4.0 STORMWATER MANAGEMENT STRATEGY

The SWM design in the ESR and Preliminary Design Report was based on the assumption that upstream lands would remain generally undeveloped. Based on this assumption, clean storm water runoff from upstream areas would not be conveyed to the roadway's storm water management facilities (SWMF), but rather directed to the existing downstream receivers, without passing through the SWMF. This requires a separate conveyance system for the roadway flow (i.e. sewer and / or ditches) and upstream external flow (interceptor ditches and road crossing culverts). Upstream lands are still generally undeveloped but development plans have advanced since the 2007 EA Addendum. Where possible these plans have been considered in the design of SWM measures for the Terry Fox Drive project.

The Terry Fox Drive Phase 2 project crosses two distinctively different watersheds. From the southern limit of the project near Richardson Side Road to approximately Station 14+000, the alignment in located in the Carp River Subwatershed. The remainder of the project is within the upper reaches of the Shirley's Brook watershed. Since the subwatersheds have different criteria, separate management strategies have been developed to achieve the goals outlined in Section 1.0 of this report. The following summarizes SWM constraints and criteria for both subwatersheds:

Carp River Watershed Drainage/SWM Design Considerations

- Since the clay soils require surcharging of embankment, the lower road profile is preferred;
- The clay soils limit potential for infiltration BMPs;
- Since the new roadway is within the Carp River Floodplain, a lower profile will reduce the floodplain displacement;
- Since the alignment is located within the regulatory floodplain, an end-of-pipe stormwater facility will displace floodplain storage;
- A floodplain embayment is located on the easterly/upstream side of Terry Fox Drive, which must remain connected to the main floodplain; and
- 'Normal' stormwater water quality control (i.e. 70% TSS removal) is required according to the subwatershed study.

Shirley's Brook Watershed Drainage/SWM Constraints

- Since the alignment crosses a railroad track, planning for future grade separation is required;
- The location identified for SWM facility identified in the 2007 Study north of the railway is within a PSW;
- The location identified for SWM facility identified in the 2007 Study south of the railway is in an area of important habitat (Blandings turtle);
- Clay soils are identified immediately adjacent to Shirley's Brook and limit infiltration BMPs; and;
- The small size of the contributing areas from the right-of-way limit the use of wet ponds and constructed wetlands as a SWM alternative;

- 'Enhanced' stormwater quality control (i.e. 80% TSS removal) and pre-development runoff equal to post-development runoff for the 1:100-year event stormwater quantity control is required according to subwatershed study.

4.1 Screening of Potential SWM Practices

Both conveyance and outlet area (end of pipe) controls measures have been considered in the development of the surface water management strategy. **Table 2** summarizes the screening of potential stormwater management practices.

Table 2: Screening of Potential SWM Practices

Stormwater Management Practice	Applicable?	Rationale
Pervious Catch Basins	No	Clay soils prohibit infiltration. Not acceptable standard City of Ottawa.
Pervious Sewer Systems	No	Clay soils prohibit infiltration. Not acceptable standard City of Ottawa.
Grassed Swales	Yes	Potential to be used in conjunction with other measures, especially in the Carp River area, where longitudinal grades are low. According to MOE guidelines, grasses swales are effective when drainage areas are < 2 ha and they are most effective when depth of flow is minimized and bottom width maximized. Grassed swales with slopes up to 4% can be used for water quality purposes.
In-Line Devices (Oil-Grit Separators)	Yes	Acceptable for quality control subject to drainage area size and City agreement related to maintenance requirements.
Wet Ponds	Yes	Acceptable for quantity and quality control. Drainage area should be 5 ha or more to maintain permanent pool.
Dry Ponds	No	Dry ponds provide quantity control, but will not achieve required quality control for either subwatershed.
Constructed Wetlands	Yes	Surface area required not available in the Carp River portion of the project, but this type of facility has good potential in the Shirley's Brook subwatershed, especially if it can be integrated with the existing wetland features.

4.2 Storm Water Management – Carp River Subwatershed

4.2.1 Alternatives and Evaluation

Alternative 1 – Do Nothing

With this alternative, this portion of Terry Fox Drive would have no SWM quality or quantity controls. The 'do nothing' alternative was rejected because of the adverse impacts of not treating runoff.

Alternative 2 – Two Ponds located on West Side of Terry Fox Drive in Floodplain Area

Figure 6 is an excerpt from the 2007 Preliminary Design Report, which recommended two SWM facilities located on the 'downstream side' of Terry Fox Drive in the flood plain of the Carp River. The need for two facilities rather than one larger one arose from the need to maintain connectivity between the main floodplain and an embayment, east of the road alignment as shown in **Figure 7**. The concept presented in the 2007 Preliminary Design was based on connectivity being provided by a concrete culvert across Terry Fox Drive, which would divide the stormwater facility into two parts.

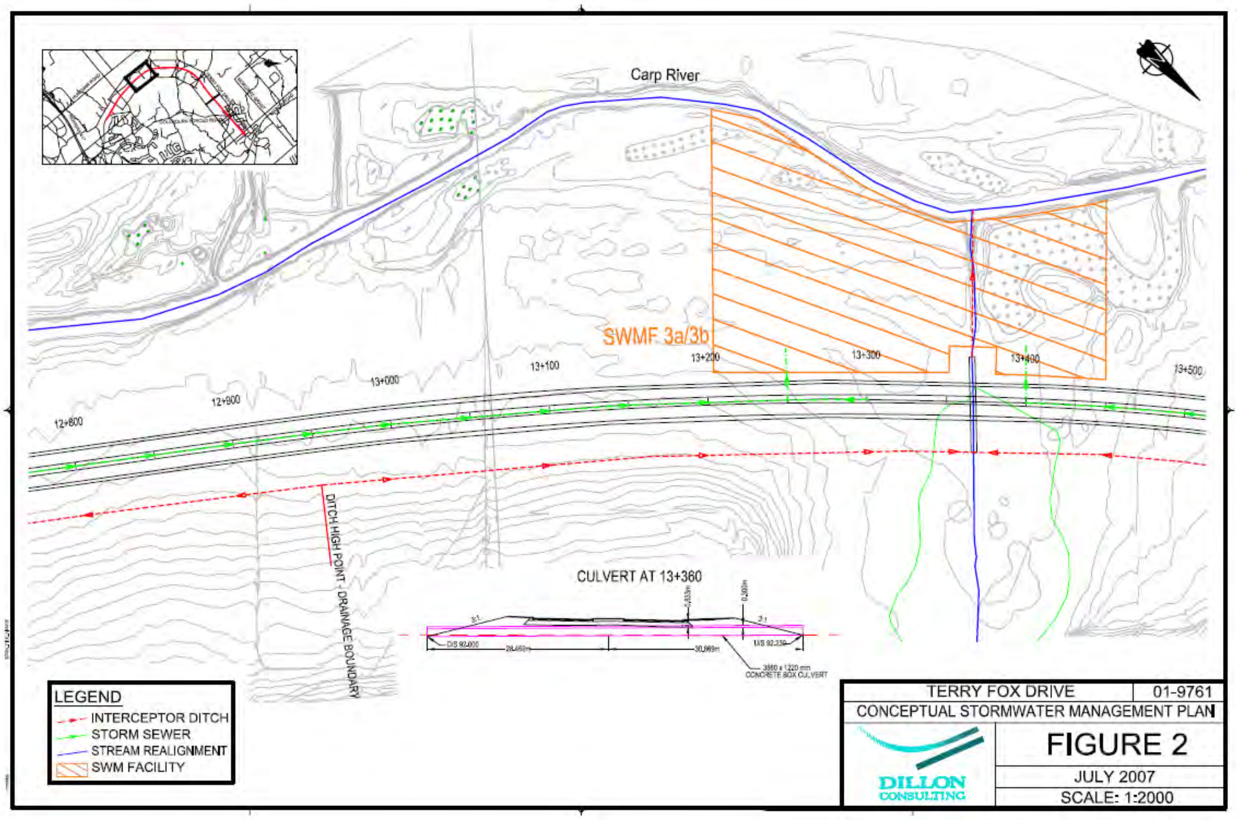
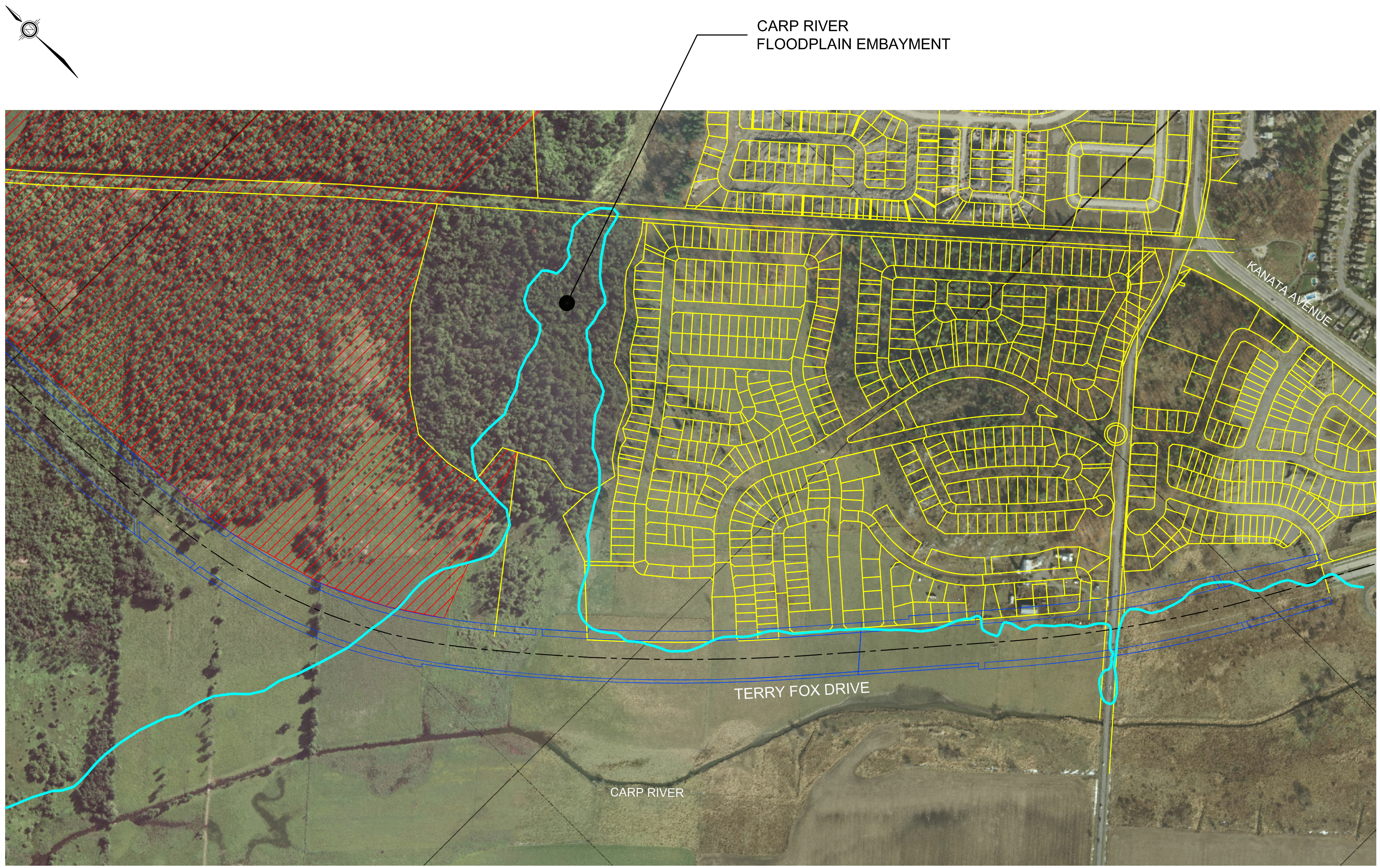


Figure 6: Location of SWMF 3a and 3b from the 2007 Draft PDR



LEGEND:

- OUTLINE OF CARP RIVER FLOODPLAIN
- FUTURE DEVELOPMENT
- DRAFT APPROVED FUTURE DEVELOPMENT

FIGURE 7
CARP RIVER FLOOD PLAIN
AND TERRY FOX DRIVE

TERRY FOX DRIVE EXTENSION
RICHARDSON SIDE ROAD
TO SECOND LINE ROAD
STORMWATER MANAGEMENT
REPORT

DILLON CONSULTING

DATE: DECEMBER 2009

SCALE: N.T.S.

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16 December 2009 2:26:09 PM G:\cad\2009\09-1518 Ottawa - Terry Fox Drive Final Design\Report Figures\SWM Report\FIG 7 Carp River Flood Plain.dwg

In 2007, SWM facilities 3a and 3b were designed to provide both quantity and quality control - the criteria in place when the ESR was prepared in 2000. This design concept was developed to service the roadway only, and required a single storm sewer on Terry Fox Drive through the floodplain area to convey flows to SWMF 3a. A drawback of the location of these facilities is that the displacement of floodplain storage. The Mississippi Valley Conservation Authority (MVCA) has indicated that the location of these two ponds within the primary part of the floodplain is not desirable. Also, since the original conceptual design was completed, the 2004 Subwatershed Study updated the design criteria for the Carp River, such that only water quality treatment is required prior to discharge to the river.

Alternative 3 – Combined Facility on Easterly Side of Terry Fox Drive

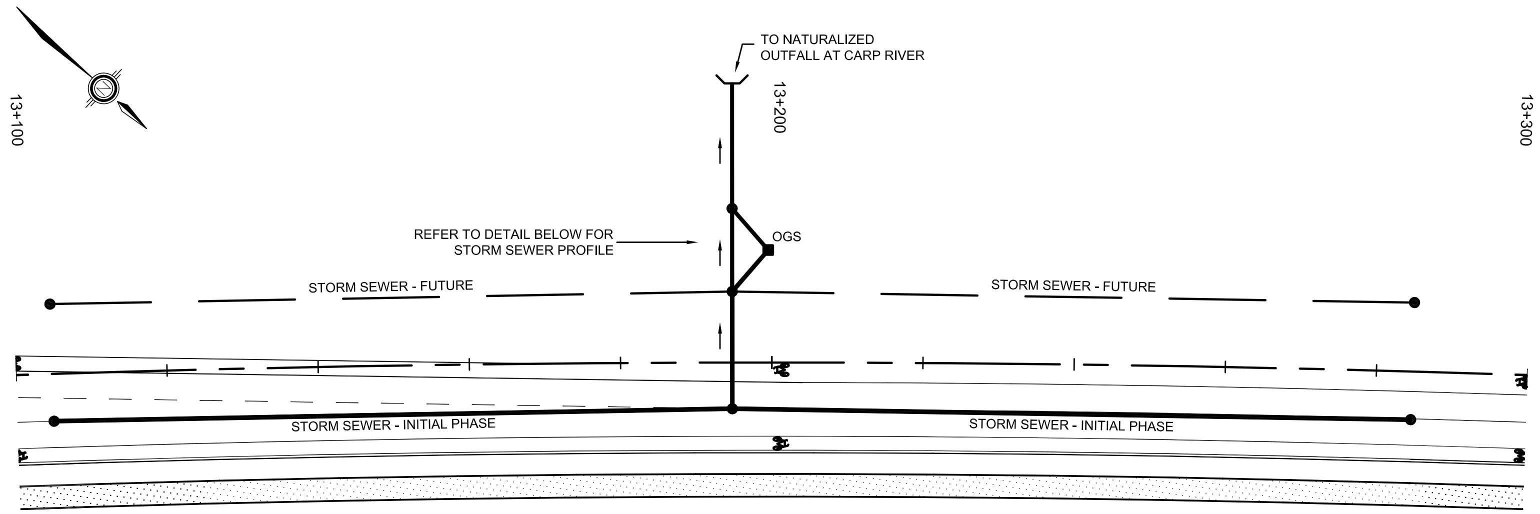
Since the Draft PDR was prepared in 2007, the IBI Group has prepared a conceptual SWM plan for the Richardson Ridge development, upstream of Terry Fox Drive. The conceptual plan consists of a joint stormwater facility for quality control for both the development and Terry Fox Drive.

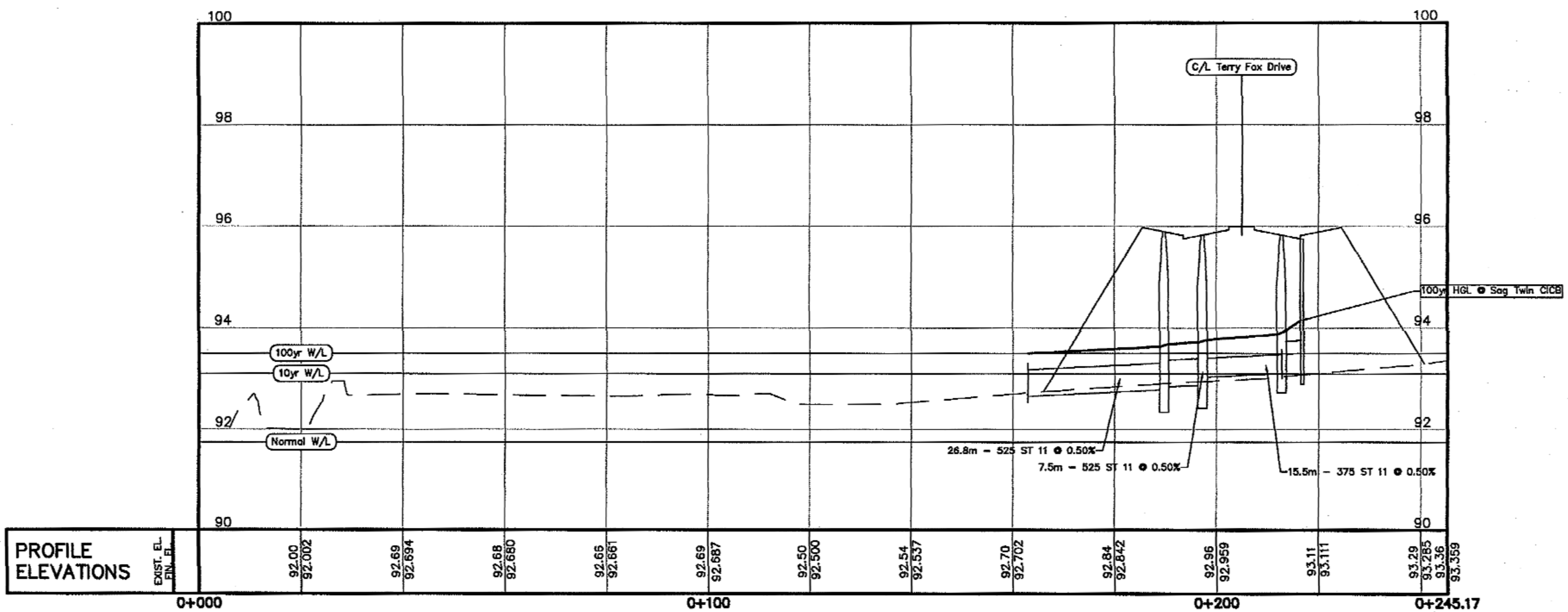
The MVCA has indicated that the location of this proposed pond is preferred to a downstream location, but more details are required to ensure that a facility can be provided in this area and still maintain the floodplain connectivity. Also, it may be difficult to coordinate the timing of the design of the joint use facility with the design and construction timing of Terry Fox Drive since design and approvals for Terry Fox Drive are required by late 2009. Conveying flows along Terry Fox Drive to a centralized facility will also raise the height of the road profile significantly, complicating the geotechnical design, increasing costs and significantly increasing floodplain impacts.

Alternative 4 – Series of Oil Grit Separators along the Portion of Terry Fox Drive Located within the Carp River Floodplain

Alternative 4 will provide quality control for the first 25mm of runoff through the use of regularly spaced oil-grit separators and naturalized swales along the length of Terry Fox Drive in the floodplain. This concept is based on the use of groups of eight catch basins with an oil grit separator located at the outlet of each group of catchbasins. For the initial two lane section, there will be less than eight catch basins for each outlet. This concept reflects the focus on water quality treatment and water quantity goals in the 2004 Carp River Watershed/Subwatershed Study. As well, extremely challenging geotechnical constraints were a key factor for exploring this alternative.

Oil grit separators provide the required quality control and avoid the impact of constructing SMWF 3a and 3b in the floodplain area. The reduced length and size of the storm sewer required to convey surface water runoff to each outlet significantly lowers the roadway profile compared to the design included in the Preliminary Design Report. The concept of groupings of catchbasins directed to several outlets, as presented at the Public Open House (June 22, 2009), is shown on **Figure 8**.





LEGEND:

FIGURE 8
OIL/GRIT SEPARATOR CONFIGURATION

TERRY FOX DRIVE EXTENSION
RICHARDSON SIDE ROAD TO SECOND LINE ROAD

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4.2.2 Preferred SWM Alternative

Table 3 summarizes the evaluation of SWM alternatives for the portion of roadway within the Carp River Subwatershed.

Table 3: Evaluation of SWM Alternatives in Carp River Watershed

Alternative Carp River Subwatershed	Description	Evaluation
1	Do Nothing	Not an acceptable alternative since it does not meet study goals and design criteria
2	Two Wet Pond SWMFs located in the floodplain west of Terry Fox Drive, for management of flows from Terry Fox Drive only	Meets water quality control criteria and provides quantity control. MVCA does not support location in floodplain due to floodplain displacement The single storm sewer required to carry flows to the SWMFs results in a relatively high roadway profile to maintain design cover
3	Single Wet Pond SWMF located east of Terry Fox Drive, as a joint use facility for Terry Fox Drive and upstream development	Meets water quality control criteria. May be a challenge to maintain connection to floodplain embayment. Requires detailed design coordination with design of Richardson Ridge. This development is only at conceptual design stage. The single storm sewer required to carry flows to the SWMFs results in a relatively high roadway profile to maintain design cover
4	Series of smaller diameter storm sewers with multiple outlets and an Oil – Grit Separator on the outlet from each group of catchbasins	Meets water control criteria of the Carp River Subwatershed Study, provides opportunity to lower road profile, which in turn reduces floodplain impacts. Helps to meet geotechnical challenges (consolidation and settlement) Drainage areas are well within acceptable ranges for use of oil-grit separators.

The preferred solution for stormwater management within the Carp River floodplain utilizes a system of storm sewers, oil grit separators and enhanced swales to treat and convey roadway runoff to the Carp River. The design is illustrated in **Figure 9**.

Table 4 summarizes the drainage areas and the runoff generated from the 10-year and 100-year events calculated using the Rational Method and the City of Ottawa IDF curves.

LEGEND:

- OUTLINE OF CARP RIVER FLOODPLAIN
- PROPERTY BOUNDARY
- WATER COURSE
- GRASS SWALES
- OIL / GRIT SEPARATORS

FIGURE 9

STORMWATER MANAGEMENT STRATEGY CARP RIVER FLOODPLAIN

TERRY FOX DRIVE EXTENSION

RICHARDSON SIDE ROAD TO SECOND LINE ROAD STORMWATER MANAGEMENT REPORT

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Table 4: Summary of Oil Grit Separators along Carp River Floodplain

OGS	Station	Drainage Area	10-year peak flow (m3/s)	100-year Peak flow (m3/s)
1	12+100	1.93	0.75	1.09
2	12+480	2.16	0.90	1.31
3	12+715	2.02	0.84	1.23
4	12+950	1.92	0.80	1.16
5	13+200	1.89	0.78	1.15
6	13+435	7.58	3.14	4.60

OGS-1 will be a shared facility servicing a portion of the Broughton Lands subdivision and Terry Fox Drive. The remaining storm sewer outlets direct roadway runoff to oil grit separators and then to enhanced swales conveying treated runoff to the Carp River. This design takes advantage of natural low points along the ROW, minimizing construction requirements and environmental impacts. According to the MOE Stormwater Management Planning and Design Manual (2003), for swales with typical urban swale dimensions (0.75 bottom width, 2.5:1 side slopes and 0.5 m depth), the contributing area is generally limited to < 2 ha to maintain contact area between the water and the swale so that TSS removal is effective. The MOE recommend channel gradients of 0.5%, maximum allowable flow rates of 0.15 m3/s and maximum allowable velocity of 0.5 m/s. The design of grassed swales is based on MOE guidelines to achieve polishing benefits for water quality. The channels will be designed to ensure channel stability under a range of flows.

The road profile has been designed to provide small drainage areas to allow standard sized oil-grit separator units to adequately treat the runoff for oil-grit separators units 1 to 5. These drainage areas also meet the criteria put forth by the MOE for grassed swales. The obverts of the outlet of the storm sewers are deigned to be above the Carp River 10-year flood elevation, in accordance with the City of Ottawa design criterion. The drainage area of unit OGS-6 may require two units or one large, custom unit depending on runoff analysis to be completed during Detailed Design.

Consultation with the City identified Vortech units as the preferred hydrodynamic (oil grit)separators based on maintenance considerations. Each system is designed based on site size, site runoff coefficient, regional precipitation intensity distribution and anticipated pollutant characteristics. ”Typically Vortechs are designed to achieve an 80% annual solids load reduction based on lab generated performance curves for either 50 µm particles, or a particle gradation found in typical urban runoff” (Contech Stormwater Solutions, p. 2). The Vortech units will be designed so that the outlets are free flowing in a 10-year event, i.e., the obvert is not submerged. This meets City of Ottawa criteria. During flood events, when the obvert is submerged, the unit acts like a settling chamber rather than a hydrodynamic separator.

4.3 Storm Water Management - Shirley's Brook Subwatershed

4.3.1 Alternatives and Evaluation

The following section provides an overview of the existing, interim and ultimate hydrologic conditions of Shirley's Brook and its tributaries, which are impacted by the extension of Terry Fox Drive. The stormwater management strategy recommended for the Shirley's Brook subwatershed is a result of careful consideration of changes to the hydrologic conditions imposed on the drainage areas and the fact that portions of Shirley's Brook and its tributaries are identified as coldwater fisheries in the vicinity of the proposed roadway. Based on the receiving water sensitivity, 'Enhanced' water quality treatment with 80% long-term suspended solids removal is required.

Existing Shirley's Brook Hydrologic Conditions

The existing drainage areas associated with this section of Terry Fox Drive are shown in **Figure 2**. Under existing conditions, the catchment areas up and downstream of the proposed road corridor are heavily vegetated and display relatively mild topographic relief. Based on a review of available topographic mapping and aerial photographs, the hydrologic conditions can be described as having significant depression storage, particularly in catchment areas SB1, SB4 and SB5. The existing depression storage provides some flow attenuation as a result of topographic relief and the limited conveyance capacity of the intermittent channels connecting the swampy/pond areas. To assess the impact of the road development on Shirley's Brook and determine the requirements for stormwater quantity control, a hydrologic model of existing conditions was developed using Visual Otthymo v. 2.

A summary of the existing condition model, the existing condition hydrologic input parameters, model schematics, and model assumptions are summarized in **Appendix A** of this report.

Ultimate Shirley's Brook Hydrologic Conditions

Ultimately, future urban development and the expansion of Terry Fox Drive to four lanes will require significant modification to Shirley's Brook and its tributaries in order to maintain their function as natural watercourses. Under ultimate conditions one of the Shirley's Brook tributaries will be re-aligned along the north-westerly side of the proposed Terry Fox Drive corridor, cutting across the existing rail corridor, eventually connecting into the main branch of Shirley's Brook upstream of Terry Fox Drive. This concept is presented in the Shirley's Brook Position Paper prepared by Dillon in May 2003. This ultimate re-alignment the Shirley's Brook tributary results in significant changes to the configuration of the drainage areas upstream of Terry Fox Drive. To accommodate the ultimate drainage conditions the following drainage infrastructure components are required, including:

- One hydraulic crossing, CV-5 will be required to convey flows generated by the diverted drainage areas SB3, SB4, SB5, SB6 and SB7 and drainage area SB1 through the Terry Fox Drive corridor (this culvert will be constructed as part of the initial work in 2010).
- One hydraulic crossing, RC-1 will be required to convey flows generated by the diverted drainage areas SB3, SB4, SB5, SB6 and SB7 through the rail corridor just west of the Terry

Fox Drive corridor (this culvert is not required until the ultimate re-alignment is completed).

- The ultimate realignment will consist of approximately 1000m of Shirley's Brook tributary re-alignment to convey diverted flows from the previously described drainage areas to RC-1 and subsequently to CV-5.
- Major and minor system flows from the Terry Fox Drive corridor will be conveyed via the proposed roadway surface and storm sewers from drainage areas TFD1, TFD2 and TFD3 to the easterly side of the roadway corridor. Surface water runoff from the major and minor systems will discharge to a roadside swale that will convey runoff in a southerly direction toward the rail corridor (these measures will be constructed as part of the initial construction in 2010).

The ultimate alignment of Shirley's Brook, the drainage features and the modified drainage areas of Shirley's Brook associated with Terry Fox Drive are illustrated on **Figure 10**. To assess the hydrologic impact of the road development and diversion of drainage areas upstream of Terry Fox Drive the existing condition Visual Otthymo model was modified to reflect the ultimate condition. A summary of the ultimate condition model, the ultimate condition hydrologic input parameters, model schematic and model assumptions are summarized in **Appendix A**.

<u>Interim Shirley's Brook Hydrologic Conditions</u>

This section documents the changes proposed as part of the 2010 initial phase of construction. This construction will result in a number of interim Shirley's Brook hydrologic conditions. It is assumed that future urban development, expansion of Terry Fox Drive from 2 to 4 lanes and the ultimate re-alignment of Shirley's Brook will take place as part of the ultimate expansion of Terry Fox Drive to 4 lanes. Until that time, Shirley's Brook and its tributaries will continue to exist in their current arrangement of channels and intermittent overland flow routes. To accommodate the interim condition until such time as the Shirley's Brook re-alignment takes place the following drainage infrastructure components have been incorporated into the design of the roadway corridor:

- Two terrestrial crossings, TCV-2 and TCV-3, will be utilized to convey intermittent flow generated by SB6 and SB7 catchment areas. These culverts will remain as terrestrial crossings when catchment areas SB6 and SB7 are diverted to re-aligned Shirley's Brook.
- One hydraulic crossing, CV-6 will be required to convey existing Shirley's Brook tributary flows generated by drainage areas SB4 and SB5 from the north-westerly side of the roadway corridor to the south-easterly side of Terry Fox Drive, maintaining the flow path along the existing tributary alignment.
- Approximately 160m of Shirley's Brook tributary re-alignment will be required to relocate the existing channel from under the proposed roadway embankment to a location along the proposed right toe-of-slope from STA 14+900 to STA 15+060. The minor relocation is required to maintain connectivity of the tributary and convey flows from SB4, SB5, SB6, SB7 and SB8.
- Major and minor system flows from the Terry Fox Drive corridor will be conveyed via the proposed roadway surface and storm sewers from drainage areas TFD1, TFD2 and TFD3 to the easterly side of the roadway corridor. Surface water runoff from the major and minor systems will discharge into the existing Shirley's Brook tributary channel or a roadside swale that will convey runoff in a southerly direction toward the rail corridor.

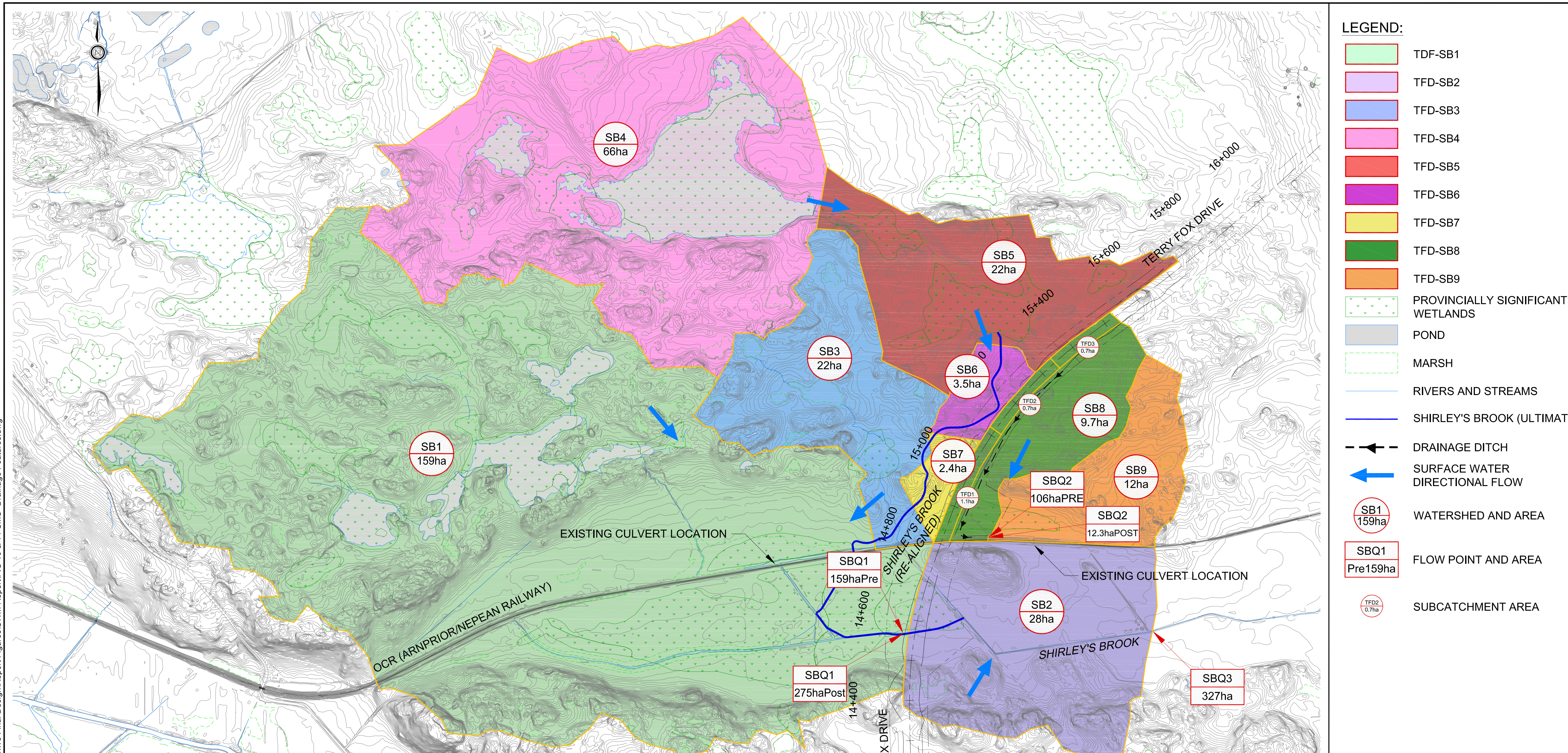

FIGURE 10
DRAINAGE FEATURES OF SHIRLEY'S BROOK (ULTIMATE CONDITION)

TERRY FOX DRIVE EXTENSION
RICHARDSON SIDE ROAD TO SECOND LINE ROAD
STORMWATER MANAGEMENT REPORT

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The interim hydrologic conditions, the drainage features and the modified drainage areas of Shirley's Brook associated with Terry Fox Drive are illustrated on **Figure 11**. To assess the hydrologic impact of the 2-lane roadway configuration and interim diversion of drainage areas along the easterly side of Terry Fox Drive the existing condition Visual Otthymo model was modified to reflect the interim condition. A summary of the interim condition model, the interim condition hydrologic input parameters, model schematic and model assumptions are summarized in **Appendix A**.

For each of the existing, interim and ultimate scenarios, peak flows were compared at the following locations:

- SBQ1 – Located at the existing Shirley's Brook crossing of the proposed Terry Fox Drive alignment (location of Culvert CV 5);
- SBQ2 – Located just upstream (north) of the rail corridor, this location is representative of the area directly impacted by interim and ultimate modifications to the Shirley's Brook drainage areas; and,
- SBQ3 – Located downstream (east) of Terry Fox Drive, this location is representative of total system flow from the area impacted by the proposed roadway extension.

The results of hydrologic modeling of this portion of the Shirley's Brook subwatershed are summarized in **Table 5** for the three flow reference locations noted above. The summary data also includes a comparison of projected flows at SBQ1 and SBQ2 between existing and interim/ultimate condtions.

Table 5: Summary of Existing, Interim and Ultimate Peak Flows (m^3/s) in Shirley's Brook

Return Period	SBQ1			SBQ2			SBQ3 – System			Difference in Peak Flows in Shirley's Brook – SBQ1/SBQ3			
										Existing Condition VS Interim Condition		Existing Condition VS Ultimate Condition	
	Existing	Interim	Ultimate	Existing	Interim	Ultimate	Existing	Interim	Ultimate	SQB1	SBQ2	SBQ1	SBQ2
2-year	0.255	0.255	0.424	0.184	0.206	0.232	0.557	0.561	0.561	0	+0.022	+0.169	+0.048
5-year	0.491	0.491	0.820	0.356	0.358	0.324	1.077	1.074	1.074	0	+0.002	+0.329	-0.032
10-year	0.682	0.682	1.142	0.495	0.494	0.387	1.495	1.486	1.486	0	-0.001	+0.460	-0.108
25-year	0.953	0.953	1.602	0.694	0.688	0.469	2.087	2.069	2.069	0	-0.006	+0.649	-0.225
50-year	1.162	1.162	1.958	0.848	0.838	0.528	2.541	2.516	2.516	0	-0.010	+0.796	-0.320
100-year	1.396	1.386	2.992	1.012	0.999	0.589	3.026	2.993	2.993	-0.010	-0.013	+1.596	-0.423

The following general observations can be made regarding the hydrologic conditions within the portion of the Shirley's Brook subwatershed that will be impacted by the extension of Terry Fox Drive.

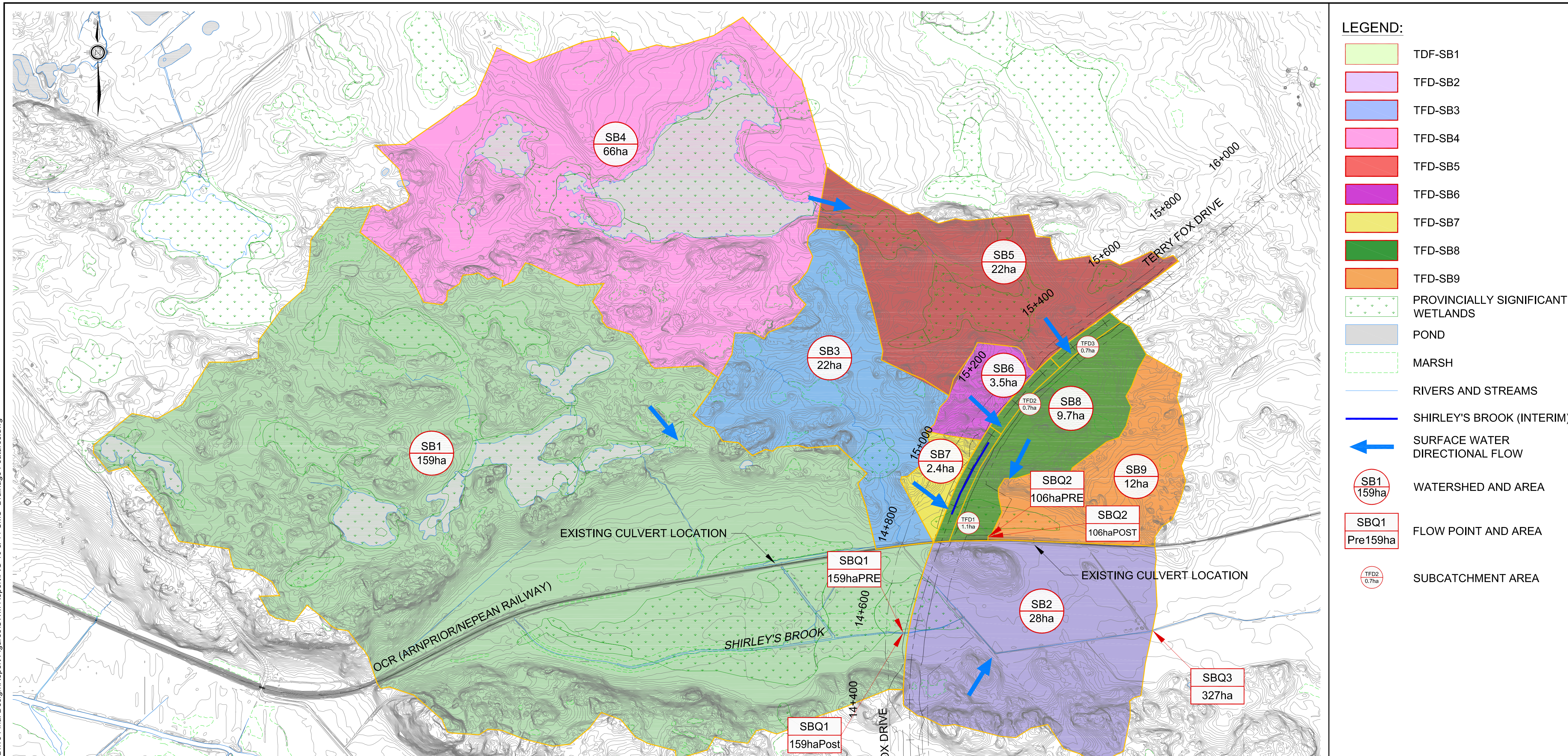

FIGURE 11

DRAINAGE FEATURES OF SHIRLEY'S BROOK (INTERIM CONDITION)

TERRY FOX DRIVE EXTENSION

RICHARDSON SIDE ROAD TO SECOND LINE ROAD
STORMWATER MANAGEMENT REPORT

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Interim Shirley's Brook Condition

- The interim 2-lane roadway configuration will maintain the existing drainage areas associated with SBQ1, therefore there are no projected changes to flows through the full range of design storms at that location.
- The interim 2-lane roadway configuration will result in negligible increases in peak flows for the 2 and 5-year design storm event and minor decreases in peak flows for the 10 through 100-year design storm events at SBQ2 and within the tributary area immediately upstream of the rail corridor. The changes in peak flows at SBQ2 are a result of changes in the hydrologic characteristics, increase in imperviousness and resultant time of concentration, of drainage areas TFD1, TFD2 and TFD3 over existing conditions.
- As noted in **Table 5**, there are no changes to the system flow-rates projected at SBQ3 for the full range of design storm events since the overall contributing drainage area upstream of the reference location is being maintained.

Ultimate Shirley's Brook Re-alignment

- The ultimate re-alignment of Shirley's Brook along the north-westerly side of Terry Fox Drive will result in significant increase in peak flows at SBQ1 and within the Shirley's Brook river reach immediately downstream of Terry Fox Drive. The increase in peak flows throughout a range of design storms at SBQ1 are a direct result of diverting runoff from drainage areas SB3-SB7 (additional 116 ha) via the re-aligned brook to the upstream side of Terry Fox Drive.
- The ultimate re-alignment of Shirley's Brook will result in significant decreases in peak flows at SBQ2 and within the tributary area immediately upstream of the rail corridor with exception to the 2-year design storm event. The decrease in peak flows throughout the 5 to100-year range of design storms at SBQ2 are a direct result of diverting runoff from drainage areas SB3-SB7 (diversion of 116 ha) via the re-aligned brook to the upstream side of Terry Fox Drive. Although the ultimate 4-lane configuration of Terry Fox Drive will result in increased imperviousness within the Terry Fox Drive road corridor the diversion of drainage areas results in a net reduction of peak flows and runoff volumes to the Shirley's Brook tributary.
- As noted in **Table 5**, there are no changes to the system flow-rates projected at SBQ3 for the full range of design storm events since the overall contributing drainage area upstream of the reference location is being maintained.

To further illustrate the hydrologic characteristics of the existing, ultimate and interim Shirley's Brook conditions the 10-year design flow hydrographs for SBQ2 are shown below **(Figure 12)**. The effect of increased levels of imperviousness within the Terry Fox Drive corridor for the interim 2-lane roadway configuration is illustrated by the graph. The higher runoff coefficient and short time of concentration cause a spike in peak flows, but the spike occurs prior to the time of concentration for the total contributing drainage area. As a result the peak flows for the existing and interim condition remain the same but the volumetric runoff increases as indicated by the increase area under the interim condition graph. The effect of diverting significant upstream drainage area contributions via re-aligned Shirley's Brook tributary is also illustrated by the graph. The higher runoff coefficient and short time of concentration cause a spike in the peak flow, but the overall peak is reduced significantly. The reduction in runoff volume is further illustrated by the significantly reduced area under the ultimate condition graph.

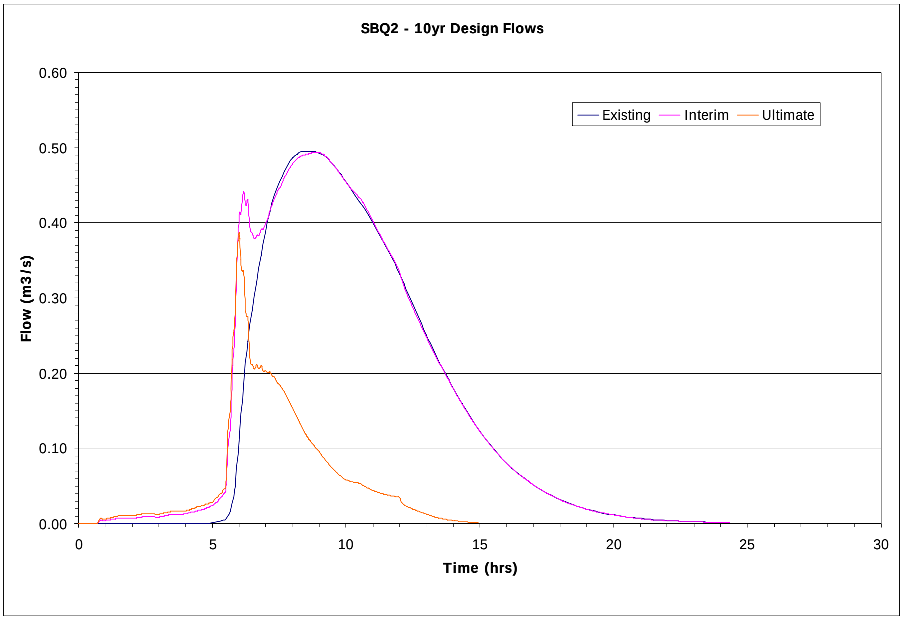


Figure 12: Existing, Interim and Ultimate Run-off Hydrographs (SBQ2)

Based on the results of the hydrologic analysis completed on the Shirley's Brook subwatershed area the following conclusions, regarding stormwater quantity control requirements, can be made:

- Although neither reference location SBQ1 or SBQ2 experience peak flow rate increases due to increased levels of imperviousness and reduced times of concentration of the drainage areas within the Terry Fox Drive corridor, it is recognized that flow rates will increase marginally over the initial period of time during a storm event. The example hydrograph previously illustrated shows elevated flow rates occurring from time zero to seven hours into the event during the 10-year design storm event. This minor increase in runoff rate results in additional runoff volume discharging to Shirley's Brook from the Terry Fox Drive corridor. Although the minor increase in runoff rate during the initial portion of the storm event is well below the overall peak flow rates generated by the drainage areas, the increase in runoff volume results in a need to provide some stormwater quantity control of runoff from the Terry Fox Drive corridor. Stormwater quantity management should target control of the minor increase in peak flow rate during the initial portion of the storm events for the ultimate and interim corridor conditions.
- The impacts of diverting approximately 116 ha of drainage area to SBQ1 via the ultimate re-alignment of the Shirley's Brook tributary to the upstream side of Terry Fox Drive has a significant impact on the peak flows at reference locations SBQ1 and SBQ2. Re-alignment of the Shirley's Brook tributary significantly increases overall peak flow rates at SBQ1 and significantly reduces overall peak flow rates at SBQ2. The increase in peak flow due to the diversion of drainage areas upstream of SBQ1 results in a need to either apply quantity control of flows upstream of the Terry Fox Drive corridor to reduce peaks or to increase the

conveyance capacity of the portion of Shirley's Brook channel between SBQ1 and SBQ3 to accommodate the projected increases in flows.

The stormwater management alternatives for the portion of Terry Fox Drive that falls within the Shirley's Brook subwatershed area have been developed considering the quality control objectives previously defined in **Section 4.0** of this report for the ultimate Shirley's Brook condition. Quantity control considerations have been developed based on the outcome of the hydrologic modeling previously described in this section and detailed in **Appendix A** of this report. The characteristics of the roadway and surrounding area imposed significant constraints on the applicability of certain types of stormwater management quality control techniques. Additional consideration must be given in order to satisfy the interim conditions imposed by the 2-lane roadway configuration and maintenance of Shirley's Brook tributary flows through the Terry Fox Drive corridor.

Based on design constraints a number of alternatives have been developed to address the stormwater management requirements for the Shirley's Brook subwatershed area. Each alternative was then evaluated based on technical effectiveness, feasibility, constructability, cost and long-term maintenance and operation requirements.

Alternative 1 – Do Nothing

With this alternative, this portion of Terry Fox Drive Phase would have no SWM quality or quantity control. The 'do nothing' alternative was rejected because of the many adverse impacts of not providing quality control of runoff generated by the Terry Fox Drive corridor. This approach is also not consistent with the Shirley's Brook subwatershed design criteria. The 'do nothing' alternative does not address interim stormwater management quality or quantity requirements for the interim 2-lane roadway configuration.

Alternative 2 – Wet Ponds at Right of Way Drainage Outlets

This concept was presented in the 2007 PDR and draft SWM report (referred to as SWMF 4a and 4b). However, given the small drainage areas of both 4a (2.1 ha) and 4b (3.7 ha), and the MOE recommendation of a minimum of 5 ha to sustain a wet pond, this alternative is not recommended. The sensitive nature of Shirley's Brook and the PSWs at both locations requires that some end-of–pipe treatment be applied. The reduced runoff potential from the interim 2-lane roadway configuration is not conducive of sustaining a wet pond configuration for both SWMF 4a and 4b.

Alternative 3 – Constructed/Improved Wetlands at 4a and 4b

The small drainage areas of related to the SWMF 4a and 4b identified in the 2007 PDR also restrict the feasibility of constructed wetlands. MOE recommends a minimum drainage area of 5 – 10 ha for these kinds of facilities. It is not feasible to meet the fore-bay design criteria for the small volumes generated by the drainage areas. Also, a constructed wetland would have direct impacts on the adjacent PSW. Enhancement of the existing wetlands was also considered, but construction activities could potentially cause significant disturbance to this important environmental feature. The reduced runoff potential from the interim 2-lane roadway configuration is not conducive of sustaining a wet pond configuration for both SWMF 4a and 4b.

Alternative 4 – Oil Grit Separators/Grassed Swales

This alternative utilizes oil-grit separators to provide quality control for the road drainage areas within the Shirley's Brook Subwatershed. The oil-grit separators will discharge flow into enhanced swales located adjacent to the roadway embankment. The enhanced swales will subsequently discharge to Shirley's Brook or the appropriate receiving watercourse. The swales will be designed to provide further quality control, targeting the minor increase in peak flows during the initial portion of design storms. Peak flow reduction will be achieved by providing storage of runoff within a wide flat bottom ditch arrangement with minimal longitudinal grade. Low gradient will help to keep velocities low during frequent storm events. Velocity control will help reduce downstream erosion potential in Shirley's Brook. This alternative can be configured to provide water quality and quantity measures that will meet the Subwatershed objectives for both the interim and ultimate configuration of Shirley's Brook and Terry Fox Drive.

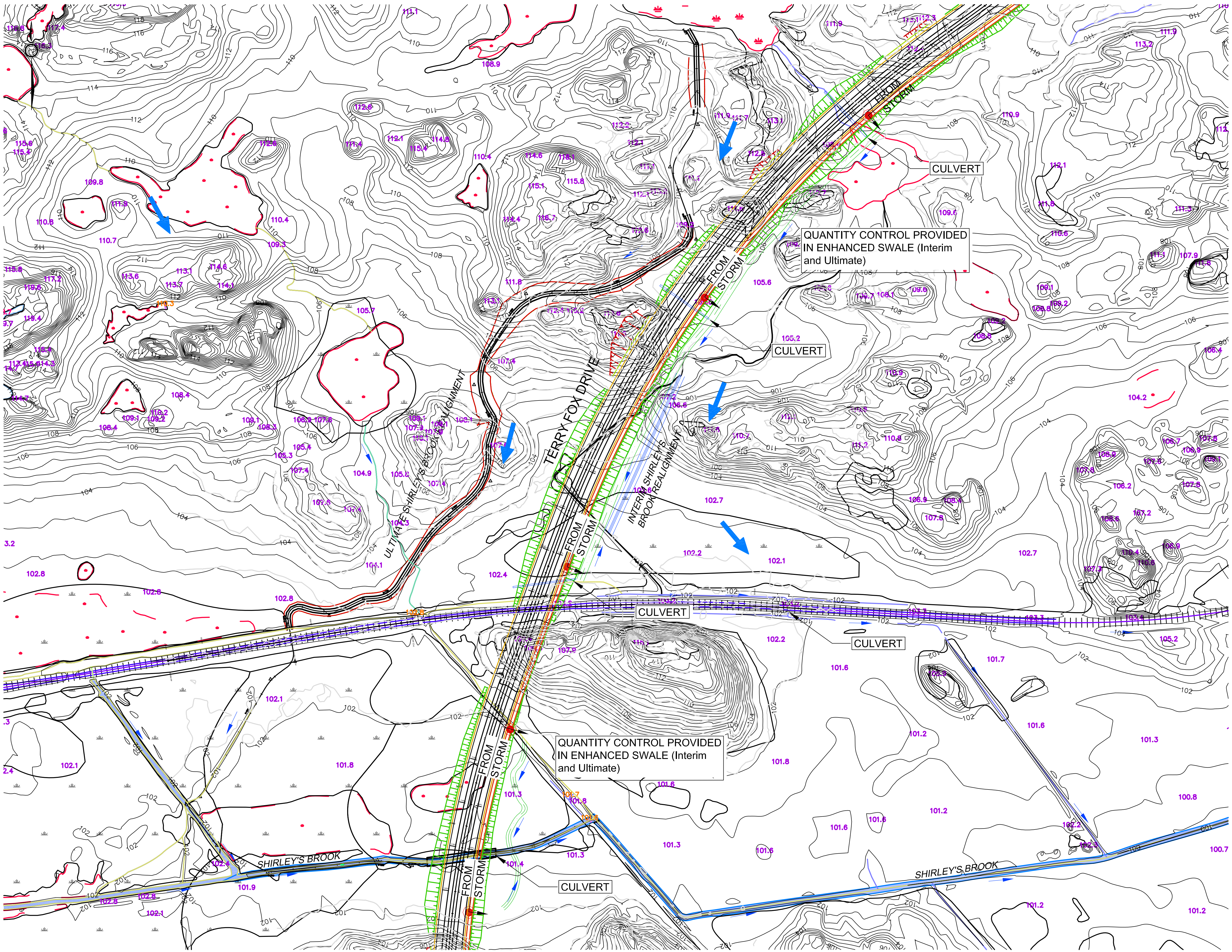
Table 6 summarizes the evaluation of the SWM alternatives for the portion of roadway within the Shirley's Brook Subwatershed.

Table 6: Evaluation of SWM Alternatives in Shirley's Brook Subwatershed

Alternative	Description	Evaluation
1	Do Nothing	Not an acceptable alternative as it does not meet study goals and design criteria
2	Wet Pond SWMF	Meets water quality and quantity control criteria. However, the contributing drainage areas are considered to be too small to maintain a wet pond according to MOE guidelines. The footprint of a wet pond impacts PSW and habitat for species at risk.
3	Constructed Wetland SWMF	Meets water quality and quantity control criteria Drainage areas are considered to be too small to maintain a wet component of the wetland, according to MOE guidelines The footprint of a wetland impacts PSW and habitat for species at risk.
4	Oil-Grit Separator and Enhanced Swales	Takes advantage of naturally existing features and minimizes impacts to significant wetland and habitat for species at risk. Meets water quality and quantity criteria.

4.3.2 Recommended Design Option – Shirley's Brook Subwatershed

The recommended SWM concept for the Shirley's Brook watershed consists of oil-grit separators servicing the Terry Fox Drive corridor drainage areas used in conjunction with enhanced swales. Quality control will be provided by the oil-grit separators and quantity control will be provided by the enhanced swales located adjacent to the Terry Fox Drive road embankment. Quality and quantity management of roadway runoff will permit discharges to the sensitive Shirley's Brook watercourses to maintain critical base flow and integrated with the surrounding wetlands. The preferred solution is shown on **Figure 13.**



LEGEND:

- ENHANCED SWALE
- WATER COURSE
- PROPERTY LIMITS
- TOE OF SLOPE
- SURFACE WATER DIRECTIONAL FLOW
- OIL / GRIT SEPARATORS
- PROVINCIALLY SIGNIFICANT WETLANDS

FIGURE 13
STORMWATER MANAGEMENT STRATEGY SHIRLEY'S BROOK

TERRY FOX DRIVE EXTENSION
RICHARDSON SIDE ROAD TO SECOND LINE ROAD STORMWATER MANAGEMENT REPORT - DRAFT

DILLON CONSULTING

DATE: DECEMBER 2009

SCALE: NTS

09-1518

23 December 2009 4:22:04 PM C:\Documents and Settings\30\dm\Local Settings\Temporary Internet Files\OLK4D\FIG 12 TFD - Shirley's Brook.dwg

Based on MOE Design Guidelines and the Shirley's Brook Subwatershed Study, the SWM solution should provide an 'Enhanced' level of protection for cold water habitat receiving waters and remove 80% of TSS. Field investigations in 2009 highlighted the significance of the area located adjacent Terry Fox Drive where the road crosses a forested swamp. The oil-grit separator design is based on annual sediment loading and can provide the enhanced protection required by the MOE. The enhanced swales provide additional polishing of runoff to protect this environmentally sensitive area.

Special Considerations

Although the Terry Fox Drive project includes the ultimate realignment of Shirley's Brook it is recognized that the interim 2-lane roadway configuration and existing Shirley's Brook alignment may exist for an extended period of time. The ultimate Shirley's Brook re-alignment will redirect SB3, SB4, SB5, SB6 and SB7 to SB1 upstream of Terry Fox Drive resulting in reduced flow at the existing 900 mm culvert crossing the rail corridor. The area upstream of the existing 900 mm culvert has been identified as an environmentally sensitive wetland feature.

As previously described and summarized in **Table 5** there are projected to be small increases in peak flows for the 2 and 5-year design storm and incremental increases in the projected flow rates during the initial portion of the storm events for all design storm events. Since the tributary of Shirley's Brook will be maintained in its existing position on the east side of the Terry Fox Drive corridor and re-aligned for approximately 160 m from STA 14+900 to 15+060, it may be difficult to incorporate a system of low-gradient flat bottom ditches into the roadway corridor.

Further consideration will be given to the final location and configuration of stormwater management quantity control measures within the portion of the Terry Fox Drive corridor upstream of SBQ2. Ideally a system of enhanced swales would be incorporated into the road cross-section that would be suitable to provide the required quantity control of runoff for both interim and ultimate condition. Interim conditions and conflicts with the location of the existing Shirley's Brook channel may require storage of surface water runoff within the roadway corridor in a system of drainage ditches located adjacent to the initial 2-lane road. The ditches within the roadway embankment could be designed to provide some storage for the 2 and 5-year design flows by controlling discharge to pre-development levels. These interim storage features would be located immediately upstream of TCV-2, TCV-3 and CV-6 and outlet through the minor storm sewer system. Ultimately these storage features would be eliminated even though peak flows from the TFD1, TFD2 and TFD3 drainage area increase under future conditions (addition of two lanes). The rail corridor ditch/channel system and culvert used to convey these flows to will not be adversely impacted by the change since the ultimate condition will see significant reductions in runoff rates due to the diversion of flows upstream of Terry Fox Drive.

Ultimately Shirley's Brook will be re-aligned shifting the convergence point of Shirley's Brook flows from the downstream side of Terry Fox Drive to the upstream side of the corridor resulting in the dramatic increase in peak flows noted in **Table 5**. Although quantity control could be achieved through the design of the Shirley's Brook Realignment upstream of Terry Fox Drive by altering the configuration of the existing wetland, this approach should only be taken if development of the lands east of Terry Fox Drive does not take place. If the lands east of the corridor are developed the portion of Shirley's Brook east of Terry Fox Drive will be re-aligned to a suitable location along the rail corridor. Rather than providing quantity control for increased Shirley's Brook flows upstream of Terry Fox Drive, it is recommended that the conveyance capacity of the brook be increased from SBQ1 to SBQ3. Beyond SBQ3 the projected system flow rates remain the same for the ultimate conditions within the subwatershed as noted in **Table 5**.