Canada-United States-Ontario-Michigan
Border Transportation Partnership

Practical Alternatives Evaluation Assessment Report

Stormwater Management Plan

DRAFT

July 2007
Revised March 2008

Preface

The Detroit River International Crossing (DRIC) Environmental Assessment Study is being conducted by a partnership of the federal, state and provincial governments in Canada and the United States in accordance with the requirements of the Canadian Environmental Assessment Act (CEAA), the Ontario Environmental Assessment Act (OEAA), and the U.S. National Environmental Policy Act (NEPA). In 2006, the Canadian and U.S. Study Teams completed an assessment of illustrative crossing, plaza and access road alternatives. This assessment is documented in two reports: *Generation and Assessment of Illustrative Alternatives Report - Draft November 2006)* (Canadian side) and *Evaluation of Illustrative Alternatives Report (December 2006)* (U.S. side). The results of this assessment led to the identification of an Area of Continued Analysis (ACA) as shown in Exhibit 1.

Within the ACA, practical alternatives were developed for the crossings, plazas and access routes alternatives. The evaluation of practical crossing, plaza and access road alternatives is based on the following seven factors:

- Changes to Air Quality
- Protection of Community and Neighbourhood Characteristics
- Consistency with Existing and Planned Land Use
- Protection of Cultural Resources
- Protection of the Natural Environment
- Improvements to Regional Mobility
- Cost and Constructability

This report pertains to the Cost and Constructability factor and is one of several reports that will be used in support of the evaluation of practical alternatives and the selection of the technically and environmentally preferred alternative. This report will form a part of the environmental assessment documentation for this study.

Additional documentation pertaining to the evaluation of practical alternatives is available for viewing/downloading at the study website (www.partnershipborderstudy.com).

Table of Contents

List of Figures

List of Tables

Appendices

1. Introduction

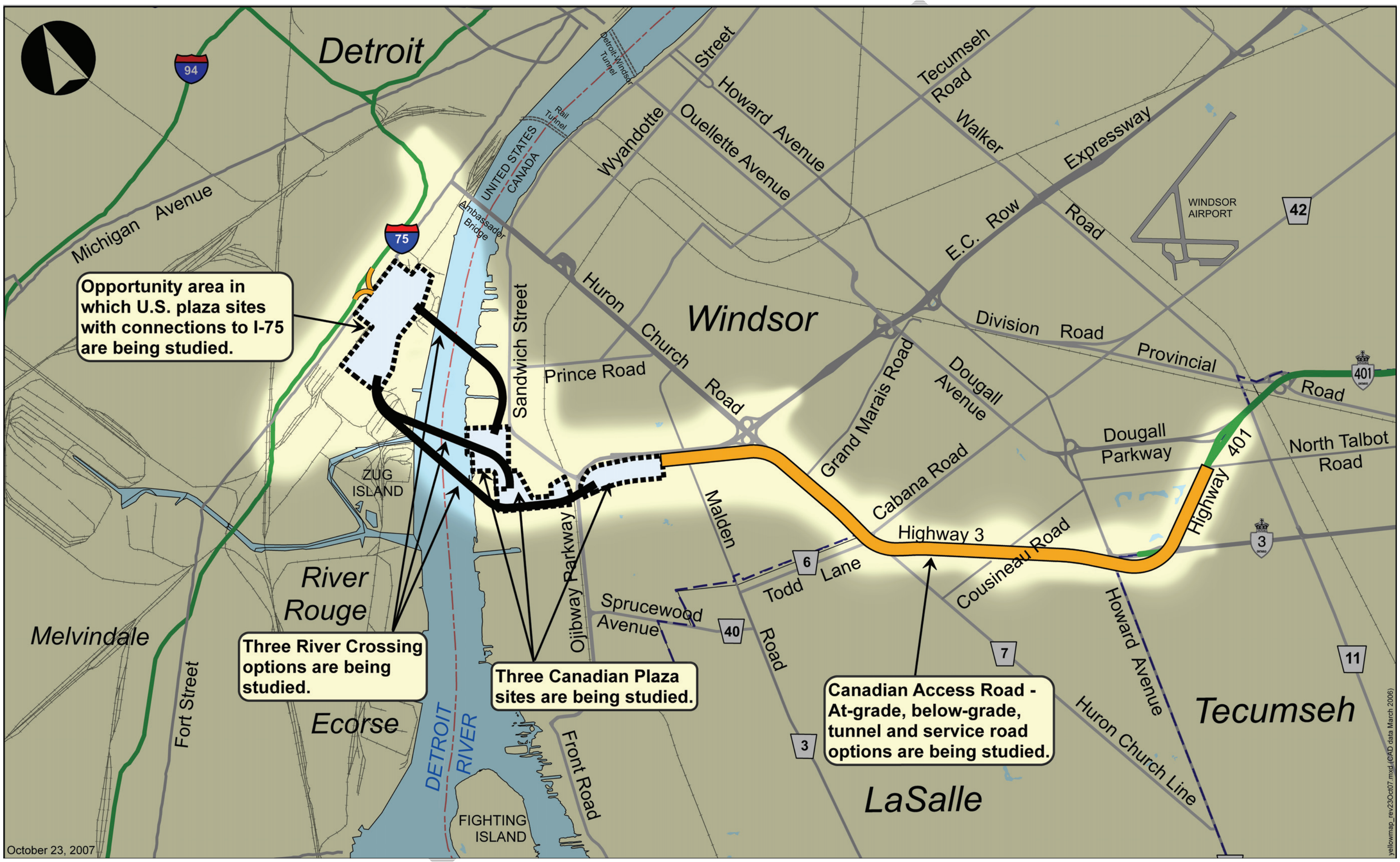
The Canada-U.S.-Ontario-Michigan Border Transportation Partnership (The Partnership) composed of Transport Canada (TC), the Ontario Ministry of Transportation (MTO), United States Federal Highway Administration (FHWA) and the Michigan Department of Transportation (MDOT) is undertaking an Environmental Assessment Study for the proposed Detroit River International Crossing (DRIC).

The Detroit River International Crossing (DRIC) study is a bi-national planning study that will lead to the identification of a single technically and environmentally preferred alternative for access roads, plazas and a new river crossing. The study is being conducted in accordance with the requirements of the Ontario Environmental Assessment Act (OEAA) and the Canadian Environmental Assessment Act (CEAA) in Canada and the U.S. National Environmental Policy Act (NEPA) in the United States.

The Ontario Ministry of Transportation (MTO) is leading the Canadian work program in coordination with Transport Canada (TC). The Michigan Department of Transportation (MDOT), in coordination with the United States Federal Highway Administration (FHWA) is leading the U.S. work program.

The Partnership retained URS Canada Inc. to assist the government in undertaking the Canadian side Environmental Assessment Study for the expanded Detroit River International Crossing. As part of the Environmental Assessment Study, a stormwater management analysis has been completed for the access road and plaza alternatives to address the highway drainage and potential impact of the proposed Highway 401 to the nearby watercourses and drainage crossings. This report identifies the stormwater management plan prepared for the various roadway alternatives extending from Ojibway Parkway to North Talbot Road and Canadian plaza alternatives. The study limit is shown on Figure 1-1. A stormwater management analysis for the International bridge crossing will be completed separately.

FIGURE 1-1: STUDY LIMIT



2. Background Review

Several studies have been previously conducted within the study area. These were reviewed to obtain information on the existing drainage condition and stormwater management practices within the study area. Relevant information obtained from these studies was used as input data to assist in the identification and analyses of stormwater management alternatives for the proposed Highway 401.

The following reports were reviewed as part of the preparatory investigations. The pertinent information extracted from each document is also identified.

Functional Design Report
Lennon Drain - Talbot Road to Avon Drive

Prepared by La Fontaine, Cowie, Buratto & Associates Limited, March 1993

- Based on this report, Lennon Drain catchment area is approximately 1,200 acres (485 ha) that extends easterly from Talbot Road. It is bounded to the north by Cabana Road, to the east by Concession Line, to the south by Highway 401 and by Cousineau Road to the west.
- Lennon Drain within the study area is a trapezoidal channel with a 10 ft. wide low flow channel and was designed to provide online storage. The online storage has a total capacity of 23,500 m^3 for the 100-year storm. The existing 100-year storm flow is conveyed within the improved channel.
- With the online storage the 100-year flow was restricted to 229.6 cubic feet per second (6.5 m^3/s).

Stormwater Management Alternatives
for the Turkey Creek Watershed within the City of Windsor

Prepared by MacLaren Engineers – Lavalin, June 1989

- This report proposed two basic stormwater management strategies for the Turkey Creek watershed, namely: stormwater detention facilities to control future runoff from new development to present levels and channel improvements to contain the existing 100-year flood.
- On-site detention was recommended for new industrial and commercial developments.
- The study identified peak flows at major intersections as follows:

Location	Drainage Area (ha)	100-year Peak Flows (m^3/s)	
		Present	Future
Grand Marias Drain at Huron-Church Line	2837	39.5	62.6
Outlet of Basin Drain	173	4.7	8.1
Lennon Drain at Huron Church Line	353	8.3	11
Cahill Drain at Huron Church Line	676	12.1	27.6

- The study also identified the requirement for further studies to recalculate flood levels along the major watercourses based on the significantly revised flood flows determined during the study.

Master Drainage Plan
Township of Sandwich South

N.K. Becker and Associates Ltd., October 1986

- The plan identified present and future storm drainage problems and improvements to the drainage system to maintain storm runoff at pre-development levels. The plan also includes stormwater management policies for new developments.
- Included in the study area is a tributary of Wolfe Drain located east of Highway 401 and north of Highway 3 (Talbot Road). This tributary outlets to Cahill Drain and ultimately to Turkey Creek.
- Wolfe Drainage catchment is approximately 200 hectares, identified in the report as Sub-catchment 201. The 100-year peak flow was computed to be 8.1 m^3/s.
- The master plan recommended improvement to Wolfe Drain with on-site runoff controls. All new development is required to implement on-site stormwater management controls.

Based on the review of the previously published studies as summarized above, it is concluded that the peak flows as identified in the 1989 McLaren report would still be appropriate for use in the conceptual design of a stormwater management plan for the various alternative roadways. It is noted that the watershed studies would have to be updated at the preliminary design stage of the preferred roadway alternative.

3. Existing Storm Drainage Condition

Within the study area there are nine (9) recipient drainage systems that would receive runoff from the proposed Highway 401. They are identified as McKee Drain, Titcombe Drain, Basin Drain, Marentette Mangin Drain, Turkey Creek, Lennon Drain, Cahill Drain West Tributary, Cahill Drain and Wolfe Drain. The watercourse locations relative to Highway 401 are shown on Figure 3-1. All of the drainage systems are part of the Turkey Creek system, which ultimately outlets to the Detroit River. All of the existing drainage systems have been impacted upon by urbanization, with Turkey Creek, Cahill Drain and Wolfe Drains being significantly altered. As an example, Turkey Creek upstream of Huron Church Road has been concrete lined to Dougall Avenue.

A number of hydrologic and hydraulic investigations have been completed on the existing drainage systems. However, as the investigations were conducted between the 1970's and the early 1990's, updates are required in order to refine the peak flows associated with each. The updated models would include the flow attenuation benefits associated with stormwater management plans that have been implemented in support of development. For the Practical Alternative phase of the DRIC study the previously computed and approved flows have been considered appropriate for use. New hydrologic analyses would be required at all stream crossings to confirm the sizing of required conveyance facilities. Fluvial geomorphologic investigations would also be required to confirm the sensitivity of the drainage systems to erosion and to establish target erosion flow rates for the use in design of future stormwater management plans.

4. Stormwater Design Criteria

4.1. Storm Drainage

The proposed Highway 401extension will be classified as a freeway with a design speed of 120 km/hr. Culverts over 6.0 m span, according to MTO Directive B-100, for the proposed Highway 401 are to be designed based on a 100-year design flow (refer to Table 4.1)

TABLE 4.1: DRAINAGE CRITERIA

Road Classification	Bridges and Culverts			
	Total span up to 6.0 m	**Freeboard Requirement**	**Total span over 6.0 m**	**Freeboard Requirement**
Freeway Urban Arterial	50-year	1m freeboard from edge of pavement	100-year	1m freeboard from soffit
Rural Arterial Collector Road	25-year	1m freeboard from edge of pavement	50 year	1m freeboard from soffit
Local Road	10-year	1m freeboard from edge of pavement	25 year	1m freeboard from soffit

* Source: MTC Design Flood Criteria, Ministry Directive B-100, Issued 80-10-16

The minor system associated with the new roadway would be designed to capture and convey the 10-year storm. Where the roadway is below grade, the new sewer system would be designed to capture the 100-year event. In areas where the major system cannot be maintained to a reasonable outlet, the minor system should convey the 100-year storm without flooding to the traveled four inside lanes.

For areas with a drainage area greater than 125 ha, structures are to be sized to convey the Regional Storm with no significant increase in the flood level from that of the existing condition. Based on discussions with the Essex Region Conservation Authority, the Regional Storm for the study area is equivalent to the 100-year event.

4.2. Stormwater Management

The MNR and the MOE have both published specific criteria regarding water quality and flood flow control. For this project, Level 1 protection would be provided for water quality.

Runoff to Turkey Creek and other adjacent watercourses would be controlled to the pre-development levels for all storm events up to and including the 100-year return period.

5. Stream Crossing Impact Assessment

A total of seven (7) alternative roadway alignments and profiles for Highway 401 have been established for consideration. They are identified as Alternatives 1A, 1B, 2A, 2B, 2B-Revised, 3, and The Parkway. The details of each are described in the following section of this report. From a surface water resource perspective, each alternative has a varying degree of impact on the existing flow conveyance features (i.e. watercourses, drains etc.). Where impacts are considered to be significant, those impacts must be mitigated by the implementation of appropriate flow conveyance improvement measures.

The proposed Highway 401 Alternatives consider four options for the roadway profile. They include the following:

- **At Grade –** the proposed road profile follows that of the existing ground. New stream crossings would be sized based on MTO Directive B100.
- **Below Grade –** the proposed road profile is below the existing ground. This would potentially result in the new roadways potentially obstructing the flow associated with the natural drainage systems that they cross.
- **Tunnel –** the proposed road profile is below the invert of the existing stream systems. With this option the new roadway would have minimal impact on the existing drainage systems.
- **Short Tunnel –** the proposed road profile is below the existing ground with a concrete cover overtop of the highway for short sections. The concrete cover would be topped with soil and landscaping to provide natural crossings for pedestrian and vehicular traffic.

The following describes the impact assessments completed for each of the seven roadway alternatives considered and details of the recommended mitigation plan. Table 5.1 provides a summary of the proposed drainage improvements.

TABLE 5.1: SUMMARY OF STREAM CROSSING ALTERNATIVES

Location	Roadway Alternative						
	1A	1B	2A	2B	2B Revised	3	4
	At Grade	Below Grade	At Grade	Below Grade	Modified Below Grade	Tunnel	The Parkway
	Replace Existing Roadways		Alignment Offset from Existing Roadways				Alignment Offset from Existing Roadways
Titcombe Drain	Storm Sewer or 1200 mmØ Culvert	Storm Sewer or 1200 mmØ Culvert	Storm Sewer or 1200 mmØ Culvert	Storm Sewer or 1200 mmØ Culvert	Storm Sewer or 1200 mmØ Culvert	Storm Sewer or 1200 mmØ Culvert	Storm Sewer or 1200 mmØ Culvert
Basin Drain	2.1 m x 1.5 m Box Culvert	2.1 m x 1.5 m Box Culvert	2.1 m x 1.5 m Box Culvert	2.1 m x 1.5 m Box Culvert	2.1 m x 1.5 m Box Culvert	2.1 m x 1.5 m Box Culvert	2.1 m x 1.5 m Box Culvert
Marentette Mangin Drain	Storm Sewer	Storm Sewer	Storm Sewer	Storm Sewer	Storm Sewer	There will be no long-term impacts	Storm Sewer
Turkey Creek	Bridge Extension	Syphon 25 m x 2 m Box or Tunnel Roadway	New Bridge	Syphon 25 m x 2 m Box or Tunnel Roadway	New 3 Cell 10 m x 2 m Box or Equivalent	There will be no long-term impacts	New 3 Cell 10 m x 2 m Box or Equivalent
Lennon Drain	Extension of Existing 2.6 m x 1.2 m culvert	3 m x 1.5 m Syphon	Extension of Existing 2.6 m x 1.2 m culvert	3 m x 1.5 m Syphon	3 m x 1.5 m Syphon	There will be no long-term impacts	6 m x 1.2m Culvert or Re-aligned Channel
Cahill West Tributary	1200 mmØ or Diversion to Cahill Drain	1200 mmØ or Diversion to Cahill Drain	1200 mmØ or Diversion to Cahill Drain	1200 mmØ or Diversion to Cahill Drain	1200 mmØ or Diversion to Cahill Drain	There will be no long-term impacts	1200 mmØ or Diversion to Cahill Drain
Cahill Drain Crossing	Replacement of Existing Culvert with a 4.5m x 1.5m Box Culvert	4.5 m x 1.5 m Syphon or Tunnel	New 4.5 m x 1.5 m Box Culvert	4.5 m x 1.5 m Syphon or Tunnel	4.5 m x 1.5 m Syphon or Tunnel	There will be no long-term impacts	4.5 m x 1.5 m Syphon or Tunnel
Cahill Drain/Wolfe Drainage	Re-aligned Open Drain or 4.5 m x 1.5 m Closed System	Re-aligned Open Drain or 4.5 m x 1.5 m Closed System	Retain Existing Channel	Retain Existing Channel	Retain Existing Channel	There will be no long-term impacts	Retain Existing Channel

The following provides a summary of the options considered to mitigate potential impacts of the new roadway on the existing drainage system.

5.1. Alternative 1A - At Grade

With this alternative both the extension of flow conveyance facilities and the construction of new facilities would be required. All replacement / new structures would be designed in accordance with MTO Directive B-100. The following provides a description of the proposed modifications at each of the major watercourse crossings. A plan, profile and typical section of the new roadway are provided in Figures 6-1, 6-2 and 6-3 respectively.

i) Titcombe Drain

Runoff from the catchment area associated with Titcombe Drain would be picked up by the storm sewer system being constructed to accommodate runoff from the new Highway 401. This would allow for the potential quality treatment of all runoff from the Titcombe Drain upstream of the new roadway. If it is found that when more detailed topographic information is available that the grades do not permit the capture of flow within the new storm sewer, then a 1200 mmØ culvert would be provided for in the design of the new roadway to safely convey flow.

ii) Basin Drain

A new 2.1 m x 1.5 m concrete box culvert would be constructed to convey the 100-year flow from the Basin Drain catchment area. Given the close proximity of the new culvert with the existing structure under E.C. Row Expressway, consideration could be given to connecting both facilities. If the system is to remain open between the two culverts than realignment of Basin Drain should be considered to improve the hydraulic efficiency of the system at both the inlet and outlet Results of the hydraulic analysis are provided in Appendix A.1

iii) Marentette Mangin Drain

With Alternative 1A the proposed Highway 401 would be below in the area of the drain. As a result of this all flows upstream of the new roadway would have to be collected by the new storm sewer system and pumped downstream. Based on the available information there is very little catchment area associated with the drain upstream of the proposed Highway 401 which will have to be captured. By intercepting the upstream runoff there is the possibility of providing quality treatment for all of the flow as part of the Highway 401 stormwater management plan.

iv) Turkey Creek

Alternative 1A would utilize the existing Turkey Creek bridge structure. An extension of the existing structure would be required in order to accommodate the additional proposed lanes.

v) Lennon Drain

At the Lennon Drain crossing the proposed roadway would follow the alignment and profile of the existing structure. The existing 2.6 m x 1.2 m box culvert would have to be extended to accommodate the extra lanes. As previously noted, an update of the watershed model is required in order to confirm the design flows and the need for replacement. As a minimum, extension of the existing culvert would be required to accommodate the additional lanes. The hydraulic analysis associated with the new culvert design is included in Appendix A.1

vi) Cahill Drain West Tributary

The proposed road profile at the crossing is approximately 2 m above that of the existing roadway. Replacement of the existing culvert with a 1200 mmØ concrete pipe is proposed to provide an improved level of flow hazard protection. An alternative approach is to redirect the West Tributary in an easterly direction approximately 150 m to outlet to the Cahill Drain main channel. Both options are considered to be viable. The hydraulic analysis associated with the new culvert design is included in Appendix A.1.

vii) Cahill Drain

The proposed roadway at the existing Cahill Drain crossing will be below by approximately 6 m. As a result of this, the new roadway would impede surface runoff. The developed proposal is to relocate the crossing in a westerly direction by approximately 170 m. This would allow Cahill Drain to continue to flow by gravity past the new roadway. The new box culvert would have an opening size of approximately of 4.5 m x 1.5 m. If the Cahill Drain West Tributary is diverted to the new crossing the opening size would have to increased in order to handle the additional flow. As previously noted, the subject watershed model must be updated to confirm peak outflows and required culvert sizes. The hydraulic analysis associated with the proposed culvert alternative is included in Appendix A.1.

viii) Cahill / Wolfe Drain

With Alternative 1A Cahill / Wolfe Drain would be realigned in a northerly direction and run parallel to the new service road. The existing cross sectional area of the channel would be maintained in order to provide the required 100-year flow conveyance. It is noted that the new alignment of the Drain must also be adjusted to accommodate any stormwater management requirements (ponds).

An alternative to having an open drain is to provide a closed conveyance system located under the northbound service Road. To accommodate the 100-year flow a 4.5 m x 1.5 m box culvert is required. Providing a closed drainage system would have the least impact on the adjacent lands as it would continue to accommodate direct access to the residential lands to the north from the Northbound service road. With the open channel option each private driveway would require a culvert to cross the drain. A typical cross section of each option is given in Figure 6-3. Results of the detailed hydraulic analysis for the proposed enclosed conveyance system are provided in Appendix A.1.

5.2. Alternative 1B – Below Grade

Alternative 1B has a similar alignment to that of Option 1A, however the roadway is below grade for much of its length. This below roadway results in a number of the watercourse crossings potentially being obstructed. This would necessitate the introduction of syphons to convey flow below the new roadway or alternatively the roadway tunneled under the subject drainage systems. A plan, profile and typical roadway section of Alternative 1B are provided in Figures 6-4, 6-5 and 6-6 respectively. The following provides a description of the proposed improvements required at the major stream crossings.

i) Titcombe Drain

Runoff from the catchment area associated with Titcombe Drain would be picked up by the storm sewer system being constructed to accommodate runoff from the new Highway 401 right-of-way. This would allow for the potential quality treatment of all runoff from the Titcombe Drain catchment area. If grades do not permit the capture of flow within the new storm sewer, then a 1200 mmØ culvert would be provided for in the design of the new roadway. The Flow Master analysis output for the new structure is given in Appendix A.2.1.

ii) Basin Drain

A new 2.1 m x 1.5 m concrete box culvert would be constructed to convey the 100-year flow from the Basin Drain catchment area. Given the close proximity of the new culvert with the existing structure consideration could be given to connecting both facilities. If the system is to remain open between the two culverts than realignment of Basin Drain should be considered to improve the hydraulic efficiency of the system. The Culvert Master hydraulic analysis output is given in Appendix A.2.2.

iii) Marentette Mangin Drain

With Alternative 1A the proposed Highway 401 would be below in the area of the drain. As a result of this all flows upstream of the new roadway would have to be collected by the new storm sewer system and pumped downstream. Based on the available information there is very little catchment area associated with the drain upstream of the proposed Highway 401 which will have to be interrupted. By intercepting the upstream runoff there is the possibility of providing quality treatment, as part of the Highway 401 stormwater management plan.

iv) Turkey Creek

Two options were considered to convey flow past Highway 401. The first option would include the construction of a syphon that would capture and convey the 100-year flow below the new below roadway. Based on the use of the PCSWM model and assuming that there would be no significant increase in the 100-year flood level upstream of the roadway a 25 m wide by 2 m high structure would be required with its invert approximately 12 m below the existing invert of Turkey Creek. The sloped entrance and exit to this syphon would extend approximately 25 m upstream and downstream of the actual crossing. The inlet structure would be specially designed to address potential ice and debris jams that would affect the conveyance capacity of the structure. An emergency overflow structure would be included in the design to ensure that the required capture capacity is maintained with no increase in flood hazard potential upstream. With the syphon alternative the inlet would have to be maintained on a regular basis and all debris captured at the inlet grate removed. A detailed PCSWM support analysis output is provided in Appendix A.2.4.1.

An alternative to the construction of a syphon is a lowering of the proposed Highway 401 roadway profile at the stream crossing by an additional 4 m. This would allow the roadway to be tunneled under Turkey Creek. Although Turkey Creek would be affected initially as a result of the construction of the roadway there would be no long term impacts on the stream.

v) Lennon Drain

To convey flow past the new roadway a 3 m wide by 1.5 m high syphon is proposed. A separate flow control 2.6 m x 1.2 m concrete culvert would have to be constructed upstream in order to maintain the flood attenuation benefits associated with the existing online pond. As the lands immediately upstream of the roadway, west of the drain are developed special consideration must be given to the design of the inlet structure. Consideration must also be given to the effects of ice and debris jams upstream of the syphon inlet structure. The provision of floodproofing measures such as flood control berms etc. must be considered in the development of the overall strategy to safely convey flow past the below Highway 401 and provide appropriate flood proofing benefits to the upstream urbanized area. The detailed PCSWM syphon analysis output is given in Appendix A.2.4.2.

vi) Cahill Drain West Tributary

The diversion of this tributary in an easterly direction to Cahill Drain is proposed. Detailed topographic surveys are required to confirm the feasibility of this approach. Alternatively the system could be syphoned below the new roadway.

vii) Cahill Drain

Cahill Drain is the second largest drainage system that crosses the new highway. With the below roadway two options are being considered. They include construction of a syphon to take the channel below the roadway or lowering the roadway profile below that of the existing drainage system. If a syphon is to be constructed, it will require a 4.5 m x 1.5 m opening. Results of PCSWM syphon analysis for Cahill Drain crossing is provided in Appendix A.2.4.3.5 Urbanization has significantly encroached onto Cahill Drain. Any changes to how the system functions may as a result have a significant impact on the efficiency of the upstream collection system. Of the two options considered, tunnelling under the watercourse would have the least impact on the flow conveyance of the system. This is of particular importance as consideration is being given to the potential enclosing of Wolfe Drain.

viii) Cahill Drain / Wolfe Drain

As proposed for Alternative 1A there are two options available, realignment of the channel or the construction of a new 4.5 m x 1.5 m closed system. The Flow Master was used to establish the preliminary size of the new closed system. Its output is included in Appendix A.2.3. Of the two options considered, construction of an enclosed system would have the least impact on the existing landuse.

5.3. Alternative 2A – At Grade

Alternative 2A has similar characteristics to that of Alternative 1A. The new roadway however would run south of and parallel to the existing Highway 3, Huron Church Road and E.C. Row Expressway, as opposed to utilizing the existing road right of ways. By offsetting the new roadway, the existing Northbound service road would continue to be used to service the existing development. Plan, profile and typical roadway section are provided in Figures 6-7, 6-8 and 6-9 respectively.

The primary differences between Alternative 2A and 1A are summarized as follows:

- New bridge provided at Turkey Creek crossing with similar characteristics to that of the existing structure.
- Existing Cahill / Wolfe Drain is left as an open channel following its existing alignment.

The hydraulic analysis output for all stream crossings and drainage associated with Alternative 2A is given in Appendix A.3.

5.4. Alternative 2B – Below Grade

Alternative 2B has an alignment similar to that of Alternative 2A but with the roadway now being below. The primary difference in stream crossing improvements between Alternative 2B and 2A is the potential realignment of Wolfe Drain in a northerly direction to accommodate a stormwater management facility (see Section 6.0). A plan, profile and typical cross section of the proposed roadway are provided in Figures 6-10, 6-11 and 6-12 respectively.

As discussed in Section 5.3, there are two options being considered for the crossing of Cahill Drain, they include the construction of a syphon and tunneling. The hydraulic analysis output for Alternative 2B is given in Appendix A.4. The syphon analysis output for Cahill Drain is included in Appendix A.2.4.3

5.5. Alternative 2B Revised – Modified Below Grade

Alternative 2B Revised is a modified Alternative 2B. A plan, profile and typical roadway section are provided in Figures 6-13, 6-14 and 6-15 respectively. As opposed to a syphon or tunnel being constructed at the Turkey Creek crossing, this alternative recommends raising the road profile above the channel. A new three cell 10 m x 2.0 m box culvert or equivalent would be constructed to maintain the existing 100-year flood hazard condition. With this alternative, the new roadway would have minimal impact on either the form or function of Turkey Creek.

The hydraulic analysis output for Titcombe and Basin Drain crossings is given in Appendix A.5.1 and A.5.2 respectively. The PCSWM syphon analysis output for Lennon Drain and Cahill crossing are provided in Appendix A.2.4.2 and Appendix A.2.4.3 respectively. The detailed HEC-RAS analysis output for Turkey Creek for the pre and post development conditions are provided in Appendices A.5.3.1 and A.5.3.2 respectively.

5.6. Alternative 3 - Tunnel

Alternative 3 has the least impact on the existing drainage systems as the new roadway would be constructed below the existing natural drainage features. Any impacts would be short term, related to the construction technique. A plan, profile and typical roadway section are provided in Figures 6-16, 6-17 and 6-18 respectively.

A complete summary of the stream crossing options for each of the Roadway Alternative is given in Table 5.1.

5.7. The Parkway Alternative

The Parkway Alternative was developed based on refining Practical Alternatives 1B, 2B and 3, including the addition of several short tunnels. A plan, profile and typical roadway section are provided in Figures 6-19, 6-20 and 6-21 respectively. The short tunnel provides several opportunities to provide a natural landscape overtop of the highway, and provide grass-lined overland drainage.

The crossings will comprise of the same requirements as Practical Alternative 2B-Revised.

The hydraulic analysis output for Titcombe and Basin Drain crossings is given in Appendix A.5.1 and A.5.2 respectively. The PCSWM syphon analysis output for Lennon Drain and Cahill crossing are provided in Appendix A.2.4.2 and Appendix A.2.4.3 respectively. The detailed HEC-RAS analysis output for Turkey Creek for the pre and post development conditions are provided in Appendices A.5.3.1 and A.5.3.2 respectively.

6. Stormwater Management Plan

6.1. Screening of Alternatives

A list of stormwater management practices (SWMP's) was screened, along with the "do nothing" alternative, with consideration of the general advantages and disadvantages, experience, and practical feasibility for the site-specific conditions, such as:

- Integration with the standard type of drainage (storm sewers and outside ditches);
- Space available (within the proposed right-of-way), and practical outlet points;
- Impact to existing landuse.

Although the "do nothing" alternative was considered, it was determined that this is not an acceptable course of action. The proposed increase in pavement area and the associated potential increase in pollutant loading to the receiving watercourses would result in negative effects such as reduced stream water quality, degraded aquatic habitat, flooding, and in-stream erosion, which necessitates provision of appropriate mitigation measures.

The list of SWMP's reviewed for appropriateness included:

1) Storage SWMP's such as wet ponds, dry ponds, constructed wetlands and underground storage tanks;
2) Infiltration SWMP's such as infiltration basins, infiltration trenches, sand filters and porous pavement;
3) Vegetative SWMP's such as buffer strips, grassed swales and filter strips;
4) Soft SWMP's such as conservation/restoration and source controls; and
5) Special purpose SWMP's such as oil/grit separators and filter devices.

Based on an initial screening of SWMP's, it was concluded that:

- Storage SWMP's (e.g. ponds) can be effective in providing combined quality/quantity control where drainage areas are sufficient and space is available.
- SWMP's based on infiltration can be effective in treating stormwater runoff, but their effectiveness is limited with respect to flooding and erosion control. Disadvantages include the high level of maintenance required and the potential for clogging. It should also be noted that the relatively high salt concentration associated with a highway would be infiltrated directly into the groundwater, which is not considered acceptable.
- Vegetative SWMP's such as grassed swales provide water quality treatment primarily by filtering out fine sediments and promoting infiltration, but can also be used to provide secondary erosion control. Filtering of highway runoff can also be accomplished with vegetative buffers and filter strips. Grassed swales are primarily designed to provide water quality control by limiting flow velocities and increasing the wetted perimeter, while enhanced grass swales have permanent rock check dams to detain water during small events and/or flat bottoms to increase storage and contact. Vegetative SWMP's can be readily applied to highway situations, and are relatively inexpensive and particularly

effective for small catchment areas. Given the limited availability of land this option was not considered appropriate.

- The implementation of soft SWMP's such as conservation/restoration and source control of pollutants such as de-icing salt are beyond the scope of this study and are addressed through MTO's policies and guidelines for roadway maintenance.
- Oil/grit separators are used to trap and retain oil and/or sediment in detention chambers, usually located below ground. They are often used as spill controls, pre-treatment devices or end of pipe controls as part of a multi-component approach for water quality control. They are usually used for small sites.

Based on the results of the screening process and the site conditions, the solutions retained for further analysis were storage SWMP's and oil/grit separators. The storage SWMP's will provide quality treatment, erosion control and quantity control for the upstream catchment area. Storage SWMP's will be utilized to match existing peak flow conditions to the receiving watercourses in an effort to emulate existing conditions within the watersheds. Oil/grit separators will provide quality treatment to the upstream catchment areas, and will be utilized only for small catchment areas such as highway ramps.

For future studies, it is recommended that continued research and analysis be conducted toward utilizing a treatment train approach for providing quality treatment. This would consist of using multiple SWMP's in series, such as vegetated SWMP's in addition to oil/grit separators or storage SWMP's.

6.2. Fish Habitat

As part of the overall Detroit River International Crossing Study, a report entitled "*Practical Alternatives Evaluation Working Paper, Natural Heritage*" dated July 2007, was conducted to determine potential impacts the proposed development will have on the area. The report includes potential impacts on vegetation, wildlife, and fish habitat, as well as fishery habitat classification. Information on fish habitat for the receiving watercourses is integrated with the design of stormwater management facilities, as adequate stormwater quality treatment from the proposed development will be required for watercourses with sensitive fishery habitat.

From this report, all watercourses within the Study Area are classified as warmwater fish habitat, either supporting sportfish communities or baitfish communities. The only exception is the Detroit River, which supports coldwater fish habitat, in addition to warmwater fish habitat. Table 6.1 provides a summary of the Natural Heritage Study findings with regards to fish habitat classification of the receiving watercourses.

TABLE 6.1: SUMMARY OF RECEIVING WATERCOURSE FISH HABITAT

Receiving Watercourse *	Fishery Habitat	Fishery Classification
Detroit River	Coldwater/Warmwater	Important Fish Habitat
McKee Drain	Warmwater	Important Fish Habitat
Titcombe Drain	Warmwater	Important Fish Habitat
Basin Drain	Warmwater	Marginal Fish Habitat
Marentette Mangin Drain	No Fish Habitat	No Fish Habitat
Turkey Creek	Warmwater	Marginal Fish Habitat
Lennon Drain	Warmwater	Important Fish Habitat
Cahill Drain	Warmwater	Important Fish Habitat
Wolfe Drain	Warmwater	Marginal Fish Habitat

* Refer to Figure 3-1 for location

6.3. Proposed Stormwater Management Plans – Roadway Design

The proposed stormwater management strategy developed for Alternative 1A, 1B, 2A, 2B, 2B Revised, 3, and the Parkway Alternative consists of utilizing oil/grit separators and stormwater management facilities to provide quality and quantity control. Plan, profiles and typical roadway sections for each Alternative are included in Figures 6-1 to 6-21 inclusive.

It is noted that because of the terrain and the consideration of using below roadways, pumping stations will be required in order to maintain drainage to the existing natural features. The developed stormwater management plan is based on the premise that the existing flow characteristics and water balance will be maintained.

Based on the established road profiles for each roadway alternative, catchment areas were identified and peak flows determined using the Rational Method. The existing condition was modeled as completely undeveloped with an assumed runoff coefficient of 0.30. The proposed condition was considered to be completely impervious, therefore a runoff coefficient of 0.90 was assumed. Preliminary storm sewer profiles were established in order to confirm the potential need for pumping stations. The conceptual storm sewer profiles are shown on the previously referenced drawings. Once the preferred roadway alternative has been established, then a detailed hydrologic and hydraulic analyses will be completed to confirm catchment areas, sewer design details, pond area requirements etc. Where possible the number of proposed stormwater management facilities and pumping stations and land area requirements will be minimized.

In order to achieve the quality treatment required for the receiving watercourses, Enhanced Protection Level quality treatment will be provided. Stormwater management wet ponds located upstream of the receiving watercourses will provide the highest quality treatment to overland runoff, while providing quantity control to prevent downstream erosion and flooding. Wetponds have been designed following the MOE Stormwater Management Planning and Design Manual (2003) to provide quality protection level as well as quantity control for up to the 100-year design storm. The permanent pool requirements for the wetponds were sized based on the Enhanced Protection Level criteria, providing 80% long-term suspended solids removal, as provided in Table 3.2 of the MOE Stormwater Management Planning and Design Manual (2003), for 85% Imperviousness. In the case of the Proposed Highway 401, the required permanent pool storage volume would be 210 m^3/ha (250 m^3/ha for 85% Imperviousness minus 40m^3/ha for extended detention). For determining the permanent pool storage requirements, the upstream drainage area considered for each pond consisted of the proposed Highway Extension ROW only.

Extended detention for the wet ponds was determined based on the greater of the extended detention requirements as set by the MOE Stormwater Management Planning and Design Manual (2003), or the 25 mm erosion storm released over 24 hours. The 25 mm erosion storm storage requirements were calculated using the runoff from the 25 mm storm over the proposed Highway Extension ROW area. The release rate for the erosion storm storage volume was based on an average release over 24 hours. In all cases, requirements for the 25 mm erosion storm were greater than the MOE extended detention requirements. In addition, providing a steady release of the erosion storm over an extended period of time will provide a net-benefit to the baseflow of the receiving watercourses. This will be particularly beneficial to watercourses that have fishery habitat, but experience intermittent baseflow.

Quantity requirements for the stormwater management wet ponds were determined to able to provide storage for the 2-year through 100-year storms. Release rates for the wet ponds within the site were based on matching the existing conditions peak flows from the proposed Highway Extension ROW area. Specific details of the pond designs will be provided in the Preliminary design.

The following provides a description of the stormwater management plan prepared for each of the Highway 401 alternatives.

6.3.1. Alternative 1A – At Grade

The proposed Highway 401 – Alternative 1A Preliminary Stormwater Management Plan is identified in Figure 6-1. A typical roadway and sewer profile is given in Figure 6-2. The total drainage area for this alternative is in the order of 41 ha. Runoff from the proposed development will drain to Cahill drain, Lennon Drain, Marintette Mangin Drain, Basin Drain and Titcombe Drain, all tributaries of the Turkey Creek Watershed.

The proposed approach to providing quality and quantity control for Alternative 1A is to construct a Stormwater Management Facility downstream of each of the drainage catchments. The SWM facilities will provide Enhanced Level quality treatment as well as quantity control from the 25mm erosion storm up to the 100-year storm to pre-development conditions.

In addition to these facilities, the feasibility of utilizing onsite controls such as enhanced swales and oil grit separators were also investigated. The suitability of using enhanced swales as a conveyance control will be examined in more detail when a Highway option is chosen. The oil/grit separator for Drainage Area 107 was considered as an alternate approach along with underground storage.

As discussed in Section 5.1, two possible options are being considered for the handling of runoff along Cahill and Wolfe Drains. Under Option 1, Cahill and Wolfe Drains would be realigned north of the new 2-lane service road. From Drainage Area 107 (refer to Figure 6-1 will have to be directed first to SWM Pond 1A-P8 treated and then released to Wolfe Drain. Under Option 2, replacement of the existing trapezoidal channel by a 4.5 m x 1.50 m reinforced concrete box culvert under the proposed northbound service road, there is no opportunity to construct a Stormwater Management Facility in the existing residential area. An alternative to the pond would be to construct an underground storage facility below the northbound service road and discharge to Wolfe Drain. This structure would be designed to control all outflows up to the 100-year event to the pre-development condition. Oil/grit separators would also be required for quality control. With this option Wolfe Drain would not have to be realigned. The new underground storage facility would be constructed immediately south of the enclosed Wolfe Drain and would outlet to Wolfe Drain.

Table 6.2 provides a summary of the preliminary stormwater management plan prepared for Alternative 1A. Figure 6-1 identifies the Stormwater Management Plan showing the possible location of stormwater management facilities. The existing and proposed condition hydrologic analysis output for Alternative 1A drainage areas are provided in Appendix B.1 and B.2 respectively. Stormwater management computations associated with pond sizing are given in Appendix C.1

TABLE 6.2: ALTERNATIVE 1A – STORMWATER MANAGEMENT PLAN

Drainage Area ID	Drainage Area (ha)	100-year Peak Flow (m^3/s)		Stormwater Management Facility Req't				Recipient Drainage System
		Existing	Proposed	Facility ID	Storage Volume (m^3) Quality	Storage Volume (m^3) Quantity	Pond Area (m^2)	
100	6.36	0.37	2.40	1A-P1	1,590	2,400	6,100	Titcombe Drain
101	2.53	0.16	0.99	1A-P2	633	1,000	4,700	Basin Drain
102	5.60	0.68	2.12	1A-P3	1,400	1,400	5,700	Marentette Mangin Drain
103	2.60	0.16	1.02	1A-P4	650	1,000	4,300	Turkey Creek
104	2.50	0.21	1.14	1A-P5	625	800	4,200	Lennon Drain
105	2.50	0.18	1.06	1A-P6	625	900	4,200	Lennon Drain
106	5.60	0.34	2.17	1A-P7	1,400	2,100	5,700	Cahill Drain
*107	3.10	0.18	1.16	1A-P8	775	1,200	4,500	Wolfe Drain
108	3.96	0.23	1.50	1A-P9	990	1,500	5,000	Wolfe Drain
109	6.60	0.27	1.91	1A-P9	1,650	2,900	6,100	Wolfe Drain

* Alternate stormwater management measure, underground storage and oil-grit separator

More specific details of the proposed stormwater management facilities will be provided at the preliminary design stage. It is noted that lowest points of Drainage Areas 102, 104, 106, and 108 as identified on Figure 6-1 are located approximately 7m below the existing grade. Pumping of stormwater runoff to the proposed Stormwater Management Facility is required. Table 6.3 summarizes the pumping station locations and requirements for Alternative 1A. Preliminary storm sewer profiles are provided in Figure 6-2.

TABLE 6.3: ALTERNATIVE 1A – SUMMARY OF PUMPING REQUIREMENTS

Drainage ID	Pumping Station	100-year Peak Flow (m^3/s)	Drainage Outlet
102	13+746	2.12	SWM Pond 1A-P3
104	10+085	1.14	SWM Pond 1A-P5
106	11+733	2.17	SWM Pond 1A-P7
108	10+030	1.50	SWM Pond 1A-P9

* Refer to Figure 6-1 for location

6.3.2. Alternative 1B – Below Grade

The proposed Highway 401 – Alternative 1B Preliminary Stormwater Management Plan is identified in Figure 6-4. The total drainage area for this alternative is in the order of 41 ha. Runoff from the proposed development will drain to Cahill Drain, Lennon Drain, Marentette Mangin Drain, Basin Drain and Titcombe Drain, all tributaries of the Turkey Creek Watershed.

The proposed approach to providing quality and quantity control for Alternative 1B is to construct a Stormwater Management Facility downstream of each of the drainage catchment as shown on Drawing 6-4. The SWM facilities will provide Enhanced Level quality treatment as well as quantity control from the 25mm erosion storm up to the 100-year storm to pre-development conditions. An alternate approach was considered for Drainage Area 107, utilizing underground storage to provide quantity control and an oil/grit separator to provide quality treatment.

An alternate option for Drainage Areas 102 and 103 is to direct the flow into one stormwater management facility (SWM Pond 1BP3 and 1BP4 combined) and drain the treated and controlled flow to Turkey Creek as shown in Figure 6-4. The feasibility of this option would be dependent on the alternative selected for the roadway profile below Turkey Creek.

As with Alternative 1A, there will be two alternate stormwater management measures for Drainage Area 106, depending on which of the Cahill and Wolfe Drain drainage options are selected. Under Option 1, Cahill and Wolfe Drain would be realigned north of the new 2-lane service road, runoff from Catchment 106 will be directed first to SWM Pond 1A-P7 and the controlled outflow released to Wolfe Drain. Under Option 2, replacement of the existing trapezoidal channel by a 4.5 m x 1.50 m reinforced concrete box culvert under the proposed northbound service road, there is no opportunity to construct a Stormwater Management Facility in the existing residential area. Underground storage is necessary to control the 100-year peak flows to predevelopment level and treat the outflows via oil/grit separator. Figure 6-6 gives a typical roadway section that shows the two flow conveyance options for Wolfe Drain.

Table 6.4 provides a summary of the preliminary stormwater management plan for Alternative 1B – Below Grade with pond area requirements. Figure 6-4 identifies the Stormwater Management Plan showing the possible location of stormwater management facilities.

TABLE 6.4: ALTERNATIVE 1B – STORMWATER MANAGEMENT PLAN

**Drainage Area ID	Drainage Area (ha)	100-year Peak Flow (m^3/s)		Stormwater Management Facility Req't				Recipient Drainage System
				Facility	Storage Volume (m^3)		Pond Area (m^2)	
		Existing	Proposed	ID	Quality	Quantity		
100	6.36	0.36	2.37	IA-P1	1,600	2,400	6,100	Titcombe Drain
101	2.70	0.20	1.18	1A-P2	700	900	4,400	Basin Drain
102	5.38	0.34	2.16	1A-P3	1,400	2,000	5,600	Marentette Mangin Drain
103	4.50	0.26	1.70	1A-P4	1,200	1,700	5,200	Turkey Creek
104	2.74	0.21	1.20	1A-P5	700	900	4,400	Lenon Drain
105	7.21	0.38	2.57	1A-P6	1,800	2,800	6,400	Cahill Drain
*106	6.17	0.27	1.90	1A-P7	1,600	2,600	5,600	Wolfe Drain
107	6.56	0.27	1.90	1A-P8	1,700	2,900	6,100	Wolfe Drain

* Alternate stormwater management measure, underground storage and oil/grit separator
** Refer to Figure 6-4 for location

Details of the proposed stormwater management facilities will be provided at the preliminary design stage. Stormwater Management Computations for pond sizing are provided in Appendix C.2. Rational Method calculations for existing and proposed conditions are provided in Appendix B.1 and B.2 respectively.

It is noted that Drainage Areas 102 to 106 of the proposed Highway 401 will be located approximately 15 m below the existing ground elevation. As a result, pumping of stormwater runoff to the proposed Stormwater Management Facilities will be required. Preliminary profiles of the storm sewer systems are given in Figure 6-5. Table 6.5 summarizes the pumping station locations and requirements for Alternative 1B.

TABLE 6.5: ALTERNATIVE 1B – SUMMARY OF PUMPING REQUIREMENTS

Drainage ID	Pumping Station	100-year Peak Flow (m^3/s)	Drainage Outlet
102	13+752	2.16	SWM Pond 1B-P3
103	15+112	1.70	SWM Pond 1B-P4
104	10+650	1.20	SWM Pond 1B-P5
105	11+420	2.57	SWM Pond 1B-P6
106	13+165	1.90	SWM Pond 1B-P7

6.3.3. Alternative 2A – At Grade

The proposed stormwater management plan for Alternative 2A is shown on Figure 6-7. A preliminary storm sewer profile required to service the area and a typical roadway section are provided in Figures 6-8 and 6-9 respectively.

Based on the established road profile as provided in Figure 6-8, eight drainage areas have been defined. Their limits are shown in Figure 6-7. The estimated 100-year peak flows from each of these areas under existing and proposed conditions are summarized in Table 6.6. The Rational Method computations for the pre and post development conditions are given in

Appendices B.1 and B.2 respectively.

The proposed approach to providing quality and quantity control for Alternative 2A is to construct a Stormwater Management Facility downstream of each of the drainage catchments.

TABLE 6.6: ALTERNATIVE 2A – STORMWATER MANAGEMENT PLAN

*Drainage Area ID	Drainage Area (ha)	100-year Peak Flow (m^3/s)		Stormwater Management Facility Req't				Recipient Drainage System
		Existing	Proposed	Facility ID	Storage Volume (m^3) Quality	Storage Volume (m^3) Quantity	Pond Area (m^2)	
100	6.36	0.36	2.37	2A – P1	1700	3700	6700	Titcombe Drain
101	1.69	0.13	0.73	2A – P2	540	1000	4000	Basin Drain
102	5.19	0.30	1.96	2A – P3	1400	3000	5600	Marentette Mangin Drain
103	3.31	0.21	1.30	2A – P4	840	1900	4600	Turkey Creek
104	4.93	0.34	2.07	2A – P5	1100	2800	5000	Lennon Drain
105	2.61	0.19	1.11	2A – P6	450	1500	3700	Cahill Drain
106	5.30	0.29	1.92	2A – P7	1600	3100	5900	Cahill Drain
107	7.06	0.38	2.53	2A – P8	1800	4100	6200	Wolfe Drain

* Refer to Figure 6-7 for location

As shown in Table 6.6, eight wet ponds are required in order to address the stormwater management requirements. Their locations are shown on Figure 6-7. Runoff from Drainage Areas 100, 101, 103 and 105 will discharge directly to the ponds via storm sewer. The stormwater from Drainage Areas 101, 104, 106, and 107 will have to be pumped to the ponds. Table 6.7 summarizes the pumping requirements associated with this alternative.

The estimated pond areas associated with the new facilities are summarized in Table 6.6. The SWM facilities will provide Enhanced Level quality treatment as well as quantity control from the 25mm erosion storm up to the 100-year storm to pre-development conditions. The stormwater management pond computations are provided in Appendix C. The suitability of using enhanced swales in conjunction with the stormwater management facilities will be examined in more detail when a Highway option is chosen.

TABLE 6.7: ALTERNATIVE 2A – SUMMARY OF PUMPING REQUIREMENTS

Drainage ID	Pumping Station	100-year Peak Flow (m^3/s)	Drainage Outlet
100	11+500	2.37	SWM Pond 2A – P1
101	12+693	0.73	SWM Pond 2A – P2
102	13+727	1.96	SWM Pond 2A – P3
103	14+300	1.30	SWM Pond 2A – P4
104	10+367	2.07	SWM Pond 2A – P5
105	11+150	1.11	SWM Pond 2A – P6
106	12+150	1.92	SWM Pond 2A – P7
107	10+000	2.53	SWM Pond 2A – P8

* Refer to Figure 6-7 for location

6.3.4. Alternative 2B – Below Grade

The proposed stormwater management plan for Alternative 2B is shown in Figure 6-10. A Preliminary storm sewer required to service the area and a typical roadway section are provided in Figures 6-11 and 6-12 respectively.

Based on the established road profile as given in Figure 6-11, seven drainage areas have been defined. Their limits are shown on Figure 6-10. The estimated 100-year peak flows from these areas under existing and proposed conditions are summarized in Table 6.8. The Rational Method output for the pre and post development con is included in Appendices B.1 and B.2 respectively.

As summarized in Table 6.8, seven wet ponds are being proposed to address the stormwater management requirements of the site. The stormwater from Drainage Areas 100 and 101 will be discharged to the proposed ponds via storm sewer directly. The stormwater from Drainage Areas 102, 103, 104, 105, and 106 will have to be pumped to the ponds. Table 6.9 summarizes the pumping requirements associated with this alternative. All stormwater from the wet ponds will be drained to the watercourse by the gravity.

The required pond areas and storage volumes to address quality and quantity requirements are summarized in Table 6.8. The SWM facilities will provide Enhanced Level quality treatment as well as quantity control from the 25mm erosion storm up to the 100-year storm to pre-development conditions. The stormwater management computations associated with the pond sizing are included in Appendix C.

TABLE 6.8: ALTERNATIVE 2B – SUMMARY OF STORMWATER MANAGEMENT PLAN

*Drainage Area ID	Drainage Area (ha)	100-year Peak Flow (m^3/s)		Stormwater Management Facility Req't				Recipient Drainage System
		Existing	Proposed	Facility ID	Storage Volume (m^3) Quality	Storage Volume (m^3) Quantity	Pond Area (m^2)	
100	6.36	0.36	2.37	2B – P1	1,700	3,700	6,700	Titcombe Drain
101	2.13	0.16	0.92	2B – P2	500	1,200	4,000	Basin Drain
102	6.54	0.37	2.44	2B – P3	1,700	3,800	6,100	Pump to Marentette Mangin Drain
103	7.21	0.32	2.25	2B – P4	2,100	4,300	6,700	Pump to Turkey Creek
104	2.34	0.18	1.04	2B – P5	700	1,300	4,200	Pump to Lennon Drain
105	5.77	0.27	1.84	2B – P6	1,500	3,400	5,800	Pump to Cahill Drain
106	9.32	0.49	3.32	2B – P7	2,400	5,400	7,200	Pump to Wolfe Drain

* Refer to Figure 6-10 for location

TABLE 6.9: ALTERNATIVE 2B – SUMMARY OF PUMPING REQUIREMENT

Drainage ID	Pumping Station	100-year Peak Flow (m^3/s)	Drainage Outlet
100	11+450	2.37	SWM Pond 2B - P1
101	12+693	0.92	SWM Pond 2B – P2
102	14+000	2.44	SWM Pond 2B – P3
103	14+264	2.25	SWM Pond 2B – P4
104	10+500	1.04	SWM Pond 2B – P5
105	11+500	1.84	SWM Pond 2B – P6
106	10+000	3.32	SWM Pond 2B – P7

6.3.5. Alternative 2B Revised – Modified Below Grade

Alternative 2B Revised has a similar alignment to that of Alternative 2B. The road profile however has now been revised to include a minimum slope of 0.5% as opposed to 0.3%. At Turkey Creek the Highway 401 proposed profile now goes overtop of the watercourse as opposed to going underneath. With this alternative the number of potential stormwater management facilities has also been minimized. This, however, has resulted in the storm sewer system being lower than that required for Alternative 2B. At the final design stage, economic and social impact assessments will have to be completed to confirm which approach is the preferred. A plan, profile and typical road section for Alternative 2B – Revised is given in Figures 6-13, 6-14 and 6-15 respectively.

Based on the new road profile, four drainage areas have been defined. They are identified on Figure 6-13. For each area the 100-year peak outflow has been computed for the pre and post development condition based on the use of the Rational Method. For the post development condition the computed peak flows were based on the preliminary profile of the storm sewer system as given in Figure 6-14. Results of the Rational Method analyses are summarized in Table 6.10. The Rational method output for the pre and post development conditions are included in Appendices B.1 and B.2 respectively.

As shown in Table 6.10, four wet ponds are being proposed to address the stormwater management requirements. Their locations are identified on Figure 6-13. The stormwater from Drainage Area 100 will be discharged directly to the pond via a storm sewer. The stormwater from Drainage Area 101, 102, and 103 will have to be pumped to the ponds. Table 6.11 summarizes the pumping requirements. All stormwater from the wet ponds will be drained to the adjacent watercourse by gravity. The SWM facilities will provide Enhanced Level quality treatment as well as quantity control from the 25mm erosion storm up to the 100-year storm to pre-development conditions.

The required pond areas and quality and quantity storage volume requirements are summarized in Table 6.10. The stormwater management computations associated with the pond sizing are included in Appendix C.5.

TABLE 6.10: ALTERNATIVE 2B REVISED PROFILE – SUMMARY OF STORMWATER MANAGEMENT PLAN

*Drainage Area ID	Drainage Area (ha)	100-year Peak Flow (m^3/s)		Stormwater Management Facility Req't				Recipient Drainage System
				Facility	Storage Volume (m^3)		Pond Area (m^2)	
		Existing	Proposed	ID	Quality	Quantity		
100	6.36	0.37	2.54	2BR-P4	2100	3700	6700	Drain to Titcombe Drain
101	8.67	0.42	3.12	2BR-P3	2200	5100	6900	Pump to Basin Drain
102	6.22	0.32	1.55	2BR-P2	1600	3600	5900	Pump to Lennon Drain
103	19.43	0.57	4.89	2BR-P1	4900	12000	10000	Pump to Cahill Drain

* Refer to Figure 6-13 for location

TABLE 6.11: ALTERNATIVE 2B REVISED – PUMPING REQUIREMENTS

Drainage ID	Pumping Station	100-year Peak Flow (m^3/s)	Drainage Outlet
100	11+470	2.54	SWM Pond 2BR – P4
101	13+000	3.12	SWM Pond 2BR – P3
102	15+100	1.55	SWM Pond 2BR – P2
103	11+580	4.89	SWM Pond 2BR – P1

6.3.6. Alternative 3 – Tunnel

This alternative would involve the construction of a tunnel along a significant length (approximately 6.75 km) of the new roadway. A plan, profile and typical section of the tunnel alternative is given in Figures 6-16, 6-17 and 6-18 respectively.

A preliminary stormwater management plan was prepared for this alternative and is given in Figure 6-16. The proposed approach is to provide three wetpond facilities for the larger catchments which includes Drainage Areas 100, 101, 108 and 109. They are identified as facilities 3-P1, 3-P2 and 3-P3 on Figure 6-16 respectively. The quality and quantity storage volumes to be provided by each facility are summarized in Table 6.12. The SWM facilities will provide Enhanced Level quality treatment as well as quantity control from the 25mm erosion storm up to the 100-year storm to pre-development conditions. The stormwater management computations associated with the pond sizing are included in Appendix C.

There are a number of smaller catchment areas within the study area, associated with the ramps, that would drain to the new tunnel. Those areas are identified as Drainage Areas 102, 103, 104, 105, 106 and 107 on Figure 6-16. It is anticipated that the 100-year flow from these areas would be accommodated by the storm sewer system that will service the length of roadway within the tunnel. A profile of the new sewers is given in Figure 6-17. Based on the conceptual storm sewer design there would be two pumping stations required within the tunnel, one to discharge to Cahill Drain and the second to Turkey Creek. Two oil/grit separators would be required to treat all flow pumped from the tunnel. The oil/grit separators should also take into consideration the treatment of any spill conditions. The 100-year flow from Drainage Areas 102 and 103 would drain to the pumping station located at Chainage 14+300 located within the tunnel. The 100-year flow from Drainage Areas 104, 105, 106 and 107 would drain to the pumping station located at Chainage 11+500.

The computed pre and post development 100-year peak flows for all catchments drainage to the tunnel are summarized in Table 6.12. The Rational Method output is included in Appendices B.1 and B.2 respectively.

Alternative 3 also includes the requirement for the pumping of the 100-year runoff from Drainage Areas 101 to SWM Pond 3-P2 and Drainage Area 108 to SWM Pond 3-P3. A complete summary of the pumping requirements associated with Alternative 3 is given in Table 6.13.

TABLE 6.12: ALTERNATIVE 3 – STORMWATER MANAGEMENT PLAN

Drainage Area ID	Drainage Area (ha)	100-year Peak Flow (m^3/s)		Stormwater Management Facility Req't				Recipient Drainage System
		Existing	Proposed	Facility ID	Storage Volume (m^3) Quality	Storage Volume (m^3) Quantity	Pond Area (m^2)	
100	6.36	0.37	2.40	3-P1	1,600	2,400	6,100	Titcombe Drain
101	2.80	0.17	1.08	3-P2	700	1,100	4,500	Titcombe Drain
102	0.34	0.03	0.16	Oil/Grit Separator	-	-	-	Tunnel Storm Sewer Outfall Station 14+300, Turkey Creek
103	0.34	0.03	0.16		-	-	-	
104	0.14	0.02	0.07	Oil/Grit Separator	-	-	-	Tunnel Storm Sewer Outfall Station 11+500, Cahill Drain
105	0.19	0.02	0.10		-	-	-	
106	0.17	0.02	0.09		-	-	-	
107	0.19	0.02	0.09		-	-	-	
108	2.16	0.13	0.84	3-P3	600	800	10,200	Wolfe Drain
109	6.56	0.27	1.90	3-P3	1,700	2,900		

TABLE 6.13: ALTERNATIVE 3 – SUMMARY OF PUMPING REQUIREMENTS

Drainage ID	Pumping Station	100-year Peak Flow (m^3/s)	Drainage Outlet
101	13+000	1.08	Pond 3 – P2
108	10+095	0.84	Pond 3 – P3
Tunnel Storm Sewer Outfall	11+500	0.35	Oil / grit separator to Cahill Drain
Tunnel Storm Sewer Outfall	14+300	0.32	Oil / grit separator to Turkey Creek

6.3.7. The Parkway Alternative

The Parkway Alternative, as shown on Figures 6-19, 6-20, and 6-21 was developed based on refining Practical Alternatives 1B, 2B and 3, including the addition of several short tunnels. The Parkway Alternative proposes significant changes at the roadway interchanges. Three pedestrian crossings have also been included in the design. Short tunnels have now been incorporated into the design at each of the crossings, which allows for the creation of large landscaped areas. These landscaped areas can facilitate pathways and potentially flow conveyance structures associated with drainage features that are affected by the new roadway. As evident from the plan view provided in Figure 6-19, the Parkway Alternative includes a much larger landscaped area.

Based on the new road profile and alignment a drainage assessment was completed and the 100-year peak outflow established based on the Rational Method for the pre and post development conditions. Table 6.14 provides a summary of the computed flows at each of the proposed pond locations. The Rational Method output for the pre and post development conditions are included in Appendices B.1 and B.2 respectively.

A preliminary stormwater management plan has been established for the Parkway Alternative. The Parkway Alternative includes the construction of seven stormwater management facilities. Their locations are shown on Figure 6-19. At five of the proposed wetpond facilities (P2 to P5), flow would have to be pumped from the depressed Highway 401. Table 6.15 gives a summary of the pumping requirements associated with the Parkway Alternative. All stormwater from the wet ponds will be drained by gravity to the adjacent watercourses.

The quality and quantity storage volume requirements are summarized in Table 6.14. The stormwater management computations associated with the pond sizing are included in Appendix C.5.

Watercourse crossing structures for the Parkway Alternative would be similar to those proposed for Practical Alternative 2B. New culverts would be required at the Turkey Creek, Basin Drain, Titcombe Drain, and McKee Drain crossings. The Lennon Drain and Cahill Drain crossings would require a siphon to convey flows.

TABLE 6.14: THE PARKWAY ALTERNATIVE – SUMMARY OF STORMWATER MANAGEMENT PLAN

*Drainage Area ID	Drainage Area (ha)	100-year Peak Flow (m^3/s)		Stormwater Management Facility Req't				Recipient Drainage System
		Existing	Proposed	Facility ID	Storage Volume (m^3) Quality	Storage Volume (m^3) Quantity	Pond Area (m^2)	
100	5.10	0.25	1.69	2C-P1	1,100	2,050	17,300	Wolfe Drain
101	8.70	0.47	3.15	2C-P2	1,850	3,400	28,400	Burk Drain
102	16.40	0.74	5.18	2C-P3	3,450	6,850	33,900	Wolfe Drain
103	12.20	0.58	4.00	2C-P4	2,600	5,000	19,600	Pump to Cahill Drain
104	11.30	0.68	4.39	2C-P5	2,400	4,150	13,300	Pump to Turkey Creek
105	9.50	0.45	3.08	2C-P6	2,000	3,900	8,900	Marentette Mangin Drain
106	6.00	0.32	2.16	2C – P7	1,260	2,350	13,400	Titcombe Drain

- Refer to Figure 6-19 for location

TABLE 6.15: THE PARKWAY ALTERNATIVE – SUMMARY OF PUMPING REQUIREMENT

Drainage ID	Pumping Station	100-year Peak Flow (m^3/s)	Drainage Outlet
102	13+260	5.18	SWM Pond 2C – P3
103	11+170	4.00	SWM Pond 2C – P4
104	14+820	4.39	SWM Pond 2C – P5
105	13+675	3.08	SWM Pond 2C – P6
106	11+620	2.16	SWM Pond 2C – P7

A comparison of the stormwater management requirements associated with each of the roadway alternatives is given in Table 6.16.

TABLE 6.16: SUMMARY OF STORMWATER MANAGEMENT PLAN

Roadway Alternative	No. of Stormwater Management Facilities	Estimated No. of Pumping Stations
1A – At Grade	10	4
1B – Below Grade	8	5
2A – At Grade	8	4
2B – Below Grade	7	5
2B Revised – Below Grade	4	3
3 – Tunnel	3	4
The Parkway Alternative	7	5

7. Plaza Options

7.1. Stormwater Management Plan

Several Plaza options have been designed to provide primary and secondary inspection and toll collection along with associated queuing lanes, parking, and buildings. There are three potential sites identified for the construction of the Plaza to service the international bridge. Their locations are shown on Figure 7.1. Each of the Plaza options are between 33 ha to 43 ha in size, consisting mostly of asphalt pavement and building rooftops. The principle concern for large sites with a high imperviousness and vehicular traffic is providing stormwater treatment for frequent vehicular pollutants (oil, coolant, gasoline, etc), roadside grit and garbage (gravel, sand, cigarette butts), infrequent pollutant spills, and controlling the increase of overland runoff to the receiving watercourses. In addition, Enhanced Quality treatment will be required in accordance to the MOE document "*Stormwater Management Planning and Design Guidelines*", dated 2003, which states removal of a minimum of 80% total suspended solids (TSS), as well as quantity control to the 100-year storm, where appropriate.

Therefore, due to the overall size of the project sites and treatment required, stormwater management for each of the Plaza Options will consist primarily of stormwater management ponds and/or oil grit separators. Preliminary stormwater management block sizes are identified on the prepared conceptual plans for each of the Plaza Options. The established size, location and configuration of the blocks for each of the options will be refined at the preliminary design stage once specific details of the site plans associated with each of the Plaza Options have been refined. Where proposed stormwater management facilities outlet to natural features, downstream constraints will have to be assessed, the results of which used to confirm the operational characteristics of the stormwater management plan. Although conceptual in detail, careful consideration has been given to establishing approaches in design that addresses the grading constraints that are inherent with the existing natural attributes of the subject sites. It is noted that because of the flat topography and potential distance from the proposed facilities to a suitable outlet, significant fill maybe required in order to service the site. Alternatively, consideration could be given to the possibility of providing a pumping station to control the water level within the proposed stormwater management facilities. For each site a stormwater management plan has been prepared based on a review of the topographical features, environmental and urban constraints and the requirements for providing quality and quantity control.

There may be opportunities to incorporate alternative stormwater solutions, including permeable pavers, perforated storm sewer pipes, Green Roof systems, and infiltration basins into the Plaza designs. Permeable Pavers provide quantity treatment through storing and infiltrating stormwater runoff under the Plaza, however quality treatment requirements cannot be accurately measured. In addition, a study will be required to determine the extent of infiltration within the native soils receiving the runoff to ensure full effectiveness. Green Roof systems provide quality treatment in addition to a natural water balance through infiltration and evapotranspiration of stormwater runoff on building rooftops. Many alternative stormwater solutions will be explored further in the preliminary design stage, as increased data on the preferred Plaza Option will be available. Once the preferred Plaza Option is selected, the best and most current SWM practices will be utilized to provide quality treatment, including on-site treatments and source control treatments.

Selection of the preferred Plaza Option is dependent on a number of considerations, the most significant of which is the location of the new Detroit River crossing. The three identified crossing sites are shown on Figure 7.1. Once the river crossing location has been established than the preferred location of the Plaza associated with that alternative can be confirmed and a comparative assessment of the technical and environmental merits associated with each can be completed.

The following provides conceptual details of the preferred stormwater management plan prepared for each of the Plaza Options considered.

7.1.1. Plaza Option ‘A”

The Plaza Option “A” as shown on Figure 7.2 is located in the southeast corner of the intersection of the Ojibway Parkway and the Essex Terminal Railway. The site is rectangular in shape, has an area of approximately 37 hectares and parallels the E.C.ROW Expressway for a distance of approximately 1500m. The easterly limit of the site is Malden Road. At the west limit of the site the new Plaza would intercept Matchette Road. That roadway would have to be terminated at the E.C.ROW Expressway to accommodate the Plaza.

Runoff from the site is accommodated by three drainage systems, the most significant one being Titcombe Drain. That system traverses the site approximately 300m west of Plaza Option “A’s easterly boundary. All of the subject property east of Matchette Road drains in a southerly direction eventually out letting to Titcombe Drain. West of Matchette Road a small area drains northerly towards the Objibway Parkway. The remaining lands drain southerly approximately 800m following the Ojibway Parkway to a manmade drain. That drain intercepts the overland flow and directs it in a westerly direction to the Detroit River.

With the subject site having very little topographic relief from east to west and the site being in excess of 1500m in length, servicing the property without the requirement for significant fill will be a challenge. The development stormwater management plan as shown on Figure 7.2 includes the construction of a linear wetpond feature that parallels the south boundary of the site. With this type of facility the invert of the storm outfalls required to service the development area would be the same at the west limit of the site as at the east limit. This would significantly reduce the fill requirements of the site associated with its servicing needs. The proposed sewer system, a conceptual layout of which is given in Figure 7.2, includes a series of lateral trunks that would outlet to the proposed stormwater management facility at various locations along its length. At each of the outlets a forebay would be provided to capture the sediment being carried by the sewer flow. An access road would be provided to each of the forebays to facilitate cleanout. Between each forebay the wetpond feature would narrow to encourage sediment deposition within the constructed forebay but would still be wide enough to function as a flow conveyance facility. A conceptual plan of the facility is given in Figure 7.2.Outflow from the Plaza Option “A” can be directed either to Titcombe Drain that traverses the subject site or alternatively a new outlet provided to the Detroit River. With either alternative, flow would still have to be maintained to Titcombe Drain in order to ensure that the proposed works do not negatively impact the ecological condition of the recipient drainage system. If the primary outflow from the Plaza Option “A” is to the Titcombe Drain, the release rates would be based on matching the predevelopment condition.

If the primary outflow is to the Detroit River than there are two potential options, they include a new storm sewer following Broadway Street or alternatively enhancement of an existing drainage system that currently conveys flow form the Ojibway Parkway to the Detroit River. The potential locations of the outlet conveyance facilities are shown on Figure 7.3. Based on a review of the potential technical and environmental impacts associated with the outlet options the preferred approach is to direct flow from Plaza "A" directly to Titcombe Drain.

The proposed wetpond facility would provide both quality and quantity control. In the event of a contaminant spill (ie. Oil, chemical, etc.) within the Plaza, a shut-off valve or alternative damming procedure will be required within the pond. This will be determined during the detailed design stage, but must be considered throughout the design process.

A secondary location for a stormwater management facility is proposed immediately north of the Plaza, as shown on Figure 7.2. This location provides adequate land area to accommodate a stormwater management facility to provide treatment for the Plaza, and is located immediately adjacent to the Titcombe Drain, providing access to an outfall location. In addition, as the Titcombe Drain is a sensitive fish habitat, the alternate location for the stormwater management facility will help minimize the proposed impact on the watercourse. However, this location is not preferred due to the grading requirements attributed with a single facility, previously discussed. In addition to the additional fill required for the storm sewer grading requirements, the pond location is at the upstream portion of the Titcombe Drain, increasing the stormwater management permanent pool elevation, therefore increasing the initial grades of the storm sewers.

7.1.2. Plaza Option "B" and "B1"

The Plaza Option "B" is approximately 35 ha, consisting primarily of pavement and commercial buildings. The proposed Highway 401 enters from the east, with the roadway to the new bridge extending to the north. Stormwater management for the Plaza Option "B" requires quality, quantity and erosion controls for the peak flows from the Plaza, as the increase in impervious area will increase the overall peak flows from the site, as well as the overall pollutant loading. This would lead to erosion issues downstream of the site, as well as impacts to the ecological condition of the Detroit River.

Stormwater management for the Plaza Option "B" can be provided in the lands directly west of the proposed site. Currently, the lands are open space adjacent to the Detroit River, as shown in Figure 7.4. Stormwater management options for this open space could consist of a single wetpond or wetland to provide quality, quantity, and erosion treatment for the Plaza; or create a wetland system to provide quality and erosion control, with peak flows from rare events discharging directly to the Detroit River. Providing limited quantity control is not considered to be an unreasonable approach from the technical perspective given the close proximity of the wetpond facility to the Detroit River.

The proposed stormwater management plan as shown on Figure 7.4 includes drainage corridors along both the north and south boundaries of the proposed wetland facility. These corridors would convey the overland flow in excess of the 5 year storm event around the facility. This would minimize the potential for resuspension of the deposited sediment and ensure that the facility continues to function as designed. In the event of a contaminant spill (ie. Oil, chemical, etc.) within the Plaza, a shut-off valve or alternative damming procedure will be required within the pond. This will be determined during the detailed design stage, but must be considered throughout the design process.

For the Plaza Option "B", it is our recommendation to explore using a stormwater management facility to provide only quality and erosion treatment, with higher peak events discharging directly to the Detroit River using an engineered channel and outlet structure.

The Plaza Option "B1" is approximately 33 ha, consisting primarily of pavement and commercial buildings. The proposed Highway 401 enters from the east, with the roadway to the new bridge exiting to the north. Stormwater management for the Plaza Option "B1" will require quality, quantity and erosion controls for the peak flows from the Plaza, as the increase in impervious area will increase the overall peak flows from the site, as well as the overall pollutant loading. This would lead to erosion issues downstream of the site, as well as impacts to the ecological condition of the Detroit River.

There are two alternative approaches for stormwater management for the Plaza Option "B1". Stormwater management Alternative 1 consists of creating two ponds in the green spaces south of the proposed plaza, as shown in Figure 7.5. These green spaces can be converted to stormwater management facilities utilizing the existing drain to connect the facilities, discharging to the Detroit River via an outlet channel. The two pond system provides closer outlets for the sewer system, lowering the overall grading requirements of the Plaza. The two major ponds would be connected by a linear wetland/wetpond feature. The linear feature would be designed such that there would always be an open portion to ensure that there is no restriction to the conveyance of flow from one pond to the other. The two pond system would function as one with one outlet structure that would control the release rate to the Detroit River. In the event of a contaminant spill (ie. Oil, chemical, etc.) within the Plaza, a shut-off valve or alternative damming procedure will be required within the pond. This will be determined during the detailed design stage, but must be considered throughout the design process.

Stormwater management Alternative 2 consists of a single stormwater management pond located at the southwest corner of the site, adjacent to the tollbooths, to provide quality, quantity, and erosion treatment to the Plaza Option "B1". This facility will have a shorter easement to the Detroit River; as well require less land for construction. However, as the overall length of the Plaza Option "B1" is approximately 1000m, the storm sewer system collecting overland runoff will require a considerable grade difference to service the entire site (a grade difference of approximately 6m). This would greatly increase the construction cost due to fill requirements, as well as present geotechnical complications in order to provide structural support for the additional fill load.

For the Plaza Option "B1", the preferred stormwater management plan, based on engineering considerations would be associated with Alternative 1. This alternative helps to minimize the fill requirements of the site, needed to service the property. In addition by reducing the amount of surcharging associated with the placement of fill on the site, the geotechnical issues and timing for proper compaction would be greatly reduced.

7.1.3. Plaza Option " C"

The Plaza Option "C" is approximately 43 hectares in area and is bounded by Sandwich Street to the east, the Detroit River to the west and the Windsor Salt Property to the north. Of the various Plaza options considered Plaza Option "C" is one of the closest to the Detroit

River. A conceptual plan of the Plaza and its relative location to the Detroit River is given in Figure 7.6.

Although it is recognized that current stormwater management guidelines as adopted by the approval agencies includes both quality and quantity control the close proximity of the subject Plaza to a significant drainage system (Detroit River) would suggest that quantity control would not be a component of the design. The safe conveyance of the flow to the Detroit River for all storms up to and including the 100 year event would be the primary quantity control objective associated with the stormwater management plan. Public safety as it relates to flood hazard condition would also be an issue to be addressed by the design.

As shown on Figure 7.6 the minor system flows from the subject site would be accommodated by storm sewer systems that would outlet to a stormwater management facility located north of Prospect Ave. Although the storm sewers would be designed to accommodate the 5-year flow, the proposed stormwater management plan would not include provision for any significant flow attenuation. Potential discharge locations to the Detroit River for the major system flows would follow Prospect Ave, and are shown in Figure 7.6. Depending on the final grades of the site and the fill requirements to provide positive overland drainage, consideration could be given to designing the new storm sewer system to accommodate the 100-year peak flow. Uncontrolled outflows from the proposed facilities would be conveyed directly to the Detroit River via storm sewer system (see Figure 7.6).

Quality control would be provided by the proposed wetpond facility, providing an enhanced level of quality treatment. However, due to the grading requirements associated with a single wetpond location, alternative outlets may be required. In an effort to decrease the overall grading, the southern portion of the Plaza may have to outlet directly to the Detroit River, with quality treatment provided by alternative best management practices such as oil/grit separators. However, it should be noted that mechanical measures to provide quality treatment, such as oil/grit separators, would require regular maintenance in the form of vacuum truck clean-outs. Maintenance would occur approximately twice each year, or based on overall pollutant loading.

In the event of a contaminant spill (i.e. Oil, chemical, etc.) within the Plaza, a shut-off valve or alternative damming procedure will be required upstream of all outlets to the Detroit River. This will be determined during the detailed design stage, but must be considered throughout the design process.