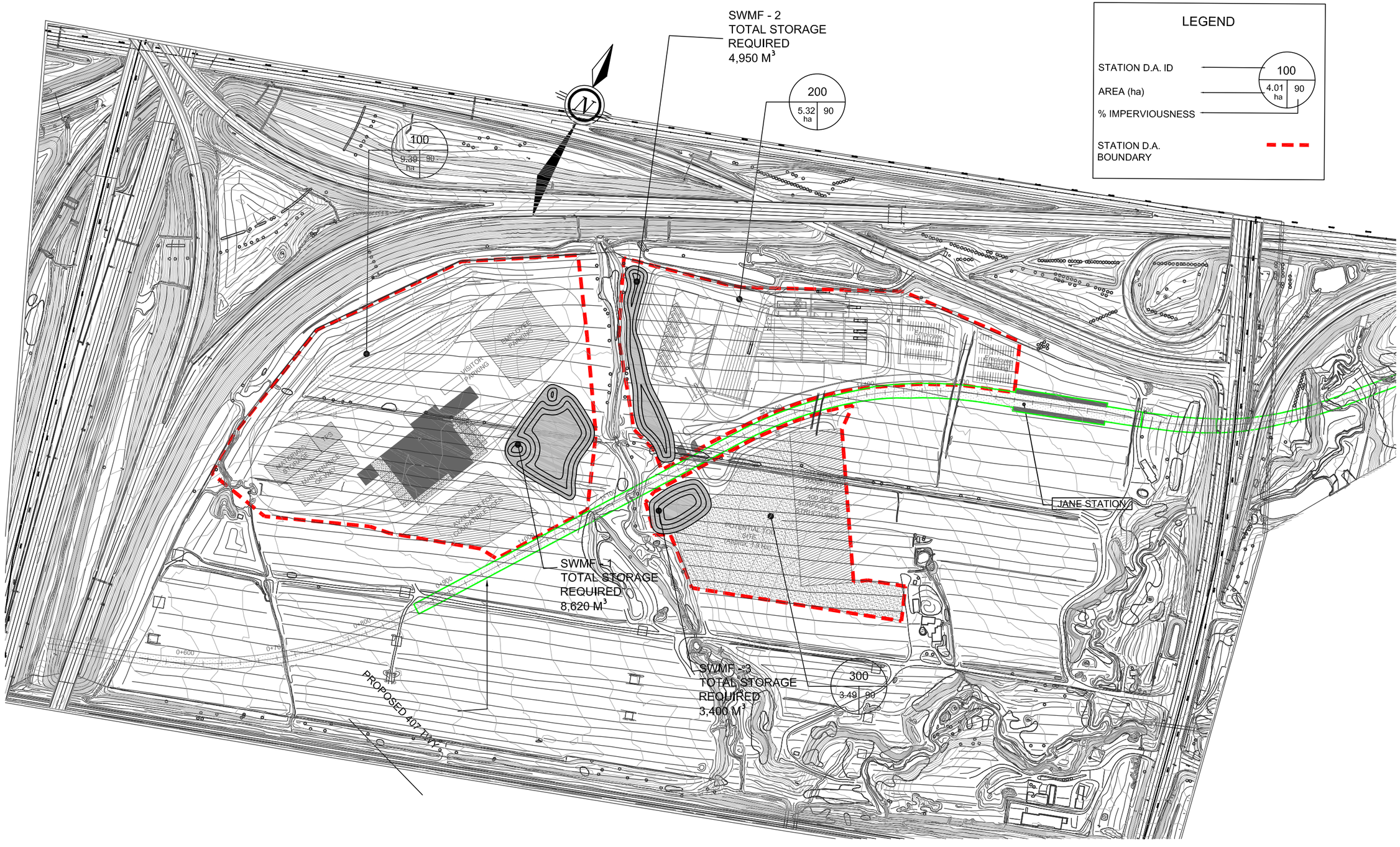

Hydrograph 5: HRP 833 (100 - yr event)
Flow (m3/s)
Time (hr)
0
10
20
30
40
50
60
70
80
90
Post-Development Condition
Pre-Development Condition

APPENDIX B

HYDROLOGIC ANALYSIS OF 407 TRANSITWAY FACILITIES

Stations, Parking lots, Workyards

JANE STATION



J:\DIVISION\WATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY - DRAINAGE\DRAWINGS\DESIGN\STATION LAYOUT.DWG

100m 0 200m

DATE: AUGUST, 2010

SCALE: 1: 4000

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JANE STATION - SWM

FIGURE No : 5.1

Visual OttHYMO Modelling Schematics – 10: HUMBER RIVER (JANE ST Station Facilities)

Pre and Post – Development Condition Scenarios

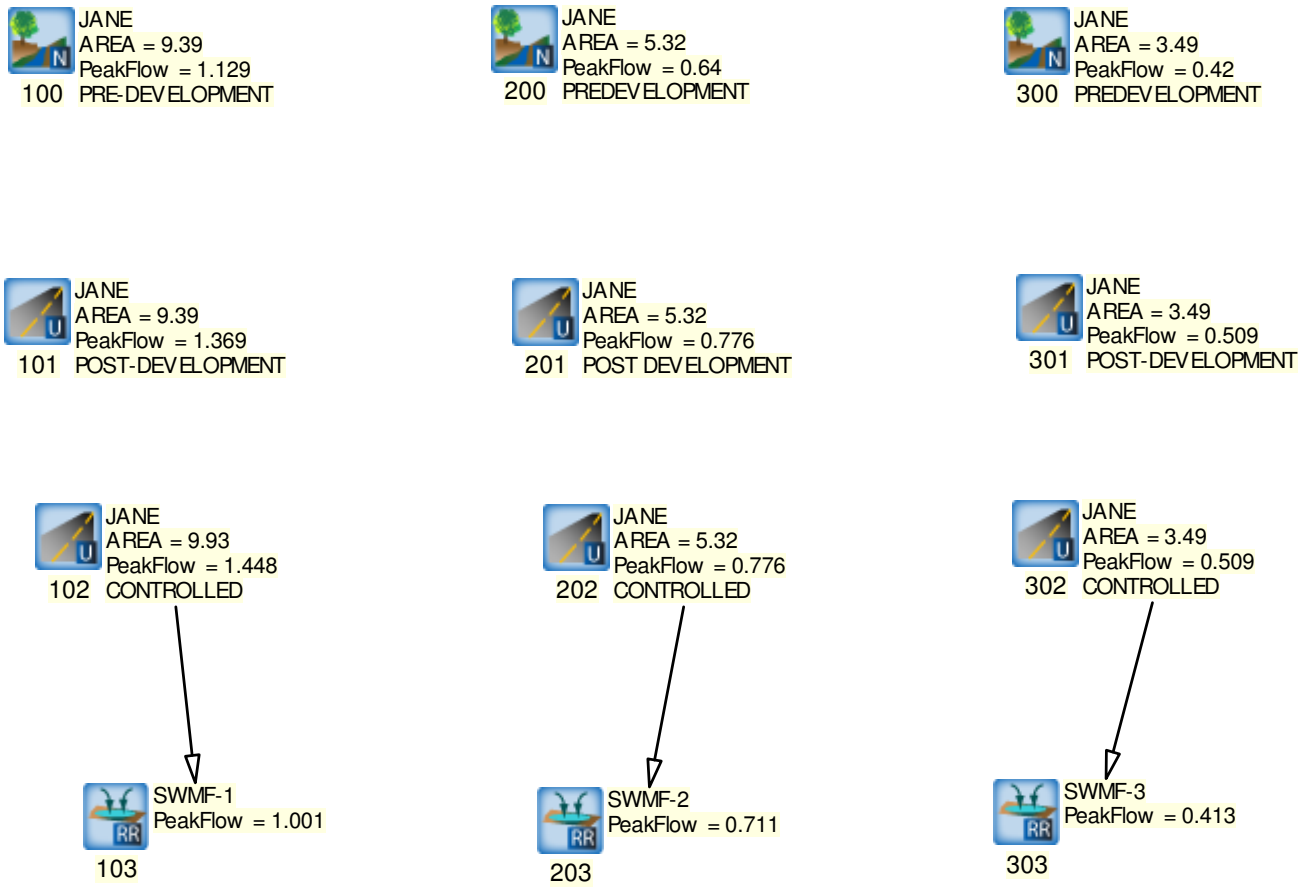

Table 5.1 - Jane Station proposed SWM

JANE STATION (A=9.39ha)			
2-yr	0.20	0.19	0.22
5-yr	0.33	0.28	0.28
10-yr	0.43	0.40	0.32
25-yr	0.56	0.58	0.36
50-yr	0.65	0.64	0.39
100-yr	0.76	0.71	0.43
Regional	1.13	1.00	0.58
JANE STATION (A=5.32ha)			
2-yr	0.12	0.12	0.11
5-yr	0.19	0.19	0.14
10-yr	0.24	0.24	0.16
25-yr	0.31	0.30	0.18
50-yr	0.37	0.37	0.2
100-yr	0.43	0.42	0.22
Regional	0.64	0.71	0.25
JANE STATION (A=3.49ha)			
2-yr	0.08	0.07	0.07
5-yr	0.12	0.11	0.09
10-yr	0.16	0.15	0.11
25-yr	0.21	0.19	0.12
50-yr	0.24	0.23	0.13
100-yr	0.28	0.27	0.15
Regional	0.42	0.41	0.18

Jane Station - SWMF 1 - Design Parameters

Pond Catchment Area 9.39 ha

Water Quality Storage Requirements

MOE (2003, Table 3.2)

Level 1	250 m3/ha	Interpolated from Table 3.2 (MOE)		
Extended	40 m3/ha	(or 25mm rainfall event whichever greater)	*375.60*	m3
25 mm Event	25 mm		*2,347.50*	m3
% imperviousness	85 %			
Permanent Volume Required			*1,971.90*	m3

Quantity Control Required

Total Volume required up to and including the 100 yr storm **4,300.00** m3

Total Pond Volume Required (Permanent and Extended) **8,619.40**

Settling Calculations

$$Dist = \sqrt{\frac{r \times Q_p}{V_s}}$$

Dist	18	Minimum Forebay length	m
r	2	Lenth to width ratio	-
Qp	0.05	Peak flow rate from the pond during design quality storm	m3/s
Vs	0.0003	settling velocity'	m/s

Dispersion Length

$$Dist = \frac{8Q}{dV_f}$$

Minimum Width 1 m

Dist	10	Minimum Dispertion Length
Q	0.93	Inlet Flow Rate
d	1.50	Depth of the Permanent Pool
Vf	0.5	Desired Velocity in the Forebay

(0.15 m/s is the maximum permissible velocity before erosion occurs in a channel (MOE))

Design Quality Storm

MOE Eq 3.7

$$i_{25} = 43C + 5.9$$

A	9.39	Area
C	85	Runoff Coefficient
i	42.45	Intensity
Qp	0.93	Flow Rational Method

Jane Station - SWMF 2 - Design Parameters

Pond Catchment Area 5.32 ha

Water Quality Storage Requirements

MOE (2003, Table 3.2)

Level 1	250	m3/ha	Interpolated from Table 3.2 (MOE)		
Extended	40	m3/ha	(or 25mm rainfall event whichever greater)	*212.80*	m3
25 mm Event	25	mm		*1,330.00*	m3
% imperviousness	85	%			
Permanent Volume Required				*1,117.20*	m3

Quantity Control Required

Total Volume required up to and including the 100 yr storm **2,500.00** m3

Total Pond Volume Required (Permanent and Extended) **4,947.20**

Settling Calculations

$$Dist = \sqrt{\frac{r \times Q_p}{V_s}}$$

Dist	23	Minimum Forebay length	m
r	2	Lenth to width ratio	-
Qp	0.08	Peak flow rate from the pond during design quality storm	m3/s
Vs	0.0003	settling velocity'	m/s

Dispersion Length

$$Dist = \frac{8Q}{dV_f}$$

Minimum Width 1 m

Dist	6	Minimum Dispertion Length
Q	0.52	Inlet Flow Rate
d	1.50	Depth of the Permanent Pool
Vf	0.5	Desired Velocity in the Forebay

(0.15 m/s is the maximum permissible velocity before erosion occurs in a channel (MOE))

Design Quality Storm

MOE Eq 3.7

$$i_{25} = 43C + 5.9$$

A	5.32	Area
C	85	Runoff Coefficient
i	42.45	Intensity
Qp	0.52	Flow Rational Method

Jane Station - SWMF 3 - Design Parameters

Pond Catchment Area 3.49 ha

Water Quality Storage Requirements

MOE (2003, Table 3.2)

Level 1	250	m3/ha	Interpolated from Table 3.2 (MOE)		
Extended	40	m3/ha	(or 25mm rainfall event whichever greater)	*139.60*	m3
25 mm Event	25	mm		*872.50*	m3
% imperviousness	85	%			
Permanent Volume Required				*732.90*	m3

Quantity Control Required

Total Volume required up to and including the 100 yr storm **1,800.00** m3

Total Pond Volume Required (Permanent and Extended) **3,405.40**

Settling Calculations

$$Dist = \sqrt{\frac{r \times Q_p}{V_s}}$$

Dist	23	Minimum Forebay length	m
r	2	Lenth to width ratio	-
Qp	0.08	Peak flow rate from the pond during design quality storm	m3/s
Vs	0.0003	settling velocity'	m/s

Dispersion Length

$$Dist = \frac{8Q}{dV_f}$$

Minimum Width 0 m

Dist	4	Minimum Dispertion Length
Q	0.34	Inlet Flow Rate
d	1.50	Depth of the Permanent Pool
Vf	0.5	Desired Velocity in the Forebay

(0.15 m/s is the maximum permissible velocity before erosion occurs in a channel (MOE))

Design Quality Storm

MOE Eq 3.7

$$i_{25} = 43C + 5.9$$

A	3.49	Area
C	85	Runoff Coefficient
i	42.45	Intensity
Qp	0.34	Flow Rational Method

GO BARRIE STATION

J:\DIVISION\WATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY – DRAINAGE\DRAWINGS\DESIGN\STATION LAYOUT.DWG

LEGEND

STATION D.A. ID — 300

AREA (ha) — 4.01 ha

% IMPERVIOUSNESS — 90

STATION D.A. BOUNDARY

100m 0 200m

DATE:	AUGUST, 2010
SCALE:	1: 4000

Ontario

Delcan

625 COCHRANE DRIVE, SUITE 500
MARKHAM, ONTARIO L3R 9R9
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HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

GO BARRIE STATION - SWM

FIGURE No : 5.2

Visual OttHYMO Modelling Schematics – 11: DON RIVER (Don River Station Facilities)

Pre and Post – Development Condition Scenarios

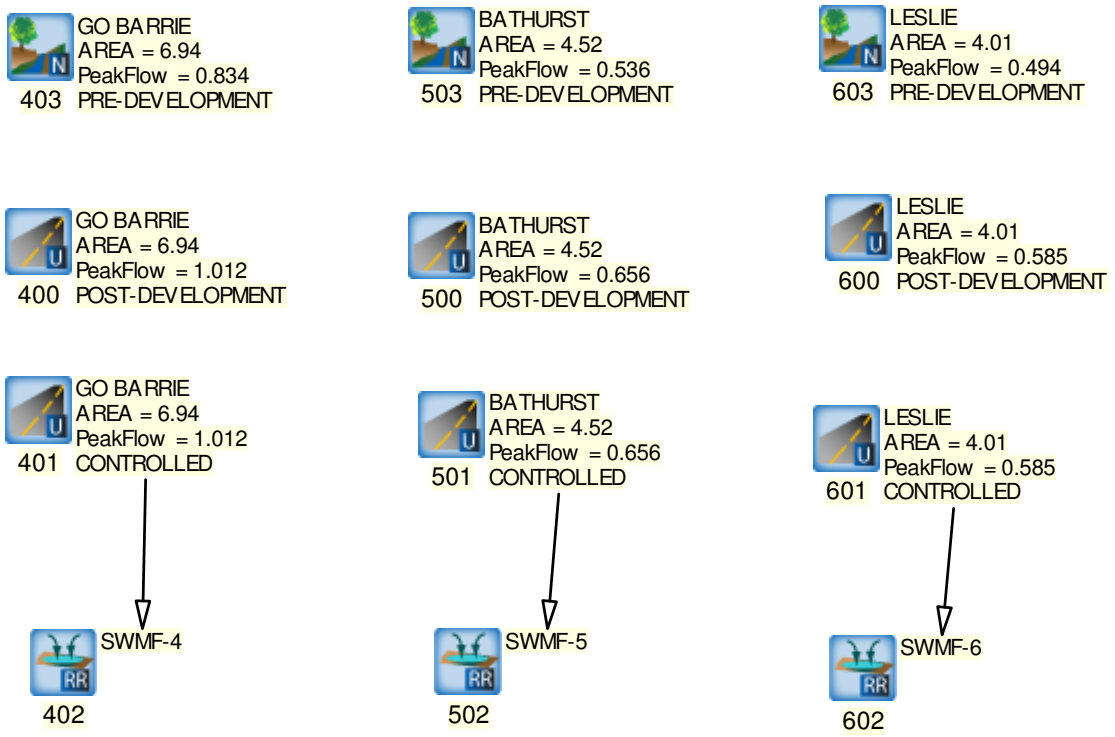

Table 5.2 - Go Barrie Station proposed SWM

Return Period	Pre-Dev peak flows (m^3/s)	Post-Dev release rates (m^3/s)	Storage required (ha.m)
GO BARRIE STATION (A=6.94ha)			
2-yr	0.15	0.15	0.15
5-yr	0.24	0.23	0.18
10-yr	0.32	0.32	0.21
25-yr	0.41	0.41	0.24
50-yr	0.48	0.49	0.26
100-yr	0.56	0.55	0.29
Regional	0.83	1.01	0.31

GO Barrie Station - SWMF 4 - Design Parameters

Pond Catchment Area 6.94 ha

Water Quality Storage Requirements

MOE (2003, Table 3.2)

Level 1	250	m3/ha	Interpolated from Table 3.2 (MOE)		
Extended	40	m3/ha	(or 25mm rainfall event whichever greater)	*277.60*	m3
25 mm Event	25	mm		*1,735.00*	m3
% imperviousness	85	%			
Permanent Volume Required				*1,457.40*	m3

Quantity Control Required

Total Volume required up to and including the 100 yr storm **2,900.00** m3

Total Pond Volume Required (Permanent and Extended) **6,092.40**

Settling Calculations

$$Dist = \sqrt{\frac{r \times Q_p}{V_s}}$$

Dist	23	Minimum Forebay length	m
r	2	Lenth to width ratio	-
Qp	0.08	Peak flow rate from the pond during design quality storm	m3/s
Vs	0.0003	settling velocity'	m/s

Dispersion Length

$$Dist = \frac{8Q}{dV_f}$$

Minimum Width 1 m

Dist	7	Minimum Dispertion Length
Q	0.69	Inlet Flow Rate
d	1.50	Depth of the Permanent Pool
Vf	0.5	Desired Velocity in the Forebay

(0.15 m/s is the maximum permissible velocity before erosion occurs in a channel (MOE))

Design Quality Storm

MOE Eq 3.7

$$i_{25} = 43C + 5.9$$

A	6.94	Area
C	85	Runoff Coefficient
i	42.45	Intensity
Qp	0.69	Flow Rational Method

BATHURST STATION

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LEGEND

STATION D.A. ID — 300

AREA (ha) — 4.01 ha

% IMPERVIOUSNESS — 90

STATION D.A. BOUNDARY

EXISTING WOODLOTS (BAKER SUGERBUSH)

500
4.52 ha | 90

EXISTING SIDEWALK

BAYVIEW AVENUE

RICHMOND HILL GOLF CLUB

SWMF - 5 TOTAL STORAGE REQUIRED 4380 M^3

PROPOSED 407 TWY

HIGHWAY 7

BATHURST STATION

HIGHWAY 407

100m 0 200m

DATE: AUGUST, 2010

SCALE: 1: 4000

Ontario

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BATHURST STATION SWM

FIGURE No : 5.3

Table 5.3 - Bathurst Station proposed SWM

Return Period	Pre-Dev peak flows (m^3/s)	Post-Dev release rates (m^3/s)	Storage required (ha.m)
BATHURST STATION (A=4.52ha)			
2-yr	0.09	0.09	0.10
5-yr	0.15	0.14	0.12
10-yr	0.19	0.19	0.14
25-yr	0.25	0.25	0.16
50-yr	0.30	0.29	0.18
100-yr	0.35	0.34	0.19
Regional	0.54	0.53	0.23

Bathrust Station - SWMF 5 - Design Parameters

Pond Catchment Area 4.52 ha

Water Quality Storage Requirements

MOE (2003, Table 3.2)

Level 1	250 m3/ha	Interpolated from Table 3.2 (MOE)		
Extended	40 m3/ha	(or 25mm rainfall event whichever greater)	*180.80*	m3
25 mm Event	25 mm		*1,130.00*	m3
% imperviousness	85 %			
Permanent Volume Required			*949.20*	m3

Quantity Control Required

Total Volume required up to and including the 100 yr storm **2,300.00** m3

Total Pond Volume Required (Permanent and Extended) **4,379.20**

Settling Calculations

$$Dist = \sqrt{\frac{r \times Q_p}{V_s}}$$

Dist	23	Minimum Forebay length	m
r	2	Lenth to width ratio	-
Qp	0.08	Peak flow rate from the pond during design quality storm	m3/s
Vs	0.0003	settling velocity'	m/s

Dispersion Length

$$Dist = \frac{8Q}{dV_f}$$

Minimum Width 1 m

Dist	5	Minimum Dispertion Length
Q	0.44	Inlet Flow Rate
d	1.50	Depth of the Permanent Pool
Vf	0.5	Desired Velocity in the Forebay

(0.15 m/s is the maximum permissible velocity before erosion occurs in a channel (MOE))

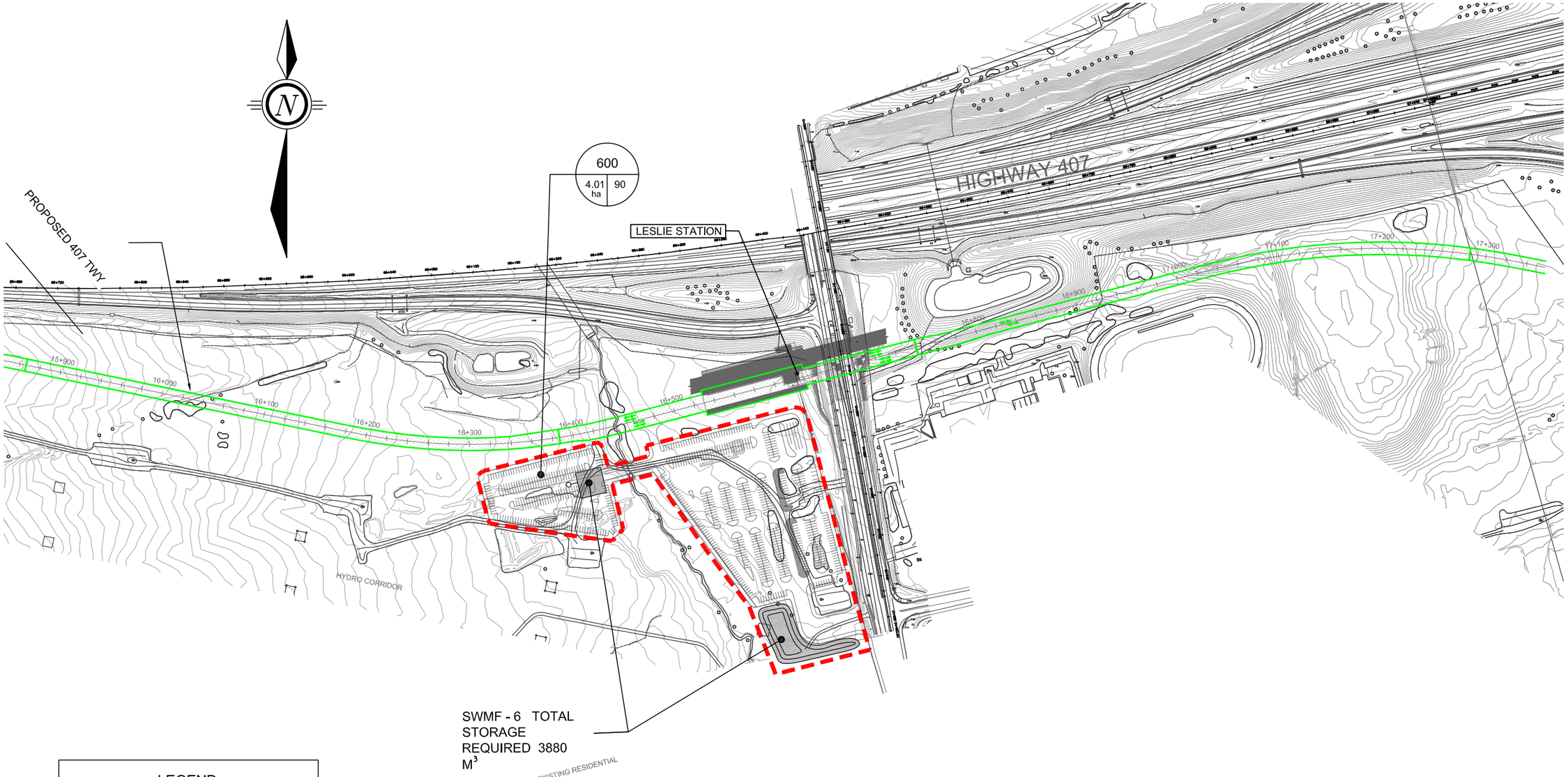
Design Quality Storm

MOE Eq 3.7

$$i_{25} = 43C + 5.9$$

A	4.52	Area
C	85	Runoff Coefficient
i	42.45	Intensity
Qp	0.44	Flow Rational Method

LESLIE STATION



LEGEND

STATION D.A. ID — 300

AREA (ha) — 4.01 ha

% IMPERVIOUSNESS — 90

STATION D.A. BOUNDARY

100m 0 200m

DATE: AUGUST, 2010

SCALE: 1: 4000

Ontario

Delcan

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HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

LESLIE STATION SWM

FIGURE No : 5.4

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Table 5.4 - Leslie Station proposed SWM

Return Period	Pre-Dev peak flows (m^3/s)	Post-Dev release rates (m^3/s)	Storage required (ha.m)
LESLIE STATION (A=4.01ha)			
2-yr	0.09	0.09	0.08
5-yr	0.15	0.15	0.10
10-yr	0.20	0.19	0.12
25-yr	0.25	0.24	0.14
50-yr	0.30	0.28	0.15
100-yr	0.35	0.32	0.16
Regional	0.49	0.55	0.18

Leslie Station - SWMF 6 - Design Parameters

Pond Catchment Area 4.52 ha

Water Quality Storage Requirements

MOE (2003, Table 3.2)

Level 1	250	m3/ha	Interpolated from Table 3.2 (MOE)		
Extended	40	m3/ha	(or 25mm rainfall event whichever greater)	*180.80*	m3
25 mm Event	25	mm		*1,130.00*	m3
% imperviousness	85	%			
Permanent Volume Required				*949.20*	m3

Quantity Control Required

Total Volume required up to and including the 100 yr storm **1,800.00** m3

Total Pond Volume Required (Permanent and Extended) **3,879.20**

Settling Calculations

$$Dist = \sqrt{\frac{r \times Q_p}{V_s}}$$

Dist	23	Minimum Forebay length	m
r	2	Lenth to width ratio	-
Qp	0.08	Peak flow rate from the pond during design quality storm	m3/s
Vs	0.0003	settling velocity'	m/s

Dispersion Length

$$Dist = \frac{8Q}{dV_f}$$

Minimum Width 1 m

Dist	5	Minimum Dispertion Length
Q	0.44	Inlet Flow Rate
d	1.50	Depth of the Permanent Pool
Vf	0.5	Desired Velocity in the Forebay

(0.15 m/s is the maximum permissible velocity before erosion occurs in a channel (MOE))

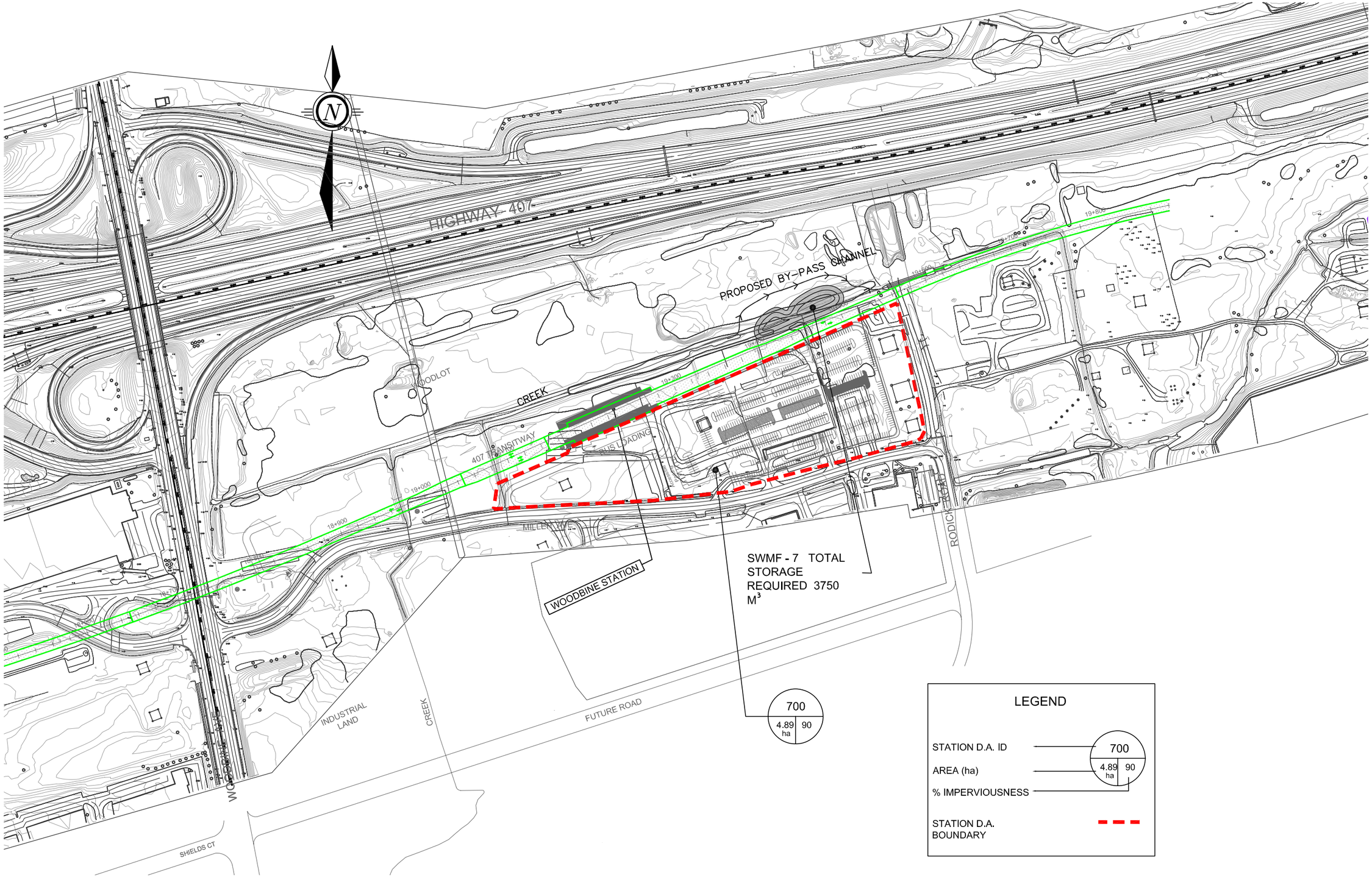
Design Quality Storm

MOE Eq 3.7

$$i_{25} = 43C + 5.9$$

A	4.52	Area
C	85	Runoff Coefficient
i	42.45	Intensity
Qp	0.44	Flow Rational Method

WOODBINE STATION



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100m 0 200m

DATE: AUGUST, 2010

SCALE: 1: 4000

Ontario

Delcan

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HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

WOODBINE STATION SWM

FIGURE No :

5.5

Visual OttHYMO Modelling Schematics – 12: ROUGE RIVER (Woodbine Station)

Pre and Post – Development Condition Scenarios

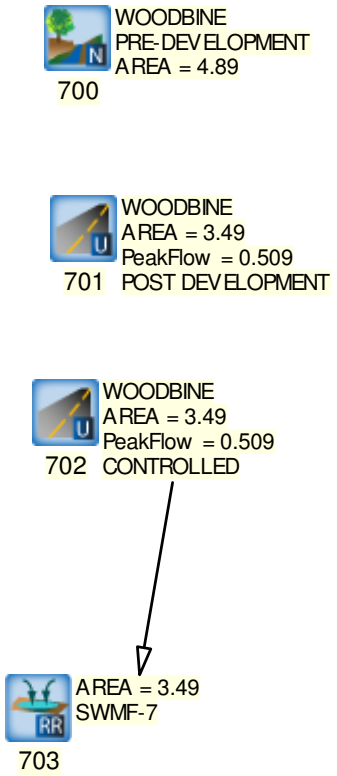

Table 5.5 - Woodbine Station proposed SWM

Return Period	Pre-Dev peak flows (m^3/s)	Post-Dev release rates (m^3/s)	Storage required (ha.m)
WOODBINE STATION (A=4.89ha)			
2-yr	0.10	0.09	0.07
5-yr	0.17	0.15	0.08
10-yr	0.22	0.20	0.10
25-yr	0.28	0.25	0.11
50-yr	0.33	0.28	0.12
100-yr	0.38	0.34	0.13
Regional	0.58	0.48	0.15

Woodbine Station - SWMF 7 - Design Parameters

Pond Catchment Area 4.89 ha

Water Quality Storage Requirements

MOE (2003, Table 3.2)

Level 1	250	m3/ha	Interpolated from Table 3.2 (MOE)		
Extended	40	m3/ha	(or 25mm rainfall event whichever greater)	*195.60*	m3
25 mm Event	25	mm		*1,222.50*	m3
% imperviousness	85	%			
Permanent Volume Required				*1,026.90*	m3

Quantity Control Required

Total Volume required up to and including the 100 yr storm **1,500.00** m3

Total Pond Volume Required (Permanent and Extended) **3,749.40**

Settling Calculations

$$Dist = \sqrt{\frac{r \times Q_p}{V_s}}$$

Dist	23	Minimum Forebay length	m
r	2	Lenth to width ratio	-
Qp	0.08	Peak flow rate from the pond during design quality storm	m3/s
Vs	0.0003	settling velocity'	m/s

Dispersion Length

$$Dist = \frac{8Q}{dV_f}$$

Minimum Width 1 m

Dist	5	Minimum Dispertion Length
Q	0.48	Inlet Flow Rate
d	1.50	Depth of the Permanent Pool
Vf	0.5	Desired Velocity in the Forebay

(0.15 m/s is the maximum permissible velocity before erosion occurs in a channel (MOE))

Design Quality Storm

MOE Eq 3.7

$$i_{25} = 43C + 5.9$$

A	4.89	Area
C	85	Runoff Coefficient
i	42.45	Intensity
Qp	0.48	Flow Rational Method

APPENDIX C

HYDRAULIC ANALYSIS

Table 6.2 : Flows, water levels upstream of proposed 407 TWY structures, freeboard and clearance for 100-yr event

Return Period	NOTES	2-year		5-year		10-year		25-year		50-year		100-year				Regional	
Creek Ref No		Q (m^3/s)	US WL (m)	Q (m^3/s)	US WL (m)	Q (m^3/s)	US WL (m)	Q (m^3/s)	US WL (m)	Q (m^3/s)	US WL (m)	Q (m^3/s)	US WL (m)	Clearance (m)	Freeboard (m)	Q (m^3/s)	US WL (m)
Creek Ref # 1 Bridge 55m span HEC-RAS ST 150	New HEC-RAS model created; Flows taken from Table D.2 – Humber River, Hydrology Model Update, Estimated Peak Flows – Future Condition, TRCA	5.30	187.04	8.60	187.17	11.60	187.30	14.70	187.42	23.10	187.69	29.2	187.86	1.19	2.97	49.90	188.34
Creek Ref # 2 Bridge 70m span HEC-RAS ST 46.096	Updated TRCA's HEC-RAS model	37.80	192.19	59.00	192.31	74.60	192.38	94.80	192.61	111.40	192.95	127.20	193.29	0.90	2.99	244.00	195.90
Creek Ref # 3	no analysis required, no upstream catchment area; tributary starts downstream of 407 TWY	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Creek Ref # 4 Bridge 70m span HEC-RAS ST 6.0155	Updated TRCA's HEC-RAS model-West Don-Basin 6 Flows from HEC-RAS model	5.26	185.30	6.36	185.52	7.59	185.69	21.25	186.18	31.81	186.46	44.18	186.99	2.08	3.29	89.64	190.20
Creek Ref # 5 Bridge 80m span HEC-RAS ST 5.0575	Updated TRCA's HEC-RAS model-West Don-Basin 5	16.90	187.03	24.63	187.28	31.38	187.45	40.51	187.62	53.51	187.81	75.50	188.07	2.53	3.71	313.13	190.38
Creek Ref # 6 Bridge 10m span HEC-RAS ST 170	New HEC-RAS model created; flow through channel determined using West Don-Basin5' Overflow	--	--	--	--	--	--	--	--	--	--	2.39	199.21	0.54	1.75	11.46	199.60
Creek Ref # 7 Box Culvert (4.84x2)m	Flows calculated with Visual OttHYMO model, using hydrologic model from TRCA; storm pipe	0.94	--	1.57	--	2.04	--	2.71	--	3.224	--	3.77	--	--	--	10.14	--
Creek Ref # 8	No analysis required, 407TWY alignment located above existing crossing; WL provided is 100-yr WL of existing Hwy 407 pond (D6)	--	--	--	--	--	--	--	--	--	--	--	179.30 (SWMF D6 dwg)	--	--	--	--
Creek Ref # 9	No analysis required, 407TWY alignment located above existing crossing; WL provided are for existing Hwy 7 culvert (ST 23.15-Basin 23 East Don) - downstream side	--	166.95	--	167.20	--	167.36	--	167.79	--	167.92	--	168.07	--	--	--	170.16
Creek Ref # 10	No analysis required, 407TWY alignment located above existing crossing; no info regarding existing creek WL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Creek Ref # 11 Bridge 50m span HEC-RAS ST 30.0628	Updated TRCA's HEC-RAS model-East Don-Basin 30	18.61	190.99	40.90	191.44	51.47	191.60	69.75	191.88	84.65	192.07	100.49	192.20	2.57	3.78	110.13	192.27
Creek Ref # 12 Bridge 37m span HEC-RAS ST 130	New HEC-RAS model created; flows calculated with Visual OttHYMO model, using hydrologic model from TRCA	11.77	180.24	18.54	180.38	22.37	180.46	27.54	180.55	31.60	180.60	35.82	180.65	0.35	1.33	43.81	180.72
Creek Ref # 13 HEC-RAS ST	No floodplain mapping available - Creek has been enclosed - No analysis needed	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Creek Ref # 14 Bridge 83m span HEC-RAS ST 250	New HEC-RAS model created; flows calculated with Visual OttHYMO model, using hydrologic model from TRCA	10.04	176.75	13.24	176.85	15.58	176.91	19.25	177.00	21.41	177.04	42.71	177.61	2.49	4.47	44.62	179.39
Creek Ref # 15	No analysis required, 407TWY alignment located above existing crossing	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Creek Ref # 16	No analysis required, 407TWY alignment located above existing crossing; no info regarding existing creek WL	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--

Existing Floodplain Mapping from TRCA

J:\DIVISION\WATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY – DRAINAGE\DRAWINGS\FLOODPLAINMAPPING\TT4003-FPM-EXISTING.DWG

HIGHWAY 407

SPADINA SUBWAY EXTENSION

JANE STREET

BLACK CREEK

LIMIT OF MAPPING

LIMIT OF MAPPING

HUMBER RIVER SHEET 13

STEELES AV.

JANE ST.

HWY # 407

PEGLAR RD.

LOT 1 CON 4 W.Y.S.

LOT 2 CON 4 W.Y.S.

LOT 3 CON 4 W.Y.S.

LOT 4 CON 4 W.Y.S.

LOT 5 CON 4 W.Y.S.

LOT 1 CON 5 W.Y.S.

LOT 2 CON 5 W.Y.S.

LOT 3 CON 5 W.Y.S.

LOT 4 CON 5 W.Y.S.

LOT 5 CON 5 W.Y.S.

1+000 1+200 1+300 1+400 1+500 1+600 1+700 1+800 2+000 2+100 2+200 2+300

46.02 46.03 46.04 46.05 46.06 46.07 46.08 46.081 46.082 46.09 46.10 46.11 46.12 46.121 46.122 46.13 46.131 46.132 46.14

185.18 185.64 185.73 191.64 191.65 191.67 194.33 197.82 194.64 196.42 196.88 196.88 196.88 196.88 196.89 196.87 200.38

LEGEND

- Regulatory Flood Line
- Water Feature
- 193 Contour Line
- 199.50 Spot Elevation
- Hec-Ras Section
  - Cross-Section Length
  - Regional Flood Elevation (m)
  - 172.00 / 13.00
  - 14.080 Cross-Section Number
  - 100-Yr Existing Flood Elevation (m)
- 13+900 Proposed Transitway Alignment

100m 0 200m

DATE:	AUGUST, 2010
SCALE:	1 : 4000

Ontario

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FAX: 905-943-0400

HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

EXISTING FLOODPLAIN MAPPING (TRCA) - BLACK CREEK (REF #2) - HUMBER RIVER

FIGURE No : 6.2

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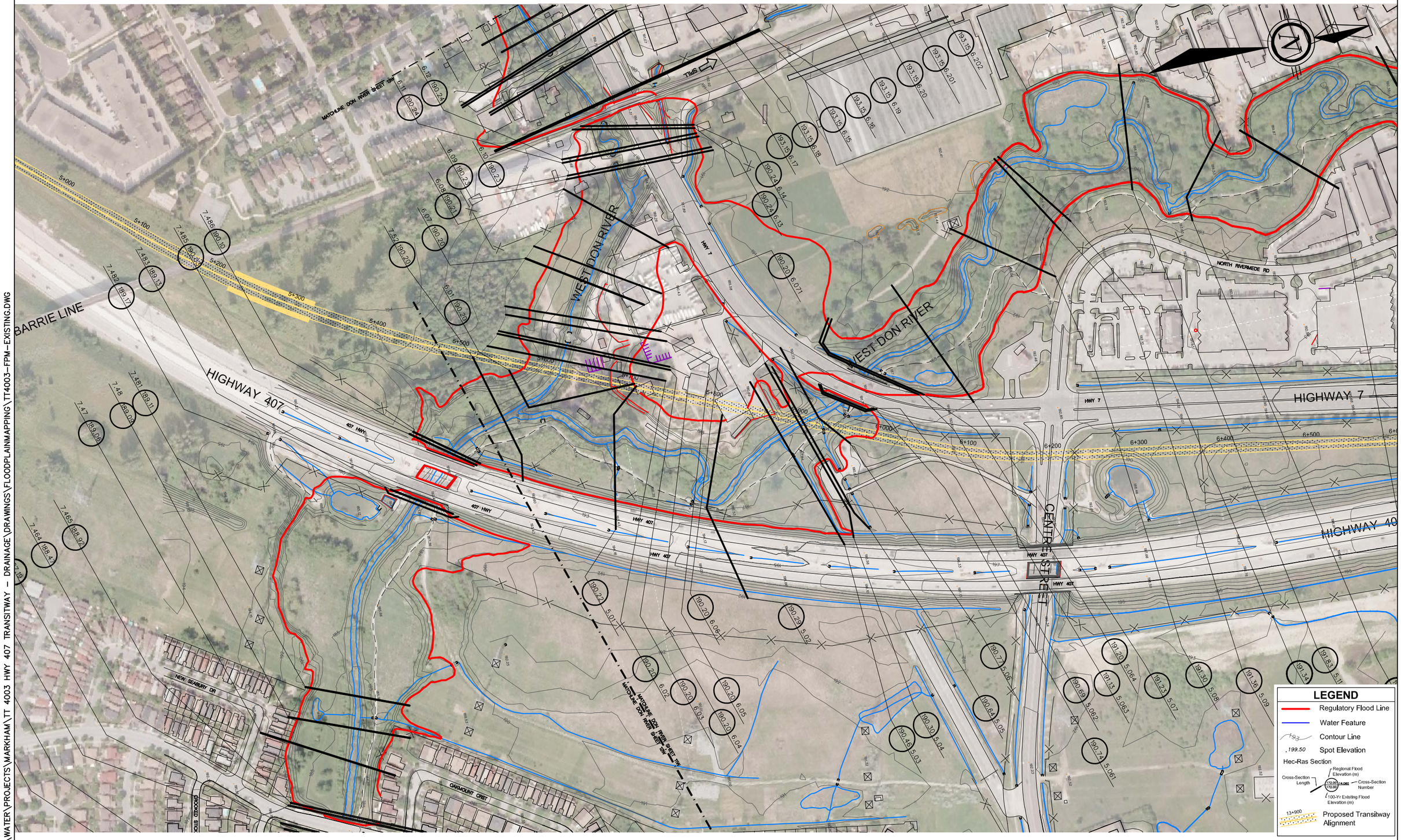

100m 0 200m

DATE:	AUGUST, 2010
SCALE:	1 : 4000

Ontario

Delcan

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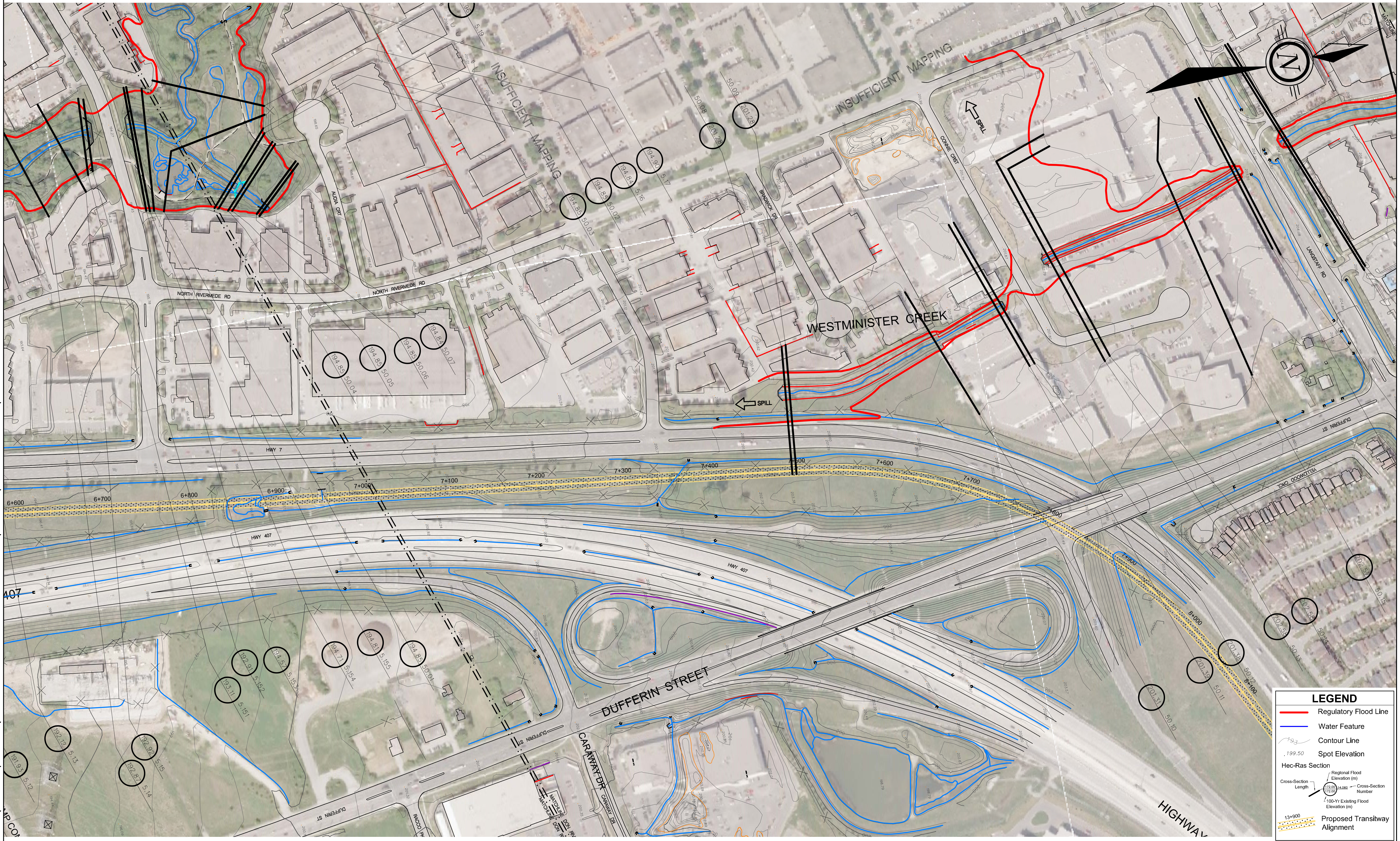
HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

EXISTING FLOODPLAIN MAPPING (TRCA) - WEST DON RIVER (REF #4 & 5) - DON RIVER

FIGURE No :

6.3



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100m 0 200m

DATE: AUGUST, 2010

SCALE: 1 : 4000

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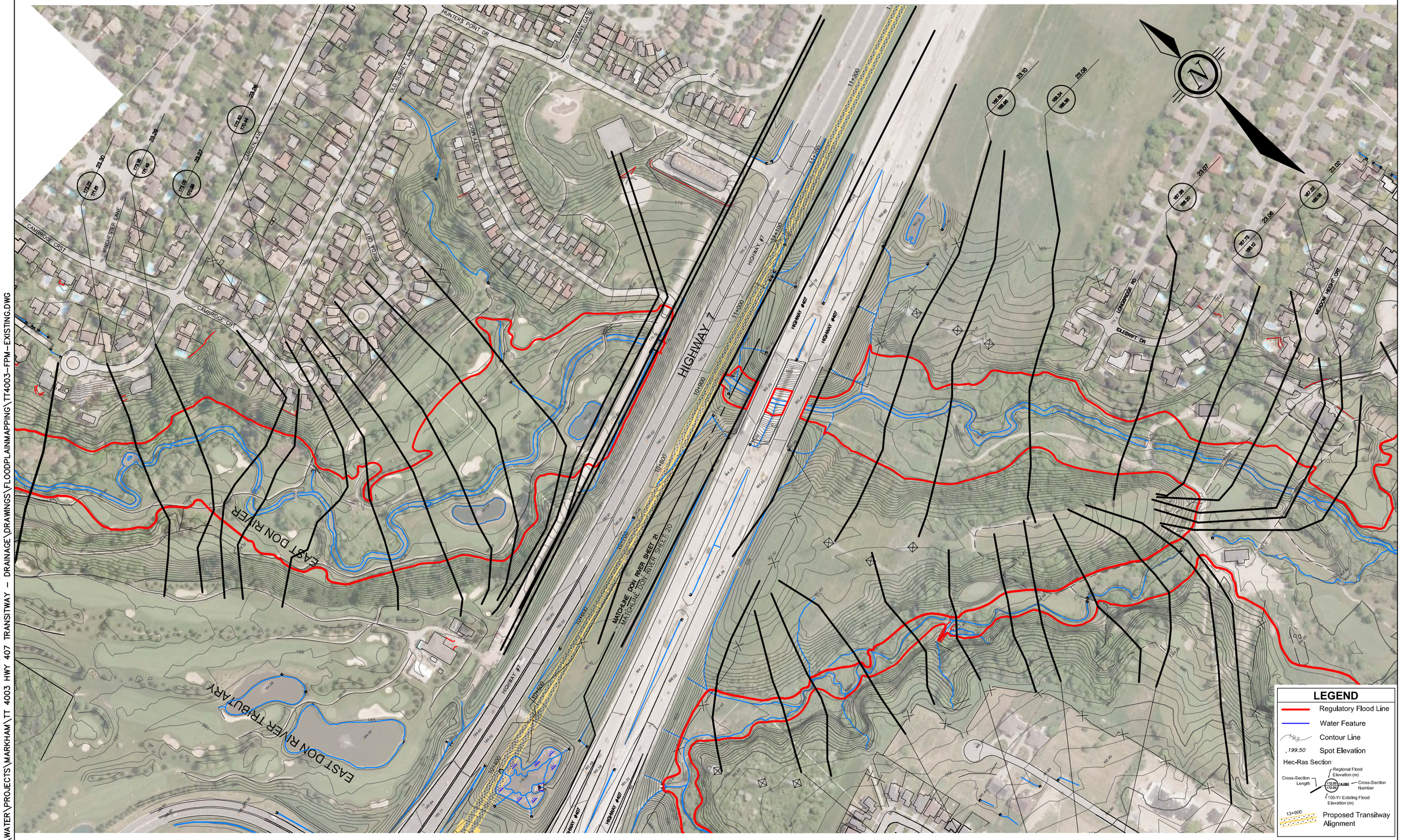
FAX: 905-943-0400

HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

EXISTING FLOODPLAIN MAPPING (TRCA) - WESTMINISTER CREEK (REF #6) - WEST DON

FIGURE No : 6.4

J:\DIVISION\WATER\PROJECTS\MARKHAM\TT 4003 HWY 407 TRANSITWAY – DRAINAGE\DRAWINGS\FLOODPLAINMAPPING\TT4003-FPM-EXISTING.DWG



100m 0 200m

DATE:	AUGUST, 2010
SCALE:	1 : 4000

Ontario

Delcan

625 COCHRANE DRIVE, SUITE 500
MARKHAM, ONTARIO L3R 9R9
TEL: 905-943-0500
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HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

EXISTING FLOODPLAIN MAPPING (TRCA) - EAST DON RIVER (REF #9) - DON RIVER

FIGURE No : 6.5

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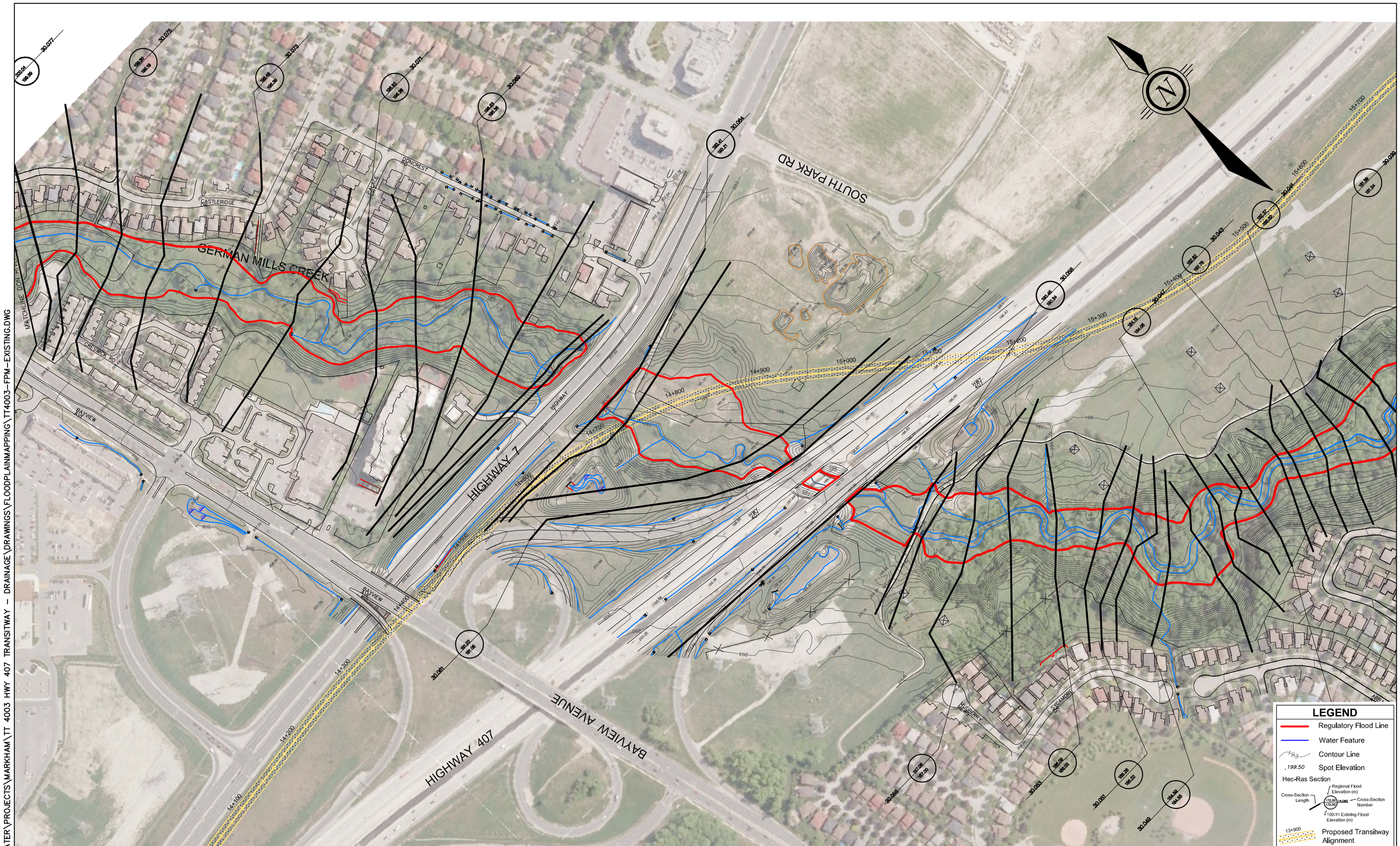

100m 0 200m

DATE:	AUGUST, 2010
SCALE:	1 : 4000

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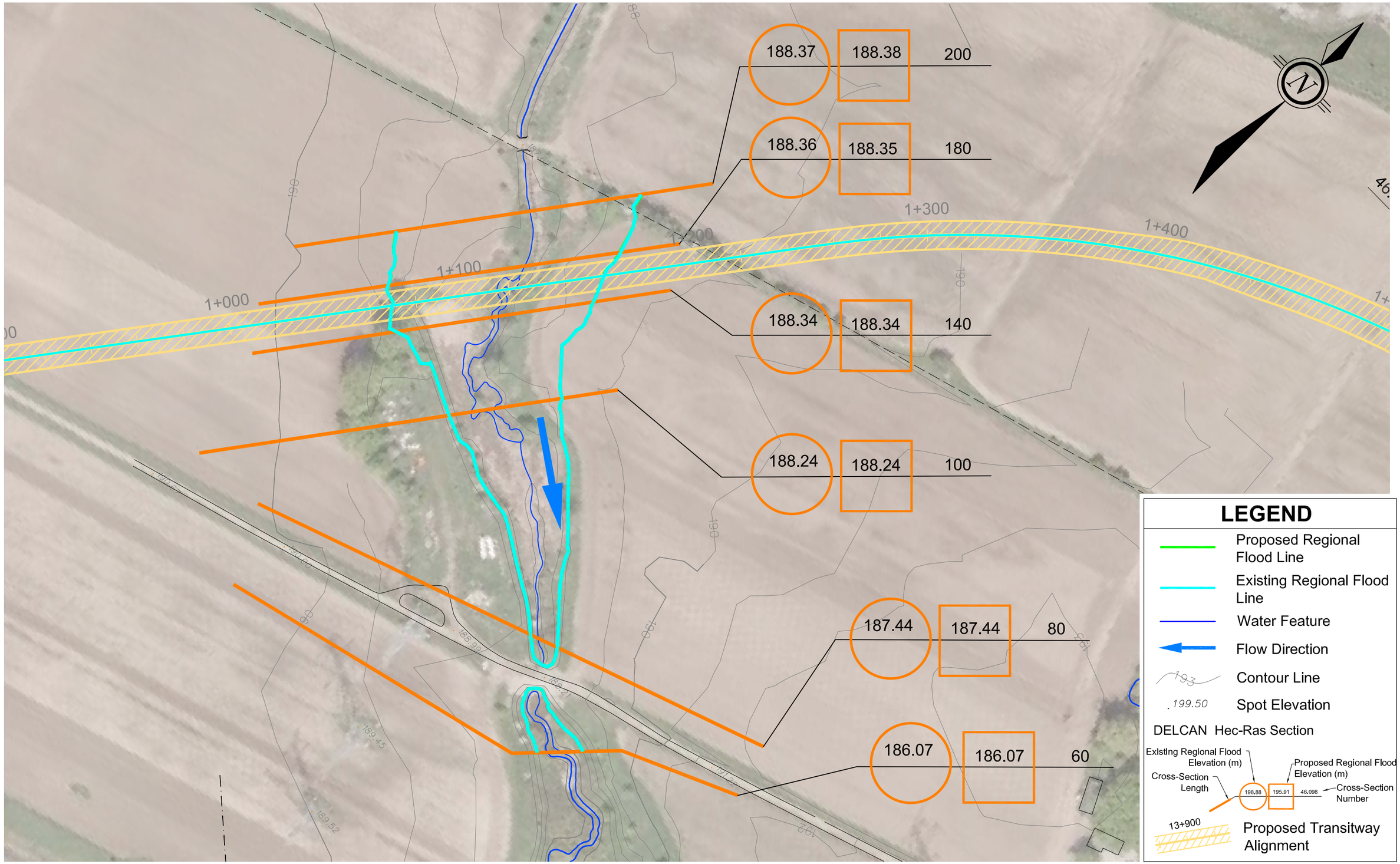
HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

EXISTING FLOODPLAIN MAPPING (TRCA) - GERMAN MILLS (REF #11) - EAST DON

FIGURE No : 6.6

PROPOSED HYDRAULIC ANALYSIS
HUMBER RIVER



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25m 0 50m

DATE:	AUGUST, 2010
SCALE:	1 : 1500

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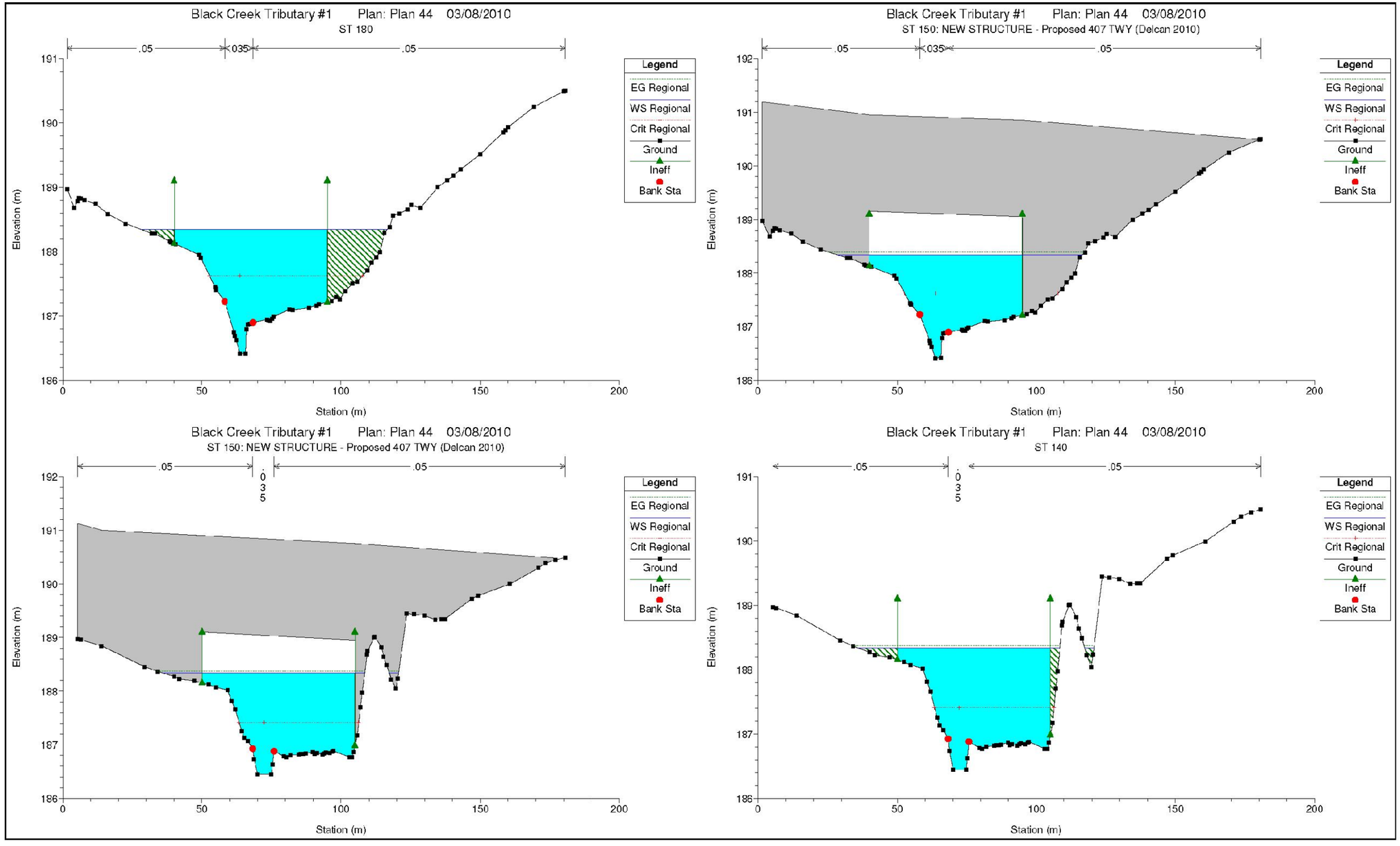
HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

PROPOSED FLOODPLAIN MAPPING - TRIBUTARY 1 OF BLACK CREEK (Ref #1)

FIGURE No : 6.7



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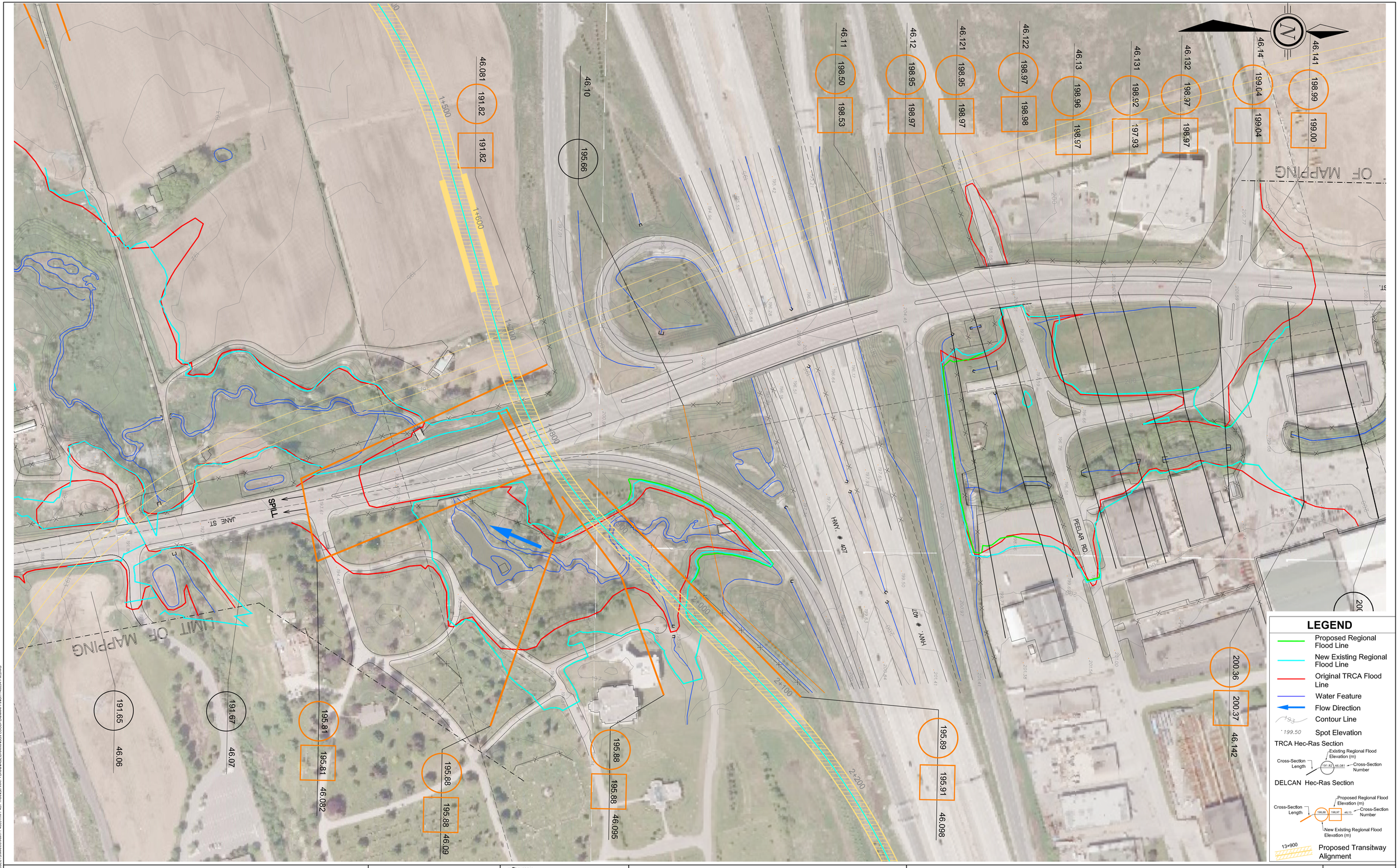
	DATE: AUGUST, 2010 SCALE: N.T.S.	Ontario	Delcan 625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400	**HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT** **HEC-RAS CROSS SECTIONS AT CREEK REF. # 1**	FIGURE No : **6.7-1**



50m 0 100m

DATE: AUGUST, 2010

SCALE: 1 : 1500

Ontario

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MARKHAM, ONTARIO L3R 9R9
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FAX: 905-943-0400

HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

PROPOSED FLOODPLAIN MAPPING - BLACK CREEK (REF #2) - HUMBER RIVER

FIGURE No : 6.8

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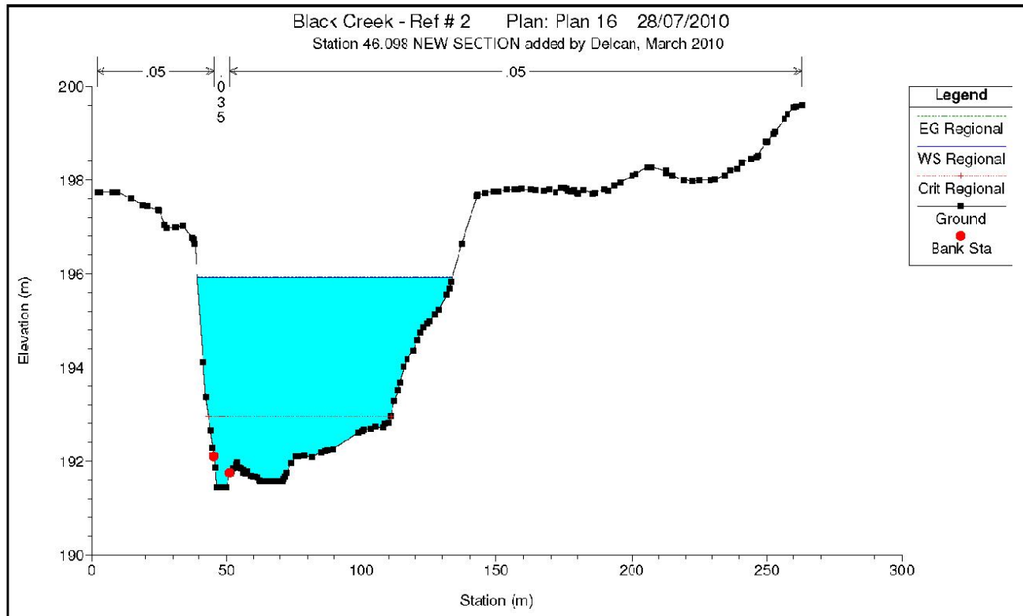

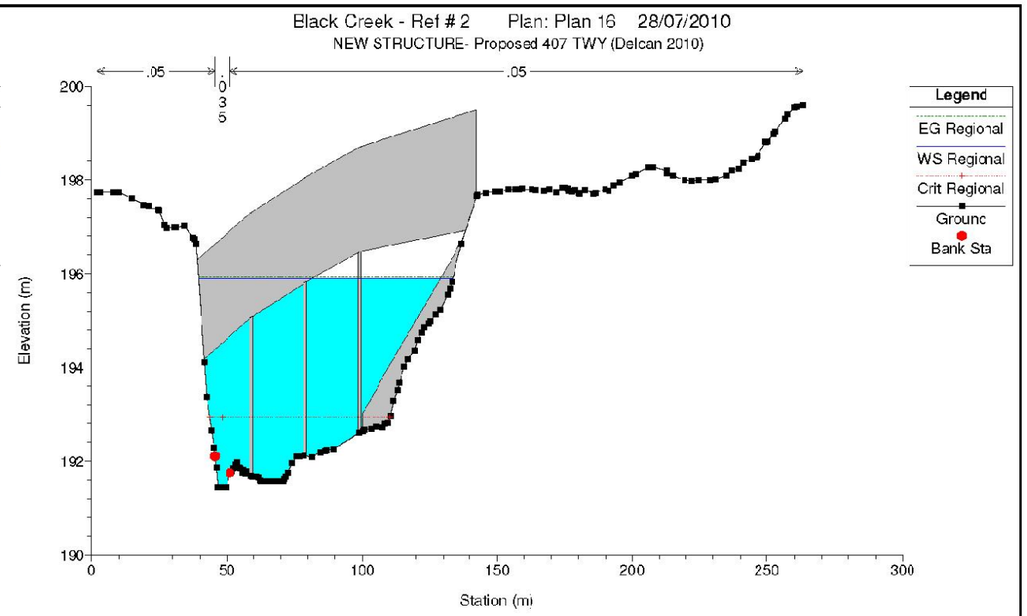

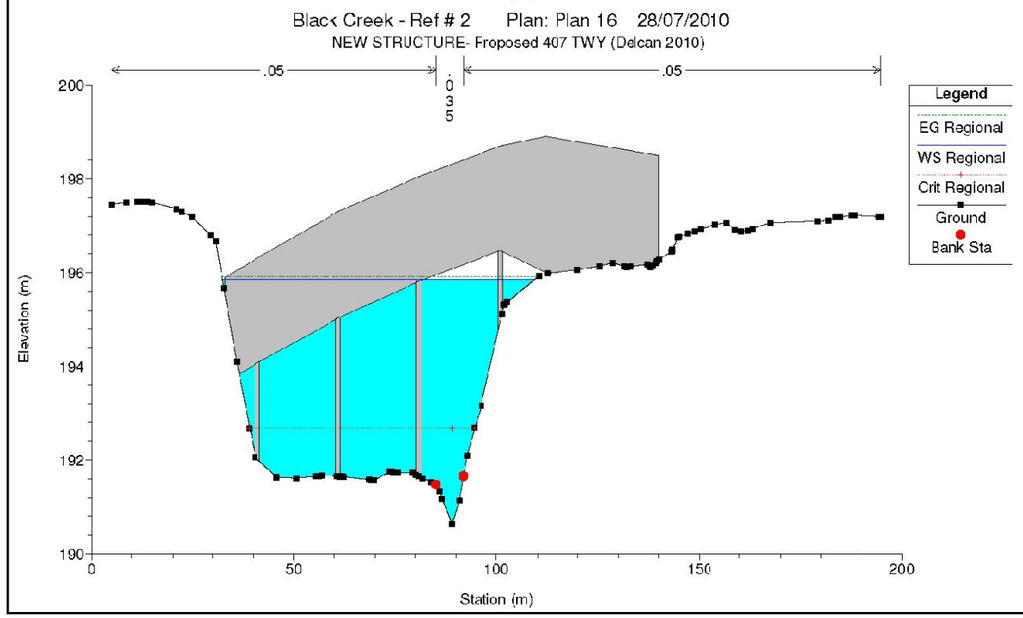

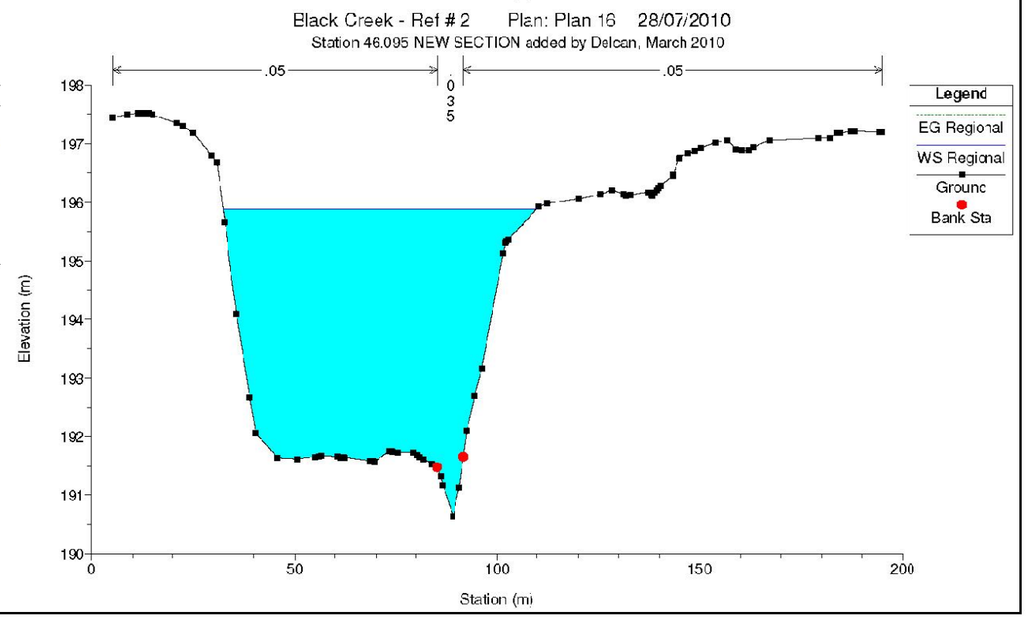

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	DATE: AUGUST, 2010 SCALE: N.T.S.	Ontario	Delcan	625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400	**HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT** **HEC-RAS CROSS SECTIONS AT CREEK REF. # 2**	FIGURE No : **6.8-1**

PROPOSED HYDRAULIC ANALYSIS
DON RIVER

NOTE:
SCETION #7.52 IS THE SAME AS SECTION # 5.00 AND 6.00

LEGEND

- Proposed Regional Flood Line
- New Existing Regional Flood Line
- Original TRCA Flood Line
- Water Feature
- Flow Direction
- Contour Line
- 199.50 Spot Elevation

TRCA Hec-Ras Section

DELCAN Hec-Ras Section

13+900 Proposed Transitway Alignment

50m 0 100m

DATE: AUGUST, 2010
SCALE: 1 : 1500

Ontario

Delcan

625 COCHRANE DRIVE, SUITE 500
MARKHAM, ONTARIO L3R 9R9
TEL: 905-943-0500
FAX: 905-943-0400

HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

PROPOSED FLOODPLAIN MAPPING - WEST DON RIVER (REF #4 & 5) - DON RIVER

FIGURE No : 6.9

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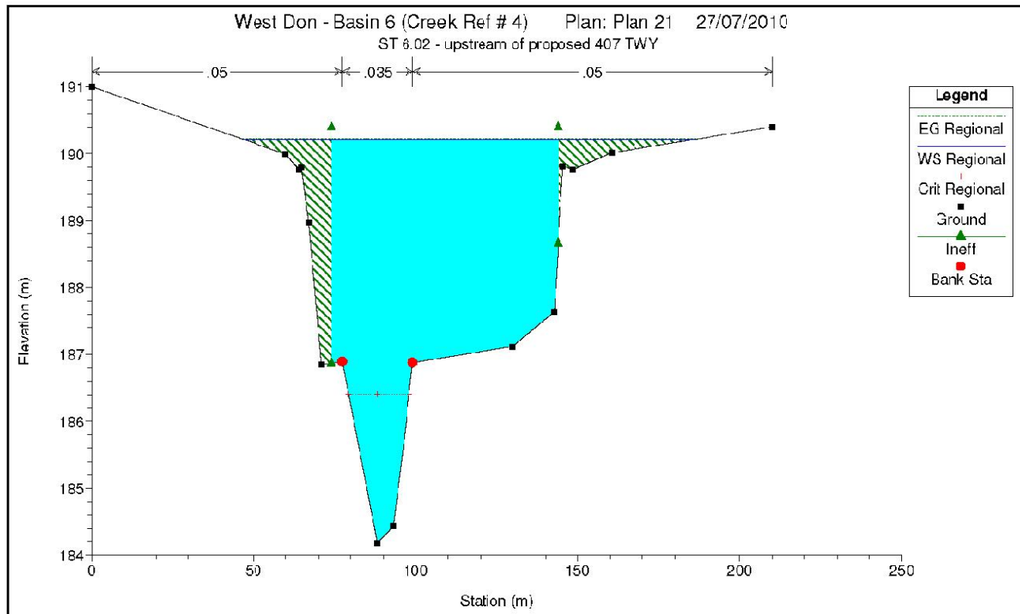

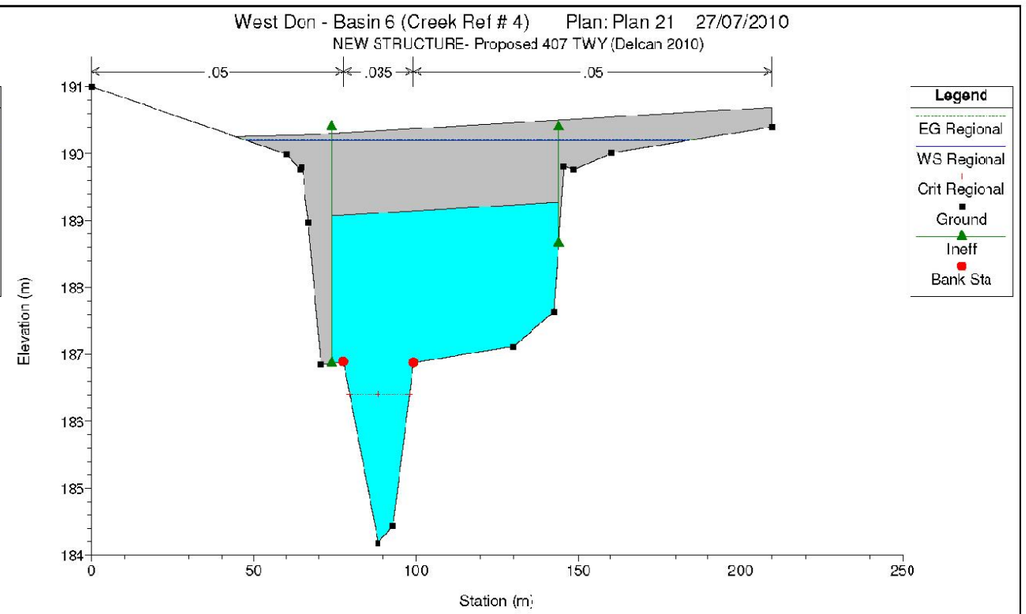

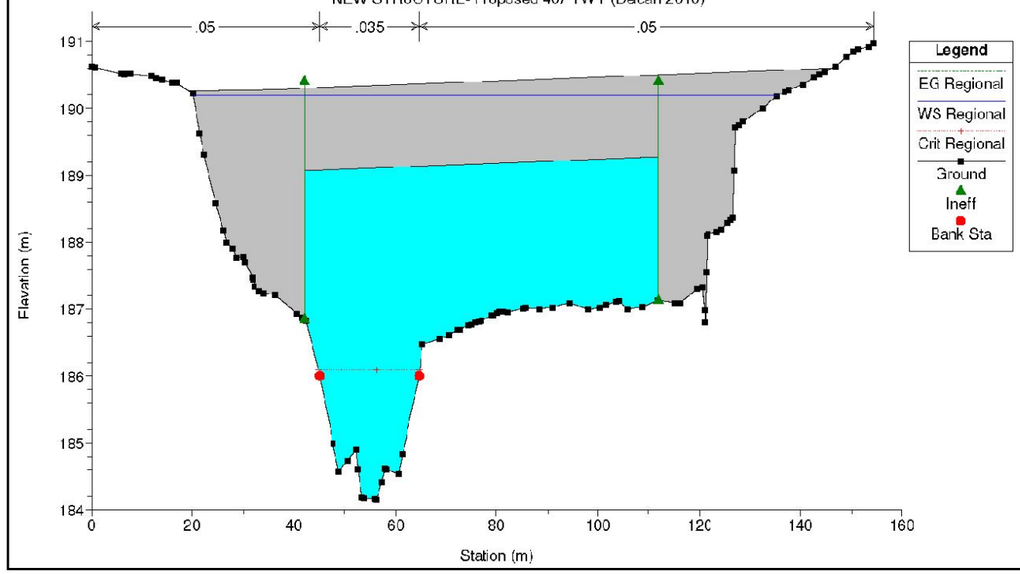

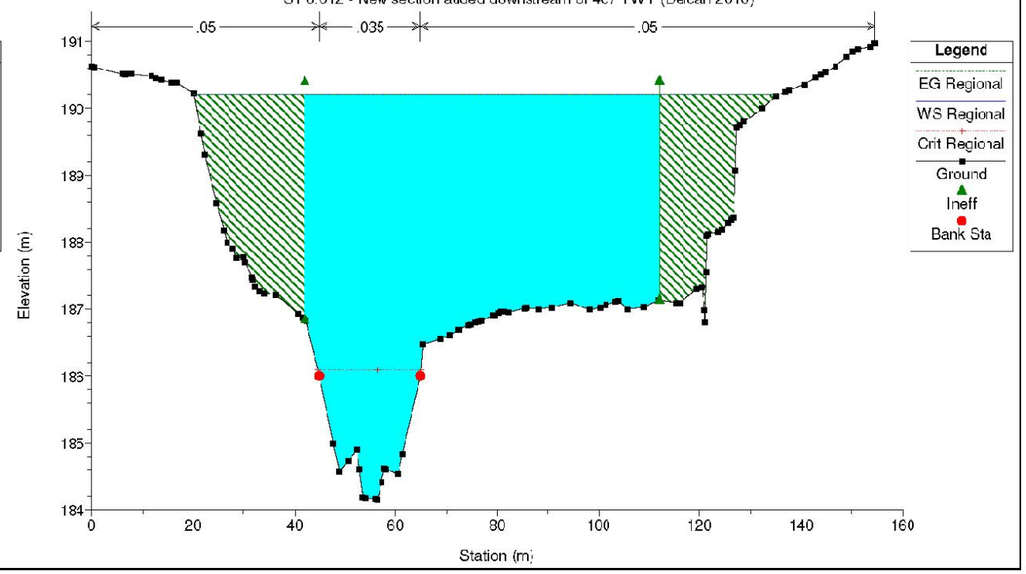

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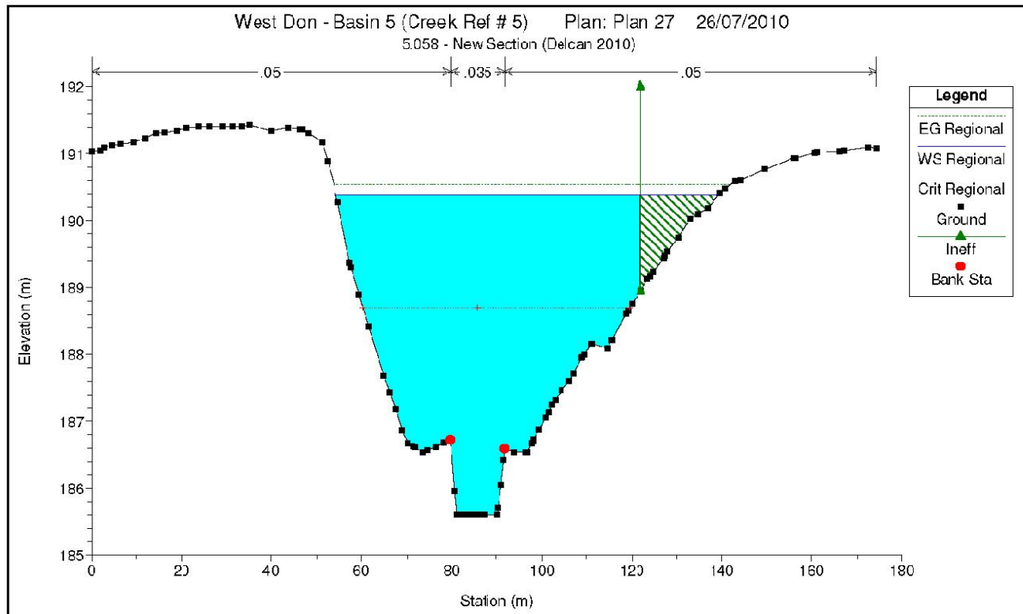
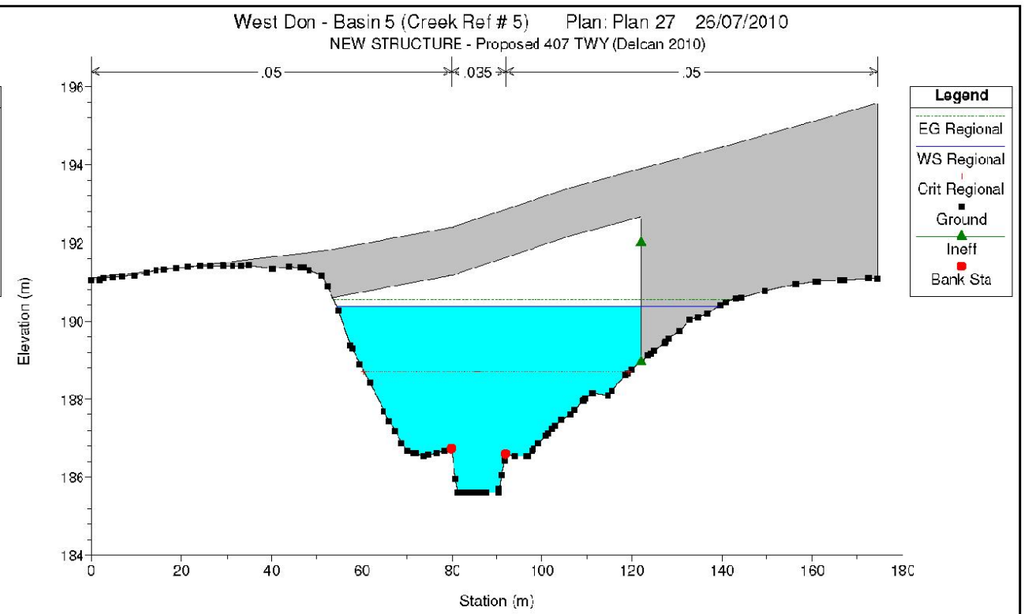
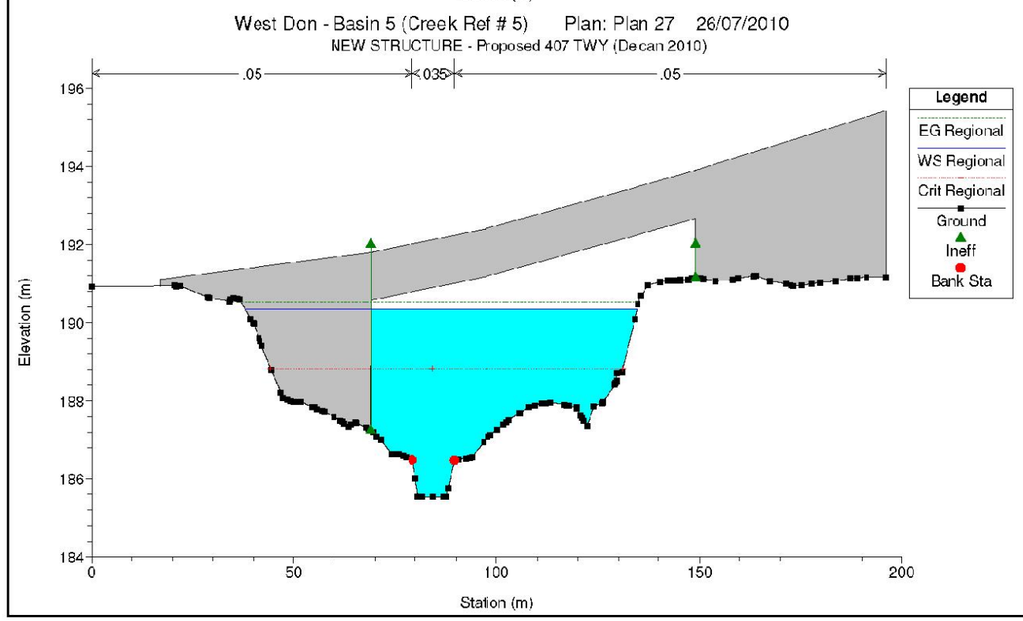
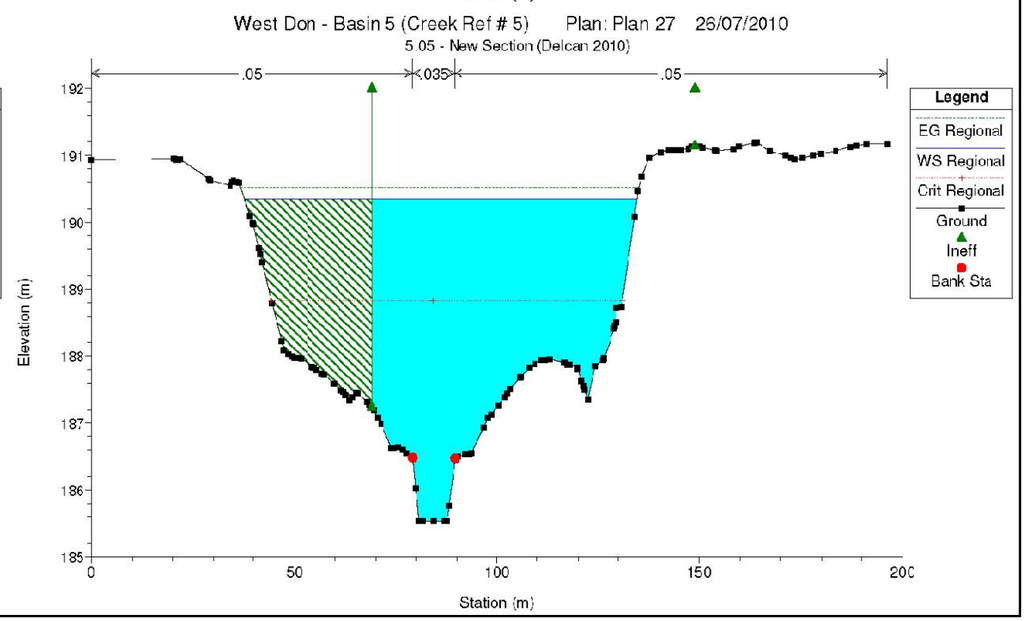
	DATE: AUGUST, 2010 SCALE: N.T.S.	Ontario	Delcan 625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400	**HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT** **HEC-RAS CROSS SECTIONS AT CREEK REF. # 4**	FIGURE No : **6.9-1**









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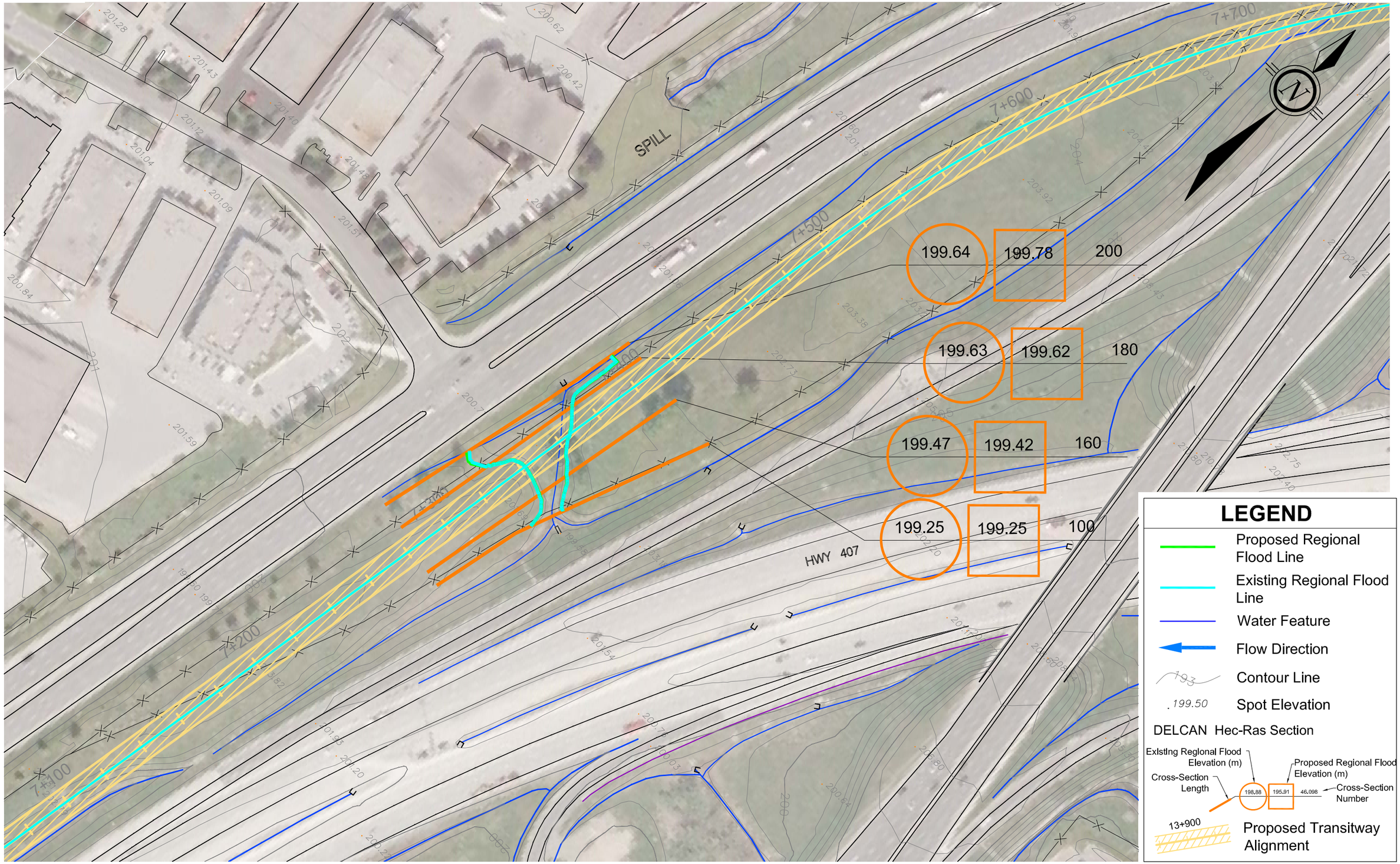
	DATE: AUGUST, 2010 SCALE: N.T.S.	Ontario	Delcan 625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400	**HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT** **HEC-RAS CROSS SECTIONS AT CREEK REF. # 5**	FIGURE No : **6.9-2**



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25m 0 50m

DATE:	AUGUST, 2010
SCALE:	1 : 1500

Ontario

Delcan

625 COCHRANE DRIVE, SUITE 500
MARKHAM, ONTARIO L3R 9R9
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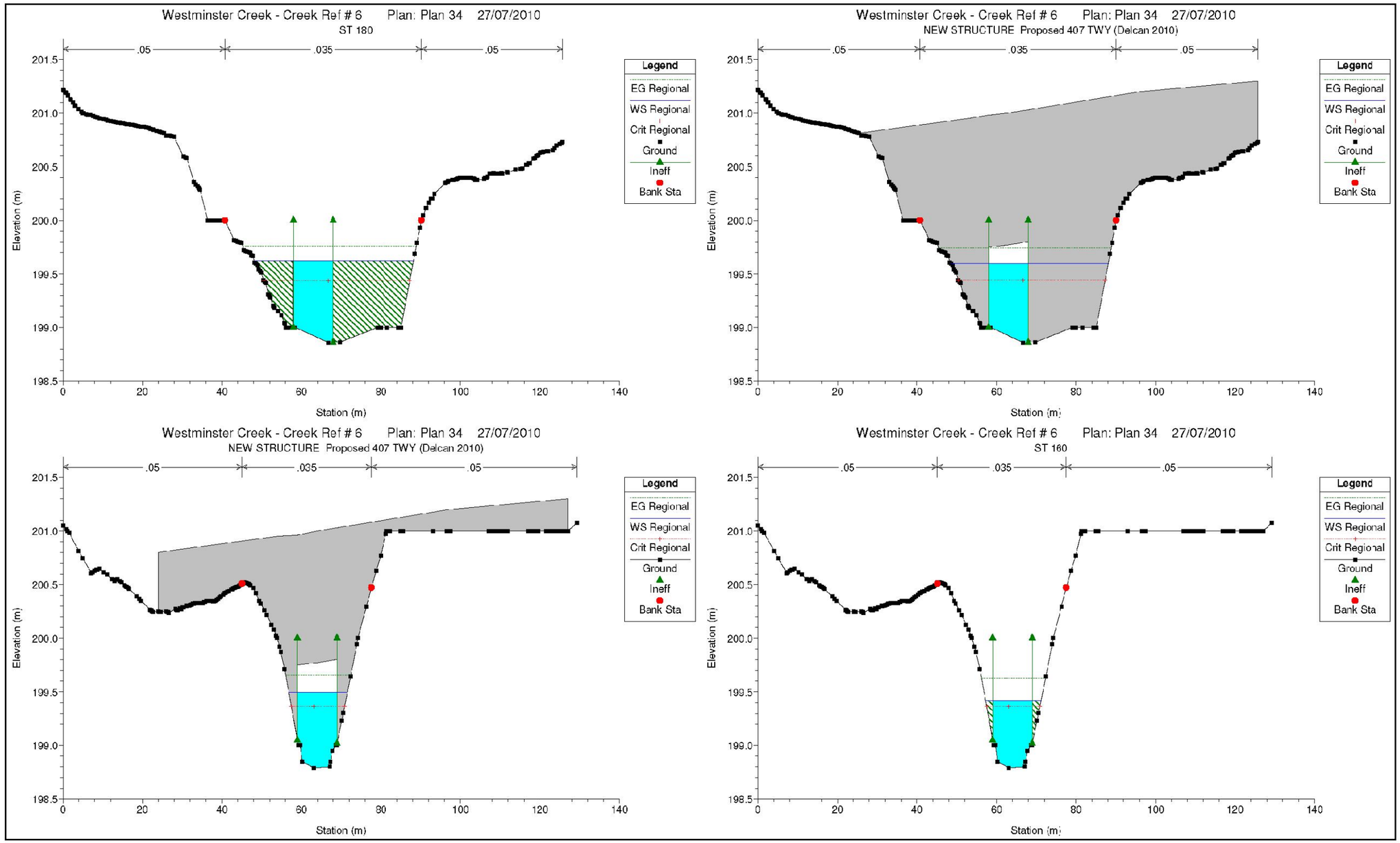
FAX: 905-943-0400

HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

PROPOSED FLOODPLAIN MAPPING - WESTMINSTER CREEK (Ref #6)

FIGURE No : 6.10



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	DATE: AUGUST, 2010 SCALE: N.T.S.	Ontario	Delcan	625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400	**HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT** **HEC-RAS CROSS SECTIONS AT CREEK REF. # 6**	FIGURE No : **6.10-1**

50m 0 100m

DATE: AUGUST, 2010

SCALE: 1 : 1500

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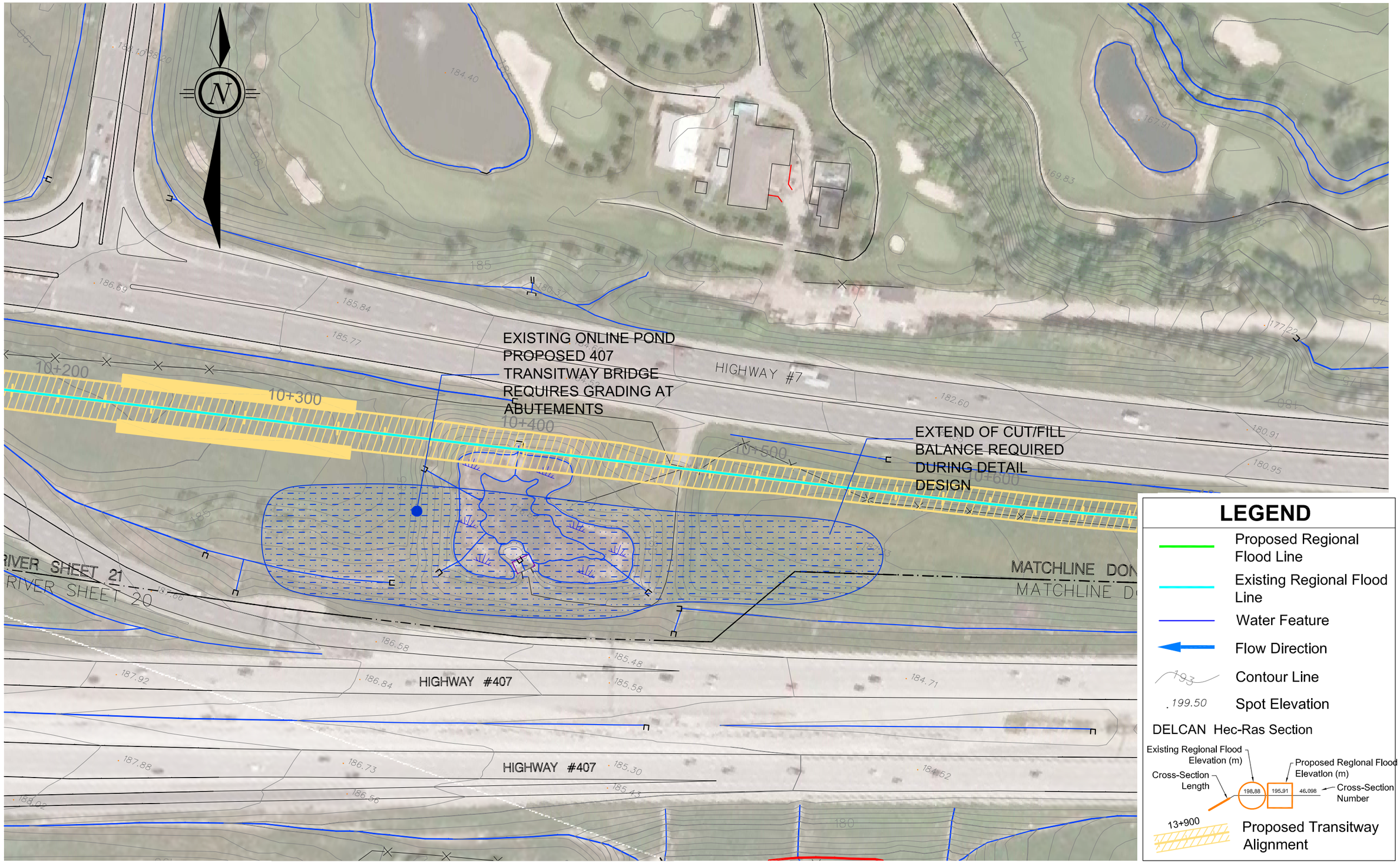
HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

PROPOSED CROSSING & STORM SYSTEM - UNKNOWN CREEK (Ref #7)

FIGURE No : 6.11



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25m 0 50m

DATE:	AUGUST, 2010
SCALE:	1 : 1500

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HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

PROPOSED 407 TRANSITWAY CROSSING CUT/FILL AREA - EAST DON RIVER(Ref #8)

FIGURE No : 6.12

50m 0 100m

DATE: AUGUST, 2010

SCALE: 1 : 1500

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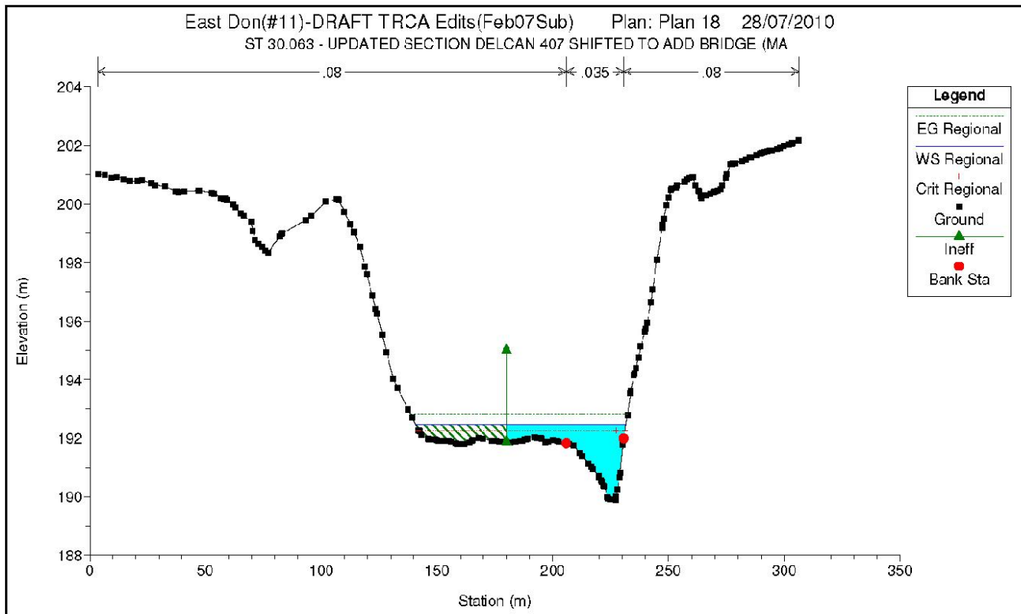
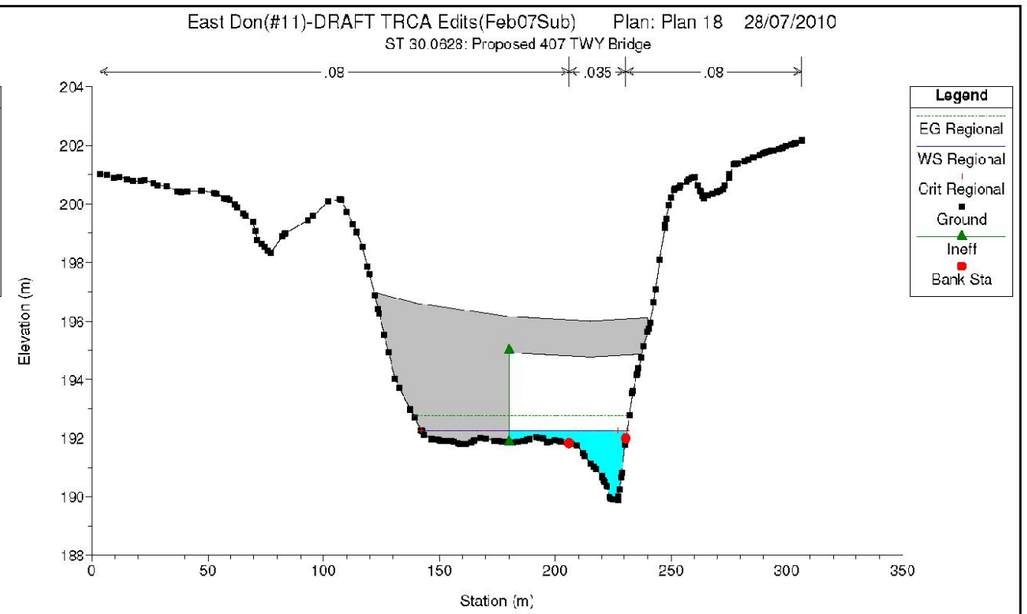
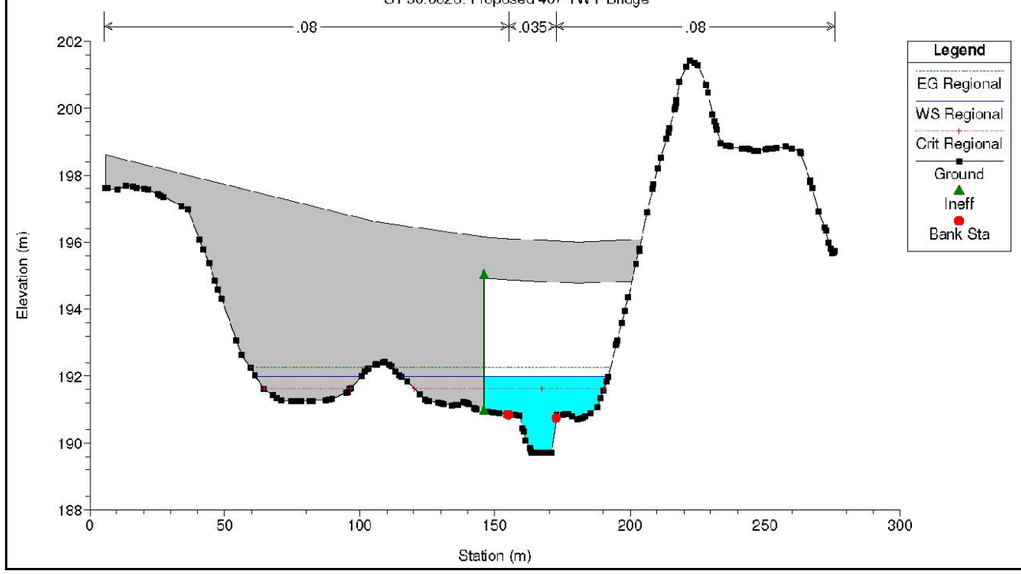
HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

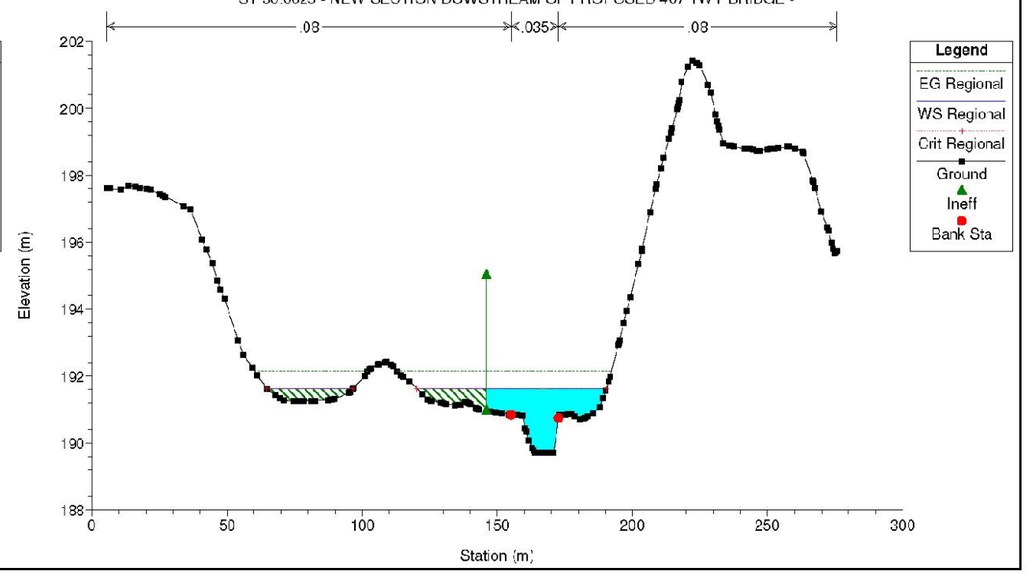
PROPOSED FLOODPLAIN MAPPING - GERMAN MILLS CREEK (REF #11) - EAST DON RIVER

FIGURE No : 6.13









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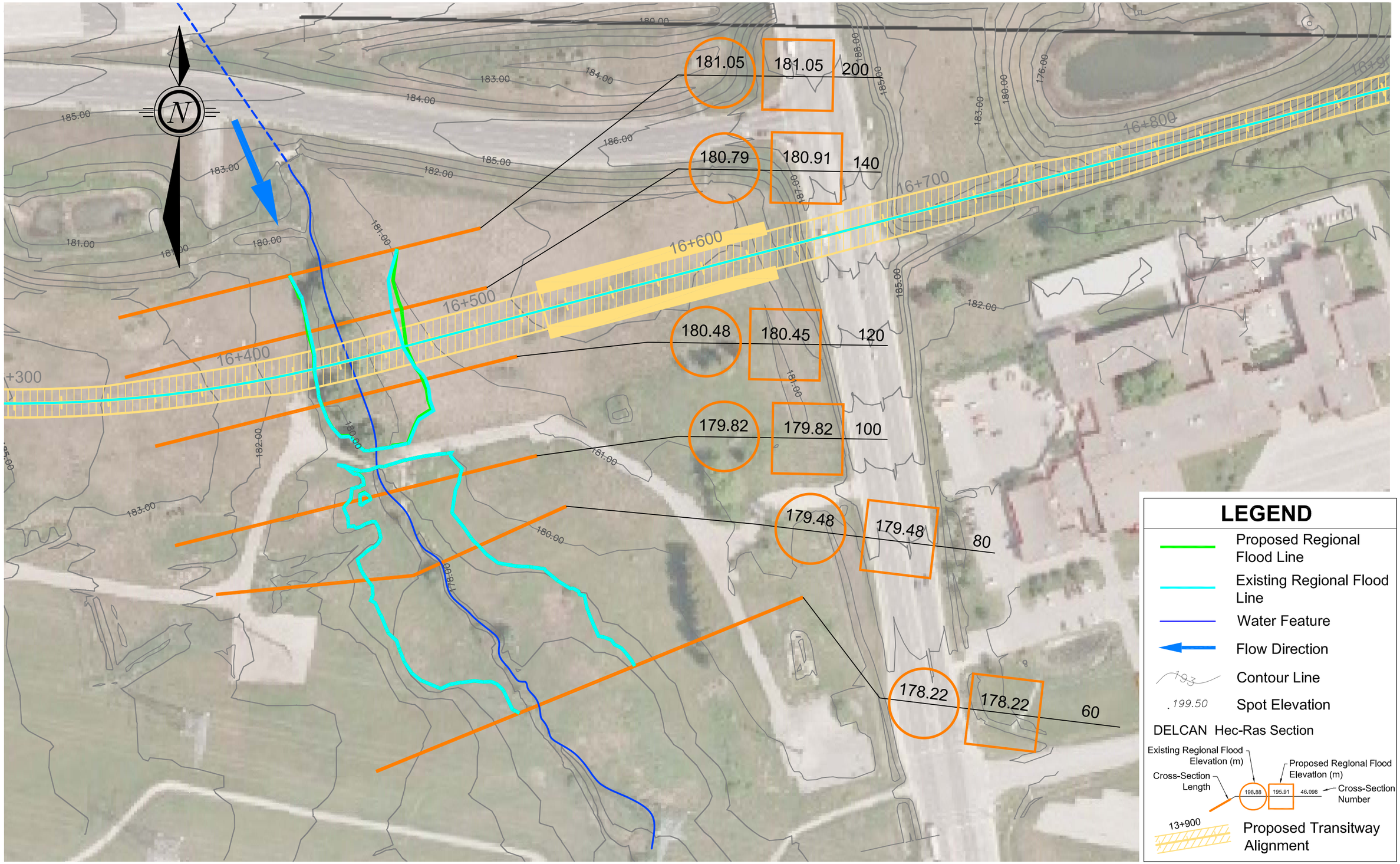

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25m 0 50m

DATE:	AUGUST, 2010
SCALE:	1 : 1500

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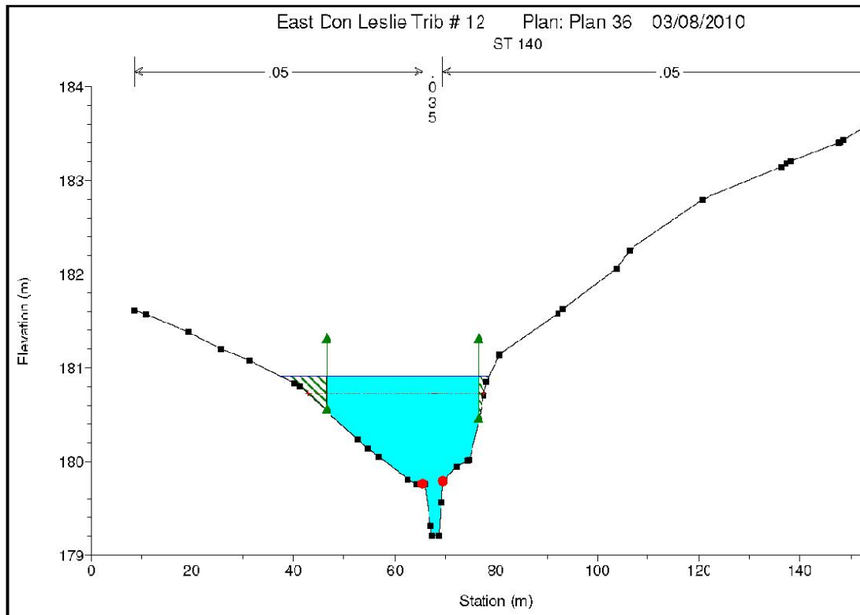
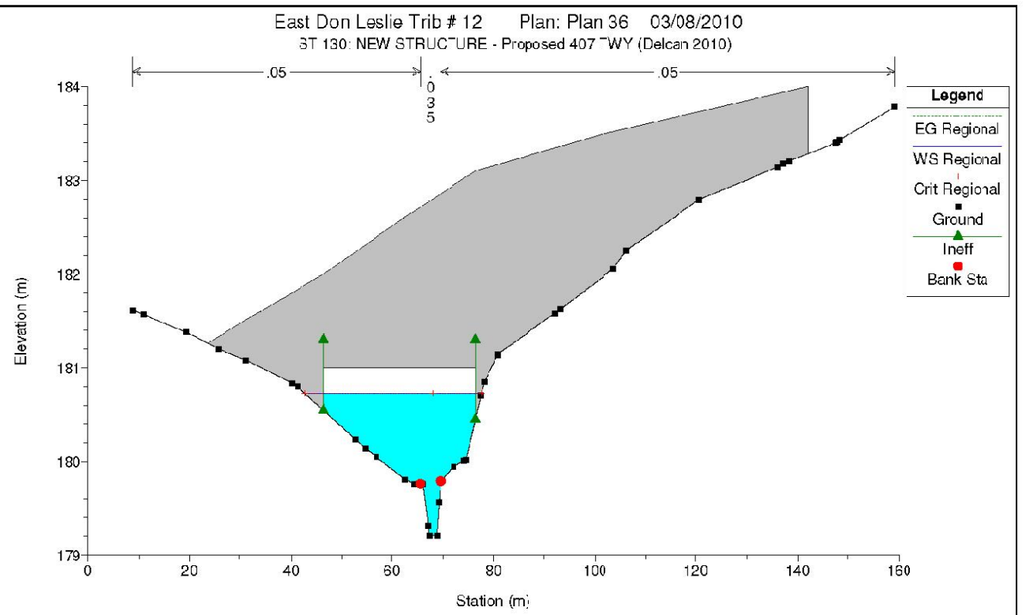
FAX: 905-943-0400

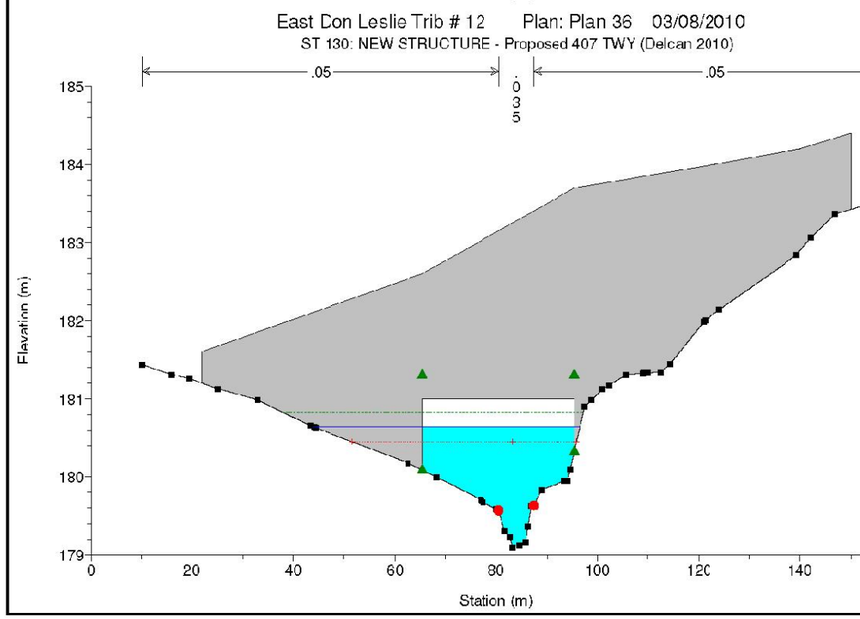
HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

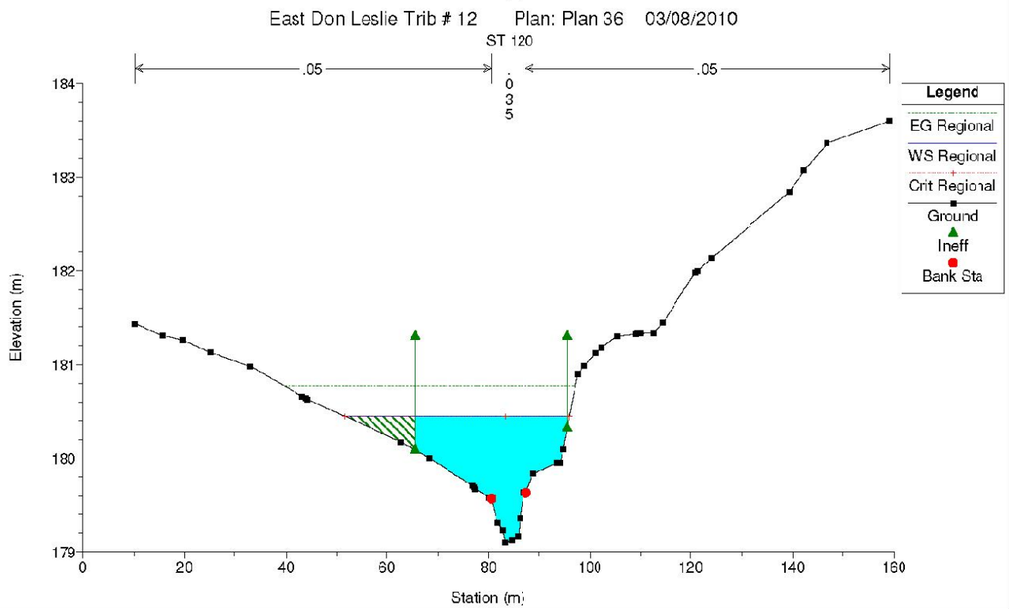
PROPOSED FLOODPLAIN MAPPING - TRIBUTARY 1 OF GERMAN MILLS CREEK (Ref #12)

FIGURE No : 6.14









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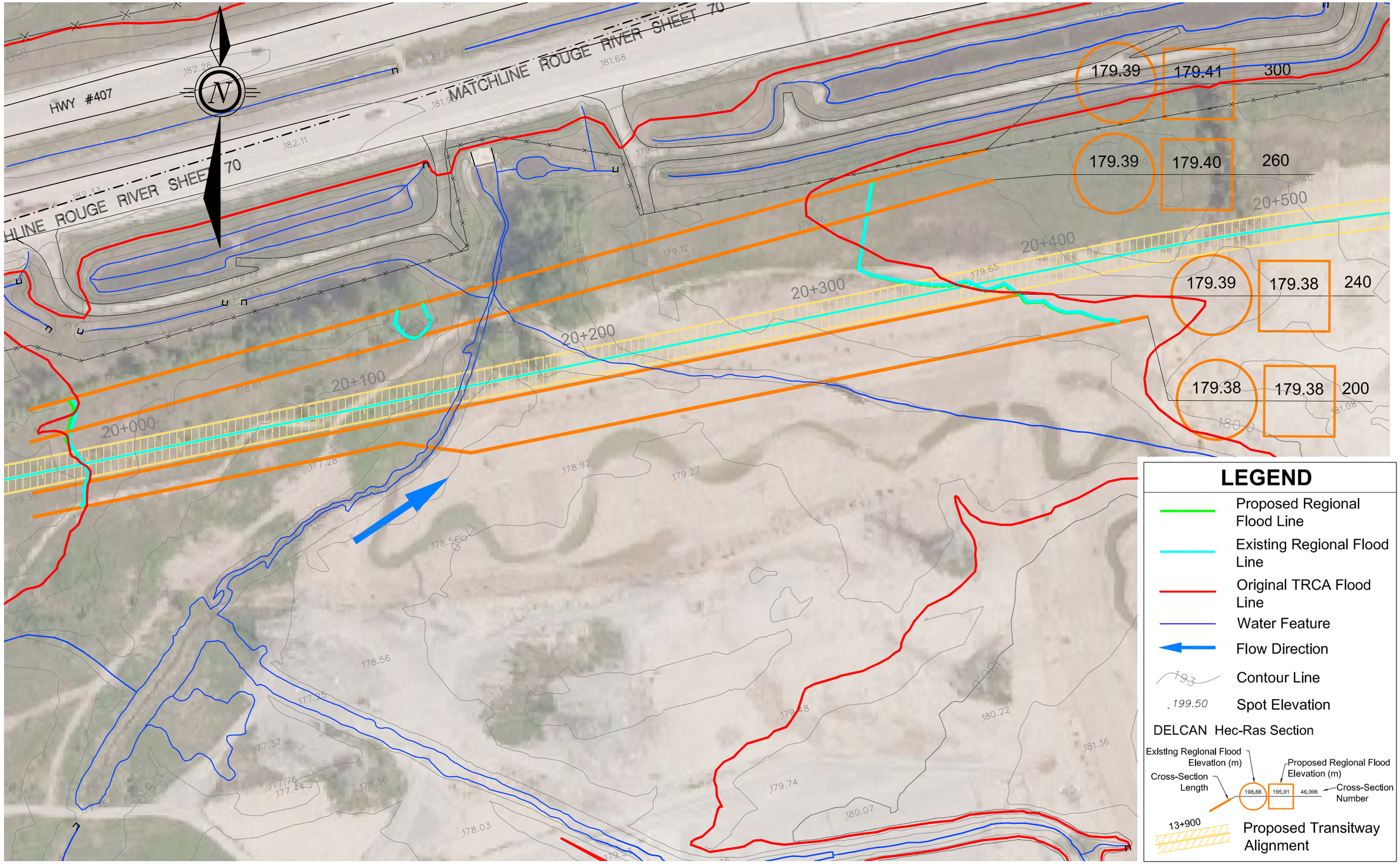
	DATE: AUGUST, 2010 SCALE: N.T.S.	Ontario	Delcan	625 COCHRANE DRIVE, SUITE 500 MARKHAM, ONTARIO L3R 9R9 TEL: 905-943-0500 FAX: 905-943-0400	**HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT** **HEC-RAS CROSS SECTIONS AT CREEK REF. # 12**	FIGURE No : **6.14-1**

PROPOSED HYDRAULIC ANALYSIS
ROUGE RIVER



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25m 0 50m

DATE:	AUGUST, 2010
SCALE:	1 : 1500

Ontario

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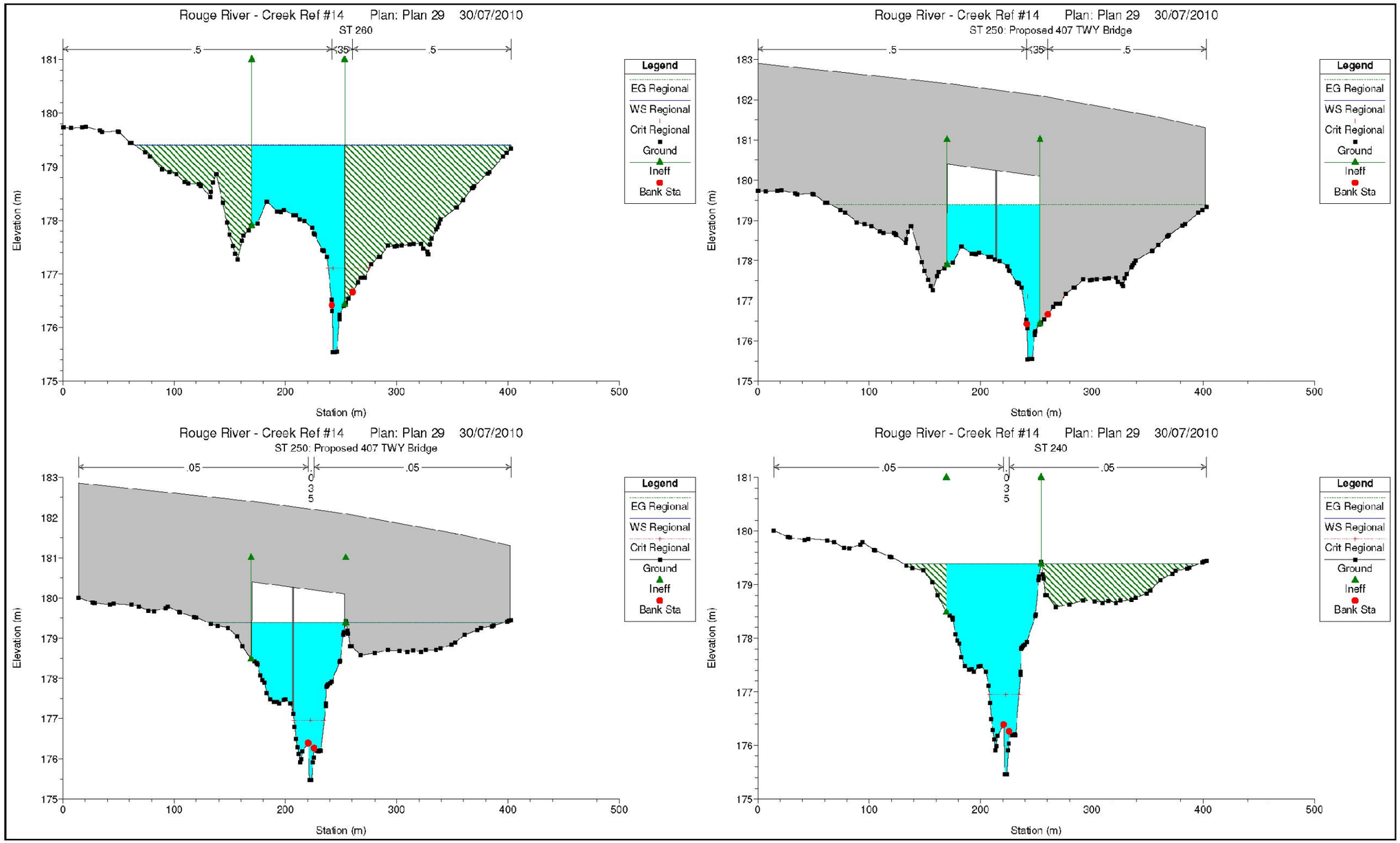
625 COCHRANE DRIVE, SUITE 500
MARKHAM, ONTARIO L3R 9R9
TEL: 905-943-0500
FAX: 905-943-0400

HWY 407 TRANSITWAY (GWP 252-96-00) EA - PRELIMINARY DESIGN REPORT

PROPOSED FLOODPLAIN MAPPING - ROUGE RIVER (Ref #14)

FIGURE No : 6.15



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