5.2 Groundwater

5.2.1 Rationale for Selection as Valued Environmental Component

Groundwater was selected as a VEC because of its potential importance to the water supply of residents, and because of its relationship with surface water conditions. Some residents have noted the potential for the proposed Project to affect groundwater extraction or transmission from areas that would be intercepted by the proposed alignment. The potential for the disruption or contamination of the groundwater drinking supply for nearby residents therefore requires assessment. Water contaminants include a wide variety of inorganic and organic substances including road salt, as well as physical properties such as silt load and water temperature.

The potential environmental effects of the Project activities on Groundwater resulting from construction and operation, as well as malfunctions, accidents or unplanned events, specifically the accidental spillage of oil or fuel from vehicles, or hazardous cargos from trucks are assessed.

5.2.2 Environmental Assessment Boundaries

5.2.2.1 Spatial and Temporal

The spatial boundaries for the Project include the proposed RoW and the area of influence beyond the boundaries of the proposed RoW. The area of influence or capture area of a typical low yield domestic water well for highway-related potential environmental effects is usually less than about 100 m, and generally where the well is hydraulically downgradient of the proposed RoW. Project related contamination (*i.e.*, road salt) within this capture area could potentially affect well water quality. Vibration damage to a drilled or dug well is generally a function of distance between the energy source and well, and seismic properties of the aquifer materials. With respect to rock type, risk is greater for fractured crystalline bedrock than for overburden wells or sandstone wells. Risk from blasting or major excavation is greatest within 50 m, moderate from 50 to 200 m, and expected to be minimal beyond about 200 m. The assessment boundaries with regard to potential groundwater interactions depend on the type of work being done. Blasting effects are considered for drilled wells within 500 m on both sides of the proposed RoW in those areas found to require blasting for excavation. Potential environmental effects of accidental spills are considered within 500 m hydraulically down-gradient of the proposed RoW assuming highly permeable media (*i.e.*, sand and gravel aquifers), or mineralized bedrock. Road salting environmental effects are considered for all wells located hydraulically downgradient of the proposed alignment.

With respect to temporal boundaries, most physical and chemical environmental effects on groundwater resources are likely to be temporary and to occur during the construction phase. Residual environmental effects from road de-icing materials could occur throughout the operation phase of the Project. Potential accidents due to spills could occur in both phases of the Project. The temporal boundaries of the Project include the construction period as well as operation of the Project in perpetuity.

5.2.2.2 Administrative and Technical

Water quality is protected through federal and provincial legislation and guidelines. Baseline information for this assessment included available well driller's reports and water chemistry results for wells in the area, as provided by NBDELG from their water well database. A technical boundary for this assessment is that a well water inventory was not undertaken for this study. A residential well water survey will, however, be conducted of wells within 500 m of a blasting area prior to implementing blasting operations in specific areas at risk, or major excavations requiring de-watering, so that appropriate mitigation or compensation can be implemented in the event of an unforeseen environmental effect.

5.2.3 Residual Environmental Effects Rating Criteria

A *significant residual environmental effect* is defined as a Project-related environmental effect that degrades the quality of groundwater resources by exceeding the maximum acceptable concentrations of one or more parameters as specified in the *Guidelines for Canadian Drinking Water Quality* (GCDWQ) for potable domestic water supplies (Health Canada 2003) for a period of more than 30 days. In the event that concentrations of a parameter currently exceed the GCDWQ, any Project-related increase in the parameter concentration is considered significant. A Project effect that reduces the quantity of groundwater recoverable from the aquifer on a sustainable basis to meet present and future needs of current users is also considered significant.

5.2.4 Existing Conditions

This section describes the existing conditions associated with groundwater in the area, including geology, hydrogeology, and groundwater use. These conditions reflect the combined environmental effects of all existing projects and land uses.

5.2.4.1 Physiography and Drainage

Perth-Andover to Woodstock falls into the Chaleur Uplands physiographic division. The Chaleur Uplands comprises a slightly undulating peneplain, varying in elevation between 244 and 305 m. Swampy plains and occasional lakes characterize the uplands, interspersed with eroded valleys and by intervening ridges and peaks, some of which attain elevations in excess of 600 m.

The primary drainage feature within the zone of influence of the Project is the Saint John River and its tributaries. Surface runoff will directly or indirectly discharge to the Saint John River. Groundwater flow is anticipated to follow regional surface topography, towards the Saint John River and/or one of its tributaries.

5.2.4.2 Surficial Geology

Surficial geology of Perth-Andover to Woodstock generally consists of blanket (0.5 to 3 m thick) and veneer (discontinuous over rock, less than 0.5 m thick) lodgement and ablation till. This till often reflects the composition of the underlying bedrock, with silty deposits predominating in areas of sandstone or conglomerates.

Gravel deposits are found in most of the major beds and valley floors within the region. Meltwaters from retreating glaciers brought large quantities of sand and gravel into the main Saint John River Valley and its major tributaries. These deposits are considered to be of local importance for their reserve of available groundwater and for granular resources.

Other Quaternary deposits, including ice-contact stratified materials, glaciofluvial outwash, and post-glacial alluvial terraces may also be found within the zone of influence of the Project. However, the extent of these deposits is poorly defined.

5.2.4.3 Bedrock Geology

The local geology is predominantly highly folded calcareous and argillaceous sedimentary rocks and slates, sandstones and conglomerates of Silurian and/or Ordovician age. A small number of faults are positioned as to intersect the proposed alignment. The faults have been identified in the area of the proposed alignment at Perth-Andover, at the area of the existing on/off ramps; just south of where the proposed alignment crosses Price Brook; and at Upper Woodstock, where the proposed alignment crosses Guisiguit Brook.

5.2.4.4 Hydrogeology

In general, the outwash channel and terrace deposits located along the Saint John River are the most important aquifers in the region. These deposits are supplying water to the municipal systems in Woodstock and Hartland, and Bath. About 60 percent of the wells developed in these units have yields between 0.8 and 2 L/s, while 10 percent of the wells yield greater than 4 L/s. Maximum recorded yield is in the order of 100 L/s (NBDOE 1980). The water quality from these unconsolidated glacial deposits is considered to be very good. However, with the exception of approximately 300 m of proposed alignment near Woodstock, the RoW does not intercept these units.

Based on hydrogeological mapping (NBDOE 1980), the proposed alignment may also intercept Quaternary granular deposits in the vicinity of Bryson Brook (less than 1 km of the alignment) and in Waterville (approximately 2 km of alignment). These deposits are typically limited in extent, although large yields may be found locally.

The hydrogeologic units underlying the majority of the proposed alignment between Perth-Andover and Woodstock consist of bedrock in which the groundwater reservoir is relatively small. Within these units, groundwater is confined to fractures and cleavage within the rock. The average well yield in these units is 0.9 L/s (NBDOE 1980). Sufficient water is usually found for domestic water systems, but yields from these bedrock aquifers are not large enough to support major municipal or industrial water supplies.

Overall, the water quality from the bedrock within the zone of influence of the Project can be described as good. The water is generally found to be hard to very hard due to the calcium associated with the bedrock. Nitrate concentrations on occasion have been found to be above background levels in private wells within the farming districts due to agricultural practices.

5.2.4.5 Municipal Water Supplies

The municipalities of Perth-Andover, Bath, Hartland, and Woodstock rely on groundwater for part or all of their water supply. However, the proposed alignment between Perth-Andover and Woodstock is not within 500 m of the municipal wells. Currently, although wellfield protection studies have been completed or are in progress, none of these communities have received designation under the *Wellfield Protected Area Designation Order – Clean Environment Act* (NBDELG 2003b). Once designated, highways may not be constructed within Zone A of the wellfield protected area (*i.e.*, within 100 to 250 days groundwater travel time of the well). The proposed alignment does not intersect the proposed Zone A protected areas of any of the wellfields.

Based on information provided by the municipalities, the proposed alignment does not intersect any existing water distribution lines.

5.2.4.6 Private Water Wells

The proposed alignment passes through predominantly rural settings. Residential water supplies outside of the municipalities noted in Section 5.2.4.5 are provided by individual on-site dug or drilled wells. Approximately 340 properties have been identified as potentially having a private well. For identification purposes, all properties with a building within 500 m of the proposed alignment were assumed to have an on-site well. The majority of these properties are located near roads that are crossed by the proposed alignment, as indicated on Figure 3.2.

Currently, approximately 25 properties with wells have been purchased by NBDOT and the on-site wells decommissioned, pursuant to Section 27 *Water Well Regulation* under the *Clean Water Act*. Each of the wells was filled and sealed in a manner sufficient to prevent both the entry of surface water and the intermixing of groundwater from different aquifers. Should additional domestic wells be encountered during construction, they will be decommissioned as per the NBDELG *Guidelines for Decommissioning of Wells*.

The NBDELG provided Well Driller's Reports and water chemistry data from its database for water wells drilled within the zone of influence of the Project. Construction information for six wells was provided by the NBDELG, and is summarized in Table 5.2.1. In general, the wells were drilled to moderate depths, and provided moderate yields. In most of the wells, bedrock was encountered at shallow depths and the casing length met the minimum requirement (*i.e.,* 6 m).

Table 5.2.1 Summary of Water Well Constructions within 500 m of the RoW

PID	Casing Length (m)	Well Depth (m)	Yield (L/s)	Depth to Bedrock (m)
10178648	na	35.1	0.34	2.4
10134914	5.8	59.4	0.53	1.8
10139434	6.1	41.1	0.53	4.3
10043362	12.2	47.2	0.76	10.7
10224731	6.1	44.2	1.14	2.7
10064723	6.1	93.0	0.53	0.3
Minimum	5.8	35.1	0.34	0.3
Maximum	12.2	93.0	1.14	10.7
Mean	7.3	53.3	0.64	3.7

Water chemistry results were available from three wells as summarized in Table 5.2.2. The results are consistent with earlier reports that indicated the groundwater in the area is relatively hard, and suggest that all three samples were obtained from the bedrock aquifers.

In two of the samples, the concentration of nitrate/nitrite was at or near the guideline for Canadian drinking water (Health Canada 2003). Guidelines for nitrate and nitrite are based on potential human health effects.

Table 5.2.2 Well Water Chemistry

	Units	CDWQ[1]	Samples		
Aluminum	mg/L	0.1	0.009	< 0.03	< 0.025
Alkalinity	mg/L	-	204	200	170
Antimony	ug/L	6	2.6	< 1	< 1
Arsenic	ug/L	25	7.3	< 1	< 1
Barium	mg/L	1	0.078	0.067	< 0.01
Boron	ug/L	5000	0.01	0.011	< 0.2

Table 5.2.2 Well Water Chemistry

	Units	CDWQ[1]	Samples		
Cadmium	ug/L	5	-	< 0.1	< 0.5
Calcium	mg/L	-	115.88	112	71.8
Chloride	mg/L	250	78.96	59.6	10.8
Chromium	ug/L	50	-	-	15
Conductivity	µSIE/cm	-	767	732	378
Copper	ug/L	1000	1	2	< 10
Fluoride	mg/L	1.5	0.09	0.024	< 0.1
Hardness (as $CaCO_3$)	mg/L	-	333.9	324.5	197.8
Iron	mg/L	0.3	0.031	< 0.001	0.019
Lead	ug/L	10	< 1	1.4	< 1
Magnesium	mg/L	-	10.81	10.9	4.5
Manganese	mg/L	0.05	< 0.01	0.001	< 0.01
NO_2 (as N)	mg/L	3.2	< 0.05	<0.05	< 0.05
NO_3 (as N)	mg/L	10	10	**10.85**	1.32
NO_X (as N)	mg/L	10	10	**10.9**	1.37
pH		6.5 - 8.5	7.79	7.8	7.65
Potassium	mg/L	-	2.52	2.52	0.241
Selenium	ug/L	10	-	-	< 1
Sodium	mg/L	-	23.05	19.6	3.3
Sulfate	mg/L	500	40.68	40.5	8.87
Titanium	ug/L	-	0	< 1	< 1
Turbidity	NTU	1	0.1	0	0.4
Zinc	ug/L	5000	11	14	22
Total Coliforms	P/A[2]	0	**P**	A	**P**
E. coli	P/A	0	A	A	A

Notes:
[1] CDWQ = Canadian Drinking Water Quality Guidelines (Health Canada 2003)
[2] P/A = Presence/Absence
BOLD = parameter exceeds CDWQ
'-' = value not available

Total coliform were present in two of the three well water samples. Total coliform are considered to be an indicator of the overall water quality. The guideline for total coliform is based on health considerations. In well water, the presence of total coliform in the absence of E. coli is an indicator that the well is prone to surface water infiltration and therefore at risk of contamination from the surface.

The concentration of chloride in two of the three samples was relatively high (*i.e.*, > 50 mg/L) compared to typical concentrations in Canadian drinking water of 10 mg/L (Health Canada 1996). However, all concentrations were less than the guideline for Canadian drinking water (Health Canada 2003). These concentrations may be the result of local geological conditions, or may reflect environmental effects from winter road salt storage and/or application by the property owner or an adjacent landowner. The guideline for chloride concentrations in drinking water is based on aesthetic objectives (*i.e.*, taste, corrosion of pipes).

5.2.4.7 Potentially Contaminating Land Uses

Based on available NBDELG records, three abandoned dumpsites are located within 500 m of the proposed RoW.

One dumpsite (PID No. 65053217) is located in Perth-Andover, approximately 400 m to the east of the proposed alignment. From 1940 to 1950, the site operated as an open municipal dump with burning. Although the site has since been covered with soil, the disposal area of this dumpsite reportedly covered 1.5 hectares. The general soil type at this dumpsite is described as gravel/clay. As the site is located between the proposed alignment and the Saint John River, it is considered to be downgradient of the proposed alignment. NBDELG records indicate that this site is being monitored. Since this site is being monitored and is located 400 m downgradient of the proposed RoW, mitigation during construction of the proposed TCH would not be required.

The second abandoned dumpsite (PID No. 10064343 and 10090546) is located on the A. Brown Road in Summerfield, approximately 100 m from the proposed RoW. This site is owned by NBDOT and operated from the early 1970's until its closure in 1994. The dumpsite is located on a side hill. Reportedly, the disposal area covered 0.37 hectares and was an open trench municipal dump with burning. The general soil type at this dumpsite is gravelly sandy silt with some clay. Surface and groundwater from the properties would be expected to flow to the north, following topography towards the Lower Guisiguit Brook, approximately 140 m from the dump site. The NBDELG has completed assessment and long term monitoring of this site, and considers the closure work to be 99 percent complete (M. Barner, pers. comm. 2003). As a result, mitigation during construction of the proposed TCH would not be required.

A third dumpsite (PID No. 10224301) is located in Florenceville, approximately 300 m from the eastern ramp alignment of the Dump Road crossing. From 1957 to 1969, the site was operated as an open municipal dump with burning. The disposal area of this dumpsite reportedly covered 31.5 hectares. A recent assessment (Craig Hydrogeologic 2003) indicates that groundwater and surface water drainage at the site are anticipated to be to the west, towards the proposed alignment. Based on discussions with the NBDELG (A. Spencer, pers. comm., 2003), additional work would typically be required for a site of this type; however, as the site is now privately owned, a timeframe for completing additional site investigations and improvements could not be provided. There has been no groundwater sampling completed at the site, nor was a water sample collected from a domestic well-located 100 m downgradient of the dumpsite. A small watercourse, located between the eastern ramp alignment and the dumpsite, is expected to provide a hydrologic barrier, and hence interaction between the Project and surface drainage from the dumpsite is not anticipated. As the Project alignment in the vicinity of the eastern ramp is located in a large fill, interaction with groundwater originating from the dumpsite is not anticipated.

5.2.5 Environmental Effects Analysis

5.2.5.1 Project-VEC Interactions

This section evaluates the potential for Project-related activities to affect groundwater quality and/or quantity. Table 5.2.3 provides a summary of the potential environmental effects resulting from the Project-VEC interactions.

Table 5.2.3 Project Activity – Environmental Effects Interaction Matrix for Groundwater

Potential Interactions Between Project Activities and Environmental Effects **Valued Environmental Component: <u>GROUNDWATER</u>**		
Project Activities and Physical Works (see Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effect**	
	Change in Groundwater Quality	**Change in Groundwater Quantity**
Construction		
Site Preparation	✓	✓
Roadbed Preparation	✓	✓
Surfacing and Finishing	✓	
Watercourse Crossing Structures	✓	✓
Ancillary Structures and Facilities Construction	✓	
Operation		
Winter Safety	✓	
Proposed TCH Presence	✓	✓
Maintenance		
Proposed Maintenance	✓	
Vegetation and Wildlife Management		✓
Accidents, Malfunctions and Unplanned Events		
Hazardous Material Spills	✓	

5.2.5.1.1 Construction

Construction activities that have the potential to affect groundwater quality and/or groundwater quantity include:

- clearing, grubbing and stripping of vegetation during site preparation;
- blasting and major excavations associated with roadbed preparation and site preparation for watercourse crossings and bridge construction; and
- surfacing and temporary ancillary facilities which involve the application and mixing of asphalt.

The clearing, grubbing and stripping of vegetation may lead to increased surface runoff, since there is no vegetation to intercept precipitation or impede the flow of water. Surface runoff from cleared and grubbed areas typically contains sediments. Shallow wells and springs, which are more susceptible to direct surface water influence, could experience an increase in turbidity if exposed to this runoff. As well, increasing the amount of surface runoff reduces the amount of infiltration into the ground, thereby decreasing the amount of groundwater recharge.

Blasting activities are commonly the cause of complaint from well owners. The major complaints of changes in well water quality include increased turbidity, discoloured water, and nitrate and/or coliform contamination due to damage of casing seal. The major complaints for changes in well water production capacity include loss of quantity production, air in water and/or water lines, damage to pump, and damage to well screen or borehole.

Major excavations associated with cut-and-fill operations during roadbed preparations and watercourse crossings have the potential to affect groundwater quantity and/or quality in nearby or down-gradient shallow water wells. Typical complaints are temporary increases in turbidity and decreased yield or "dry" wells due to a lowering in the water table.

Runoff during paving operations and from asphalt plant locations may contain dissolved hydrocarbons. At least part of this runoff will infiltrate the ground, introducing dissolved contaminants into the groundwater flow system. Vibrations from equipment have also been reported to environmentally effect water wells in close proximity, generally resulting in temporary increases in turbidity.

5.2.5.1.2 Operation

Operation of the highway has the potential to affect groundwater quality and/or groundwater quantity by:

- affecting local groundwater quality due to dissolved contaminants in runoff from the highway;
- lowering of the water table due to ditching, cutting, and grading; and
- reducing groundwater recharge due to the increase in impervious surface area and changes in drainage patterns.

Runoff from roads and highways may contain contaminants such as lubricants, coolants, vehicle deposits, and road salt (US EPA 1996). Some runoff may infiltrate into the ground, introducing dissolved contaminants into the groundwater system. As road salt is applied directly to the road surface, its potential to affect the groundwater system is considered to be substantially higher than other potential contaminants whose origins are vehicle-related.

Impervious materials, such as asphalt, prevent the infiltration of precipitation into the ground, thereby reducing the amount of groundwater recharge. Similarly, ditching and cutting modify local drainage patterns, thereby reducing groundwater recharge and potentially resulting in a local lowering of the water table.

5.2.5.1.3 Maintenance

Runoff during paving operations may contain dissolved hydrocarbons. At least part of this runoff will infiltrate into the ground, introducing dissolved contaminants into the groundwater flow system. Vibrations from equipment have also been reported to affect water wells in close proximity, generally resulting in temporary increases in turbidity.

Since NBDOT uses mechanical means to maintain vegetation control, ongoing maintenance of vegetation is not expected to affect groundwater quality. However, the removal of vegetation will reduce the amount of precipitation that is intercepted, thereby increasing runoff. This could result in a local reduction in groundwater recharge and a lowering of the water table.

5.2.5.1.4 Accidents, Malfunctions and Unplanned Events

Malfunctions and accidents that could potentially affect groundwater quality include fuel spills, resulting in hydrocarbon contamination of downgradient aquifers. Also, the accidental releases of blasting chemicals (such as ammonia, nitrates, and fuel oil) directly into the groundwater are considered.

5.2.5.2 Environmental Effects Analysis and Mitigation

The criteria for characterizing the magnitude of environmental effects are described in the key for each phase of the Project. The criteria for characterizing the geographic extent of environmental effects are as follows:

- < 1 km^2 (includes the area within a 100 m radius of a typical low yield domestic well);
- 1-10 km^2 (includes the area within a 500 m radius of a single well);
- 10-50 km^2 (includes the area within 500 m downgradient of the RoW);
- 50-100 km^2 (includes the area within 500 m either side of the RoW); and
- > 100 km^2 (includes the area outside of the Assessment Area).

5.2.5.2.1 Construction

During construction of the proposed TCH and associated roads and structures, several activities could result in a change in groundwater quality or quantity. These include grubbing and stripping of vegetation during site preparation; blasting and major excavations associated with roadbed preparation and site preparation for watercourse crossings and bridge construction; and surfacing and temporary ancillary facilities which involve the application and mixing of asphalt. The sections following Table 5.2.4 evaluate the potential residual environmental effects resulting from the interaction between construction activities and groundwater, and proposed mitigative strategies.

Table 5.2.4 Environmental Effects Assessment Matrix for Groundwater (Construction)

Environmental Effects Assessment Matrix
Valued Environmental Component: GROUNDWATER
Phase: Construction

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Site Preparation	Change in groundwater quality (A)	• Erosion and sediment control measures will be taken to reduce surface runoff	2	3	1/1	R	2
	Change in groundwater quantity (A)	• Erosion and sediment control measures will be taken to reduce surface runoff	1	4	1/1	R	2
Roadbed Preparation	Change in groundwater quality (A)	• Preblast well surveys • Ripping instead of blasting near residential areas • Erosion control (EPP, EFG) • Remedial action as necessary to restore damaged wells and provide temporary potable water as needed	2	3	1/1	R	2
	Change in groundwater quantity (A)	• Preblast well surveys • Ripping instead of blasting near residential areas • Erosion control (EPP, EFG) • Minimize water table lowering • Remedial action as necessary to restore damaged wells and provide temporary potable water as needed	1	4	1/1	R	2
Surfacing and Finishing	Change in groundwater quality (A)	• Erosion and sediment control measures will be taken to reduce surface runoff as required	1	3	1/1	R	2

Table 5.2.4 Environmental Effects Assessment Matrix for Groundwater (Construction)

Environmental Effects Assessment Matrix
Valued Environmental Component: GROUNDWATER
Phase: Construction

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Watercourse Crossing Structures	Change in groundwater quality (A)	• Preblast well surveys • Ripping instead of blasting near residential areas • Minimize water table lowering • Remedial action as necessary to restore damaged wells and provide temporary potable water as needed	2	3	1/1	R	2
	Change in groundwater quantity (A)	• Preblast well surveys • Ripping instead of blasting near residential areas • Minimize water table lowering • Remedial action as necessary to restore damaged wells and provide temporary potable water as needed	1	4	1/1	R	2
Ancillary Structures and Facilities Construction	Change in groundwater quality (A)	• Managed site, as per EPP and EFG, and any other applicable permits or regulations	1	3	1/1	R	2

Key:

Magnitude:
1 = Low: *e.g.,* affecting the available quantity or quality of groundwater resources in the shallow or deep aquifer, such that these resources are either unavailable or unusable at levels that are indiscernible from natural variation
2 = Medium: *e.g.,* limiting the available quantity or quality of groundwater resources, such that these resources are occasionally rendered unusable to current users for periods up to two weeks at a time
3 = High: *e.g.,* limiting the available quantity and quality of groundwater resources, such that these resources are rendered unusable or unavailable for current users during the life of the Project

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10-50 km^2
4 = 50 – 100 km^2
5 = > 100 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 - 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Site Preparation

Clearing and Grubbing

Clearing, grubbing and stripping activities associated with site preparations will decrease interception of precipitation by vegetation and increase runoff in these areas, which would result in a reduction of groundwater recharge (*i.e.*, a decrease in groundwater quantity) and an increase in water turbidity within shallow wells and springs.

Erosion from grubbed and stripped areas is only a concern to shallow dug wells and springs in very close proximity to the proposed RoW (*i.e.*, a few tens of metres) and where direct overland flow of silt occurs. Potable springs have not been identified close to the proposed RoW and, based on the surficial geology mapping, the overburden materials along the majority of the proposed alignment are expected to be relatively shallow (*i.e.*, less than 3 m) reducing the potential for shallow dug wells. Environmental effects to surface watercourses by uncontrolled erosion are a more important concern (refer to Section 5.2.4).

Erosion control systems will be in place to manage runoff from the construction areas, minimizing the amount of runoff that occurs. Several generic measures that can be taken to prevent sedimentation and minimize erosion potential include: fitting the development to the terrain; construction sequencing to minimize soil exposure; retaining existing vegetation as long as possible; vegetation and mulching of denuded areas; diverting runoff away from denuded areas; minimizing length and steepness of slopes; keeping runoff velocities low; properly sizing and protecting drainage ways and outlets; intercepting sediments on site; and inspecting and maintaining control measures. Erosion control measures are identified in the EPP (Section 4) and EFG (Sections 4.2, 4.3) and are expected to include erosion control fencing, check dams, use of mulch (possibly from shrubs and trees removed during clearing) and, if necessary, sedimentation control ponds. As these erosion control measures also slow the transport of surface runoff, they will also increase the potential for localized infiltration to groundwater.

Roadbed Preparation and Watercourse Crossing Structures

Blasting and Excavations

Blasting can cause environmental effects in adjacent wells ranging from minor temporary turbidity to rare complete collapse of the well. The severity of the environmental effect is proportional to distance, physical and seismic properties of the bedrock being excavated, age and construction method of the well, well yield, and blast magnitude. Most of the proposed alignment avoids populated areas; however, a number of properties with the potential for on-site wells have been identified. Ripping techniques will be used where possible in lieu of blasting, in proximity to residential water wells.

Major excavations through tills could lead to a drop in groundwater table elevations in proximity to the cut. The degree of water level lowering will be proportional to the depth of the cut below the natural water table level, the distance between the well and the cut, and the hydraulic properties of the overburden materials (*i.e.*, larger and faster decline in higher permeability media). Dug wells near the edge of a cut could suffer sufficient water level decline to become dry. Drilled wells are not likely to be adversely affected by overburden cuts.

The time required to keep excavations open will be minimized during construction. Any dug wells located within 50 m of a major highway cut or overpass will therefore be inspected, measured for water level and depth, and inventoried for possible future reference. If the quantity or quality of water is affected in the individual wells, remedial action will be implemented (*e.g.*, temporary water supply, provision of new deep well). Based on the hydrogeology within the zone of influence of the Project, it is anticipated that most of the water wells in close proximity to the proposed alignment are completed in bedrock and hence are unlikely to be noticeably affected by large excavations.

Surfacing and Ancillary Structures

Runoff from paving areas may contain dissolved hydrocarbons, and vibration from equipment may cause temporary increases in turbidity in adjacent wells. However, the concentration of dissolved hydrocarbons in any runoff from these areas is expected to be at trace levels. Proper staging of the paving (*e.g.*, dry weather application, drainage controls as required, paving of the roadway in sections) and vibration controls will minimize any potential impacts.

Based on consideration of the potential environmental effects of the individual activities associated with the construction phase of the Project, the proposed mitigation (*e.g.*, EPP and EFG), and the residual environmental effects criteria, the environmental effects on Groundwater by these activities are considered not significant.

5.2.5.2.2 Operation

The following provides an evaluation of key potential Project-VEC interactions for the operation phase of the Project as summarized in the environmental effects assessment matrix (Table 5.2.5). Operation of the Project will continue in perpetuity upon completion of the construction phase of the Project.

The main potential adverse environmental effect on Groundwater during the operation and maintenance phase of the Project is change in groundwater quality due to road-runoff. Although there are a number of potential contaminants in road runoff (*e.g.*, lubricants, coolants, vehicle deposits), road salt is considered to have the greatest potential to affect groundwater quality. During winter, salt is used by NBDOT on road surfaces to aid in melting snow, and to provide clear road conditions. Road salt can enter into the environment (surface water, groundwater and soil) through storage and application of these salts. The highest concentrations are usually associated with winter and spring thaws. Environment Canada has concluded that "road salts that contain inorganic chloride salts with or without ferrocyanide salts are "toxic" as defined in Section 64 of CEPA" (Environment Canada 2001c).

Table 5.2.5 Environmental Effects Assessment Matrix for Groundwater (Operation)

Environmental Effects Assessment Matrix
Valued Environmental Component: GROUNDWATER
Phase: Operation

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Winter Safety	Change in groundwater quality (A)	• Proper salt management • Apply drainage controls • Remedial action as necessary to restore damaged wells and provide temporary potable water as needed	1	1-3	1/3	R	2
Proposed TCH Presence	Change in groundwater quality (A)	• Minimize extent of clearing	1	3	1/6	R	2
	Change in groundwater quantity (A)	• Minimize extent of clearing	1	4	1/6	R	2

Key:

Magnitude:
1 = Low: *e.g.,* affecting the available quantity or quality of groundwater resources in the shallow or deep aquifer, such that these resources are either unavailable or unusable at levels that are indiscernible from natural variation
2 = Medium: *e.g.,* limiting the available quantity or quality of groundwater resources, such that these resources are occasionally rendered unusable to current users for periods up to two weeks at a time
3 = High: *e.g.,* limiting the available quantity and quality of groundwater resources, such that these resources are rendered unusable or unavailable for current users during the life of the Project

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10-50 km^2
4 = 50 – 100 km^2
5 = > 100 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 - 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Environment Canada recently completed an assessment of road salt under CEPA. Recognizing that a total ban of road salt could potentially compromise human safety, the focus of road salt risk management is on implementation measures that optimize winter road maintenance practices so as to not jeopardize road safety while minimizing the potential environmental effects (Environment Canada 2001c). Therefore Environment Canada has categorized road salt as a Track 2 substance, requiring Life-Cycle Management. Management instruments to reduce the potential environmental effects of road salts are being developed through a national multi-stakeholder group (which involves representation from NBDOT) working in conjunction with Environment Canada. A proposed *Code of Practice for the Environmental Management of Road Salts* was published in the *Canada Gazette* on September 30, 2003.

The period for comment is now complete, and Environment Canada will publish the file Code in 2004. Under the proposed Code, all organizations that use more than 500 tonnes of road salt per year (*e.g.*, NBDOT), should prepare and implement a salt management plan.

NBDOT is committed to developing best salt management practices in a continued effort to reduce the environmental effects of road salt on the environment. Currently the EPP (Section 6.2) and the EFG (Section 5.6) identify salt storage and application protection measures. Application rates identified in the Highway Maintenance Management System Field Manual (NBDOT 1992b) will be used to maximize the efficiency of salting and sanding. The drainage of salt laden runoff away from residences and their wells along ditching will likely mitigate this potential environmental effect on any nearby residential wells. Road maintenance activities will be managed to minimize the potential effects on adjacent residential wells.

Once the highway has been completed, there will be a permanent decrease in the amount of infiltration to groundwater. However, as the surface extent of the proposed highway within any one watershed is substantially smaller than the total watershed area, the magnitude of this effect will be imperceptible to groundwater users.

Based on consideration of the potential environmental effects of the individual activities (*i.e.,* road salt application) and the physical presence of the proposed TCH and associated roads, the proposed mitigation (*e.g.*, EPP, EFG, Highway Maintenance Management System Field Manual (NBDOT 1992b), drainage controls), and the residual environmental effects significance rating criteria, the environmental effects on Groundwater by these activities are considered not significant.

5.2.5.2.3 Maintenance

Routine highway maintenance may potentially interact with groundwater. An evaluation of these Project-VEC interactions is summarized in Table 5.2.6.

Runoff from paving areas may contain dissolved hydrocarbons, and vibration from equipment may cause temporary increases in turbidity in adjacent wells. However, the concentration of dissolved hydrocarbons in any runoff from these areas is expected to be at trace levels. The potential for environmental effects will be mitigated by the effective implementation of the EPP (Section 6.1) and EFG (Section 4.4). Proper staging of the paving (*e.g.*, dry weather application, drainage controls as required, paving of the roadway in sections) and vibration controls will minimize any potential environmental effects. The likelihood of an environmental effect on Groundwater from runoff and vibration environmental effects during paving activities is considered to be very low.

Table 5.2.6 Environmental Effects Assessment Matrix for Groundwater (Maintenance)

Environmental Effects Assessment Matrix
Valued Environmental Component: GROUNDWATER
Phase: Maintenance

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Proposed TCH Maintenance	Change in groundwater quality (A)	• Drainage and vibration controls • Remedial action as necessary to restore damaged wells and provide temporary potable water as needed	1	1-3	1/1	R	2
Vegetation and Wildlife Management	Change in groundwater quantity (A)	• Minimize extent of clearing	1	3	1/1	R	2

Key:

Magnitude:
1 = Low: *e.g.,* affecting the available quantity or quality of groundwater resources in the shallow or deep aquifer, such that these resources are either unavailable or unusable at levels that are indiscernible from natural variation
2 = Medium: *e.g.,* limiting the available quantity or quality of groundwater resources, such that these resources are occasionally rendered unusable to current users for periods up to two weeks at a time
3 = High: *e.g.,* limiting the available quantity and quality of groundwater resources, such that these resources are rendered unusable or unavailable for current users during the life of the Project

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10-50 km^2
4 = 50 – 100 km^2
5 = > 100 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 - 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Based on consideration of the potential environmental effects of the individual activities associated with the maintenance of the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g.,* EPP, EFG, drainage controls), and the residual environmental effects significance rating criteria, the environmental effects on Groundwater by these activities are considered not significant.

5.2.5.2.4 Accidents, Malfunctions and Unplanned Events

The evaluation of key potential Project-VEC interactions for accidents, malfunctions and unplanned events is summarized in the environmental effects assessment matrix (Table 5.2.7). The main issues related to Groundwater are hazardous material spills.

The release of hazardous materials into the environment may result from the leaks from machinery used during construction, from fuel and chemical transportation accidents, from blasting chemicals, or from leaks from storage facilities. The accidental release of a large quantity of a hazardous liquid onto the ground could render the local groundwater resource unusable for a long period of time, possibly the life of the Project (in perpetuity). However, the likelihood of construction or maintenance related accidents of high magnitude occurring is very low due to the storage and handling procedures in the EPP (Sections 4.19, 6.5 and 8.1), EFG (Section 5.0), and applicable regulations.

Table 5.2.7 Environmental Effects Assessment Matrix for Groundwater (Accidents, Malfunctions and Unplanned Events

Environmental Effects Assessment Matrix **Valued Environmental Component: GROUNDWATER** **Phase: Accidents, Malfunctions and Unplanned Events**							
Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Hazardous Materials Spills	Change in groundwater quality (A)	• Implementation of emergency environmental response plan in the event of a spill • Remedial action as necessary to restore damaged wells and/or provide temporary potable water as needed • In event of a spill during operation, the TDG SOP will be followed.	1-3	1-6	1/1	R/I	2

Key:

Magnitude:
1 = Low: *e.g.,* affecting the available quantity or quality of groundwater resources in the shallow or deep aquifer, such that these resources are either unavailable or unusable at levels that are indiscernible from natural variation
2 = Medium: *e.g.,* limiting the available quantity or quality of groundwater resources, such that these resources are occasionally rendered unusable to current users for periods up to two weeks at a time
3 = High: *e.g.,* limiting the available quantity and quality of groundwater resources, such that these resources are rendered unusable or unavailable for current users during the life of the Project.

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10-50 km^2
4 = 50 – 100 km^2
5 = > 100 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 - 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Accidents during the operational phase of the Project are primarily related to traffic accidents, most importantly the potential spill of a transport vehicle carrying hazardous cargo (*e.g.*, petroleum products). The transport of dangerous goods is strictly regulated by New Brunswick and Canada. Spill response is very well co-ordinated by Provincial and Federal authorities. Emergency response plans are in place and would be implemented in the event of a chemical release to the environment. Under Section 7 of the *Transportation of Dangerous Goods Act*, an emergency response assistance plan (ERAP) is required when the quantity of dangerous goods exceeds a certain limit. The ERAP would be followed in the event of a spill. Assuming that emergency spill response plans are in place and carried out effectively, it is considered extremely unlikely (almost no chance of occurrence) that a spill event capable of producing a high magnitude environmental effect (Table 5.2.7) would occur during the life of the Project (in perpetuity). Therefore, a significant environmental effect from a large-scale spill is considered possible, but extremely unlikely.

Based on consideration of the potential environmental effects an accident, malfunction, or unplanned event involving the release of a hazardous material into the groundwater, the proposed mitigation (*e.g.*, EPP, EFG, ERAP), and the residual environmental effects significance criteria, the environmental effects on Groundwater by these accidents is considered significant. However, the potential for adverse environmental effects of this magnitude to occur is considered to be very low and highly unlikely.

5.2.5.3 Determination of Significance

Table 5.2.8 summarizes the significance potential of residual environmental effects resulting from the interaction between Project activities and groundwater, taking into account any proposed mitigation. Based on consideration of the Project-related and it is concluded that the groundwater resources in the vicinity of the Project have the capacity to meet the needs of the present and those of the future.

Table 5.2.8 Residual Environmental Effects Summary Matrix for Groundwater

Residual Environmental Effects Summary Matrix Valued Environmental Component: GROUNDWATER				
Phase	**Residual Environmental Effects Rating**	**Level of Confidence**	**Likelihood**	
			Probability of Occurrence	**Scientific Certainty**
Construction	NS	3	1	3
Operation	NS	3	1	3
Maintenance	NS	3	1	3
Accidents, Malfunctions and Unplanned Events	S	3	1	3
Project Overall	NS	3	1	3

Key
Residual Environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Level of Confidence
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgement
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgement
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence
N/A = Not Applicable
*As determined in consideration of established residual environmental effects rating criteria.

5.2.5.4 Monitoring and Follow-up

A number of wells may be located within 500 m of the Project, particularly near locations where the proposed alignment crosses an existing road. The developer(s), on behalf of NBDOT, will complete an inventory of residential water wells within 500 m prior to initiating any blasting. This will include an interview with the well owner, documentation of well construction specifics, collection of a water sample for chemical and bacteria analysis, and photographic documentation of the well location. Where several wells are present within the 500 m blast monitoring radius, selected representative proximity wells will be inspected, sampled, and closely monitored during the construction phase.

If dug wells are located within 50 m of a major (> 5 m) highway cut or overpass, these wells will be inspected (measuring depth, yield and water level in dug wells) by a licensed well inspector, and sampled for baseline water quality.

The developer(s) will implement a contingency plan to provide temporary water during construction, and to repair or replace any wells found to be permanently damaged, in the event that wells are adversely affected by the Project.

5.3 Surface Water

5.3.1 Rationale for Selection as Valued Environmental Component

Surface Water was selected as a VEC because of the potential for interactions between Project activities and the physical aquatic environment, and because of the relationship between surface water conditions and the health of fish and fish habitat. Surface Water is also a VEC because of some recreational contact (primarily angling) on the larger streams that cross the RoW. None of the streams are used as a water supply, thus issues relating to human drinking water quality and quantity are not assessed.

In the context of this VEC, Surface Water is defined as the chemical, physical and biological attributes of surface water including, but not limited to, suspended sediments, flow regime, water quality and water quantity. Surface Water includes any flowing or free-standing water in lakes, reservoirs, ponds, rivers, streams, or other watercourses. The Project is not expected to interact with brackish or saline waters.

Surface Water VEC includes consideration of sulfide bearing rock drainage potential. The concern with sulfide bearing rock is its drainage potential into surface waters due to the fresh exposure of bedrock as a result of the highway construction where the grades require bedrock exposure and excavation. The primary potential environmental effect of sulfide bearing rock drainage is a potential pH reduction of adjacent waterbodies.

In this section, the environmental effects of the Project activities on the Surface Water environment resulting from construction and operation, as well as malfunctions, accidents or unplanned events are assessed.

5.3.2 Environmental Assessment Boundaries

5.3.2.1 Spatial and Temporal

The spatial boundaries (the "Assessment Area") for the assessment of the potential environmental effects of the Project on surface water include all watercourses that will be crossed by the proposed TCH, from the headwaters to the confluence with the Saint John River, and all open-water surface water bodies (*i.e.,* lakes and ponds) within 500 m of construction activities.

The temporal boundaries for the assessment of the potential environmental effects of the Project on surface water include the periods of construction, operation and maintenance of the Project in perpetuity.

5.3.2.2 Administrative and Technical

Surface Water is protected through federal and provincial legislation. Water quality of watercourses is protected in New Brunswick under the *Clean Water Act*. As noted above, activities that could alter water quality of watercourses are regulated under the *Clean Environment Act—Watercourse Alteration Regulation*. Under the *Water Classification Regulation—Clean Water Act*, water quality standards are established for classified lakes and rivers in New Brunswick. As the watercourses within the Assessment Area have not been classified, it is assumed that all of the watercourses may be classified as Class A, which would require that the watercourses be managed to have water quality and aquatic life as it occurs naturally. The quality of water for recreational use is assessed in relation to the *Recreational Water Quality Guidelines and Aesthetics* (CCME 1999). The quality of water from an aquatic perspective are assessed in relation to the *Canadian Water Quality Guidelines for the Protection of Aquatic Life* (CCME 1999) and in compliance with subsection 36(3) of the *Fisheries Act* regarding the deposit of a deleterious substance.

Information used to assess surface water resources was obtained during field surveys as well as through map and aerial photograph interpretation. Qualitative observations include those that were made when performing field inspections of the Project watercourse crossing locations using NBDNR/DFO stream survey and habitat assessment forms. A desktop hydrologic evaluation of the watercourse crossings was undertaken involving delineation of watershed boundaries, calculation of drainage areas, channel lengths and slopes, and runoff volumes. Watercourses that were crossed more than once, either by a combination of the highway, an access road or have an existing crossing, required a single hydrologic evaluation.

Water quality data collected include temperature, dissolved oxygen, nitrate + nitrite, ammonia, pH, chloride, sulfate, turbidity, sodium, calcium, iron, manganese, copper, and zinc. Rock samples were obtained and analysed to determine potential for sulfide bearing rock drainage.

With respect to culvert and bridge installations, the *Fisheries Act* (Section 35) requires the protection of fish habitat in all watercourses that bear fish. This is administered in the province of New Brunswick by the *Watercourse Alteration Regulation* and the *Clean Water Act*. Applications will be made for *Watercourse and Wetland Alteration Permits*. This application process applies to all activities (construction of watercourses, clearing, repairing and maintenance) within 30 m of a watercourse. Watercourse crossings will be installed according to the *Watercourse Alteration Technical Guidelines* developed by NBDELG (2002b). In addition, all watercourse crossings of more than 1.2 meters in diameter and/or more than 25 meters in length, and/or with a slope above 0.5% will follow the *Guidelines for the Protection of Fish and Fish Habitat – The Placement and Design of Large Culverts* (DFO 1999).

It is the professional judgement of the study team that the data that are available to characterize the existing conditions and the existing knowledge regarding the Project-VEC interactions are sufficient to support the EA.

5.3.3 Residual Environmental Effects Rating Criteria

A *significant residual environmental effect* on Surface Water quality is one that causes a long-term (*i.e*., 30 days or more). Project related exceedance of the CCME guidelines for the protection of aquatic life or recreation (CCME 1999).

According to CCME (1999) during clear flow periods, anthropogenic activities should not increase suspended sediment concentrations by more than 25 mg/L over background levels during any short-term exposure period (*i.e*., 24 hours or less). For long term exposure (*i.e*., 30 days or more), average suspended sediment concentrations in clear systems should not be increased by more than 5 mg/L over background levels.

In clear streams, small induced exceedances in suspended sediment concentrations above 25 mg/L change from background levels for short term exposures (*e.g*., 24 hours) are likely to cause behavioural and low sublethal effects on fish, all of which are reversible. Based on extrapolation from severity-of-ill-effects analysis, a long-term exposure guideline has been set at an average suspended sediment change in 5mg/L (*e.g*., for exposures lasting 30 days). This exposure translates to minor physiological stress and increased rates of coughing and respiration for the most sensitive group of aquatic organisms (CCME 1999a).

A *significant residual environmental effect* on Surface Water quantity is one that changes the quantity of Surface Water such that fish habitat is temporarily lost or avoided and natural recruitment would not re-establish the community to its original composition, density and extent in one generation.

5.3.4 Existing Conditions

The proposed TCH will be constructed west of the existing TCH through an area dominated by steep hills and valleys. A total of forty-three watercourses along the 70 km length of the proposed TCH have been assessed. A number of other watercourses were identified in maps but were not found during the field surveys.

There are three lakes located within 500 m of the alignment - Leith Lake (Figure 3.2B, Appendix C), Reid Lake (Figure 3.2B, Appendix C), and Bishops Lake (Figure 3.2A, Appendix C). Bishops Lake is a spring fed lake that is 100 m east and on a watercourse that is upstream of the proposed TCH. Reid Lake is approximately 450 m west on a watercourse not crossed by the proposed TCH. Leith Lake is

100 m east and is downstream, but is not on a watercourse that will be directly affected by the Project. In addition to lakes within 500 m of the alignment, Ketch Lake and Payson Lake are considered to be environmentally significant areas (ESA) within the zone of influence of the Project (Guidelines, Appendix A). Ketch Lake is 1.7 km west of the proposed TCH RoW. Ketch Lake drains to Two Mile Brook, which is a tributary of Big Presque Isle Stream. Two Mile Brook is upgradient and upstream of any Project activities. Payson Lake is 3.5 km west of the proposed TCH, just north of the town of Woodstock. There are no anticipated interactions between the Project and these lakes, therefore the lakes are not characterized in this section and they are not carried forward in the environmental assessment.

The character of the surrounding country changes from north to south along the alignment. In general, the northern section between Perth-Andover and Florenceville has more topographic relief and is more forested. The southern section between Florenceville and Woodstock is a region of rolling hills and plateaus that has been extensively cleared and is now used primarily for agriculture and grazing. The existing land use conditions are described in more detail in Section 5.8.4.

5.3.4.1 Hydrology

The hydrology of the watercourses in the vicinity of the Project is determined primarily by the climatic conditions and the topography of both the Project RoW and the watersheds that are intersected. In determining the potential environmental effects of the Project on the local watercourses, qualitative and quantitative observations have been made.

Factors such as watershed drainage area, channel and basin slopes, and the fraction of each watershed that is covered in lakes are important quantitative measurements to consider in the evaluation of proposed watercourse crossings. Table 5.3.1 presents a summary of these physiographic characteristics for the 43 watercourse crossings that were identified along the alignment. These streams are numbered from 1 to 43 in this CSR and are shown on Figures 3.2A-D, Appendix C.

5.3.4.2 Existing Climate

The mean annual precipitation (MAP) for the Project RoW is approximately 1000 mm per year and the mean annual runoff (MAR) is approximately half of that at 500 mm per year (Acres 1977). Environment Canada rainfall data exists for the St. John River Valley (Fredericton and Saint-Leonard). In Fredericton, 24 hour rainfalls with return periods of 50 and 100 years are estimated at 102.3 mm and 111.3 mm, respectively (Environment Canada, unpublished data). For Saint-Leonard, 24 hour rainfalls with return periods of 50 and 100 years are estimated at 93.5 mm and 102.0 mm, respectively (Environment Canada, unpublished data). Peak flows are typically observed during the spring freshet while the lowest flows are typically observed during the dry summer months. A few of the Project watercourse crossings (*i.e.,* WC21 – Tributary to Upper Guisiguit Brook, WC23 – Tributary to Lower

Guisiguit Brook and WC34 – Tributary to Big Presque Isle Stream) are expected to be intermittent as there may be no streamflow in the steep small watersheds during summer months with prolonged periods of drought.

5.3.4.3 Climate Change

The following climate information is extracted from a background paper titled *Water Sector: Vulnerability and Adaptation to Climate Change* which was presented during a Canadian Society of Civil Engineering conference held in Moncton, New Brunswick, May 11 to 12, 2000 (GCSI and MSC 2000). This document was prepared with support from the Climate Change Action Fund, National Resources Canada with authors from Global Change Strategies International Inc. (GCSI) and the Meteorological Service of Canada (MSC).

The above document discusses the climate trends associated with an increase in the global mean temperature due to increased greenhouse gases in the atmosphere (particularly carbon dioxide, CO_2). The trends are based on General Circulation Models or Global Climate Models (GCM's) that have been developed in Canada, U.S.A., U.K., and Germany. These models anticipate that the concentration of CO_2 in the atmosphere will double between the year 2000 and the year 2050.

The following relevant statements that were extracted from the document are presented below.

- For a doubled CO_2 atmosphere, by the second half of the coming century, temperature increases for summers, over Canada, as projected would average about 4°C. For winter months (Dec, Jan, Feb) increases of 6°C or more are projected for most of central Canada, with slightly lower values in the east and west.
- A winter precipitation increase of 0 to 20% is projected for Atlantic Canada.
- In summer, only small increases in precipitation are projected for Atlantic Canada.
- Nationally, precipitation has increased 1.7% of the mean per decade over the period 1948 to 1985.

Table 5.3.1 Summary of Watershed Physiographic Characteristics for Project Crossings

WC ID#	Watercourse Crossing Name*	Drainage Area (km^2)	Drainage Length (km)	Channel Length (km)	Avg Basin Slope (%)	Crossing Slope (%)	Lake Area (%)
1	Wark Brook	6.01	4.13	3.8	4.72	3.03	0
2	Tributary to Saint John River	0.87	1.34	0.84	10.67	5.17	0
3	Tributary to Saint John River	0.90	1.82	1.18	8.9	2.94	0
4	Tributary to Saint John River	0.91	1.30	0.72	8.08	5.00	0
5	Tributary to Saint John River	0.49	1.13	0.37	13.70	5.00	0
6	Tributary to Saint John River	0.91	1.89	.86	9.37	12.50	0
7	Plant Brook	0.85	1.65	1.21	13.15	9.38	0
8	Demerchant Brook	0.88	1.71	1.37	13.45	17.65	0
9	Bryson Brook	0.57	1.60	0.62	11.25	7.14	0
10	Tributary to Brown Brook	0.87	2.14	1.47	7.73	3.33	0
11	Tributary to Brown Brook	0.34	1.24	0.35	11.94	12.50	0
12	Tributary to Brown Brook	0.78	1.92	1.21	8.18	6.25	0
13	Tributary to Brown Brook	0.37	1.56	0.23	9.17	7.69	0
14	Graham Brook (Access Rd. D)	0.81	1.49	0.94	8.26	4.55	0
15	Graham Brook (outflow from Bishop Lake)	0.40	0.92	0.21	0.6	0.6	6.9
15e	Graham Brook (existing lower road)	0.55	1.47	1.43	0.68	3.12	7.26
16	Graham Brook	3.78	3.57	3.20	4.90	1.30	1.91
17	Tributary to River de Chute/McMullin Brook (Access Rd. F)	0.22	1.00	0.04	9.00	8.33	0
18	River de Chute	75.4	15.1	13.9	0.59	2.66	0.08
19	Tributary to Upper Guisiguit Brook	1.24	1.64	0.35	3.96	2.63	5.26
20	Upper Guisiguit Brook	37.1	12.8	11.8	0.82	0.97	3.78
21	Tributary to Upper Guisiguit Brook	0.08	0.60	0	7.00	4.00	0
22	Tributary to Lower Guisiguit Brook	1.91	2.54	1.62	2.36	0	4.84
23	Tributary to Lower Guisiguit Brook	0.60	1.49	0.55	3.83	6.67	0
24	Lower Guisiguit Brook/Tributary to Lower Guisiguit Brook	29.5	10.2	7.72	1.64	0.77	0.99

Table 5.3.1 Summary of Watershed Physiographic Characteristics for Project Crossings

WC ID#	Watercourse Crossing Name*	Drainage Area (km^2)	Drainage Length (km)	Channel Length (km)	Avg Basin Slope (%)	Crossing Slope (%)	Lake Area (%)
25	Tributary to Lower Guisiguit Brook	4.98	4.31	3.31	2.92	1.43	0.42
26	Tributary to Lower Guisiguit Brook	1.06	1.15	0.09	2.61	0	5.28
27	Tributary to Lower Guisiguit Brook	0.41	1.00	0.12	8.00	0	11.3
28	Tributary to Leith Lake Drainage	0.87	2.32	1.35	3.75	3.70	0.83
29	Headwaters to Leith Lake Drainage	0.41	1.25	0	6.10	0.77	0
30	Tributary 3 to Hunters Brook	1.18	2.18	0.44	1.97	0.54	0
31	Tributary 2 to Hunters Brook	2.58	3.53	1.75	1.47	1.20	0
32	Hunter Brook (Access Rd. J)	16.72	7.82	6.75	2.02	0.63	0.11
33	Big Presque Isle Stream	585	52.3	51.6	0.25	0.16	0.57
34	Tributary to Big Presque Isle Stream	1.81	2.54	2.24	1.29	2.34	1.36
35	Tributary to Little Presque Isle Stream	3.15	3.74	2.62	2.06	0.31	1.20
36	Little Presque Isle Stream	134.8	30.9	29.2	0.22	0.17	3.52
37	Little Presque Isle Stream	119.3	27.9	26.2	0.23	0.17	3.88
38	Lanes Creek	2.41	3.05	2.46	2.82	0.81	1.31
39	Tributary to Harper Brook	0.34	1.46	0.38	2.95	0.71	0.64
40	Tributary to Harper Brook	0.26	1.07	0.23	2.24	1.37	0.93
41	Tributary to Harper Brook	2.37	3.43	2.70	2.85	1.15	0.03
42	Harper Brook	2.70	2.53	2.08	3.75	1.05	0.04
43	Tributary to the Meduxnekeag	1.04	1.32	1.22	0.76	0.71	3.17

*refer to Figure 3.2 A-D, Appendix C for watercourse locations.

- No analyses of Canadian data are available of trends in very short duration (minutes to hours) heavy rain events which cause city street flooding, sewer overflows, erosion and flash floods, and landslides, but some analyses of heavy one-day events have been undertaken. These show that there has been an increase in precipitation in heavy events in Atlantic Canada.
- Model results indicate that there will be an increased frequency of heavy one-day rains in a doubled CO_2 climate, with return periods halved, (*e.g.,* a 20 year return period rainfall becomes a 10 year event).
- The Canadian GCM indicates that in a doubled CO_2 world, the number of weak to moderate winter storms in the northern hemisphere would decrease but the number of very severe storms would increase.
- If the frequency of short duration high precipitation intensities increase as projected, then greater soil erosion and sedimentation is likely, and more pollutants may be washed into rivers and lakes due to urban runoff.

The above information, in particular the change in the return period of storm events, should be considered during the design of the watercourse structures. Based on the information presented above, what is presently considered to be a 100 year return period rainfall (based on frequency analyses using historic data) would become a 50 year event by the year 2050.

5.3.4.4 Watercourse Characterization

The topographic conditions along the Project alignment range from mildly sloping terrain near Lower Waterville (WC38, WC39 and WC40), to steep and flashy mountainous terrain between Perth-Andover and Bairdsville (WC1 to WC15) (Figure 3.2A-D, Appendix C). The watercourses with steep basin slopes tend to have little storage and can be flashy with high flood flow magnitudes. These channels are often incised and have an increased potential for ice and debris jams. An increased potential for ice and debris jams also exist where channel slopes change from steep to mild, immediately upstream of a crossing (*i.e.,* WC3 – Tributary to Saint John River).

A brief summary of each of the 43 watercourse crossings (Figure 3.2A-D, Appendix C), is presented in the following paragraphs. The study team conducted field reconnaissance at each of these streams to support this description. The description identifies hydrotechnical issues and recommendations for design and construction including topography, bank stability, potential for erosion and type of structure.

Figure 3.2A, Appendix C

WC1 Wark Brook is located near the Perth-Andover limits, this watercourse has a large drainage area (6.01 km^2) upstream of the Project RoW. The proposed crossing has a steep southern bank, which presents potential erosion and sediment control issues. A man-made salmon pond, which diverts flow from Wark Brook, is located at the north bank. Approximately 100 m downstream of the RoW is the existing TCH, which is crossed by a 3.0 m diameter culvert.

WC2 Tributary to Saint John River is located 500-600 m west of the existing TCH, the small watershed (0.87 km^2) for this watercourse crossing is very steep (10.7% average basin slope) and flashy. No specific hydrotechnical concerns were identified for this crossing.

WC3 Tributary to Saint John River is located 700 m west of the existing TCH near Hillandale, the small watershed (0.90 km^2) for this watercourse crossing is very steep (8.90% average basin slope) and flashy with an increased ice/debris jam potential, as indicated by the incised channel and the change in channel slope from steep to mild immediately upstream of the crossing. The steep banks near the crossing indicate a high potential for sediment laden runoff to enter the watercourse during construction.

WC4 Tributary to Saint John River is located 800 m west of the existing TCH, this watercourse crosses Beaconsfield Road (north to south) at the Project RoW and flows east along the ditch to the existing TCH. The small watershed (0.91 km^2) is very steep (8.08% average basin slope), but does not appear to have an increased flooding potential.

WC5 Tributary to Saint John River is located south of Beaconsfield Road and 1 km west of the existing TCH, the small watershed (0.49 km^2) for this watercourse crossing is very steep (13.70% average basin slope), but does not appear to have an increased flooding potential.

WC6 Tributary to Saint John River is located 700 m west of the existing TCH, this watercourse has a small drainage area (0.91 km^2) upstream of the Project location. The proposed crossing is very steep (12.5 % channel slope), with steep banks that indicated the potential for erosion and sediment movement during construction. The steep banks near the crossing indicate a high potential for sediment laden runoff to enter the watercourse during construction. The field inspections indicate that the watershed is very flashy with an increased potential for ice/debris jams due to the steep, slightly incised channel.

WC7 Plant Brook is located 350 m west of the existing TCH, this watercourse has a small drainage area (0.85 km^2) upstream of the Project location. The proposed crossing is very steep (9.38% channel slope), with flow occurring in pool/riffle sequences. Steep slopes and an incised channel indicate an increased potential for ice/debris jams at the crossing.

WC8 Demerchant Brook is located 200 m west of the existing TCH, this watercourse has a small drainage area (0.88 km^2) upstream of the Project location. The proposed crossing is very steep (17.65% channel slope), with flow occurring in pool/riffle sequences. The field inspections indicate that the watershed is very flashy with an increased potential for ice/debris jams due to the steep incised channel.

The steep banks near the crossing indicate a high potential for sediment laden runoff to enter the watercourse during construction.

WC9 Bryson Brook is located 500 m west of the existing TCH, this watercourse has a small (0.57 km^2), primarily wooded watershed upstream of the Project location. The proposed crossing is steep (7.14 % channel slope), with flow occurring in pool/riffle sequences. The field inspections indicate that the watershed is very flashy with an increased potential for ice/debris jams due to the steep incised channel. The steep banks near the crossing indicate a high potential for sediment laden runoff to enter the watercourse during construction.

WC10 Tributary to Brown Brook is located 1.1 km west of the existing TCH and east of Beaconsfield Road, this watercourse has a small (0.87 km^2), primarily wooded watershed upstream of the Project location. Streamflow occurs in pool/riffle sequences, while well-vegetated floodplains exist along the channel banks. The field inspections indicate no specific hydrotechnical concerns at this location.

WC11 Tributary to Brown Brook is located 1.5 km west of the existing TCH and east of Beaconsfield Road, this watercourse has a small (0.34 km^2), primarily wooded watershed upstream of the Project location. The proposed crossing is steep (12.5 % channel slope), with flow occurring in pool/riffle sequences. The field inspections indicate that the watershed is very flashy with an increased potential for ice/debris jams due to the steep incised channel. The steep banks near the crossing indicate a high potential for sediment laden runoff to enter the watercourse during construction.

WC12 Tributary to Brown Brook is located 1.7 km west of the existing TCH and east of Beaconsfield Road, this watercourse has a small (0.78 km^2), primarily wooded watershed upstream of the Project location. The proposed crossing is fairly steep (6.25 % channel slope), with flow occurring in pool/riffle sequences. The field inspections indicate that the watershed is very flashy with an increased potential for ice/debris jams due to the steep incised channel. The steep banks near the crossing indicate a high potential for sediment laden runoff to enter the watercourse during construction.

WC13 Tributary to Brown Brook is located 1.9 km west of the existing TCH and east of Beaconsfield Road, this watercourse has a small (0.78 km^2), primarily wooded watershed upstream of the Project location. The proposed crossing is steep (7.69% channel slope), with flow occurring in pool/riffle sequences. The field inspections indicate that the watershed is very flashy with an increased potential for ice/debris jams due to the steep incised channel.

WC14 Graham Brook (access road D) is located 3 km west of the existing TCH; this watercourse crossing is located at access road D, off the Beaconsfield Road. The small watershed (0.81 km^2) for this watercourse crossing is steep (8.26% average basin slope), but does not appear to have an increased flooding potential. No specific hydrotechnical concerns were identified for this crossing.

WC15 Graham Brook (outflow from Bishop Lake) is located 2 km west of the existing TCH at the outlet from Bishop Lake, this watercourse has a small (0.40 km^2) watershed that is mainly routed through Bishop Lake (surface area 0.03 km^2). The crossing has steep banks on both sides, which have been deforested to the edge of the watercourse near the westbound lane. This is indicative of the potential for sediment laden runoff to enter the watercourse during construction. Significant beaver activity was observed at the crossing as the very mild channel and basin slopes (0.6% each) combined with the steep banks create a prime location for damming the watercourse.

WC15e (existing road) Graham Brook) is located west of the Project RoW, this watercourse flows under Scott Road through a 0.9 m diameter culvert. At the upstream end of the culvert is a wetland that is impounded by the road. This section of Scott Road is proposed to be realigned during construction, with the new crossing to be located immediately downstream of the existing crossing. No specific hydrotechnical concerns were identified for this crossing.

WC16 Graham Brook is located 1.5 km west of the existing TCH, south of Scott Road and downstream of the outlet from Bishop Lake (watercourse 15), this watercourse crossing has significant beaver activity in the mildly sloped channel. Although the watershed has a fair sized drainage area (3.78 km^2), the upstream storage at Bishop Lake and Scott Road combined with the local beaver activity create the appearance of a small streamflow in the poorly defined, braided channel. The steep banks near the crossing indicate a high potential for sediment laden runoff to enter the watercourse during construction.

WC17 Tributary to River de Chute/McMullin Brook is located 2.1 km west of the existing TCH and 0.5 km north of Route 560, this watercourse crossing is located at access road F, which connects to Dean Road to the north. The watercourse has a small watershed (0.22 km^2), as the crossing is located only 40 m from the upper end of the channel. The slope of the channel at the crossing is steep (8.26%), but the terrain and small watershed do not indicate an increased flooding potential. No specific hydrotechnical concerns were identified for this crossing.

Figure 3.2B, Appendix C

WC18 River de Chute is located 1.3 km west of the existing TCH along Route 560; this watercourse crossing has a significant watershed (75.4 km^2) that extends into Maine. There are very few lakes and wetlands (0.08% of the drainage area) upstream of the crossing to provide storage. The south bank is steep and high with a high potential for sediment laden runoff to enter the watercourse during construction. Channel bank erosion and scarring was observed during field inspections, providing evidence of ice movement and indicating the potential for ice or debris jams at the crossing. A bridge or spanning structure is recommended for this crossing.

WC19 Tributary to Upper Guisiguit Brook is located 1.6 km west of the existing TCH, the watershed (1.24 km^2) upstream of the Project RoW is primarily wooded and well-vegetated. At the crossing location the channel is well defined with no specific hydrotechnical concerns identified during the field inspections.

WC20 Upper Guisiguit Brook is located 2.1 km west of the existing TCH; this watercourse has a significant watershed (37.1 km^2) that extends into Maine. Approximately 30 m upstream of the Project RoW is a confluence that presents the potential for ice/debris jams at the crossing. During the field inspections, it was observed that significant beaver activity at the crossing had resulted in a 30 m wide, 0.5-1.0 m deep marsh area. The steep banks near the crossing indicate a high potential for sediment laden runoff to enter the watercourse during construction. Based on the large watershed area, the potential for high flows at this crossing, and the good aquatic habitat, a spanning structure is recommended.

WC21 Tributary to Upper Guisiguit Brook is located 2.2 km west of the existing TCH; this watercourse is not shown on 1:10,000 scale mapping to be crossed by the Project RoW. The upper end of the watercourse is shown at the westbound lane edge of the RoW, but field inspections did not reveal a channel or flow during the dry summer conditions.

WC22 Tributary to Lower Guisiguit Brook is located 2.2 km west of the existing TCH and north of Stairs Road, this watercourse has a watershed (1.91 km^2) that is mainly routed through wetlands located 40 m upstream. Outflow from the wetlands flows through an old culvert that has been partially blocked by beaver activity, causing the road to wash out. Steep banks on both sides of the watercourse indicate a high potential for sediment laden runoff to enter the watercourse during construction.

WC23 Tributary to Lower Guisiguit Brook is located 2.5 km west of the existing TCH and south of Stairs Road, this watercourse has a small (0.60 km^2) watershed that flows between the proposed east and westbound lanes. Construction along the present Project alignment would likely eliminate 500 m of the watercourse. Field inspections revealed a dry, well defined, incised channel indicating that the watercourse is intermittent but likely conveys high flood flows during wet conditions (*i.e.,* spring freshet).

WC24 Lower Guisiguit Brook is located 2.5 km west of the existing TCH and north of the B Smith Road and A Brown Road intersection, this watercourse has a significant watershed (29.5 km^2) which includes flow from watercourse 22. Upstream of the crossing, in the Upper Knoxford area, are Reid Lake and Lawrence Lakes. Although there is little evidence of ice scarring, the small tributary located 40 m upstream of the Project RoW indicates an increased potential for ice/debris jams at the crossing. Based on the large watershed area, the potential for high flows at this crossing, and the good aquatic habitat, a spanning structure is recommended.

WC25 Tributary to Lower Guisiguit Brook is located 3.5 km west of the existing TCH and south of the B Smith Road, this watercourse collects flow from a fair sized (4.98 km^2) watershed which includes flow from watercourses 26 and 27. There is a wide, well-vegetated floodplain, but the main channel is difficult to define as a result of beaver activity. High flood flows are not expected due to the flood flow storage in the upstream wetlands.

WC26 Tributary to Lower Guisiguit Brook is located west of the existing TCH, between Back Greenfield and Summerfield Road; the crossing is through a wooded wetland area, without a well defined main channel. The Project length is approximately 300 m through the wetland, with beaver activity observed throughout. No specific hydrotechnical concerns were identified for this crossing.

WC27 Tributary to Lower Guisiguit Brook is located west of the existing TCH, between Back Greenfield and Summerfield Road; the crossing location is in a wooded wetland area. There are many small channels, but no well defined main channel. The Project length is approximately 350 m through the wetland, with beaver activity observed throughout. No specific hydrotechnical concerns were identified for this crossing.

WC28 Tributary to Leith Lake Drainage is located west of the existing TCH and southeast of Wakem Corner, this watercourse collects runoff from a small area (0.87 km^2) upstream of the Project RoW. The channel is fairly defined with a well-vegetated floodplain on each side. The channel bottom is silt with flow occurring in pool/riffle sequences caused mainly by roots and fallen trees. No specific hydrotechnical concerns were identified for this crossing.

WC29 Headwaters to Leith Lake Drainage collects surface runoff from a small area (0.41km^2) upstream of the Project RoW. The 1:10,000 scale mapping shows the upper end of this watercourse to be located at the westbound lane centreline. Field inspections revealed this section of the small watershed to be marshy with a poorly defined channel. No specific hydrotechnical concerns were identified for this crossing.

Figure 3.2C, Appendix C

WC30 Tributary to Hunters Brook crossing collects runoff from the proposed Highway 110 interchange. The 440 m channel length that comprises the upper end of the watercourse is completely within the footprint of the proposed interchange.

WC31 Tributary to Hunters Brook is located west of Highway 103 and east of Highway 110, the Tributary 2 to Hunters Brook crossing has a watershed (2.58 km^2) that is mainly farmland drainage. The channel slope is mild (1.20%), and no specific hydrotechnical concerns were identified during the field inspections.

WC32 Hunters Brook crossing is located at access road J. This large watershed (16.7 km^2) drains to Big Presque Isle Stream, located upstream of the Project RoW. At the Hunters Brook crossing location, the channel is well defined with a mild slope (0.63%). The steep northwest bank has a high potential for sediment laden runoff to enter the watercourse during construction. Standard erosion and sediment control measures are not expected to be adequate mitigation for the sediment laden runoff. Special attention should be paid to the site layout during design of the crossing.

WC33 Big Presque Isle Stream is the most substantial of the watercourse crossings with a 585 km^2 drainage area that extends well into Maine. This is the only watercourse among the 43 crossings that has an Environment Canada hydrometric station (located upstream at Tracey Mills) to gauge the flow. At the RoW, the stream is approximately 30 m wide, with steep banks on each side. Field inspections revealed the crossing to be located on a bend with signs of ice scour on the outside bank. The steep banks near the crossing indicate a high potential for sediment laden runoff to enter the watercourse during construction. Based on the steep banks, the very large watershed, and anticipated high flood flows, a bridge is recommended for this crossing.

WC34 Tributary to Big Presque Isle Stream is located 300 m south of Dryer Road. Marsh areas upstream of the crossing provide storage with no outflow during dry summer conditions. During field inspections, the dry channel could not be located. No specific hydrotechnical concerns were identified for this crossing.

Figure 3.2D, Appendix C

WC35 Tributary to Little Presque Isle Stream crossing is located at the upstream edge of a marsh. At the RoW, the channel is poorly defined with a silt bottom as the water appeared stagnant during field inspections. The mildly sloped upstream channel connects four (4) smaller marsh areas to form a basin with significant storage upstream of the Project RoW. No specific hydrotechnical concerns were identified for this crossing.

WC36 Little Presque Isle Stream crossing (Connector Road to Hartland) is located between Stockford and Somerville, 450 m west of the existing TCH. The large watershed (135 km^2) includes Williamstown Lake and a number of smaller lakes that comprise 3.5% (4.6 km^2) of the drainage area. Channel bank erosion and scarring were observed during field inspections, providing evidence of ice movement and indicating the potential for ice or debris jams at the crossing. The steep east bank indicates a high potential for sediment laden runoff to enter the watercourse during construction. Based on the large watershed and the potential for high flood flows, a bridge or spanning structure is recommended for this crossing.

WC37 Little Presque Isle Stream crossing of the Little Presque Isle Stream is located upstream of watercourse 36 at the Waterville Deadwater, near Estey Road. Like watercourse 36, this large watershed (119 km^2) includes Williamstown Lake and a number of smaller lakes to comprise 3.9% (4.7 km^2) of the drainage area. The channel slope at the proposed crossing location is very flat (0.17%) and has the impression of water being stagnant. No specific hydrotechnical concerns were identified for this crossing. Based on the large watershed and the good aquatic habitat, a bridge or spanning structure is recommended for this crossing.

WC38 Lanes Creek is located 800 m west of the existing TCH at Lower Waterville, this watercourse crossing has a fair drainage area (2.41 km^2) that is mostly gently sloped farmland. The channel is well defined with well-vegetated floodplain. The marsh located on one (1) of the upstream branches, and a sandy channel bottom, indicate low flood flows. No specific hydrotechnical concerns were identified for this crossing.

WC39 Tributary to Harper Brook is located 600 m west of the existing TCH, this watercourse crossing has a very small drainage area (0.34 km^2) upstream of the RoW. The proposed crossing is located 300 m downstream of a very small marsh area. No flow or main channel could be identified during the field inspections as it is expected that flow occurs through the mossy ground during summer low flow conditions. No specific hydrotechnical concerns were identified for this crossing.

WC40 Tributary to Harper Brook is located 800 m west of the existing TCH, this watercourse crossing has a very small drainage area (0.26 km^2) upstream of the RoW. The proposed crossing is shown to be located between two (2) small marsh areas but no channel or flow was observed during the field inspections. No specific hydrotechnical concerns were identified for this crossing.

WC41 Tributary to Harper Brook crossing is located 600 m west of the existing TCH. Much of the 2.37 km^2 watershed is farmland with gently sloped terrain. The 1 m wide channel has a fairly mild slope (1.15%) and well-vegetated banks. No specific hydrotechnical concerns were identified for this crossing.

WC42 Harper Brook crossing is located 350 m west of the existing TCH. Much of the 2.70 km^2 watershed is farmland with gently sloped terrain. Approximately 40 m upstream of the eastbound lane is a small tributary, which poses potential ice jam problems. This should be considered during the design process.

WC43 Tributary to Meduxnekeag River crossing is located near Woodstock at the existing TCH, north of the Route 550 interchange. This crossing has marsh on both the upstream and downstream sides of the RoW, which are connected by a 0.9 m diameter corrugated steel culvert. There is sufficient storage on the upstream side of the culvert to attenuate peak flows from the 1.04 km^2 watershed. No specific hydrotechnical concerns were identified for this crossing. Although the main channel of the Meduxnekeag is not crossed by the Project, there is an Environment Canada hydrometric station near Belleville that may be used to assess hydrological conditions in the southern portion of the Project area.

5.3.4.5 Surface Water Quality

5.3.4.5.1 General Chemistry

Surface water samples were obtained from the watercourse crossings to determine general surface water quality within the zone of influence of the Project, and are presented in Table 5.3.2. General chemistry analysis for parameters such as temperature, dissolved oxygen, pH, nitrate + nitrite, ammonia and turbidity for the most part indicated good surface water quality conditions. Dissolved oxygen concentrations in Watercourses 15e, 26, 27 and 29 were below the minimum acceptable concentration according to CCME (1999a) guidelines for the protection of freshwater aquatic life. Iron concentrations in samples obtained in watercourses 15, 26 and 27 exceeded the CCME guideline for the protection of aquatic life. In general, water quality is good in the surface waters throughout the Project area.

Tables 5.3.3 and 5.3.4 summarize applicable *Environment Canada Water Quality Guidelines* (CCME 1999a).

5.3.4.5.2 Geological Interpretation

The geological information for this work was obtained from the Geological Map of New Brunswick, Map NR-1, second edition, dated 1979. The bedrock within the entire Assessment Area is contained within one geological unit. The bedrock is of Upper Ordovician or Lower Silurian in age and described as a thinly bedded limestone, calcareous shale, or a feldspathic sandstone that was deposited in a deep marine basin. Only one major fault crosses through the Assessment Area and it is located within the area just south of Perth-Andover. Based on the bedrock geology, sulfide sulfur bearing rock is expected within the Assessment Area, however, the bedrock is also expected to have a high neutralizing potential as well.

5.3.4.5.3 Sulfide Bearing Rock Drainage Potential

As part of the overall EA of the proposed TCH, issues related to potential sulfide bearing rock drainage have been reviewed. The concern with the sulfide bearing rock drainage potential comes from the fresh exposure of bedrock as a result of the highway construction where the grades require bedrock exposure and excavation.

Table 5.3.2 Water Quality Results

WC ID#	Parameter Concentration (as mg/L)															
	Sodium	Calcium	Iron	Manganese	Copper	Zinc	Ammonia (total)	pH	Chloride	Sulfate	Nitrate + Nitrite (as N)	Turbidity	Dissolved Oxygen	Temperature	Northing (19T)	Easting (19T)
1	1.72	31.4	<0.02	0.004	<0.001	<0.001	<0.05	7.9	1.1	7	0.83	0.8	6.3	12	597658.2	5176161
2	1.86	7.29	0.04	0.005	<0.001	0.001	<0.05	7.4	<0.05	5	<0.05	9.2	6.7	11.5	596956.7	5174791
3	1.82	10.1	0.03	0.006	<0.001	0.007	<0.05	7.0	<0.05	6	<0.05	3.2	8.3	14	596644.1	5173775
4	4.84	25	0.04	0.008	<0.001	<0.001	<0.05	7.6	6.4	8	0.49	1.6	8.9	11	596453	5173017
5	1.85	15.6	<0.02	0.001	<0.001	<0.001	<0.05	7.4	<0.05	6	0.15	0.5	8.3	15	596383	5172142
6	1.17	11.8	<0.02	<0.001	<0.001	<0.001	<0.05	7.4	<0.05	3	0.05	1	8.0	16	596660	5171450
7	1.71	12.9	<0.02	0.005	<0.001	<0.001	<0.05	7.5	<0.05	4	0.07	0.2	9.2	14	597024	5170609
8	1.74	9.53	<0.02	<0.001	<0.001	<0.001	<0.05	7.3	<0.05	4	0.12	0.1	7.5	14	597225	5169096
9	1.5	20.9	0.02	0.004	<0.001	<0.001	<0.05	8.1	1	4	0.14	1.4	7.8	15	597035	5168196
10	1.6	14.9	<0.02	0.001	<0.001	<0.001	<0.05	7.4	<0.05	4	<0.05	0.2	7.8	15	596473.3	5167357
11	1.3	19.2	<0.02	0.004	<0.001	0.0017	<0.05	7.7	<0.05	5	<0.05	0.2	8.1	12	596258.4	5166695
12	1.72	8.79	<0.02	<0.001	<0.001	<0.001	<0.05	7.4	<0.05	5	0.08	0.3	7.9	15	596187.9	5166483
13	1.52	11.8	0.06	0.004	<0.001	0.009	<0.05	7.5	0.5	4	0.05	2.5	7.1	16	596114.2	5166189
14a	4.78	16.3	<0.02	0.003	<0.001	<0.001	<0.05	7.6	8.2	5	0.68	0.2	6.9	13	595164.7	5165072
15e	0.99	26.5	0.16	0.022	<0.001	<0.001	<0.05	7.9	0.6	2	<0.05	1.3	**5.3**	24	596376.9	5164846
15	1.4	34.1	0.47	0.11	<0.001	<0.001	<0.05	8.1	1	4	0.14	1.4	6.4	21	596191.8	5164295
16	3.1	40.8	0.03	0.03	<0.001	<0.001	<0.05	8	6	2	0.25	1	8.2	11	596636	5163864
17a	1.57	30.5	<0.02	0.001	<0.001	<0.001	<0.05	7.8	1.3	4	0.56	0.5	6.5	10	595556	5161406
18	2.42	45.8	<0.02	0.003	<0.001	<0.001	<0.05	8	4.4	7	0.18	0.5	7.8	14	596356	5160738
19	1.2	65.5	<0.02	0.001	<0.001	<0.001	<0.05	8	6.8	6	5	0.2	8.2	9	596139.8	5159218
20	2.66	52.2	0.07	0.04	<0.001	<0.001	<0.05	7.9	7.5	7	0.57	4.8	7.2	17	595940.3	5157982
21†	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	596077.8	5157558
22	1	56.7	0.04	0.052	<0.001	<0.001	<0.05	8	2.2	6	0.12	0.6	7.0	18	596858.9	5156202
23†	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	598455.6	5155151
24	2.38	56.9	0.06	0.01	<0.001	<0.001	<0.05	8.1	8.8	6	0.85	1.7	7.2	18	598822.5	5154873
25	2.98	67	0.04	0.011	<0.001	<0.001	<0.05	8	9.5	6	1.82	0.4	5.9	16	599531.9	5153760

Table 5.3.2 Water Quality Results

WC ID#	Parameter Concentration (as mg/L)															
	Sodium	Calcium	Iron	Manganese	Copper	Zinc	Ammonia (total)	pH	Chloride	Sulfate	Nitrate + Nitrite (as N)	Turbidity	Dissolved Oxygen	Temperature	Northing (19T)	Easting (19T)
26	1.07	56.8	0.75	1.94	<0.001	<0.001	0.06	7.7	1.1	<1	<0.05	1.6	**0.9**	16	599793.9	5152132
27	2.12	55.1	0.58	0.501	<0.001	<0.001	<0.05	7.5	6.6	<1	<0.05	2.1	**4.6**	21	600091	5151080
28	2.23	52.4	0.03	0.017	<0.001	<0.001	<0.05	7.9	11.1	10	3.3	0.5	6.7	17	601804.2	5148907
29	2.5	61.9	0.21	0.152	<0.001	<0.001	<0.05	7.4	14.2	14	4.35	3.7	**3.4**	17	601919.4	5148270
30	n/d	67.4	n/d	n/d	n/d	n/d	n/d	7.9	n/d	n/d	n/d	n/d	n/d	n/d	603615.5	5143900
31	n/d	62	n/d	n/d	n/d	n/d	n/d	7.9	n/d	n/d	n/d	n/d	n/d	n/d	603940.4	5142501
32a	4.67	63.7	<0.02	0.006	<0.001	0.001	<0.05	8.1	14	7	0.97	0.4	8.4	18	603362.9	5140790
33	5.09	45	<0.02	0.004	<0.001	<0.001	<0.05	7.9	7	9.7	0.13	0.4	n/d	n/d	604504	5139676
33*	4.39	53.1	0.051	0.016	<0.0005	<0.005	0.011	8.22	9.82	10.6	0.88	1.0	n/d	n/d	unknown	unknown
34	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	605101.2	5137113
35	n/d	48.3	n/d	n/d	n/d	n/d	n/d	7.8	n/d	n/d	n/d	n/d	n/d	n/d	609111.5	5128743
36e	3.84	49.8	0.11	0.031	<0.001	<0.001	<0.05	7.7	10.3	8	0.52	0.8	n/d	n/d	61018.7	5126750
37	2.67	47.9	0.05	0.029	<0.001	<0.001	<0.05	7.9	7	7.6	0.41	0.4	n/d	n/d	608908.2	5125645
38	n/d	56	n/d	n/d	n/d	n/d	n/d	7.5	n/d	n/d	n/d	n/d	n/d	n/d	608209.2	5121358
39	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	608123.7	5120229
40	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	607894.8	5119908
41	n/d	77.3	n/d	n/d	n/d	n/d	n/d	8	n/d	n/d	n/d	n/d	n/d	n/d	607789.7	5118862
42	n/d	75.7	n/d	n/d	n/d	n/d	n/d	8	n/d	n/d	n/d	n/d	n/d	n/d	607910.5	5118299
43	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	n/c	607372.3	5115000

Notes:
bold values exceed CCME guidelines for freshwater aquatic life (CCME 1999)
* indicates sample and data collected by the province of New Brunswick; † dry channel at time of sampling
n/d = not determined; n/c = not collected

Table 5.3.3 Canadian Water Quality Guidelines

Parameter	Aquatic Life Freshwater	Agriculture	
		Irrigation	Livestock
Sodium	n/e	n/e	n/e
Calcium	n/e	n/e	1000
Iron	0.3	5	n/e
Manganese	n/e	2	n/e
Copper	0.002	0.2-1	0.5-5
Zinc	0.03	1-5	50
pH	6.5-9.0	n/e	n/e
Chloride	n/e	100-700	n/e
Sulfate	n/e	n/e	1000
Nitrate+Nitrite (as N)	n/e	n/e	100
Turbidity	n/e	n/e	n/e
Dissolved Oxygen*	6.5-9.5	n/e	n/e

1 Guidelines presented in mg/L unless otherwise noted.
n/e not established
* Guideline for the lowest acceptable D.D. concentration for early (9.5 mg/L) and other (6.5 mg/L) life stages in cold water ecosystems (CCME 1999a)

Table 5.3.4 Canadian Water Quality Guidelines for Ammonia (total, mg/L) for the Protection of Aquatic Life

Temp (°C)	pH							
	6	6.5	7	7.5	8	8.5	9	9.5
0	231	73	23.1	7.32	2.33	0.749	0.25	0.0042
5	153	48.3	15.3	4.84	1.54	0.502	0.172	0.0034
10	102	32.4	10.3	**3.26***	**1.04***	0.343	0.121	0.0029
15	69.7	22	6.98	**2.22***	**0.715***	0.239	0.089	0.0026
20	48	15.2	4.82	1.54	0.499	0.171	0.067	0.0024
25	33.5	10.6	3.37	1.08	0.354	0.125	0.053	0.0022
30	23.7	7.5	2.39	0.767	0.256	0.094	0.043	0.0021

* pH range of 7.5-8 and water temperature range of 10-15ºC is representation of summer conditions in watercourses crossed by the proposed TCH.

Objectives of the sulfide bearing rock drainage work were as follows:

- identify potential areas of Project interaction with sulfide bearing rock based on a review of available geologic mapping;
- identify potential areas of Project interaction with sulfide bearing rock based on an induced polarization field investigation;
- preferentially sample and analyze bedrock at visible outcroppings and existing rock cuts along the proposed TCH based on the results of the map review and the induced polarization investigation;
- delineate areas of low or high potential for sulfide bearing rock based on the test results;

- recommend further sampling / testing to be implemented during construction; and
- recommend general mitigative measures and disposal options with respect to sulfide bearing rock.

Prior to initiating a field sampling program, available geological mapping was reviewed to determine whether particular areas had a greater potential to have sulfide bearing bedrock based on lithology. In addition, the results from an induced polarization survey undertaken by NBDOT were reviewed in terms of any anomalous results. Anomalous results (areas of potential sulfide bearing rock) were overlain on a map with areas where road cuts are likely to exceed 3 m in depth. Based on the above information, a field sampling program was undertaken to collect samples from areas within representative geological units and in areas as close as possible to locations where deep grade cuts are proposed or in areas where anomalous results were obtained with the induced polarization survey. If possible, these samples were collected a minimum of 200 mm below the weathered zone so as to obtain an unoxidized/unweathered sample. Sampling locations are presented in Figures 3.2A-D (Appendix C).

In total 32 samples of bedrock were obtained between Perth-Andover and Woodstock. Most of the samples were obtained from rock cuts along the existing highway or secondary roads while some of the samples were obtained from outcrops located near roads. Table 5.3.5 summarizes all the samples collected and details the results of the laboratory testing performed. No attempt was made to collect samples along the actual proposed RoW, as rock outcrops were not expected. However, where existing roads crossed the proposed alignment or were located in close proximity, every effort was made to obtain samples. Even sampling distribution, within the Assessment Area, was achieved to the event practical.

All samples collected for testing were submitted to the laboratory for analysis of total sulfur. If the total sulfur concentration equaled or exceeded 0.3% by weight, then the sample was considered potentially acid generating and was submitted for testing using the modified acid based accounting (ABA) method (also known as the modified Sobek Method) to determine sulfide sulfur concentration and neutralizing potential (NP). The testing method used is from the Acid Rock Prediction Manual (MEND, March 1991). Based on the results of the ABA testing, a sample is still considered to be potentially acid generating if the sulfide sulfur concentrations exceed or equal 0.3% and the neutralizing potential / acid producing potential (NP/AP) is less than or equals 3.0 (where NP and AP are measured in kg of $CaCO_3$ / tonne of rock).

Table 5.3.5 Sulfide Bearing Rock Sampling Locations

Sample No.†	Approximate Location	Total Sulfur (% by mass)	Sulfide Sulfur (% by mass)[1]	NP/AP Ratio[2]
1	Connell Road Exit	0.144	---	---
2	Lockhart Mill Road	0.197	---	---
3	Route 2 – Harper Brook	0.120	---	---
4	Route 2 – Waterville	0.320	0.310	13.9
5	Waterville Dead Water	0.042	---	---
6	Jacksonville	0.019	---	---
7	Past Palmer Road	0.023	---	---
8	Wilmot	0.611	0.610	6.0
9	Dryer Road	0.047	---	---
10	Charleston Tower	0.082	---	---
11	Estey Road	0.190	---	---
12	St. Thomas	0.022	---	---
13	Upton	0.055	---	---
14	Florenceville	0.249	---	---
15	Sipprelle Road	0.055	---	---
16	Back Greenfield Road	0.012	---	---
17	J. Clark Road	0.027	---	---
18	Summerfield	0.125	---	---
19	Wakem Corner	0.013	---	---
20	Big Presque Isle Stream	0.052	---	---
21	Route 2 – Past Summerfield Rd	0.042	---	---
22	Route 2 – Clearview	0.148	---	---
23	Route 2 – River de Chute	0.110	---	---
24	Route 2 – Scott Road	0.396	0.394	7.1
25	Route 2 – Hillandale	0.338	0.335	12.2
26	Route 2 – West Riverside Road	0.277	0.275	11.3
27	Route 2 – Perth-Andover	0.139	---	---
35	Route 2 – Wark Brook	0.218	---	---
36	Beaconsfield Road	0.067	---	---
37	Scott Road	0.568	0.566	5.0
38	River du Chute, Past Rte 560	0.263	0.263	15.6
39	B. Smith Road	0.025	---	---

1 If the total sulfur concentration equaled or exceeded 0.3% by weight, then the sample was considered potentially acid generating and was submitted for testing using the modified acid based accounting (ABA) method to determine the NP/AP ratio.

2 NP/AP ratio is the neutralizing potential/acid producing potential, where NP and AP are measured in kg of $CaCO_3$/tonne of rock.

† Sampling locations presented in Figure 3.2A-D

A group of samples with elevated sulfide sulfur levels were obtained between Perth-Andover and River de Chute. Five samples had sulfide sulfur concentrations between 0.26 and 0.57%, however, the neutralizing potential was sufficient to raise the NP/AP ratio adequately above the recommended level of 3.0. In addition, two isolated samples between Hartland and Woodstock also had elevated levels of sulfide sulfur with a correspondingly high neutralizing potential. Overall, no samples collected as part of this study tested positive for acid generating potential. However, the presence of a concentrated group of samples with elevated sulfide sulfur levels near the northern limits of the Project is cause for concern and additional sampling and testing during construction should be undertaken. The results of this testing program indicate a range of neutralizing potential within the areas where elevated sulfide sulfur concentrations were obtained. Therefore, isolated areas may contain lower levels that could result in NP/AP ratios below 3.0.

5.3.5 Environmental Effects Analysis

5.3.5.1 Project-VEC Interactions

Surface water supplies are sensitive to environmental effects resulting from development activities. As a result development in a watershed can pose potential environmental effects to water quality. Surface water resources are hydraulically linked to groundwater resources (Section 5.2) and fish and fish habitat (Section 5.4). Surface water quality can be directly affected by the volume and quality of groundwater flowing to the surface water; while conversely, surface water quality and quantity may affect groundwater quality and quantity. Construction activities may alter existing overland drainage patterns and result in the transport of suspended solids to the nearest stream or wetland.

The key environmental issues for surface water resources from a linear development include:

- interference with drainage,
- interference with the local flood regime; and
- degradation of the water quality of surface water resources.

Table 5.3.6 provides a summary of the potential environmental effects resulting from the Project-VEC interactions. The table is divided according to each of the Project phases assessed (construction, operation and maintenance), as well as for accidents, malfunctions and unplanned events. The discussion following the table provides an analysis of key Project-VEC interactions.

Table 5.3.6 Project Activity – Environmental Effects Interaction Matrix for Surface Water

Potential Interactions Between Project Activities and Environmental Effects Valued Environmental Component: SURFACE WATER		
Project Activities and Physical Works (see Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	
	Change in Water Quantity	**Change in Water Quality**
Construction		
Site Preparation	✓	✓
Watercourse Crossing Structures	✓	✓
Roadbed Preparation	✓	✓
Surfacing and Finishing		✓
Ancillary Structures and Facilities	✓	✓
Operation		
Winter Safety		✓
Proposed TCH Presence	✓	✓
Maintenance		
Proposed TCH Maintenance		✓
Vegetation and Wildlife Management		✓
Accidents, Malfunctions and Unplanned Events		
Hazardous Material Spills		✓
Erosion and Sediment Control Failure		✓
Fire	✓	✓
Bridge or Culvert Washout		✓

5.3.5.1.1 Construction

The environmental effects associated with construction include increases in total suspended sediments, increased turbidity, change in hydrologic conditions (*e.g.,* changes in catchment area, drainage pattern, runoff characteristics), change in pH due to the potential to expose sulfide bearing rock, and increased temperature due to change in surrounding land cover (*e.g.,* change from forest cover to clearing). Recreational water quality is not likely to be affected as the principal concern would be introduction of sewage to streams used for recreational purposes. The project will not result in sewage discharge in an uncontrolled or untreated manner, hence there is no substantive interaction and this subject is not carried through the assessment.

The potential interference with the local drainage by the construction of the proposed new highway may consist of the blockage or alteration of existing drainage patterns or the creation of new drainage channels over previously undisturbed terrain.

Site Preparation

Erosion and sedimentation are possible in all phases and most activities of the Project. They are discussed here in Site Preparation because it is the first occurrence for this potential Project-VEC interaction. Erosion and sedimentation can occur anywhere and anytime soil is exposed. Potential characteristics of the proposed watercourses that may increase the risk of erosion and sedimentation include stream morphology and high discharge in the presence of erodible soils. The potential environmental effects of erosion and sedimentation on surface water is assessed in Section 5.4.5.1.1 of Fish and Fish Habitat.

Removing vegetation near riverbanks may increase bank erosion. Clearing and grubbing activities also have the potential to expose sulfide bearing rock. Drainage of sulfide bearing rock areas to watercourses can change the pH of surface waters. The ecology of the system begins to experience adverse change at pH levels below 6.0, with a reduction of diversity in plant and animal species.

Roadbed Preparation

Blasting

Blasting can have physical and chemical environmental effects on the Surface Water environment. Blasting can cause resuspension of sediments (Munday *et al.* 1986), bank failure and resultant sedimentation. Nitrogen-based explosives can reduce dissolved oxygen during nitrification and provide nutrients for aquatic plants. Nitrite promotes algal growth, which can lead to a deterioration of water quality. The potential environmental effects of blasting on surface water are assessed in Section 5.4.5.1.1 of Fish and Fish Habitat.

Excavation

Erosion and sedimentation can occur with this phase. The other primary potential environmental effect of excavation is exposing surface water to sulfide bearing bedrock and causing a pH reduction in Surface Water, as discussed above Site Preparation. Results of the preliminary sampling indicated no positive samples of sulfide bearing rock. However, the presence of a concentrated group of samples with elevated sulfide sulfur levels near the northern limits of the Project is cause for concern and will require follow up with additional sampling and testing during Construction.

Watercourse Crossing Structures

The proposed TCH will require the installation of culverts and bridges. During installation there is the potential for the discharge of sediment-laden runoff to the watercourse and for an increase in turbidity due to re-suspension of bottom sediments.

Surfacing and Finishing, and Ancillary Structures and Facilities

The handling of asphalt, concrete, hydrocarbon and hazardous materials during the construction phase and surfacing and finishing phase of the new TCH, and storage of these materials at ancillary facilities could potentially affect surface water resources. Most interactions would be considered the result of accidents, malfunctions and unplanned events.

The introduction of asphalt, and hydrocarbons to the aquatic environment can have deleterious environmental effects to water quality. The introduction of liquid concrete products or wash residues into watercourses can alter water chemistry (primarily pH). Few if any other hazardous materials besides petroleum hydrocarbons and concrete products are used in road construction.

Activities associated with the construction of ancillary facilities have the potential to expose sulfide bearing rock.

5.3.5.1.2 Operation

Winter Safety

Salting

During winter, salt is used by NBDOT on road surfaces to aid in melting snow, and to provide clear road conditions. Road salt can enter into watercourses, directly altering water chemistry. The potential environmental effects of chloride are presented in the Fish and Fish Habitat, Section 5.4.5.1.2

Sanding

The application of sand to provide increased traction during winter conditions may lead to increases in sedimentation of watercourses.

Proposed Trans-Canada Highway Presence

During the Project-related activities associated with proposed TCH presence, there is a potential for a change in water quantity. The contribution to runoff from the highway RoW will be more episodic, compared to the more gradual release of water from forested/vegetated areas, however, the potential for a substantive change in the quantity of surface water due to the highway construction is low because the surface area of the highway is relatively small compared to the area of the watersheds upgradient of the crossings of most of the watercourses. Water quality may also be affected by this interaction as runoff from pavement contains higher concentrations of suspended sediments.

The potential interference with the local flood regime by the construction of the proposed new highway would consist of the initiation or aggravation of local flooding (especially at watercourse crossings that: have large drainage basins, steep channel slopes, significant beaver activity, evidence of ice movement, an elevated ice jamming potential, and have substantial floodplains). In addition, improperly installed crossings can result in flooding and/or extensive erosion. Any improperly installed watercourse crossing structure would be considered an unplanned event, and is assessed as such.

5.3.5.1.3 Maintenance

Proposed TCH Maintenance

Maintenance of the proposed TCH may create dust and other sediment that may enter watercourses along the RoW. Maintenance of watercourse crossing structures may also introduce sediments from maintenance activities (*e.g.*, installing new liners) or may resuspend sediments when culvert blockages (*e.g.*, brush and leaves) are removed.

Vegetation and Wildlife Maintenance

Hydroseeding

Hydroseeding may result in small amounts of nutrients (*e.g.*, nitrate and phosphate) entering surface waters.

5.3.5.1.4 Accidents, Malfunctions and Unplanned Events

Accidents, malfunctions and unplanned events that may occur in association with the Project and have an adverse environmental effect on surface water resources:

- hazardous materials spills;
- erosion and sediment control failure;

- fire; and
- bridge or culvert washout.

Despite the use of proper safety facilities and procedures, it is possible to have a spill of hazardous materials during an accident, malfunction or unplanned event. A spill of hazardous materials has the potential to substantially affect the quality of the local surface water resources. Hazardous material spills could be the result of construction activities (*e.g.*, equipment fuelling or faulty vehicle components), operation activities (*e.g.*, hazardous material transport truck accident, or excessive salt application), or maintenance activities (*e.g.*, equipment fuelling).

A potential exists of failure of erosion and sediment control structures due to precipitation events. Such a failure could result in the release of a large quantity of sediment-laden runoff to receiving watercourses.

Fire could remove riparian vegetation near watercourses. Also, burned forest land may be converted for agriculture. Fire may also temporarily elevate water temperature and increase sedimentation. Fire may be caused as a result of construction activities (*e.g.*, hot equipment), operation activities (*e.g.*, discarded cigarettes or hot exhaust systems in contact with roadside vegetation), and maintenance activities (*e.g.*, hot equipment). Water required to fight the fire could affect surface water quantities. Potential environmental effects to surface water quality could result from the uncontrolled discharge of surface runoff (from fire fighting water) that may contain a wide range of contaminants from the fire.

Bridge or culvert washout may cause the loss or degradation of water quality. This could result from storms greater than accounted for in the structure design. Proper design and conservative forecasting should prevent this accident from occurring.

The potential environmental effects of bridge/culvert washout and/or ice/debris jams at the Project watercourse crossings would include local flooding. The potentially adverse environmental effects of this flooding consist of damage to private property, erosion or scarring of the watercourse banks, and washout of the highway. The environmental effects on surface water quality would consist of an increase in sediment loading in the watercourse as the channel bank and roadbed material would be added to the streamflow. A substantial structural failure could introduce enough debris in the watercourse to create a temporary blockage of water flow through the existing channel.

5.3.5.2 Environmental Effects Analysis and Mitigation

The criteria for characterizing the magnitude of environmental effects are described in the key for each phase of the Project. The criteria for characterizing the geographic extent of environmental effects are as follows:

- < 1 km^2 (includes the surface water area within 100 m of a single watercourse crossing);
- 1-10 km^2 (includes the surface water area within a 500 m of a single watercourse crossing);
- 10-50 km^2 (includes the surface water area within 500 m downgradient of the RoW);
- 50-100 km^2 (includes the surface water area within 500 m either side of the RoW);
- 100-1,000 km^2 (includes the surface water area between the RoW and the Saint John River); and
- >1,000 km^2 (includes all surface water area within the Upper Saint John River Valley).

5.3.5.2.1 Construction

During construction of the proposed TCH and associated roads and structures, several construction activities have the potential to affect surface water quality and quantity, as described in Table 5.3.7. These include any activities that involve disturbance to natural soils, and vegetation clearing that increases erosion and sedimentation, excavation of sulfide bearing bedrock, blasting, and storage and handling of hazardous materials. The sections following this table describe the mitigation strategies aimed at mitigating these potential environmental effects.

Table 5.3.7 Environmental Effects Assessment Matrix for Surface Water (Construction)

Environmental Effects Assessment Matrix
Valued Environmental Component: SURFACE WATER
Phase: Construction

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Site Preparation	Change in surface water quality (A) Change in surface water quantity (A)	• Follow EPP and EFG • Erosion/drainage control measures • Limit area of disturbance, especially within 30 m of watercourse • Minimize in stream work, work in the dry where feasible • Conduct specific sampling in sulfide rock risk areas • Follow NBDELG guidelines for sulfide rock disposal if applicable • Implement sulfide water handling and control measures where applicable • Follow beaver dam removal guidelines	1	4	2/1	R	2
Roadbed Preparation	Change in surface water quality (A) Change in surface water quantity (A)	• Follow EPP and EFG and site specific EPPs • Identify areas of acid rock drainage concern through sampling program • Obtain approval to blast from DFO • Follow DFO's blasting guidelines • Conduct specific sampling in sulfide rock risk areas • Follow NBDELG guidelines for sulfide rock disposal if applicable • Implement sulfide water handling and control measures where applicable	1	4	2/6	R	2
Surfacing and Finishing	Change in surface water quality (A)	• Follow EPP and EFG • Designated fuelling and storage area should be at least 100 m from watercourse	1	3	2/6	R	2
Watercourse Crossing Structures	Change in surface water quality (A) Change in surface water quantity (A)	• Follow EPP, EFG and site specific EPPs • Apply for Watercourse Alteration Permits, follow requirements • Follow NBDELG guidelines for watercourse alteration • Erosion control measures • Limit area of disturbance • Minimize in stream work, work in the dry where feasible	1	2	2/1	R	2

Table 5.3.7 Environmental Effects Assessment Matrix for Surface Water (Construction)

Environmental Effects Assessment Matrix **Valued Environmental Component: SURFACE WATER** **Phase: Construction**							
Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Ancillary Structures and Facilities Construction	Change in surface water quality (A) Change in surface water quantity (A)	• Follow EPP and EFG • Erosion/drainage control measures • Designated fuelling and storage area should be at least 100 m from watercourse • Conduct specific sampling in sulfide rock risk areas • Follow NBDELG guidelines for sulfide rock disposal if applicable • Implement sulfide water handling and control measures where applicable	1	1-3	2/1	R	2

Key:

Magnitude:
1 = Low: e.g., affecting the available quantity or quality of surface water resources such that these resources are either unavailable or unusable at levels that indiscernible from natural variation
2 = Medium: e.g., limiting the available quantity or quality of surface water resources such that these resources are occasionally rendered unsuitable to current users for periods of at least 2 weeks at a time
3 = High: e.g., limiting the available quantity or quality of surface water resources such that these resources are rendered unusable for current uses during the life of the Project, or for future generations beyond the cessation of construction activities

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10 - 50 km^2
4 = 50 - 100 km^2
5 = 100 - 1000 km^2
6 = >1,000 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 – 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Site Preparation

A summary of the hydrotechnical issues for each crossing is presented in Table 5.3.8. Identified in the table are the watercourses for which there is evidence of significant beaver activity, evidence of ice movement in the channel, the potential for ice/debris jams, the potential for sediment laden runoff to enter a watercourse during construction, and the potential for contaminated runoff (identified as cases where the roadway runoff is greater than 10% of the annual watercourse flow). The following subsections elaborate on the drainage, flooding and surface water quality concerns present during the site preparation phase.

Table 5.3.8 Summary of Hydrotechnical Issues for Watercourse Crossings

WC ID#	Watercourse Crossing Name*	Evidence of Beaver Activity	Evidence of Ice Movement	Ice Jam Potential	Sediment Runoff Potential	Roadway Runoff > 10% Annual Flow
1	Wark Brook				✓	
2	Tributary to Saint John River					✓
3	Tributary to Saint John River			✓	✓	
4	Tributary to Saint John River					✓
5	Tributary to Saint John River					✓
6	Tributary to Saint John River			✓	✓	
7	Plant Brook			✓		✓
8	Demerchant Brook			✓	✓	✓
9	Bryson Brook			✓	✓	
10	Tributary to Brown Brook					✓
11	Tributary to Brown Brook			✓	✓	✓
12	Tributary to Brown Brook			✓	✓	
13	Tributary to Brown Brook			✓		✓
14	Graham Brook (Access Rd. D)					
15	Graham Brook (outflow from Bishop Lake)	✓			✓	✓
15e	Graham Brook (existing lower road)					
16	Graham Brook	✓			✓	
17	Tributary to River de Chute/McMullin Brook (Access Rd. F)					✓
18	River de Chute		✓	✓	✓	
19	Tributary to Upper Guisiguit Brook					✓
20	Upper Guisiguit Brook	✓		✓	✓	
21	Tributary to Upper Guisiguit Brook					✓
22	Tributary to Lower Guisiguit Brook	✓			✓	✓
23	Tributary to Lower Guisiguit Brook					✓
24	Lower Guisiguit Brook / Tributary to Lower Guisiguit Brook			✓		
25	Tributary to Lower Guisiguit Brook	✓				
26	Tributary to Lower Guisiguit Brook					✓
27	Tributary to Lower Guisiguit Brook					✓
28	Tributary to Leith Lake Drainage					✓
29	Headwaters to Leith Lake Drainage					✓
30	Tributary 3 to Hunters Brook					✓
31	Tributary 2 to Hunters Brook					
32	Hunter Brook (Access Rd. J)				✓	
33	Big Presque Isle Stream		✓	✓	✓	

Table 5.3.8 Summary of Hydrotechnical Issues for Watercourse Crossings

WC ID#	Watercourse Crossing Name*	Evidence of Beaver Activity	Evidence of Ice Movement	Ice Jam Potential	Sediment Runoff Potential	Roadway Runoff > 10% Annual Flow
34	Tributary to Big Presque Isle Stream					✓
35	Tributary to Little Presque Isle Stream					✓
36	Little Presque Isle Stream		✓	✓	✓	
37	Little Presque Isle Stream					
38	Lanes Creek					✓
39	Tributary to Harper Brook					✓
40	Tributary to Harper Brook					✓
41	Tributary to Harper Brook					
42	Harper Brook			✓		
43	Tributary to the Meduxnekeag					✓

*refer to Figure 3.2 – A to D, Appendix C for stream locations

Drainage

It is expected that the majority of the watercourses along the proposed Project RoW are well defined with the existing local drainage concentrated through the channels. However, since the majority of the watercourses have small drainage areas, the additional drainage area from the proposed highway (*e.g.,* road surface, median, ditches) becomes important (see areas and volumes of runoff in Table 5.3.9). In addition, the paved surface will prevent absorption causing runoff to move more quickly. This will increase the "flashy" nature of stream. The design of the structures and NBDOT watershed delineations will account for the additional drainage area and associated flows.

Table 5.3.9 Surface Runoff Estimates and Comparison

WC ID#	Watercourse Crossing Name*	Roadway Area (m^2)	Annual Roadway Runoff (m^3)	Watershed Area (km^2)	Annual Watershed Flow (m^3)	Ratio of Roadway Runoff to Watershed Flow (%)
1	Wark Brook	98,460	98,460	6.01	3,005,000	3.3
2	Tributary to Saint John River	48,840	48,840	0.87	435,000	11.2
3	Tributary to Saint John River	40,980	40,980	0.90	450,000	9.1
4	Tributary to Saint John River	55,440	55,440	0.91	455,000	12.2
5	Tributary to Saint John River	34,620	34,620	0.49	245,000	14.1
6	Tributary to Saint John River	38,700	38,700	0.91	455,000	8.5
7	Plant Brook	54,600	54,600	0.85	425,000	12.8
8	Demerchant Brook	65,820	65,820	0.88	440,000	15.0
9	Bryson Brook	22,500	22,500	0.57	285,000	7.9
10	Tributary to Brown Brook	45,900	45,900	0.87	435,000	10.6
11	Tributary to Brown Brook	43,140	43,140	0.34	170,000	25.4
12	Tributary to Brown Brook	19,800	19,800	0.78	390,000	5.1
13	Tributary to Brown Brook	53,400	53,400	0.37	185,000	28.9
14	Graham Brook (Access Rd. D)	20,070	20,070	0.81	405,000	5.0
15	Graham Brook (outflow from Bishop Lake)	39,660	39,660	0.40	200,000	19.8
16	Graham Brook	80,580	80,580	3.78	1,890,000	4.3
17	Tributary to River de Chute / McMullin Brook (Access Rd. F)	27,420	27,420	0.22	110,000	24.9
18	River de Chute	108,180	108,180	75.4	37,700,000	0.3
19	Tributary to Upper Guisiguit Brook	106,320	106,320	1.24	620,000	17.1
20	Upper Guisiguit Brook	47,400	47,400	37.1	18,550,000	0.3
21	Tributary to Upper Guisiguit Brook	26,700	26,700	0.08	40,000	66.8
22	Tributary to Lower Guisiguit Brook	100,320	100,320	1.91	955,000	10.5
23	Tributary to Lower Guisiguit Brook	96,000	96,000	0.60	300,000	32.0
24	Lower Guisiguit Brook / Tributary to Lower Guisiguit Brook	59,880	59,880	29.5	14,750,000	0.4

Table 5.3.9 Surface Runoff Estimates and Comparison

WC ID#	Watercourse Crossing Name*	Roadway Area (m^2)	Annual Roadway Runoff (m^3)	Watershed Area (km^2)	Annual Watershed Flow (m^3)	Ratio of Roadway Runoff to Watershed Flow (%)
25	Tributary to Lower Guisiguit Brook	86,280	86,280	4.98	2,490,000	3.5
26	Tributary to Lower Guisiguit Brook	73,620	73,620	1.06	530,000	13.9
27	Tributary to Lower Guisiguit Brook	95,160	95,160	0.41	205,000	46.4
28	Tributary to Leith Lake Drainage	46,680	46,680	0.87	435,000	10.7
29	Headwaters to Leith Lake Drainage	75,180	75,180	0.41	205,000	36.7
30	Tributary 3 to Hunters Brook	183,540	183,540	1.18	590,000	31.1
31	Tributary 2 to Hunters Brook	102,180	102,180	2.58	1,290,000	7.9
32	Hunter Brook (Access Rd. J)	23,970	23,970	16.7	8,360,000	0.3
33	Big Presque Isle Stream	90,180	90,180	585	292,500,000	0.0
34	Tributary to Big Presque Isle Stream	190,500	190,500	1.81	905,000	21.0
35	Tributary to Little Presque Isle Stream	215,280	215,280	3.15	1,575,000	13.7
36	Little Presque Isle Stream	40,200	40,200	135	67,400,000	0.1
37	Little Presque Isle Stream	130,020	130,020	119	59,650,000	0.2
38	Lanes Creek	158,220	158,220	2.41	1,205,000	13.1
39	Tributary to Harper Brook	25,260	25,260	0.34	170,000	14.9
40	Tributary to Harper Brook	32,940	32,940	0.26	130,000	25.3
41	Tributary to Harper Brook	54,240	54,240	2.37	1,185,000	4.6
42	Harper Brook	103,380	103,380	2.70	1,350,000	7.7
43	Tributary to the Meduxnekeag	86,460	86,460	1.04	520,000	16.6
*refer to Figure 3.2A-D, Appendix C for stream locations						

Where the removal of a beaver dams is required (*e.g.*, to lower water levels), the beaver must be removed prior to the lowering of the dam by a licensed Nuisance Wildlife Control Officer in accordance with NBDNR *Beaver Dam Removal Guidelines*. The dams will be removed in accordance with the Watercourse Alteration Permit and Section 4.6 of the EFG. Typically the main constraints in removing a dam are that the dam breach cannot be wider than the average width of the channel below the dams, and any soils exposed as a result of the lowering of the water levels above the dam must be stabilized. Also, the dam will be removed in top down order to allow for a gradual release of water in the headpond.

Flooding

Three of the crossing locations (WC18 River de Chute, WC33 Big Presque Isle Stream and WC36 Little Presque Isle Stream) showed signs of active ice movement (ice scour, erosion, scarring, significant debris in channel) which could potentially be aggravated by construction of the new highway. There is limited development in or near the floodplains of most watercourses that could be affected. However, several crossing locations were assessed as having the potential for ice or debris jams, which may endanger the stability of the roadway embankment. Based on the field inspections, the following watercourses were identified as being "flashy" (due to steep channel at crossing, large stable rock) and/or had steep banks at the crossing with no floodplain. These sites would have the potential for the initiation of an ice or debris jam especially with the additional flows from the proposed highway:

- WC03 Tributary to Saint John River;
- WC06 Tributary to Saint John River;
- WC07 Plant Brook;
- WC08 Demerchant Brook;
- WC09 Bryson Brook;
- WC11 Tributary to Brown Brook;
- WC12 Tributary to Brown Brook;
- WC13 Tributary to Brown Brook;
- WC18 River de Chute;
- WC20 Upper Guisiguit Brook;
- WC24 Lower Guisiguit Brook;
- WC33 Big Presque Isle Stream;
- WC36 Little Presque Isle Stream; and
- WC42 Harper Brook.

Based on the field inspections, the following five crossings were determined to have beaver activity, which could potentially initiate or aggravate local flooding:

- WC15 Graham Brook (outflow from Bishop Lake);
- WC15 Graham Brook (existing lower road);
- WC20 Upper Guisiguit Brook;
- WC22 Tributary to Lower Guisiguit Brook; and
- WC23 Tributary to Lower Guisiguit Brook.

Surface Water Quality

The potential for the entrance of sediment laden runoff is minimal in the majority of the watercourses as the general terrain outside of the floodplain and riparian zone is relatively flat. However, at approximately one-third of the watercourse crossings, steep banks could lead to sediment laden runoff entering the watercourses. These crossings are as follows:

- WC01 Wark Brook;
- WC03 Tributary to Saint John River;
- WC06 Tributary to Saint John River;
- WC08 Demerchant Brook;
- WC09 Bryson Brook;
- WC11 Tributary to Brown Brook;
- WC12 Tributary to Brown Brook;
- WC15 Graham Brook (Bishop Lake Outflow);
- WC16 Graham Brook;
- WC18 River de Chute;
- WC20 Upper Guisiguit Brook;
- WC22 Tributary to Lower Guisiguit Brook;
- WC32 Hunters Brook;
- WC33 Big Presque Isle Stream; and
- WC36 Little Presque Isle Stream.

Table 5.3.9 presents the ratio of surface water runoff to the annual streamflow for each crossing. The potential environmental effect of contaminated runoff from the driving surface of the new highway to the watercourses is believed to be of concern where the roadway runoff volume is greater than 10% of the annual streamflow volume. The crossings that satisfy these criteria are as follows:

- WC02 Tributary to Saint John River;
- WC04 Tributary to Saint John River;
- WC05 Tributary to Saint John River;
- WC07 Plant Brook;
- WC08 Demerchant Brook;
- WC10 Tributary to Brown Brook;
- WC11 Tributary to Brown Brook;
- WC13 Tributary to Brown Brook;
- WC15 Graham Brook (Bishop Lake Outflow);
- WC17 Tributary to River de Chute;
- WC19 Tributary to Upper Guisiguit Brook;
- WC21 Tributary to Upper Guisiguit Brook;
- WC22 Tributary to Lower Guisiguit Brook;
- WC23 Tributary to Lower Guisiguit Brook;
- WC26 Tributary to Lower Guisiguit Brook;
- WC27 Tributary to Lower Guisiguit Brook;
- WC28 Tributary to Leith Lake Drainage;

- WC29 Headwaters to Leith Lake Drainage;
- WC30 Tributary 3 to Hunters Brook;
- WC33 Tributary to Big Presque Isle Stream;
- WC35 Tributary to Little Presque Isle Stream;
- WC38 Lanes Creek;
- WC39 Tributary to Harper Brook;
- WC40 Tributary to Harper Brook; and
- WC43 Tributary to Meduxnekeag River.

Erosion and sedimentation could occur during all Project phases. Erosion systems will be in place to manage runoff from the construction areas. Erosion control measures are presented in Section 5.4.5.2.1 of the Fish and Fish Habitat VEC.

Erosion protection measures such as geotextiles and geomembranes will be used as necessary to minimize suspension and removal of soil particles by flowing water. Prior to the start of construction at each site, all erosion control structures such as silt fences, buffer strips, filter berms and sediment traps will be in place to trap any suspended soil particles from entering watercourses. Monitoring of erosion control structures will be conducted to ensure the structures remain in place and operate effectively throughout the construction period. Specifically, all structures will be inspected prior to and following any rainfall event, and at least daily during prolonged periods of rainfall. Erosion control measures will not be removed until the exposed areas have been stabilized by vegetation.

During construction, a wet weather shut down policy will be in place to avoid soil disturbance during runoff periods. In addition, a watercourse monitoring program will be developed in consultation with DFO, which will include total suspended solids and pH (where the potential for sulfide bearing rock drainage exists).

Clearing and grubbing will be minimized within 30 m of the watercourse. Enough vegetation must be allowed to grow along the bank of the watercourse to maintain the stability of the banks. Vegetation will also provide shade to prevent an excessive rise in water temperature. NBDOT will avoid long skids of timber on steep slopes adjacent to watercourses as well as avoid felling or skidding trees across a watercourse. Where possible, NBDOT will not use heavy machinery within 10 m of streambanks. Any trees that need to be cut within 10 m of a watercourse will be cut by hand or by machinery able to "reach-in" within those areas.

The environmental effect of removal of vegetation is reversible through natural succession and replanting of appropriate native vegetation.

Exposure of sulfide bearing rock is a possibility during site preparation activities. Mitigation activities to deal with sulfide bearing rock exposure are discussed in the following roadbed preparation subsection.

Sulfide Bearing Rock Drainage

Preliminary sampling indicated no positive samples of sulfide bearing rock. Prior to construction, NBDOT will use the results of the induced polarization investigation to complete the determination of the potential for a Project interaction with sulfide bearing rock by preferentially sampling those areas where anomalous induced polarization readings occurred.

Based on consideration of the potential environmental effects of the individual activities required for RoW preparation of the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g.*, NBDOT EPP, EFG, site specific EPPs and *Watercourse Alteration Technical Guidelines*), and the residual environmental effects significance ratings criteria, the environmental effects on surface water quality and quantity by these activities are considered not significant.

Roadbed Preparation

Blasting will be avoided where possible but in some instances it may be unavoidable. Should blasting be required during construction in or near a watercourse, authorization will be required from DFO for the use of explosives (Section 32 of the *Fisheries Act)*. Blasting will be conducted in accordance with the EPP (Section 4.4) and EFG (Section 4.8.1) and *Guidelines for use of Explosives in Canadian Fisheries Waters* (Wright and Hopky 1998), and in full compliance with the requirements of DFO's authorization.

It is understood that the contract for the construction work would follow the normal public tendering process for NBDOT highway grading contracts. The NBDOT Standard Specifications (2003) would be followed as the contract requires and as such, this document outlines the general practices and standards that shall be applied to the work including but not limited to rock excavation (Item 108), placement of borrow (Item 121), and environmental requirements (Item 948).

It is common practice to discharge water accumulated within work areas on RoW or adjacent lands prior to proceeding with grading work. In sloping areas (vertical alignment), excavation waters or surface runoff from the RoW may need to be controlled during construction to minimize environmental effects on adjacent surface waters from erosion and sedimentation. Elevated suspended sediments, total dissolved solids and metal concentrations are common water quality issues associated with this activity, especially in seasonally wet periods.

Blasting within 50 m of a watercourse is considered part of watercourse alteration activities, and will follow the federal *Fisheries Act* guidelines for blasting.

Sulfide Bearing Rock

None of the samples collected in the preliminary sulfide bearing rock study tested positive. Sulfide bearing rock within the zone of influence of the Project is likely to have a high neutralizing potential. NBDOT intends to drill and collect bedrock samples along the proposed alignment prior to construction. Drilling at a regular interval will be undertaken within the areas where grade cuts are expected to exceed 3 m in depth. In addition, an increased sampling interval will be used for the sampling within the areas where the induced polarization investigation had identified anomalies. The samples will be tested for both sulfide sulfur content and NP/AP ratio. The magnitude of the risk can be defined by this testing and measures would only be employed where results would demonstrate a need.

Specialized disposal procedures for excavated sulfide bearing rock will be required to avoid long-term rock disposal effects, should sulfide bearing rock be exposed during Project construction activities. These procedures could include immediate disposal upon excavation, placement in covered contained holding areas for no longer than 30 days, and collection and disposal of associated low pH waters, until a final disposal site is selected. NBDELG guidance dealing with sulfide bearing materials will be followed in addition to mitigation measures outline in the EPP (Section 7.11). Final disposal would normally be undertaken in marine waters due to their neutralizing and reducing conditions. These regulations focus on disposal of sulfide bearing rock. For ocean dumping, an Ocean Dredging and Disposal Permit under the *CEPA* issued by Environment Canada would also be required. The dumping permit would apply to any rock placed in the ocean and might also apply to estuarine bodies, depending upon site location relative to the ocean.

Watercourse Crossing Structures

Preliminary details of the proposed watercourse crossing structures have been provided by NBDOT. These details (as presented in Table 5.3.10) include the type of structure (concrete pipe, concrete box, or open bottom structure), the number of structures, drainage areas and design flows. The suitability of these types of structures was reviewed based on observations made during the field inspections, as well as the crossing and watershed physiographic characteristics.

It should be noted that the drainage areas provided by NBDOT do not match those presented in other sections of this report. The drainage areas presented elsewhere in this report are based on existing (pre-construction) drainage patterns, while those presented below take into account changes in area due to the Project.

The seven structures proposed by NBDOT are in agreement with the seven crossings for which open bottom structures have been recommended. In these seven cases, the size of the crossing required precludes the installation of box or pipe culverts, which are typically the preferred crossing structures in terms of habitat destruction. In these cases open bottom structures will be used. Section 2.2.3 provides additional criteria for the selection of watercourse crossing structure type. The NBDOT proposed culverts meet or exceed the minimum hydraulic capacity requirements for all watercourse crossings based on the design flows presented below.

A review of the design flows and culvert sizes was performed using the Rational Equation and the pre-construction drainage areas presented in this report. Although the NBDOT design flows were calculated using a different methodology, the selected pipe sizes are the same with a larger diameter recommended for one crossing, WC27, Tributary to Lower Guisiguit Brook. Using the review methodology, a culvert diameter of 1500 mm would be required. This method, however, does not account for the watercourse 27 culvert functioning as a wetland cross drain, and may over-predict the required pipe diameter, as attenuation of the peak flow due to wetland storage is not considered. Further review of the minimum culvert size for WC27, Tributary to Lower Guisiguit Brook, is recommended in the final design.

Table 5.3.10 Summary of NBDOT Proposed Hydraulic Structures

WC ID#	Watercourse Crossing Name	Drainage Area (km^2)	Design Flow (m^3/s)	Estimated Concrete Box or Pipe Size (mm)	Number	Estimated Length (m)
1	Wark Brook	6.01	n/d	n/d	n/d	n/d
2	Trib to Saint John River	0.87	3.24	1800	1	186.5
3	Trib to Saint John River	0.90	3.27	1800	1	192.5
4	Trib to Saint John River	0.91	3.59	1800	1	203.5
5	Trib to Saint John River	0.49	2.66	1500	2	58.5
6	Trib to Saint John River	0.91	3.48	1800	2	54.5
7	Plant Brook	0.85	3.63	1800	2	57.5
8	Demerchant Brook	0.88	3.84	1800	2	45.5
9	Bryson Brook	0.57	2.61	1500	2	45.5
10	Trib to Brown Brook	0.87	n/d	n/d	n/d	n/d
11	Trib to Brown Brook	0.34	n/d	n/d	n/d	n/d
12	Trib to Brown Brook	0.78	n/d	n/d	n/d	n/d
13	Trib to Brown Brook	0.37	n/d	n/d	n/d	n/d
14	Graham Brook (access rd)	0.81	n/d	n/d	n/d	n/d
15	Graham Brook (Bishops Lk)	0.40	0.65	1000	2	38.5
16	Graham Brook	3.78	8.23	2700	1	170.5
17	Trib to River de Chute	0.22	n/d	n/d	n/d	n/d
18	River de Chute	75.40	68.80	structure	2	370.0
19	Trib to Upper Guisiguit Brook	1.24	n/d	n/d	n/d	n/d
20	Upper Guisiguit Brook	37.10	42.30	Bridge	2	140.0

Table 5.3.10 Summary of NBDOT Proposed Hydraulic Structures

WC ID#	Watercourse Crossing Name	Drainage Area (km^2)	Design Flow (m^3/s)	Estimated Concrete Box or Pipe Size (mm)	Number	Estimated Length (m)
21	Trib to Upper Guisiguit Brook	0.08	n/d	n/d	n/d	n/d
22	Trib to Lower Guisiguit Brook	1.91	4.31	2100	1	186.5
23	Trib to Lower Guisiguit Brook	0.60	1.81	1500	1	194.5
24	Lower Guisiguit Brook	29.50	40.40	structure	2	75.0
25	Trib to Lower Guisiguit Brook	4.98	11.70	3600 x 2400	1	170.5
26	Trib to Lower Guisiguit Brook	1.06	3.48	1800	2	57.5
27	Trib to Lower Guisiguit Brook	0.41	1.03	1000	2	54.5
28	Tributary to Leith Lk	0.87	3.07	1800	2	57.5
29	Headwaters to Leith Lk	0.41	3.63	1800	2	46.5
30	Trib to Hunters Brook	1.18	n/d	n/d	n/d	n/d
31	Trib to Hunters Brook	2.58	8.73	2400	2	42.5
32	Hunters Brook	16.70	n/d	structure	n/d	n/d
33	Big Presque Isle Stream	585	400	structure	2	120.0
34	Trib to Big Presque Isle Stream	1.81	9.68	2700	2	74.5
35	Trib to Little Presque Isle Stream	3.15	10.10	2700	2	48.5
36	Little Presque Isle Stream	135	124	structure	1	100.0
37	Little Presque Isle Stream	119	112	structure	2	60.0
38	Lanes Creek	2.41	9.54	2700	2	38.5
39	Trib to Harper Brook	0.34	n/d	1000	2	36.5
40	Trib to Harper Brook	0.26	n/d	1000	2	36.5
41	Trib to Harper Brook	2.37	5.55	2100	2	32.5
42	Harper Brook	2.70	5.65	2100	2	38.5
43	Trib to the Meduxnekeag	1.04	4.91	2100	2	40.5

n/d = not determined

Generic diagrams of typical watercourse crossing structures including: pipe culvert; box culvert, arch; and bridge, are included in Section 2.2.3. Criteria used to determine which structure will be used at each site is also included in the discussion of alternatives in Section 2.2.3.

As part of the design process, an application for a Watercourse Alteration Permit will be made to NBDELG for each watercourse crossing and other construction activities within 30 m of a watercourse. Conditions associated with the permit will be met by NBDOT.

As part of the design process, a request for determination of navigability has been made to DFO (Canadian Coast Guard) for all watercourses crossed by the proposed TCH. The following were determined to navigable:

- WC18 - River de Chute;
- WC33 - Big Presque Isle;
- WC35 - Tributary to Little Presque Isle;
- WC36 - Little Presque Isle; and
- WC37 - Little Presque Isle.

Where watercourses are determined to be navigable by DFO, watercourse crossing structures will be in compliance with the Navigable Waters Permit as issued by DFO.

During construction, an on-site monitor (environmental inspector) will ensure that the installations are conducted according to the planning process, meet the Conditions of Approval as prescribed in the Watercourse Alteration Permit and do not introduce suspended sediments or contaminants to surface waters.

All culverts will be designed following the *Guidelines for the Protection of Fish and Fish Habitat - The Placement and Design of Large Culverts, Fisheries and Oceans Canada, Maritimes Region* (DFO 1999a) and the *Watercourse Alteration Technical Guidelines* (NBDELG 2002b). Culverts will be installed following Section 5 of the EPP and Section 6 of the EFG. Bridges will be installed following Section 5 of the EPP and Section 7 of the EFG.

Surfacing and Finishing, and Ancillary Structures and Facilities Construction

Specific mitigative measures in regard to storage of hazardous materials are identified in Section 4.19 of the EPP and Section 5.0 of the EFG. Storage of hazardous materials will not occur within 100 m of a watercourse. Permanent storage areas for containers or drums will be clearly marked, have appropriate secondary containment, and be located on an impermeable floor that slopes to a safe collection area. Refuelling of equipment will not be undertaken within 30 m of a watercourse. Wastewater from washing equipment will not be released into a watercourse. Storage of all hazardous materials will comply with WHMIS requirements, and appropriate material safety data sheets will be located at the storage site. Spills or accidental release of hazardous materials are evaluated within the Accidents, Malfunctions and Unplanned Events phase.

Mitigation for Project interactions with sulfide bearing rock during ancillary structures and facilities construction activities will be mitigated as described for roadbed preparation activities.

Based on consideration of the potential environmental effects of the individual activities and physical works required for construction along the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g.*, EPP, EFG, site specific EPPs, *Watercourse Alteration Technical Guidelines*, Design criteria for Fish Passage and New Brunswick Regulations concerning sulfide bearing materials), and the residual environmental effects significance ratings criteria, the environmental effects of construction on surface water quality and quantity are considered as not significant.

5.3.5.2.2 Operation

The following provides an evaluation of key potential Project-VEC interactions for the operation phase of the Project as summarized in the environmental effects assessment matrix (Table 5.3.11). Operation of the proposed TCH will continue in perpetuity upon completion of the construction phase of the Project. The main issues in this phase of the Project related to surface water are proposed TCH presence (*e.g.,* long term erosion, sedimentation and runoff), and winter safety (*e.g.,* use of salt and sand for snow removal and providing traction). Further discussion, by Project phase follows the table.

Table 5.3.11 Environmental Effects Assessment Matrix for Surface Water (Operation)

Environmental Effects Assessment Matrix
Valued Environmental Component: SURFACE WATER
Phase: Operation

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Winter Safety	Change in surface water quality (A)	• Develop long term salt management plan • Follow EPP and EFG	1	3	2/2	R	2
Proposed TCH Presence	Change in surface water quality (A) Change in surface water quantity (A)	• Proper design of cut and fills and ditching • Site specific EPPs • Regular inspection and maintenance of watercourse crossing structures • *Watercourse Alteration Technical Guidelines*	1	3-4	5/6	R	2

Key:

Magnitude:
1 = Low: e.g., affecting the available quantity or quality of surface water resources such that these resources are either unavailable or unusable at levels that indiscernible from natural variation
2 = Medium: e.g., limiting the available quantity or quality of surface water resources such that these resources are occasionally rendered unsuitable to current users for periods of at least 2 weeks at a time
3 = High: e.g., limiting the available quantity or quality of surface water resources such that these resources are rendered unusable for current uses during the life of the Project, or for future generations beyond the cessation of construction activities

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10 - 50 km^2
4 = 50 - 100 km^2
5 = 100 - 1000 km^2
6 = >1,000 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 - 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Winter Safety

Environment Canada recently completed an assessment of road salt under *CEPA*. Recognizing that a total ban of road salt could potentially compromise human safety, the focus of road salt risk management is on implementation measures that optimize winter road maintenance practices so as to not jeopardize road safety while minimizing the potential environmental effects (Environment Canada 2001c). Therefore Environment Canada has categorized road salt as a Track 2 substance, requiring Life-Cycle Management. Management instruments to reduce the potential environmental effects of road salts are being developed through a national multi-stakeholder group (which involves representation from NBDOT) working in conjunction with Environment Canada. In accordance with Environment Canada's policy on road salt, all road agencies must develop a Salt Management Plan. NBDOT is committed to developing best salt management practices in a continued effort to reduce the environmental effects of road salt on the environment.

As per Environment Canada's Code of Practice for the Environmental Management of Road Salts, NBDOT is in the process of developing a salt management plan. The primary objective of the plan is to minimize the use of salt. The salt management plan will be grounded in the principles of safety, environmental protection, continual improvement, fiscal responsibility, efficient transport systems, accountability, measurable progress, agency-based communication, knowledgeable and skilled workforce.

Procedures outlined in the Transportation Association of Canada's Best Practices for Road Salt Management will be incorporated into the document. Specific measures of the salt management plan are not known at this time however the following elements will be incorporated into the plan:

- a commitment to achieve environmental protection without compromising road safety;
- methods to help deliver appropriate amounts of road salt in the right place at the right time;
- use of alternative methods in vulnerable areas such as groundwater recharge areas, small lakes and ponds, low flow rivers, salt sensitive vegetation and wetlands, species at risk habitat and agricultural areas;
- provisions to measure the effectiveness of road salt;
- increased monitoring of watercourses along dense highway networks; and
- a requirement that NBDOT and all developers follow the plan."

Section 6.2 of the EPP and Section 5.6 of the EFG identify salt application protection measures. Application rates identified in the Highway Maintenance Management System Field Manual (NBDOT 1992b) will be used to maximize the efficiency of salting and sanding and minimize the potential environmental effects.

Based on consideration of the potential environmental effects of the individual activities required for winter safety along the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g*., EPP, EFG, and development of best salt management practices), and the residual environmental effects significance ratings criteria, the environmental effects on surface water quality and quantity by these Project-related activities are considered as not significant.

Proposed TCH Presence

The long-term operation of the proposed TCH may create conditions that allow for erosion and sedimentation. Stabilization during construction and permanent erosion control measures will mitigate long-term environmental effects of erosion and sedimentation. Appropriate erosion control measures for each watercourse bank will be specified in site specific environmental protection plans developed as part of the highway design. These will minimize the potential for stream bank destabilization and erosion. Residual environmental effects are expected to be not significant. There is a potential for runoff from the road surface to contain contaminants that may affect surface water quality.

Field studies presented in a series of resource documents for environmental assessments with traffic volumes and winter conditions similar to the Project were reviewed to predict the extent and magnitude of potential environmental effects of the Project on local surface water quality. The following five case studies are from a Federal Highway Administration document titled "Effects of Highway Runoff on Receiving Waters – Resource Document for Environmental Assessments (Dupuis *et al*. 1985).

- The University of Washington conducted research on the effects of highway stormwater runoff on aquatic ecosystems. Green algae, zooplankton and rainbow trout were evaluated to determine the toxic effects of stormwater highway runoff on Interstate 90 which has an average daily traffic of 7,700 vehicles, similar to the 5,500 on the existing TCH between Grand Falls and Aroostook. No apparent toxicity was observed in any of the samples.

- Similar studies along the Interstate 5, with an average daily traffic of 50,000 vehicles, showed toxicity in some of the rainbow trout samples due to high concentrations of soluble metals. Higher total suspended solids concentrations were also observed in these instances. It was hypothesized that high rates of respiration result in fish being stressed by the presence of suspended particulates. The stress leads to higher volumes of water passing over the gill and further reductions in pH in the region of the gills. Under these conditions, metals are more readily desorbed from particulates and can be taken up by the fish. Subsequent experimentation indicated that runoff passing through vegetated areas dramatically decreased total suspended solids levels and levels of extractable metals.

- During a winter snowmelt event at the Wisconsin Highway 15/Sugar Creek crossing, the stream exhibited only slightly elevated chloride concentrations at a highway influenced station during a snow melt period (peak of 65 mg/L) as compared to the control station (42 mg/L during the melt), and background dry weather concentrations at all stations prior to the melt event (23 to 50 mg/L). Approximately 18.2 tons of salt had been applied to the 5.6 km long ROW tributary to the stream during the week prior to the melt event.

- In cases where increases were larger (up to 250 mg/L at a headwater tributary), during a snowmelt/rainfall event at I-85/Sevenmile Creek near Efland, North Carolina, considerably lower concentrations were observed downstream. As a result of dilution, downstream levels were 34 mg/L, as compared to 21 mg/L at the control station. Approximately 14.4 tons of salt were applied to the 7.7 km long ROW draining into the creek.

- Road salt can contribute to drift of stream benthos. Drift is a phenomenon in which organisms dislodge from the substrate and enter the water where they are swept with the current. Studies on the effect of deicing salt on drift of stream benthos indicate that drift in general, only occurs at concentrations of 1,000 mg Cl/L or more.

Highway runoff volume is equal to approximately 50% of the rainfall volume (per a given area) for a rural highway with a flush shoulder and non-paved ditches (Kobriger et al. 1981). The average total solids accumulation rate for this type of highway is approximately 5.5 kg/km of highway per day (summer conditions). This conservative value is based on 1981 technology (*e.g.,* emissions controls, gasoline quality), and it is likely that current and future accumulations are and would be less. The amount that would end up in highway runoff is a function of rainfall amount, intensity, duration, and pre-event conditions (*e.g.,* number of dry days preceding rain event). In general, rural 4-lane highway runoff has much less potential to affect watercourse water quality than does urban stormwater (Kobriger *et al*. 1981).

Potential mitigation to reduce the potential environmental effects of contaminated runoff from the proposed TCH on watercourses that have a ratio of roadway runoff to watershed flow of greater than 10% (Table 5.3.9) includes:

- increased employee awareness training prior to commencement of operation activities (*e.g.,* salt and sand application during winter) within these watersheds;
- install permanent sediment control structures (*i.e.,* check dams) in drainage ditches within these watersheds; and
- apply increased vigilance and inspection of permanent erosion and sediment control structures within these watersheds.

Culverts and bridges can become blocked with ice and/or debris. Culverts and bridges will be inspected, cleaned and repaired on a regular basis, to ensure adequate flow, and to maintain the integrity of the structure. Watercourse and Wetland Alteration Permits will be applied for any activities at these crossings. The maintenance or construction activities will be conducted according to the requirements specified in the Watercourse and Wetland Alteration Permit. Section 5 of the EPP and Section 6 and 7 of the EFG protection measures will be implemented. Erosion control measures shall be installed as required, and removed material from the watercourse will be disposed of in such a way as to prevent material from re-entering the watercourse.

Based on consideration of the potential environmental effects of the individual activities and physical works associated with winter safety and the proposed TCH presence, the proposed mitigation (*e.g.*, EPP, EFG, site specific EPPs, *Watercourse Alteration Technical Guidelines*, and regular inspection and maintenance of watercourse crossing structures), and the residual environmental effects significance ratings criteria, the environmental effects of operation on Surface Water quality are considered not significant.

5.3.5.2.3 Maintenance

The following provides an evaluation of key potential Project-VEC interactions for the maintenance phase of the Project as summarized in the environmental effects assessment matrix (Table 5.3.12). Routine highway maintenance that may potentially interact with surface water resources includes ditching, vegetation control and watercourse crossing structure repairs. Further discussion, by Project phase follows the table.

Table 5.3.12 Environmental Effects Assessment Matrix for Surface Water (Maintenance)

Environmental Effects Assessment Matrix
Valued Environmental Component: SURFACE WATER
Phase: Maintenance

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Proposed TCH Maintenance	Change in surface water quality (A)	• Follow EPP and EFG • Apply for Watercourse Alteration Permits, follow requirements • Implement necessary control measures • maintain buffer zone within 30 m of watercourse	1	3	5/6	R	2

Table 5.3.12 Environmental Effects Assessment Matrix for Surface Water (Maintenance)

Environmental Effects Assessment Matrix
Valued Environmental Component: SURFACE WATER
Phase: Maintenance

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Vegetation and Wildlife Management	Change in surface water quality (A)	• Follow EPP and EFG • Apply for Watercourse Alteration Permits, follow requirements • maintain buffer zone within 30 m of watercourse	1	3	5/6	R	2

Key:

Magnitude:
1 = Low: e.g., affecting the available quantity or quality of surface water resources such that these resources are either unavailable or unusable at levels that indiscernible from natural variation
2 = Medium: e.g., limiting the available quantity or quality of surface water resources such that these resources are occasionally rendered unsuitable to current users for periods of at least 2 weeks at a time
3 = High: e.g., limiting the available quantity or quality of surface water resources such that these resources are rendered unusable for current uses during the life of the Project, or for future generations beyond the cessation of construction activities

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10 - 50 km^2
4 = 50 - 100 km^2
5 = 100 - 1000 km^2
6 = >1,000 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 - 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Proposed TCH Maintenance

Ditching may be required to improve water flow or manage erosion or excessive vegetative growth. The primary issue of concern is the release of sediment into surface water bodies. Section 6.1.4 of the EPP and Section 4.4. of the EFG provides detailed protection measures to protect surface waters during ditching-related interactions. The end of ditching should not come within 30 m of a watercourse. Ditches should be directed into surrounding vegetation where possible, rather than entering directly into a natural watercourse. A Watercourse Alteration Permit will be applied for any activities within 30 m of a watercourse.

Vegetation and Wildlife Management

Vegetation control will be conducted by mechanical clearing during highway operation on the RoW (*e.g.,* road shoulders and interchanges). As stated in Section 6.1.6. of the EPP, there will be no herbicides used for vegetation control. For vegetation control activities within 30 m of a watercourse, when required, a Watercourse Alteration Permit will be obtained before initiation of activities. Slash shall not be allowed to enter any watercourse.

Based on consideration of the potential environmental effects of the individual activities associated with the vegetation and wildlife management along the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g.*, EPP, EFG, site specific EPPs and *Watercourse Alteration Technical Guidelines*), and the residual environmental effects significance ratings criteria, the environmental effects of maintenance on surface water quality and quantity are considered not significant.

5.3.5.2.4 Accidents, Malfunctions and Unplanned Events

The following provides an evaluation of key potential Project-VEC interactions for accidents, malfunctions and unplanned events as summarized in the environmental effects assessment matrix (Table 5.3.13). The main issues related to surface water are hazardous materials spills, erosion and sediment control failure, fire and bridge/culvert washout and ice/debris jams. These accidents are possible during all Project phases. Further discussion of each accident type follows the table.

Table 5.3.13 Environmental Effects Assessment Matrix for Surface Water (Accidents, Malfunctions and Unplanned Events)

Environmental Effects Assessment Matrix
Valued Environmental Component: SURFACE WATER
Phase: Accidents, Malfunctions and Unplanned Events

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Hazardous Material Spills	Change in surface water quality (A)	• Follow EPP and EFG procedures, and provincial and federal regulations should be followed for storage and handling of materials • Contingency plan • Employee training	1-2	3-5	1/1	R	2
Fire	Change in surface water quality (A) Change in surface water quantity (A)	• Follow EPP and EFG preventative measures • Contingency plan	1-2	4-5	1/1	R	2
Erosion and Sedimentation Control Failure	Change in surface water quality (A)	• Follow EPP and EFG • Regular inspections • Contingency plan	2	1-5	1/1	R	2

Table 5.3.13 Environmental Effects Assessment Matrix for Surface Water (Accidents, Malfunctions and Unplanned Events)

Environmental Effects Assessment Matrix
Valued Environmental Component: SURFACE WATER
Phase: Accidents, Malfunctions and Unplanned Events

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Bridge or Culvert Washout	Change in surface water quality (A)	• Design watercourse crossing to handle the 1 in 100 year peak discharge event • Conservative culvert and bridge design criteria • Regular inspection as part of maintenance program	1-2	1 -2	1/1	R	2

Key:

Magnitude:
1 = Low: e.g., affecting the available quantity or quality of surface water resources such that these resources are either unavailable or unusable at levels that indiscernible from natural variation
2 = Medium: e.g., limiting the available quantity or quality of surface water resources such that these resources are occasionally rendered unsuitable to current users for periods of at least 2 weeks at a time
3 = High: e.g., limiting the available quantity or quality of surface water resources such that these resources are rendered unusable for current uses during the life of the Project, or for future generations beyond the cessation of construction activities

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10 - 50 km^2
4 = 50 - 100 km^2
5 = 100 - 1000 km^2
6 = >1,000 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 - 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Hazardous Materials Spill

The potential environmental effects of hazardous material spills on aquatic life are described in Section 5.4.5.2.4 in Fish and Fish Habitat. It is not likely that a hazardous material spill would create a long-term Project-related exceedance of the CCME guidelines for the protection of aquatic life or recreation (CCME 1999). The likelihood of a hazardous material spill during construction will be minimized by following Section 4.19 of the EPP and Section 5 of the EFG. The likelihood of a hazardous material spill during Operation will be minimized through highway design standards, enforcement of speed limits, signage, and winter safety methods. In the event of a hazardous material spill, Section 5.7 of the EFG will be followed. Specifically, the spilled material will be controlled and contained, and NBDOT will assist with the clean up. Materials to facilitate a rapid containment and clean up of hazardous material spills will be available on site during construction in or near watercourses and wetlands. Section 5.2.5.2.4 describes the regulation of the transport of dangerous goods.

Site-specific EPPs will be developed for work near environmentally sensitive areas and these will address preparedness measures that are necessary to ensure effective emergency response in the event of spills is reflective of the level of sensitivity.

Based on consideration of an accident, malfunction, or unplanned event, involving the release of a hazardous material into Surface Water along the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g.*, EPP, EFG, Design Standards), and contingency plans (*i.e.*, EFG) the environmental effects during construction and operation of hazardous material spills are considered unlikely and not significantly. However, because of the possibility (almost no chance of occurrence) of a substantial hazardous material spill of a toxic substance directly into a watercourse, the environmental effect of an accidental hazardous material spill on surface water quality is considered as potentially significant, but extremely unlikely.

Erosion and Sediment Control Failure

The potential environmental effects of an erosion and sediment control failure, and the proposed mitigation and contingencies are discussed in Section 5.4.5.2.4 of Fish and Fish Habitat.

Based on consideration of an accident, malfunction or unplanned event, involving an erosion and sediment control failure affecting surface water along the proposed TCH and associated roads and facilities, the proposed mitigation, and contingency plans, and the environmental effects rating criteria, the potential environmental effects are considered as not significant.

Fire

The potential environmental effects a forest fire, and the proposed mitigation and contingencies are discussed in Section 5.4.5.2.4 of Fish and Fish Habitat.

Based on consideration of an accident, malfunction, or unplanned event, involving a forest fire contacting surface water along the proposed TCH and associated roads and facilities, the proposed mitigation, and contingency plans, and the environmental effects rating criteria, the potential environmental effects are considered as not significant.

Bridge or Culvert Washout

There is a potential during high flood events for portions of the highway, or bridge or culvert installations to be washed out. This could temporarily degrade water quality due to increased sedimentation, or affect habitat quantity by deposition of debris material into the stream (concrete debris, bridge/culvert materials) that could affect stream flow. Factors influencing the magnitude, duration and geographic extent of the environmental effect include amount and duration of flooding, type and size of washout, natural terrain surrounding the watercourse and location within the watershed. The extent of the environmental effects of such a road failure or washout on surface water is predicted to be low due to the small area of a watershed which is covered by the watercourse crossing. Reversibility potential is high due to the dynamic nature of stream high spring discharges and high spring bedload transportation.

Roads are most susceptible to washouts during the high flow period during and immediately following spring snow melt. Road design will focus on protection of the aquatic environment by incorporating buffer zones, drainage and erosion control features and very conservative culvert and bridge design criteria. Watercourse crossings (bridges and culverts) will be designed with a hydraulic capacity to handle at least the 1 in 100 year peak discharge event, and will follow the *Watercourse Alteration Technical Guidelines* (NBDELG 2002b). Routine maintenance practices will include inspection of watercourse crossing structures and debris will be removed as appropriate.

Based on consideration of an accident, malfunction or unplanned event, involving a bridge or culvert washout affecting surface water along the proposed TCH and associated roads and facilities, the proposed mitigation, and contingency plans, and the environmental effects rating criteria, the potential environmental effects are considered not significant.

5.3.5.3 Determination of Significance

Table 5.3.14 evaluates the significance of potential residual environmental effects resulting from the interaction between Project activities and surface water resources, after taking into account any proposed mitigation. The table also considers the level of confidence of the study team in this determination and the likelihood of potential environmental effects. The residual environmental effects are considered not significant for all Project phases. Potential hazardous material spills for the Project are considered as significant for hazardous material spills, but unlikely.

Based on consideration of the Project related and cumulative environmental effects, it is concluded that the surface water resources in the vicinity of the Project have the capacity to meet the needs of the present and those of the future.

Table 5.3.14 Residual Environmental Effects Summary Matrix for Surface Water

Residual Environmental Effects Summary Matrix
Valued Environmental Component: SURFACE WATER

Phase	Residual Environmental Effects Rating	Level of Confidence	Likelihood	
			Probability of Occurrence	Scientific Certainty
Construction	NS	3	3	3
Operation	NS	3	3	3
Maintenance	NS	3	3	3
Accidents, Malfunctions and Unplanned Events	S	3	1	3
Project Overall	NS	3	3/1	3

Key
Residual Environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Level of Confidence
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgement
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgement
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence
N/A = Not Applicable
*As determined in consideration of established residual environmental effects rating criteria.

5.3.6 Monitoring and Follow-up

The Project may result in residual environmental effects on surface water quality. In particular, total suspended solid (TSS) concentrations in watercourses may increase as a result of the mobilization of sediment from Project-related activities. An increase in TSS concentrations may elevate surface water temperature and increase the rate of sedimentation that may adversely alter fish habitat. In addition, the pH of surface water may be lowered (become more acidic) should water make contact with any sulfide bearing rock that may be exposed during Project-related activities.

The surface water monitoring program will consist of both compliance and effectiveness monitoring. During construction, compliance monitoring will ensure that all applicable environmental protection and permitting requirements for work within 30 m of a watercourse are followed, and that remedial action, if necessary, is successfully implemented. The surface water compliance monitoring will consist of the following core elements at all watercourses, as applicable:

- sampling of total suspended solids when precipitation events result in the visable overland flow of water;
- regular sampling of pH in watercourses where interaction with sulfide-bearing rock has been identified;
- inspection of all sediment and erosion control measures;
- inspection of hazardous materials storage areas (including possible sediment generating materials);

- inspection of watercourse crossing structures (including culverts) for verification of correct installation, and for subsequent signs of erosion or degradation (including beaver dams);
- development and maintenance of a log of erosion-prone areas;
- frequency of reporting to regulators; and
- exceedance thresholds and remedial actions.

The location and frequency of observations and the required sample size will be determined in consultation with NBDELG and DFO through their respective permitting and authorization processes.

Effectiveness monitoring for surface water is included in the description of effectiveness monitoring for Fish and Fish Habitat in Section 5.13.3.4.

5.4 Fish and Fish Habitat

5.4.1 Rationale for Selection as Valued Environmental Component

Fish and fish habitat was selected as a VEC because of the potential for interactions between Project activities and the freshwater biological environment; most importantly, the crossing by the proposed TCH of 43 watercourses and their related structures and activities (*e.g.*, culvert and bridge installation).

In the context of the Fish and Fish Habitat VEC, the following definitions apply.

"Fish" is defined as per the *Fisheries Act* as fish and crustaceans and any parts of fish and crustaceans; and the eggs, sperm, spawn, larvae, spat and juvenile stages of fish and crustaceans. Reference in the *Fisheries Act* to shellfish and marine animals is not included as the Project does not interact with the marine environment.

"Fish habitat" is defined as per the *Fisheries Act* as spawning, rearing, nursery, food supply, overwintering, migration corridors and any other area on which fish depend directly or indirectly in order to carry out their life processes.

In this section, the environmental effects of the Project activities on fish and fish habitat resulting from construction, operation, and maintenance as well as accidents, malfunctions and unplanned events is assessed.

5.4.2 Environmental Assessment Boundaries

5.4.2.1 Spatial and Temporal

The spatial boundaries (the "Assessment Area") for the assessment of the potential environmental effects of the Project on fish and fish habitat includes all watercourses that will be crossed by the proposed TCH, from the headwaters to the confluence with the Saint John River, and all water bodies (*i.e.*, lakes and ponds) within 500 m of construction activities; where activities associated with site preparation, construction, operation, maintenance, and accidents, malfunctions and unplanned events of the Project could potentially result in environmental effects on Fish and Fish Habitat.

The Saint John River between Perth-Andover and Woodstock is included in the assessment as the proposed TCH alignment comes within the 500 m spatial boundary for water bodies (200 m) of the Saint John River between Scott Road and Fort Road (Figure 3.2A, Appendix C).

The temporal boundaries for the assessment of the potential environmental effects of the Project on Fish and Fish Habitat include the periods of construction, and subsequent operation of the Project in perpetuity.

5.4.2.2 Administrative and Technical

Fish and fish habitat are protected through federal and provincial legislation. Fish habitat is protected under the *Fisheries Act*, and by the Department of Fisheries and Oceans (DFO's) *Policy for the Management of Fish Habitat* (DFO 1986). This policy applies to all projects and activities in or near water, which could alter, disrupt or destroy fish habitat by chemical, physical or biological means. The guiding principle of this policy is to achieve no net loss of the productive capacity of fish habitats. The *Policy for the Management of Fish Habitat* is regulated by Sections 20, 21, 22, 30, 32, 35, 37, 40 and 43, of the *Fisheries Act*, that is administered by DFO. Crossings installed in watercourses that bear fish will be subject to a harmful alteration, disruption or destruction of fish habitat (HADD) authorization from DFO.

With respect to culvert and bridge installations, the *Fisheries Act* (Section 35) requires the protection of fish habitat in all watercourses that bear fish. This is administered in the province of New Brunswick by the *Watercourse Alteration Regulation* of the *Clean Water Act*. Applications will be made for Watercourse and Wetland Alteration Permits. This application process applies to all activities (construction of watercourses, clearing, repairing and maintenance) within 30 m of a watercourse. Watercourse crossings will be installed according to the *Watercourse Alteration Technical Guidelines* developed by NBDELG (2002b). In addition, all watercourse crossings of more than 1.2 metres in diameter and/or more than 25 metres in length, and/or with a slope above 0.5% will follow the Guidelines for the Protection of Fish and Fish Habitat – The Placement and Design of Large Culverts (DFO 1999a).

In addition, Coast Guard approval under the *Navigable Waters Protection Act* will be required for proposed crossings over navigable waters, and may influence the design and installation requirements for these crossing structures. Crossing structures for navigable watercourses will be designed in consultation with the NWPP.

A search was conducted for existing information on the watercourses within the zone of influence of the Project, through discussions with NBDNR (P. Seymour, pers. comm.), and DFO (R. Jones (Salmonid Research, Moncton), E. Arseneau (Fishery Officer, Saint-Léonard), K. Dickinson (Fishery Officer, Woodstock) and T. Currie (Habitat Assessment Biologist, Moncton), pers. comm.).

Communications with the academic research community included members of the Canadian Rivers Institute (Dr. R. Cunjak and Dr. A. Curry, pers. comm.) – based at the University of New Brunswick, Fredericton.

Communications with Aboriginal people are ongoing, and a traditional ecological knowledge (TEK) study is being conducted in support of the Current Use of Lands and Resources for Traditional Purposes by Aboriginal Persons VEC (Section 5.9). This TEK study is not yet complete, but may contain information regarding use of fishery resources by Aboriginal people within the zone of influence of the Project.

The spatial boundaries for fish and fish habitat includes the proposed alignment and the immediate habitat 500 m upstream to 500 m downstream of the RoW, where activities associated with site preparation and construction, operation, and accidents, malfunctions and unplanned events of the Project could potentially result in environmental effects on fish and fish habitat.

Fish and fish habitat assessments were carried out at each of the watercourses to be crossed for the proposed TCH between Perth-Andover and Woodstock in 2002 to provide a current and thorough examination of baseline conditions. The proposed TCH route was divided into three sections and the surveys were conducted by three teams (Dillon 2003; ACER 2003; JWEL 2003a). Where route alignment changes affected any watercourses, additional fish and fish habitat surveys were conducted as required in 2003.

5.4.3 Residual Environmental Effects Rating Criteria

A *significant residual environmental effect* on fish and fish habitat is one that alters fish habitat physically, chemically, or biologically, in quality or extent, in such a way as to cause an adverse change in the ecological function of that habitat, or an adverse change (caused by avoidance and/or mortality) in the distribution or abundance of a fish species or community that is dependent upon that habitat, such that natural recruitment would not re-establish the community to its original composition, density and extent in one generation; or would result in an unmitigated or non-compensated net loss of fish habitat as defined in the *Fisheries Act*.

5.4.4 Existing Conditions

The proposed TCH will be constructed west of the existing TCH through an area dominated by steep hills and valleys. A total of 43 watercourses are crossed by the 70 km length of the proposed TCH (Figure 3.2A-D, Appendix C). A number of other watercourses were identified in maps but were determined to be dry channels, or were not found, during the field surveys.

There are three lakes located within 500 m of the alignment - Leith Lake (Figure 3.2B, Appendix C), Reid Lake (Figure 3.2B, Appendix C), and Bishops Lake (Figure 3.2A, Appendix C). Bishops Lake is 100 m east and on a watercourse that is upstream of the proposed TCH, Reid Lake is approximately 450 m west on a watercourse not crossed by the proposed TCH, and Leith Lake is 100 m east and is downstream, but is not on a watercourse that will be directly affected by the Project. There are two lakes that are considered to be environmentally significant areas in the Guidelines (Appendix A). Ketch Lake is 1.7 km west of the proposed TCH RoW. Ketch Lake drains to Two Mile Brook, which is a tributary of Big Presque Isle Stream. Two Mile Brook is upgradient and upstream of any Project activities. Payson Lake is 3.5 km west of the proposed TCH, just north of the town of Woodstock. There are no anticipated interactions between the Project and these lakes, therefore the lakes are not characterized in this section and they are not carried forward in the environmental assessment.

5.4.4.1 Fish Species of Special Conservation Concern

Species at Risk Act

There are four freshwater fish species in New Brunswick with special conservation status as designated by the federal *Species At Risk Act* (*SARA*; as listed by COSEWIC 2003):

- the Inner Bay of Fundy Atlantic salmon (*Salmo salar*) as "Endangered";
- the Lake Utopia dwarf smelt (*Osmerus* sp.) "Threatened"; and
- the redbreast sunfish (*Lepomis auritus*) and shortnose sturgeon (*Acipenser brevirostrum*) as "Species of Special Concern".

None of these four fish species of special conservation concern have been recorded within the zone of influence of the Project previously, nor were they discovered during the baseline fish surveys conducted in support of this CSR (Dillon 2003; ACER 2003; JWEL 2003a).

New Brunswick Endangered Species Act

There are no species of freshwater fish listed under the *New Brunswick Endangered Species Act*.

NBDNR General Status of Wildlife in New Brunswick

NBDNR lists five freshwater fish species of special conservation concern:

- the Lake Utopia dwarf smelt as "At Risk";
- the anadromous Atlantic salmon and the striped bass as "May Be At Risk"; and
- the Arctic char and lake trout are listed as "Sensitive".

The Lake Utopia dwarf smelt, Arctic char and lake trout do not occur within the zone of influence of the Project.

The "May Be At Risk" designation is a high concern category that includes species that are of concern because of low numbers, population declines, or habitat pressures. Both of the listed species had a historical breeding population in the Saint John River watershed. The current status of these species is described below.

The striped bass had a historical breeding population in the Saint John River, but the spawning population is believed to be extirpated since 1979 (DFO 1999b). DFO stock status reports suggest that the extirpation was the result of loss of habitat from the construction of the Mactaquac Dam, and subsequent unnatural fluctuations in water velocity and volume. Striped bass occur periodically in the Saint John River below Mactaquac, but these are believed to be feeding migrants from waters located along the northeast United States coast (DFO 1999b; Allen Curry, pers. comm.). Striped bass were not known to use the Saint John River within the zone of influence of the Project.

Anadromous Atlantic salmon in the Saint John River and its tributaries are considered as part of the Outer Bay of Fundy Atlantic salmon stock. This stock is not currently a federally protected species, however their population numbers has been decreasing over the last 100 years and reached very low numbers in the last decade (DFO 2001; 2002). Historically, Atlantic salmon provided the primary recreational and commercial fishery in the Saint John River. Today, recreational and commercial fishing for Outer Bay of Fundy Atlantic salmon in rivers has been indefinitely banned pending a substantial improvement in adult salmon returns to native rivers, including the Saint John River (E. Arseneau, pers. comm.). Adult salmon numbers in the Saint John River have declined from the 1960's estimate of over 100,000 to the year 2002 count at the Mactaquac dam of less than 500. DFO attributes this loss primarily to the cumulative environmental effects of commercial fishing and hydroelectric power generation (DFO 2001; 2002). There is currently an intensive effort to re-establish Atlantic salmon stocks in the Saint John River. Despite current low numbers of mature fish, the Atlantic salmon is still considered to be of extreme value to recreational fishermen in the Upper Saint John River Valley (E. Arseneau, pers. comm.). Therefore, the anadromous Atlantic salmon was given special consideration in the assessment of environmental effects on fish and fish habitat.

5.4.4.2 Methodology

Discussions with NBDNRE (P. Seymour, pers. comm.), and DFO (R. Jones (Salmonid Research, Moncton), E. Arseneau (Fishery Officer, Saint-Léonard), and T. Currie (Habitat Assessment Biologist, Moncton), pers. comm.] revealed a distinct paucity of information for the watercourses. Discussions with Woodstock DFO personnel (K. Dickinson, Fishery Officer, pers. comm.) provided some insight into the historical distribution of Atlantic salmon and gaspereau in the southern portion of the proposed TCH.

Discussions with members of the Canadian Rivers Institute provided no additional information for the watercourses in the Assessment Area (R. Cunjak, A. Curry, pers. comm.).

Table 5.4.1 links the watercourse reference used in those reports with the watercourse reference used in this CSR and provides information as to the reason for the proposed crossing (*i.e*., proposed TCH, existing road improvement, new access road), if there was a route alignment change post-baseline survey in 2002 affecting that watercourse, and whether or not additional fish surveys were required in 2003.

Where hydrologic and water quality conditions permitted, qualitative electrofishing surveys were conducted at all watercourse crossings within the Project area during the summer of 2002. Where recreational species were caught (*i.e.,* trout, salmon or smallmouth bass), a quantitative electrofishing survey was conducted. Barrier nets were placed at the upstream and downstream ends of the selected site, enclosing an area of at least 100 m^2, where quantity of habitat was not limiting. Electrofishing passes were conducted until the number of fish caught declined consistently in three consecutive passes. Total standing stock was estimated using the electrofishing results with the Zippin method. All fish captured during the surveys were identified to species, measured to the nearest mm and released unharmed to the stream.

Habitat assessments were carried out at each of the watercourses to be crossed for the proposed TCH route between Perth-Andover and Woodstock in 2002. All habitat surveys were conducted as per NBDNRE guidelines, using the standard stream habitat forms (Hooper *et al*.1995).

Additional surveys were conducted in the summer of 2003 due to changes in the alignment of the proposed TCH (as of 2002). These changes were made to avoid rare plants that were identified during the 2002 vegetation surveys. In addition to alignment changes, new access roads were proposed to connect land remnants to existing roads. Some of these access roads crossed watercourses outside the boundaries of the original surveys. There are also some proposed improvements for existing roads and associated watercourse crossing structures that intersect the proposed TCH. In all cases, stream habitat surveys were conducted in 2003. New fish surveys were conducted where:

- the 2003 alignment of the proposed TCH or access roads crossed a new watercourse (not included in 2002 survey); or
- the 2003 alignment of the proposed TCH or access road crossed a previously surveyed watercourse, but there was a barrier to fish passage (*e.g*., waterfall, hanging culvert, beaver dam) between the previously surveyed location and the new crossing location.

Table 5.4.1 Watercourse Names and Fish Survey Requirements

WC ID#*	Watercourse Name / Description	Back-ground Study ID#	2002 Baseline Report Author	New TCH (H) Existing (E) or Access (A)	Route Change Post 2002 Survey (Y/N)	Change in Route (m) or Distance from 2002 Survey (east / west)	2002 Fish Survey (Y/N)	2003 Fish Survey Completed (Y/N)	Watercourse Crossing Locations (Final †)	
									Easting (19T)	Northing (19T)
1	Wark Brook	PA14	JWEL	H	N	n/a	Y	N	597658.2	5176161
1a	Wark Brook (Access Rd. A)	n/a	n/a	A	N	n/a	N	N	597579	5176210
2	Tributary to Saint John River	PA13	JWEL	H	Y	31-w	Y	N	596956.7	5174719
2a	Tributary to Saint John River (Access Rd A)	n/a	n/a	A	N	n/a	N	N	596784	5174778
3	Tributary to Saint John River	PA12	JWEL	H	Y	43-w	Y	N	596644.1	5173775
4	Tributary to Saint John River	PA11	JWEL	H	Y	76-w	Y	N	596453	5173017
4a	Tributary to Saint John River	n/a	n/a	A	N	75-W	N	N	n/a	n/a
5	Tributary to Saint John River	PA10	JWEL	H	Y	246-w	Y	Y	596383	5172142
5a	Tributary to Saint John River (Access Rd. B)	n/a	n/a	A	N	n/a	N	N	n/a	n/a
6	Tributary to Saint John River	PA9	JWEL	H	Y	104-w	Y	N	596660	5171450
6a	Tributary to Saint John River (Access Rd. B)	n/a	n/a	A	N	n/a	N	Y	n/a	n/a
7	Plant Brook	PA8	JWEL	H	Y	70-e	Y	N	597024	5170609
7a	Plant Brook (Access Rd. B)	n/a	n/a	A	N		N	N	n/a	n/a
8	Demerchant Brook	PA7	JWEL	H	Y	292-e	Y	Y	597252	5169096
9	Bryson Brook	PA6	JWEL	H	Y	363-e	Y	Y	597035	5168196
10	Tributary to Brown Brook	PA5	JWEL	H	Y	20-e	Y	N	596473.3	5167357
11	Tributary to Brown Brook	PA4C	JWEL	H	Y	51-w	Y	N	596258.4	5166695
12	Tributary to Brown Brook	PA4B	JWEL	H	Y	14-w	Y	N	596187.9	5166483
13	Tributary to Brown Brook	PA4A	JWEL	H	Y	14-e	Y	N	596114.2	5166189
14a	Graham Brook (Access Rd. D)	n/a	n/a	A	N	n/r	N	Y	595164.7	5165072
15	Graham Brook (outflow from Bishop Lake)	PA3	JWEL	H	N	n/a	Y	N	596376.9	5164846
15e	Graham Brook (existing rd. lower)	n/a	n/a	E	N	n/a	N	Y	596191.8	5164295
16	Graham Brook	PA2	JWEL	H	Y	58-e	Y	N	596636	5163864

Table 5.4.1 Watercourse Names and Fish Survey Requirements

WC ID#*	Watercourse Name / Description	Back-ground Study ID#	2002 Baseline Report Author	New TCH (H) Existing (E) or Access (A)	Route Change Post 2002 Survey (Y/N)	Change in Route (m) or Distance from 2002 Survey (east / west)	2002 Fish Survey (Y/N)	2003 Fish Survey Completed (Y/N)	Watercourse Crossing Locations (Final †)	
									Easting (19T)	Northing (19T)
17a	Tributary to River de Chute / McMullin Brook (Access Rd. F)	n/a	n/a	A	N	n/r	N	Y	595556	5161406
18	River de Chute	PA1	JWEL	H	Y	245-e	Y	Y	596356	5160738
19	Tributary to Upper Guisiguit Brook	WC1A	ACER	H	N	n/a	Y	N	596139.8	5159218
20	Upper Guisiguit Brook	WC1	ACER	H	Y	81-w	Y	N	595940.3	5157982
21	Tributary to Upper Guisiguit Brook	WC2	ACER	H	N	n/a	Y	N	596077.8	5157558
22	Tributary to Lower Guisiguit Brook	WC3	ACER	H	Y	66-w	Y	N	596858.9	5156202
23	Tributary to Lower Guisiguit Brook	WC3A	ACER	H	Y	172-w	Y	N	598455.6	5155151
24	Lower Guisiguit Brook / Tributary to Lower Guisiguit Brook (lower end of watercourse #35)	WC4/ WC4A	ACER	H	Y	46	Y	N	598822.5	5154873
25	Tributary to Lower Guisiguit Brook	WC5	ACER	H	Y	33-w	Y	N	599531.9	5153760
26	Tributary to Lower Guisiguit Brook (upstream of crossing #35)	WC6	ACER	H	N	n/a	Y	N	599793.9	5152132
27	Tributary to Lower Guisiguit Brook (upstream of crossing #36)	WC7	ACER	H	N	n/a	Y	N	600091	5151080
28	Tributary to Leith Lake Drainage	WC8	ACER	H	N	n/a	Y	N	601804.2	5148907
29	Headwaters to Leith Lake Drainage	WC9	ACER	H	N	n/a	Y	N	601919.4	5148270
30	Tributary 3 to Hunters Brook	WCD15	DILLON	H	N	n/a	Y	N	603615.5	5143900
31	Tributary 2 to Hunters Brook	WCD14	DILLON	H	N	n/a	Y	N	603940.4	5142501
32a	Hunter Brook (Access Rd. J)	n/a	n/a	A	N	n/r	N	Y	603362.9	5140790
33	Big Presque Isle Stream	WCD12	DILLON	H	Y	250-e	Y	N	604504	5139676

Table 5.4.1 Watercourse Names and Fish Survey Requirements

WC ID#*	Watercourse Name / Description	Back-ground Study ID#	2002 Baseline Report Author	New TCH (H) Existing (E) or Access (A)	Route Change Post 2002 Survey (Y/N)	Change in Route (m) or Distance from 2002 Survey (east / west)	2002 Fish Survey (Y/N)	2003 Fish Survey Completed (Y/N)	Watercourse Crossing Locations (Final †)	
									Easting (19T)	Northing (19T)
34	Tributary to Big Presque Isle Stream	WCD11	DILLON	H	Y	n/r	Y	Y	605101.2	5137113
35	Tributary to Little Presque Isle Stream	WCD09	DILLON	H	N	n/a	Y	N	609111.5	5128743
36e	Little Presque Isle Stream	WCD08	DILLON	E	N	n/a	Y	N	610318.7	5126750
37	Little Presque Isle Stream	WCD07	DILLON	H	N	n/a	Y	N	608908.2	5125645
38	Lanes Creek	WCD06	DILLON	H	N	n/a	Y	N	608209.2	5121358
39‡	Tributary to Harper Brook	WCD05	DILLON	H	N	n/a	Y	N	608123.7	5120229
40	Tributary to Harper Brook	WCD04	DILLON	H	N	n/a	Y	N	607894.8	5119908
41	Tributary to Harper Brook	WCD03	DILLON	H	N	n/a	Y	N	607789.7	5118862
42	Harper Brook	WCD02	DILLON	H	N	n/a	Y	N	607910.5	5118299
43	Tributary to the Meduxnekeag	WCD01	DILLON	H	N	n/a	Y	N	607372.3	5115000

n/a = not applicable; n/c = no change; n/r = not required
* a = access road, e = existing road; † these locations reflect the final alignment at westbound centreline; ‡ no defined channel found
Sources: JWEL 2003a; ACER 2003; Dillon 2003; JWEL 2003 survey (unpublished)

Three additional qualitative surveys and two additional quantitative surveys were carried out in 2003. Ten additional stream habitat surveys were carried out in 2003. The data from these surveys are reported in this report as applicable.

5.4.4.3 Fish Survey Results

A total of 16 fish species, representing 8 families, were recorded in watercourses during the 2002 and 2003 fish surveys. Two additional species, representing 2 families, were known to exist historically in these streams, making a total of 18 fish species, representing 10 families, that are known to use watercourses that will be crossed by the proposed TCH.

The most commonly represented family was the trout and salmon family (Salmonidae or "salmonids"). Salmonids present in the Project area during the fish surveys were brook trout (S*alvelinus fontinalis*), two introduced species, the rainbow trout (*Onchorynchus mykiss*) and brown trout (S*almo trutta*), and Atlantic salmon.

The minnow family (*Cyprinidae* or "*cyprinids*") was represented by the northern redbelly dace (*Chrosomus eos*), blacknose dace (*Rhinichthys atratulus*), creek chub (*Semotilus atromaculatus*), and the common shiner (*Notropic cornutus*).

The stickleback family (*Gasterosteidae*) was represented by the 3-spine stickleback (*Gasterosteus aculeatus*), the 4-spine stickleback (*Apeltes quadracus*), and the 9-spine stickleback *(Pungitius pungitius*).

All other families were represented by a single species. These include Cottidae [slimy sculpin (*Cottus cognatus*)]; Catostomatidae [white sucker (*Catostomus commersoni*)]; Ictaluridae [brown bullhead (*Ictalurus nebulosis*)]; Centrarchidae [smallmouth bass (*Micropterus dolomieui*)]; and Percidae [yellow perch (*Perca flavescens*)].

The historical presence of Anguilladae [American eel (*Anguilla rostrata*)] and Clupeidae [alewife or gaspereau (*Alosa pseudoharengus*)] was determined in consultation with DFO (K. Dickerson, pers. comm.).

The distribution of fish species in watercourses that will be crossed by the proposed TCH, as determined during the 2002 and 2003 surveys and from information obtained from other sources, is presented in Table 5.4.2. The watercourses are listed in occurrence from north to south along the proposed TCH, and the fish species are grouped by family where applicable.

Table 5.4.2 Distribution Of Fish Species In Watercourses Crossed By The Proposed TCH

Sources: JWEL 2003a; ACER 2002; Dillon 2002; JWEL 2003 survey (unpublished)

Key

(shaded)	Presence
(stippled)	Historical Presence
(blank)	Absence

* no fish found;
** all results from 2002 survey except as noted: †2003 fish survey; ‡ 2002 and 2003 survey
ˆ DFO Personal Communication

Section	Watercourse ID#	Watercourse Name	Salmonidae: Brook Trout (bt); Atlantic Salmon (As); Rainbow Trout (rt); Brown Trout (bnt)	**Cottidae**: Slimy Sculpin	**Gasterosteidae**: Stickleback (3, 4, 9 spined)	**Catastomatidae**: White Sucker	Cyprinidae: Northern Redbelly Dace (nrd); Blacknose Dace (bnd); Creeek Chub (cc); Common Shiner (cs)	Other Species: American Eel (Ae); Brown Bullhead (bb); Gaspereau (g); Smallmouth Bass (sb); Yellow Perch (yp)
Northern Section	1	Wark Brook	bt					
	2	Trib to Saint John River	bt					
	3	Trib to Saint John River	bt					
	4	Trib to Saint John River	bt					
	5*‡	Trib to Saint John River						
	6	Trib to Saint John River	bt					
	7	Plant Brook	bt					
	8	Demerchant Brook	bt					
	9*	Bryson Brook						
	10	Trib to Brown Brook	bt					
	11	Trib to Brown Brook	bt					
	12	Trib to Brown Brook	bt					
	13*	Trib to Brown Brook						
	14†	Graham Brook (access rd)	bt					
	15‡	Graham Brook (Bishops Lk)					cc	
	16	Graham Brook	bt					
	17*†	Trib to River de Chute						
	18	River de Chute	bt					
Middle Section	19	Trib to Upper Guisiguit Brook	bt					
	20	Upper Guisiguit Brook	As, bt		4		bnd	
	21	Trib to Upper Guisiguit Brook						
	22	Trib to Lower Guisiguit Brook	bt				bnd, cc	
	23	Trib to Lower Guisiguit Brook						
	24	Lower Guisiguit Brook	bt				bnd, cc	
	25	Trib to Lower Guisiguit Brook	bt				bnd, cc	
	26	Trib to Lower Guisiguit Brook					cc	
	27	Trib to Lower Guisiguit Brook			9		bnd	
	28	Tributary to Leith Lk	bt					
	29	Headwaters to Leith Lk						
	30	Trib to Hunters Brook	bt				nrd, cc	
	31	Trib to Hunters Brook	bt				cc	
	32†	Hunters Brook	As, bt				bnd, cc	
Southern Section	33	Big Presque Isle Stream	As, rt, bntˆ		3		bnd, cc, cs	Aeˆ, sb
	34	Trib to Big Presque Isle Stream	bt				cc	
	35	Trib to Little Presque Isle Stream	bt				nrd, bnd, cc	
	36	Little Presque Isle Stream	Asˆ bnt		3		bnd, cc	Aeˆ, gˆ sb, bb, yp
	37	Little Presque Isle Stream	Asˆ bt				bnd, cc, cs	Aeˆ, gˆ sb, bb
	38	Lanes Creek	bt				nrd, cc	
	40*	Trib to Harper Brook						
	41	Trib to Harper Brook	bt					
	42	Harper Brook	bt				nrd	
	43	Trib to Meduxnekeag					nrd	

In general, there are more fish species present in the southern portion of the proposed TCH RoW than in the northern. This is particularly evident in a comparison of similarly sized Little Presque Isle Stream (13 species) with River de Chute (2 species). The most likely reason for this observed difference is a combination of changing geomorphology and land use. The area and watersheds within the spatial boundaries of the Fish and Fish Habitat VEC can be divided into the following three sections.

The "***northern section***" between Perth-Andover (Wark Brook - WC1) and River de Chute (River de Chute - WC18) (Figure 3.2A, Appendix C) has the most severe topography, and is predominantly forested. The watercourses of this area are small, narrow, and colder. Brook trout dominate this area, and there are no warm water species with only one occurrence of a cyprinid species. Slimy sculpin are abundant in this area, particularly in River de Chute (WC18).

The "***middle section***" between River de Chute (Tributary to Upper Guisiguit Brook - WC19) and Florenceville (Hunters Brook - WC32) (Figure 3.2B and C, Appendix C) has decreasing gradient, more cleared agricultural land, and is less forested. The watercourses are less free flowing, with more beaver ponds and more wetlands present. The species assemblage in this section is more diverse than the northern section, but not as diverse as the southern section, though still includes 3 cyprinid species, 2 stickleback species and brook trout and Atlantic salmon.

The "***southern section***" between Florenceville (Big Presque Isle Stream – WC33) and Woodstock (Tributary to Meduxnekeag - WC43) (Figure 3.2C and D, Appendix C) is mostly gently sloping hillsides, and predominantly cleared agricultural fields. The fish assemblages in this section are diverse and include warm/cool water species (*i.e.*, smallmouth bass, yellow perch, brown bullhead, and 4 cyprinid species), and cold water salmonids (*i.e.*, Atlantic salmon, brook trout, brown trout, and rainbow trout). Stickleback, slimy sculpin and gaspereau are also present. The two largest watersheds are located in this section, the Big Presque Isle Stream and the Little Presque Isle Stream. These larger watercourses contribute to the diversity in this section.

Information regarding fish species present in the Saint John River between Perth-Andover and Woodstock was obtained from the Canadian Rivers Institute (Allen Curry, pers. comm.). Specifically, 20 fish species from 11 families are known to use this section of the River. These fish include:

- Anguilladae [American eel];
- Catastomatidae [white sucker (*Catostomus commersoni*)];
- Centrachidae [pumpkinseed sunfish (*Lepomis gibbosus*), smallmouth bass];
- Clupeidae [alewife];
- Cyprinidae [common shiner, creek chub, fallfish (*Semotilus corporalis*), golden shiner (*Notemigonus chrysoleucas*), lake chub northern redbelly dace];
- Cyprinodontidae [banded killifish (*Fundulus diaphanous*)];
- Esocidae [chain pickerel (*Esox niger*), muskellunge (*Esox masquinongy*)];

- Ictaluridae [brown bullhead];
- Percichthyidae [white perch (*Morone americana*)];
- Percidae [yellow perch]; and
- Salmonidae [Atlantic salmon, brook trout, rainbow trout].

The current fish community compositions, densities, and distributions within the spatial boundaries of the Fish and Fish Habitat VEC provides a benchmark for the evaluation of cumulative environmental effects as they reflect the sum of the environmental effects on the fish communities of all past and presently existing projects and activities in the assessment boundaries.

5.4.4.3.1 Recreational Fish Species

Recreational fish species, as determined by DFO, in the Upper Saint John River include all salmonids, smallmouth bass, American eel, and gaspereau (alewife) (E. Arseneau, pers. comm.).

Brook trout were the most common species in the fish survey and were determined to be present in 28 of 43 watercourses as shown in Table 5.4.2. Brook trout are well established throughout the Assessment Area, and in a large variety of habitats. In more than one case, brook trout were observed within a few metres of the origin of a stream, in water only a few centimetres deep.

Atlantic salmon parr were found in only 3 of the 43 watercourses (Upper Guisiguit, Big Presque Isle and Hunters Brook), but were known to historically occur in at least 1 more (Little Presque Isle, K. Dickinson, pers. comm.). It is also likely that Atlantic salmon parr use River de Chute as rearing habitat (R. Jones, pers. comm.).

Rainbow trout were found on the Big Presque Isle Stream, but may occur in any watercourses capable of supporting trout (E. Arseneau, pers. comm.). Brown trout were found in Little Presque Isle Stream. In addition, there is a recreational fishery for brown trout on the Big Presque Isle Stream (K. Dickinson, pers. com.), though none were recorded from the fish survey. Rainbow and brown trout are not native to Atlantic Canada (Scott and Crossman 1973). They were introduced primarily through private stockings, and have self-sustaining stocks in some locations along the Upper Saint John River Valley (E. Arseneau, pers. comm.).

Smallmouth bass are considered important in terms of their recreational value to the province of New Brunswick, and in recent years, are the primary sport fish of Saint John River anglers. Smallmouth bass prefer warmer average temperature than do salmonids, and are not as adept at living in small stream environments. Smallmouth bass were recorded only in the Big and Little Presque Isle Streams at the time of the survey.

In addition to these present recreational species, there was historically a gaspereau dipnet fishery in the Little Presque Isle Stream (K. Dickinson, pers. com.).

5.4.4.4 Fish Habitat Survey Results

Table 5.4.3 contains the results of the 2002 and 2003 surveys for some of the key NBDNR parameters for habitat characterization, and also includes water quality parameters (*i.e*., temperature, pH, and dissolved oxygen) as recorded in the field at the time of sampling. Additional water quality information is included in Surface Water (Section 5.3). These results are from stream reaches containing the proposed TCH RoW.

In general, the watersheds (drainage area) of these watercourses are small (< 10 km^2), with the exception of WC18, River de Chute (69.9 km^2); WC33, Big Presque Isle Stream (600 km^2); and WC36 and WC37, Little Presque Isle Stream (110 km^2). As expected, these large watercourses contained the largest standing stocks of fish. Big and Little Presque Isle Streams also exhibited the greatest diversity of species, 10 and 12 respectively. The diversity at River de Chute may be limited by low water temperature and high flow. Of the 43 watercourses only these 3 have wet widths greater than 5 m, those being River de Chute (5.5 m), Big Presque Isle (44.3 m) and Little Presque Isle (14.7).

The summer water temperature in all streams was within the preferred range (<20°C) for brook trout (Scott and Crossman 1973) except WC15 (Graham Brook at Bishops Lake) which was a beaver pond. Likewise, the dissolved oxygen levels were also at acceptable levels for salmonids, except for WC26 and WC27 (Trib to Lower Guisiguit Brook) which are beaver ponds and WC29 (Headwaters to Leith Lake) which is classified as deadwater.

The substrate in most streams was excellent for salmonid nursery and rearing habitat. Many streams also contained possible salmonid spawning habitat (cool, clear water dominated by gravel with low embeddedness).

Table 5.4.3 Summary of Key Fish Habitat Parameters

Water-course	Drainage Area (km³)	Wet Width (m)	Channel Width (m)	Depth (cm)	Average Velocity (m/s)	Water Temp. (°C)	pH (units)	DO** (mg/L)	Substrate (%)						
									Bedrock	Boulder	Rock	Rubble	Gravel	Sand	Fines
1	6.01	1.4	2.2	10	0.04	15.7	7.2	8.0	0	15	15	30	15	5	5
2	0.87	1.0	1.7	6	0.08	14.8	7.1	8.1	0	10	20	25	20	15	10
3	0.90	0.8	1.6	5	0.10	16.8	7.3	8.5	0	5	10	20	45	20	10
4	0.91	0.8	2.1	6	0.2	17.0	7.9	9.4	0	0	5	20	50	15	10
5‡	0.49	1.0	2.5	4	0.09	15.0	7.4	8.3	0	5	10	10	25	30	20
6	0.91	1.1	2.6	9	0.17	13.8	7.4	9.2	0	5	25	30	25	10	5
6a‡	0.91	1.2	2.0	7	n/d	16.0	7.4	8.0	10	15	10	20	25	10	10
7	0.85	1.2	2.8	8	0.25	11.3	7.4	10.4	0	10	25	25	30	5	5
8‡	0.88	1.1	1.9	5	0.25†	14.0	7.3	7.5	15	15	15	15	35	5	5
9‡	0.57	0.8	1.5	6	0.20†	15.0	8.1	7.8	5	5	10	30	30	10	10
10	0.87	1.1	1.2	7	0.06	11.4	7.6	9.7	0	0	5	25	40	20	10
11	0.34	1.0	1.2	4	0.10	10.4	7.7	10.1	0	0	0	15	60	20	5
12	0.78	1.4	2.1	5	0.08	11.9	7.0	7.5	0	0	10	20	50	15	5
13	0.37	1.0	1.0	4	0.17	11.3	7.2	9.6	5	5	20	20	15	25	10
14a‡	0.81	1.0	1.5	30	0.22	13.0	7.6	6.9	0	10	5	10	30	15	30
15	0.40	2.0	20.0	40	0	16.6	7.4	6.1	0	0	0	0	0	30	70
15e‡	0.40	5.0	n/d	15	n/d	21.0	8.1	6.4	0	0	0	0	5	15	80
16	3.78	1.1	2.6	10	0.18	12.8	8.0	9.2	0	0	0	0	70	30	0
17a‡	0.22	0.5	1.5	3	0.16	10.0	7.8	6.5	0	0	5	10	75	5	5
18‡	75.4	5.5	9.0	25	0.50†	14.0	8.0	7.8	5	5	50	15	15	5	5
19	1.24	0.8	1.3	10	n/d	10.9	8.4	10.0	0	0	0	0	0	20	80
20	37.1	4.0	4.5	20	n/d	13.0	7.4	9.6	0	0	25	35	22	18	0
21	0.08	0.2	7.0	5	n/d	12.0	7.2	10.0	0	0	0	0	0	0	0
22	1.91	0.8	3.5	55	n/d	15.0	7.6	10.8	0	0	0	0	0	40	60
23	0.60	dry	4.0	dry	dry	dry	dry	dry	0	0	15	25	25	35	0
24	29.5	2.5	3.5	20	n/d	13.0	7.6	9.6	0	0	20	20	20	20	20
25	4.98	1.8	3.0	25	n/d	13.0	7.4	8.2	0	0	0	0	0	70	30
26	1.06	0.6	1.0	15	n/d	13.0	7.2	4.4	0	0	0	10	0	20	70
27	0.41	1.3	1.5	25	n/d	11.0	7.2	3.4	0	0	0	0	0	0	100
28	0.87	0.6	1.0	7	n/d	12.0	8.3	6.7‡	0	0	15	10	25	35	15
29	0.41	1.3	n/d	25	n/d	13.0	5.8	3.4	0	0	0	0	0	0	100
30	1.18	1	1.1	6	n/a	9.0	7.9	n/c	0	0	0	0	0	0	100
31	2.58	1.4	2.8	4	n/a	14.0	7.9	n/c	0	0	10	20	60	5	0

Table 5.4.3 Summary of Key Fish Habitat Parameters

Water-course	Drainage Area (km^3)	Wet Width (m)	Channel Width (m)	Depth (cm)	Average Velocity (m/s)	Water Temp. (°C)	pH (units)	DO** (mg/L)	Substrate (%)						
									Bedrock	Boulder	Rock	Rubble	Gravel	Sand	Fines
32a‡	16.7	4.5	5.5	25	0.06	18.0	8.1	8.4	0	0	5	10	35	30	20
33	585	44.3	47.1	20	2.11	15.0	8.1	n/c	0	5	10	50	35	0	0
34	1.81	1.7	1.9	15	n/d	11.0	n/c	n/c	0	0	0	0	0	60	40
35	3.15	n/d	2.5	>100	n/d	18.0	7.8	n/c	0	0	0	0	0	0	100
36	135	11.3	16.1	17	0.397	17.0	7.7	n/c	0	5	20	60	10	5	0
37	119	14.7	15.0	50	n/d	17.0	7.9	n/c	0	0	0	5	25	30	40
38	2.41	1.3	2.5	14	n/d	16.0	7.5	n/c	0	0	0	5	15	40	40
39^	0.34	n/a	n/a	n/a	n/d	n/c	n/c	n/c	n/a	n/a	n/a	n/a	n/a	n/a	n/a
40	0.26	dry	n/c	dry	dry	dry	dry	dry	n/a	n/a	n/a	n/a	n/a	n/a	n/a
41	2.37	1.4	2.4	3	n/d	16.0	8.0	n/c	0	0	0	40	40	10	10
42	2.70	3.1	3.2	19	n/d	12.0	8.0	n/c	5	0	0	70	10	5	0
43^^	1.04	n/c	n/c	n/c	n/d	n/c	n/c	n/c	n/a	n/a	n/a	n/a	n/a	n/a	n/a

* all results from 2002 survey except as noted; ** Dissolved oxygen; n/a = not available/applicable; n/d = not determined; n/c = not collected
† 2002 survey; ‡ 2003 survey; ^ watercourse not found; ^^ NBDNRE forms not used because watercourse was a wetland
Sources: JWEL 2003a; ACER 2003; Dillon 2003; JWEL 2003 survey (unpublished)

5.4.5 Environmental Effects Analysis

5.4.5.1 Project-VEC Interactions

Table 5.4.4 provides a summary of the potential Project-VEC interactions and the potential environmental effects associated with these interactions. The table is divided according to each of the Project phases assessed (construction, operation and maintenance), as well as for accidents, malfunctions and unplanned events. The discussion following the table provides an analysis of key project-VEC interactions, by Project phase.

Table 5.4.4 Project Activity – Environmental Effects Interaction Matrix for Fish and Fish Habitat

Potential Interactions Between Project Activities and Environmental Effects Valued Environmental Component: FISH AND FISH HABITAT			
Project Activities and Physical Works (see Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**		
	Change in Habitat Quantity	**Change in Habitat Quality**	**Direct Mortality**
Construction			
Site Preparation		✓	
Roadbed Preparation		✓	✓
Watercourse Crossing Structures	✓	✓	✓
Surfacing and Finishing		✓	
Ancillary Structures and Facilities		✓	
Operation			
Winter Safety		✓	
Proposed TCH Presence	✓	✓	
Maintenance			
Proposed TCH Maintenance		✓	
Vegetation and Wildlife Management		✓	
Accidents, Malfunctions and Unplanned Events			
Hazardous Material Spills		✓	✓
Erosion and Sediment Control Failure		✓	✓
Bridge or Culvert Washout		✓	✓
Fire		✓	✓

5.4.5.1.1 Construction

There are several Project-related construction activities that could affect Fish and Fish Habitat within the Assessment Area. The most substantive and likely interaction is the loss, or change, of fish habitat as a result of the installation of watercourse crossing structures. In particular, the direct removal of fish habitat from installation of culverts with a closed bottom and from stream diversions necessary to link the structure with the existing stream. Direct mortality may occur during watercourse crossing installations.

The other potential environmental effects that may occur during all construction phases (including watercourse crossings and bridge construction) include increases in total suspended sediments, increased turbidity, change in hydrologic conditions, change in pH, and increased temperature due to change in surrounding land cover (*e.g*., change from forest cover to clearing).

The Project is not anticipated to interact with the three lakes or the Saint John River, in terms of increased sedimentation during construction. However, there is the potential for some indirect environmental effects (*i.e.*, noise from construction activities) that may cause temporary avoidance of fish habitat.

Site Preparation

Clearing and Grubbing

Riparian vegetation will be cleared for the highway RoW. Removing vegetation near riverbanks removes shaded habitat and may increase bank erosion. Fish are sensitive to changes in water temperature. Shaded areas provide cooler temperatures during periods of warm, sunny weather. Any reduction in available spawning or rearing habitat or barriers to traditional spawning migration routes could undermine the reproductive potential of the local stock.

Sedimentation (increased sediment load in stream water and deposition in downstream sediments) is perhaps the most common environmental effect of construction activities on fish and fish habitat. Suspended sediment also occurs naturally in watercourses, occasionally at high concentrations. The environmental effects of sediment are well studied and understood (Anderson *et al.* 1996). Anderson, *et al.* (1996) and Trow Consulting Engineers Ltd. (1996) summarized the potential environmental effects of sedimentation and siltation on fish habitat as follows:

- degradation of water quality (*i.e.*, oxygen levels, light penetration, water temperature, water chemistry such as organics and metals) leading to changes in primary production and food availability;
- changes in stream morphology and stream bed porosity leading to degradation of spawning substrates, holding pools, instream cover and overwintering habitat;
- reducing the diversity and abundance of bottom dwelling fish food organisms; and
- the destruction of aquatic vegetation that are buried by sediments.

The potential direct environmental effects on fish are a function of the concentration duration of the exposure, sensitivity of the life stage, as well as the hardness, size and angularity of the suspended particles. They include:

- first-level behavioural responses, usually temporary and not resulting in a change in health;
- minor physiological influences where the fish may avoid the exposure but there may be environmental effects to health due to exposure or reduction in food supply;
- physiological changes due to long term exposure affecting life stages or feeding; and
- environmental effects on eggs and larvae which cannot avoid areas of exposure where larvae are most sensitive, eggs are marginally more tolerant.

Erosion and sedimentation could be associated with all phases and most activities of the Project and are discussed in Site Preparation because it is the first occurrence for this potential Project-VEC interaction. Erosion and sedimentation can occur anywhere and any time soil is exposed. Potential characteristics of the proposed watercourses that may increase the risk of erosion and sedimentation include stream morphology, high discharge, and the presence of erodible soils.

There are no unmitigated planned Project activities that should release substantial amounts of sediment to water or resuspend sediment or cause erosion. However, small increases of sediment in watercourses near construction sites are often unavoidable. Any substantive amount of sedimentation or erosion would be the result of accidents, malfunctions, or unplanned events.

Roadbed Preparation

Blasting

Blasting can have physical and chemical environmental effects on the aquatic environment. Shock waves and vibrations from blasting can damage fish swim bladders and rupture internal organs, and may kill or damage fish eggs or alevins (DFO 1995a). Blasting can cause resuspension of sediments (Munday *et al.* 1986), bank failure and resultant sedimentation and habitat avoidance. Nitrogen-based explosives can affect aquatic life through direct toxicity of the compounds, reducing dissolved oxygen during nitrification and providing nutrients for aquatic plants. Nitrite is highly toxic to fish and can reduce the oxygen carrying capacity of blood, ammonia can cause gill damage, and promote algal growth. Pommen (1983) provides detailed information on the potential chemical environmental effects of blasting.

Blasting may also result in the release of sediment to watercourses through the settling of dust and/or rock slides.

Excavation

The primary potential environmental effect of excavation is exposure of surface water to sulfide bearing bedrock and causing a pH reduction in watercourses to levels that are harmful to fish. When fish are exposed to low pH waters, the fish body fluids will lose sodium and chloride ions and plasma osmotic pressure decreases. This creates physiological stress in the fish, which can eventually cause death. Different fish species have different pH tolerances, with salmonids being quite sensitive. The ecology of the aquatic system starts to change at pH levels of 5.0 to 6.0, with a reduction of diversity and plant and animal species; pH values of 4.5 to 5.0 are harmful to salmonid eggs and fry, while pH values less than 4.0 are lethal to all salmonids. Excavation may also potentially increase sedimentation through the settling of dust.

The environmental effects of surface water exposure to sulfide bearing rock are assessed in Surface Water, Section 5.3.

Watercourse Crossing Structures

The proposed TCH will require the installation of culverts and bridges. The installation of closed bottom culverts (*e.g.,* pipes) results in the loss of fish habitat. Likewise, the installation of in-water bridge piers results in a loss of fish habitat. Direct mortality of fish may result from installation activities. Barriers to upstream movement could be created if culverts are installed with a greater than 0.5% slope, if the downstream end of the culvert is "hanging", if the culvert channelizes flow that creates increased flow velocity, if the culvert is too long, or if there is inadequate water depth caused by oversized culverts (NBDELG 2002b).

Surfacing and Finishing, and Ancillary Structures and Facilities

The handling of asphalt, concrete, hydrocarbon and hazardous materials during the construction phase and surfacing and finishing phase of the new TCH, and storage of these materials at ancillary facilities could potentially affect fish and fish habitat. Interactions other than minor chronic release (*e.g.,* minor drips from machinery) would most likely occur as the result of accidents, malfunctions and unplanned events.

The introduction of asphalt, and hydrocarbons to the aquatic environment can have harmful effects to fish and fish habitat (*e.g*., plant life). The introduction of liquid concrete products or wash residues into watercourses could destroy fish and aquatic plants due to sedimentation and changes in water chemistry (primarily pH).

5.4.5.1.2 Operation

Winter Safety

Salting

During winter, salt is used by NBDOT on road surfaces to aid in melting snow, and to provide improved road conditions. Road salt can enter the environment (surface water, groundwater and soil) through storage and application of these salts. The highest concentrations are usually associated with winter and spring thaws. According to Environment Canada (2001c) "aquatic effects of chloride on aquatic organisms are usually observed at relatively elevated concentrations (*Ceriodaphnia dubia* has a 4 day median lethal concentration of 1,400 mg/L). Exposure to such concentrations may occur in small streams located in heavily populated urban areas with dense road networks and elevated salt loadings, in ponds and wetlands adjacent to roadways, near poorly managed salt storage depots, and at certain snow disposal sites". Environment Canada has concluded that "road salts that contain inorganic chloride salts with or without ferrocyanide salts are "toxic" as defined in Section 64 of *CEPA*".

Sanding

The application of sand to provide increased traction during winter conditions (*i.e.*, snow and ice) may lead to increases in sedimentation of watercourses.

Proposed Trans-Canada Highway Presence

During the Project related activities associated with proposed TCH presence, there is a potential for a change in water quantity, and therefore habitat quantity and quality. The contribution to runoff from the highway RoW will be more episodic, compared to the more gradual release of water from forested/vegetated areas, however, the potential for a substantive change in the quantity of surface water due to the highway construction is low because the surface area of the highway is relatively small compared to the area of the watersheds upgradient of the crossings of most of the watercourses. Water quality may also be affected by this interaction as runoff from pavement may be warmer than receiving waters and may contain higher concentrations of suspended sediments.

Construction of the highway could contribute to a change in the distribution of water, such as a cut and fill resulting in water being redirected to another watershed.

5.4.5.1.3 Maintenance

Proposed TCH Maintenance

Maintenance of the proposed TCH may create dust and other sediment that may enter watercourses. Maintenance of watercourse crossing structures may also introduce sediments from maintenance activities (*e.g.*, installing new liners) or may resuspend sediments when culvert blockages (*e.g.*, brush and leaves) are removed.

Vegetation and Wildlife Maintenance

Hydroseeding

Hydroseeding may result in small amounts of nutrients (*e.g.*, nitrate and phosphate) entering surface waters.

5.4.5.1.4 Accidents, Malfunctions and Unplanned Events

Accidents, malfunctions and unplanned events that may occur in association with the Project and have adverse environmental effects on Fish and Fish Habitat include:

- hazardous material spills;
- erosion and sediment control failure;
- bridge or culvert washout; and
- fire.

Hazardous material spills may damage fish habitat and/or cause direct mortality of fish. Hazardous material spills could be the result of construction activities (*e.g.*, equipment fuelling or faulty vehicle components), operation activities (*e.g.*, hazardous material transport truck accident, or excessive salt application), or maintenance activities (*e.g.*, equipment fuelling).

Erosion and sediment control measures could fail and release sediment into watercourses during precipitation events.

Bridge or culvert washout may cause the loss or degradation of fish habitat, and direct mortality of fish. This could result from storms greater than accounted for in the structure design.

Fire could remove riparian vegetation near watercourses. Fire may also temporarily elevate water temperature and increase sedimentation. Fire may be caused as a result of construction activities (*e.g.*, hot equipment), operation activities (*e.g.*, discarded cigarettes or hot exhaust systems in contact with roadside vegetation), and maintenance activities (*e.g.*, hot equipment).

5.4.5.2 Environmental Effects Analysis and Mitigation

The criteria for characterizing the magnitude of environmental effects are described in the key for each phase of the Project. The criteria for characterizing the geographic extent of environmental effects are as follows:

- < 1 km^2 (includes the fish and fish habitat within 100 m of a single watercourse crossing);
- 1-10 km^2 (includes the fish and fish habitat within a 500 m of a single watercourse crossing);
- 10-50 km^2 (includes the fish and fish habitat within 500 m downgradient of the RoW);
- 50-100 km^2 (includes the fish and fish habitat within 500 m either side of the RoW);
- 100-1,000 km^2 (includes the fish and fish habitat between the RoW and the Saint John River); and
- >1,000 km^2 (includes all fish and fish habitat within the Upper Saint John River Valley).

5.4.5.2.1 Construction

During construction of the proposed TCH and associated roads and structures, several activities could result in environmental effects on Fish and Fish Habitat. These include:

- activities that involve disturbance to soils and removal of vegetative cover that leads to an increase in erosion and sediment rates and amounts (site preparation, road preparation, watercourse crossing structure installation);
- removal of habitat (watercourse crossing structure installation);
- potential excavation of sulfide bearing bedrock (roadbed preparation);
- noise and fish organ damage from blasting (roadbed preparation);
- storage and handling of hazardous materials (surfacing and finishing activities and ancillary structures and facility construction); and
- habitat avoidance due to Project-related noise (all activities).

The sections following Table 5.4.5 describes the mitigative strategies aimed at mitigating these potential environmental effects.

Table 5.4.5 Environmental Effects Assessment Matrix for Fish and Fish Habitat (Construction)

Environmental Effects Assessment Matrix
Valued Environmental Component: FISH AND FISH HABITAT
Phase: Construction

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Site Preparation	Change in fish habitat quality (A)	• Follow EPP, EFG • Site specific EPPs • Erosion control measures • Limit area of disturbance especially within 30 m of watercourse • Minimize instream work, if required work in the dry	1	4	2/1	R	2
Roadbed Preparation	Change in fish habitat quality (A) Direct mortality to fish (A)	• Follow EPP, EFG and site specific EPPs • Identify areas of sulfide bearing rock concern through sampling program • Obtain approval to blast from DFO • Follow DFO's blasting guidelines	1	4	2/6	R	2
Watercourse Crossing Structures	Change in fish habitat quantity (A) Change in fish habitat quality (A) Direct mortality to fish (A)	• Planning for watercourse installation using DFO and *Watercourse Alteration Technical Guidelines* • Apply for Watercourse and Wetland Alteration Permit, follow requirements • Follow NBDOT EPP and EFG • Develop site specific EPPs • Erosion control measures • Limit area of disturbance • Minimize instream work, if required work in the dry • Installation to occur from June 1 to September 30 • Compensation Plan if HADD determined by DFO	1	2	6/1	I	2

Table 5.4.5 Environmental Effects Assessment Matrix for Fish and Fish Habitat (Construction)

Environmental Effects Assessment Matrix
Valued Environmental Component: FISH AND FISH HABITAT
Phase: Construction

Project Activity (See Table 4.1.1 for list of specific activities and works)	Potential Environmental Effects	Mitigation	Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological/Socio-Cultural and Economic Context
Surfacing and Finishing	Change in fish habitat quality (A)	• Follow EPP and EFG • Designated fuelling and storage area should be at least 100 m from watercourse	1	3	2/6	R	2
Ancillary Facilities and Structures	Change in fish habitat quality (A)	• Follow EPP and EFG • Designated fuelling and storage area should be at least 100 m from watercourse	1	3	2/6	R	2

Key:

Magnitude:
1 = Low: localized effect on specific group, habitat, or ecosystem, returns to pre-Project levels in one generation or less, within natural variation
2 = Medium: portion of a population or habitat, or ecosystem, returns to pre-Project levels in one generation or less, rapid and unpredictable change, temporarily outside range of natural variability
3 = High: affecting a whole stock, population, habitat or ecosystem, outside the range of natural variation, such that communities do not return to pre-Project levels for multiple generations

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10 - 50 km^2
4 = 50 - 100 km^2
5 = 100 - 1000 km^2
6 = >1,000 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 - 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Site Preparation

Clearing and Grubbing

Clearing and grubbing will be minimized within 30 m of the watercourse. Enough vegetation must be allowed to grow along the bank of the watercourse to maintain the stability of the banks. Vegetation will also provide shade to prevent an excessive rise in water temperature. NBDOT will avoid long skids of timber on steep slopes adjacent to watercourses as well as avoid felling or skidding trees across a watercourse. Where possible, NBDOT will not use heavy machinery within 10 m of streambanks. Any trees that need to be cut within 10 m of a watercourse will be cut by hand or by machinery able to "reach in" within those areas.

As mentioned previously, erosion and sedimentation may occur during all Project phases. Erosion and sedimentation control measures and mitigation are summarized here, but apply to all phases where Project induced erosion or sedimentation is possible.

Erosion control systems will be in place to manage runoff from the construction areas. Erosion control measures are identified in Section 4.5 of the EPP and Section 4.2 of the EFG and include erosion control fencing, check dams, use of mulch (possibly from shrubs and trees removed during clearing) and, if necessary, sedimentation control ponds. As these erosion control measures also slow the transport of surface runoff, they will also increase the potential for localized infiltration to groundwater.

NBDOT will follow Section 5 of the EPP for watercourse crossing structures (including culverts), and the *Watercourse Alteration Technical Guidelines* (NBDELG 2002b) in the design and construction of all watercourse crossings. In addition, all watercourse crossings of more than 1.2 metres in diameter, and/or more than 25 metres in length, and/or with a slope above 0.5 % will follow the Guidelines for the Protection of Fish and Fish Habitat – The Placement and Design of Large Culverts (DFO 1999a). The purpose of these guidelines is to ensure a consistent approach for the protection of fish and fish habitat at culvert locations throughout Nova Scotia, New Brunswick and Prince Edward Island. The Guideline contains information on culvert design criteria, fish species of concern, potential effects of culvert installation and supporting mitigation strategies.

The design of new streambeds and banks will be done in consultation with DFO and NBDNR. The inlet and outlet of the culvert, and any new stream channels, are stabilized against erosion by use of riprap, gabions, geotechnical fabric, seeding, mulching or a combination of these.

Suspended solids should not increase by a level exceeding 10 mg/L when background suspended solids concentrations are equal to or less than 100 mg/L (CCME 1999). Suspended solids should not increase by a level exceeding 10 % of background concentrations when background concentrations are greater than 100 mg/L. The generally accepted provincial guideline is suspended solids concentrations within effluent released should not exceed 25 mg/L (monthly average) or 50 ml/L (grab sample) above background (Washburn and Gillis 1998).

For the proposed project, sedimentation and siltation will be minimized during construction and operation with use of proper mitigative steps outlined in Section 4 of the EPP and Section 4.3 of the EFG and in the *Watercourse Alteration Technical Guidelines* (NBDELG 2002b). Instream work will be conducted so as not to coincide with periods of increased sensitivity such as spawning and egg incubation times. In general, instream work will be conducted between June 1 and September 30, where possible. Any in-stream work occurring after September 30 would be considered an unplanned event. In such a case, appropriate permits (*i.e.,* Watercourse and Wetland Alteration Permit and HADD authorization) would be obtained. During this period, low water flows, and dry soil also make watercourse installation easier.

Instream work will be conducted outside of this period when seasonal weather conditions permit and where there is no anticipated environmental effect on sensitive life stages. Instream work will also occur outside of this period when work must be completed prior to the onset of winter conditions, or where the advantages of completing the work (*e.g.*, sediment control structures) prior to winter conditions justifies late season work. In the event of instream work in sensitive watercourses outside of the June 1 to September 30 season, DFO will be consulted, and appropriate permits and authorizations (*i.e.,* Watercourse and Wetland Alteration Permit and HADD authorization) will be obtained. Any instream work completed after September 30 will require continuous monitoring during the work period and inspection of sediment control mitigation during periods of substantial visible overland flow of water (*e.g.,* major thaw events). Alternative sediment control mitigation may be required during the winter period. For example, floating silt barriers may be anchored into ice to trap sediment flowing on top of the ice surface (Trow Consulting Engineers Ltd. 1996). Alternative sediment control techniques will be discussed with DFO prior to authorization of late season instream work.

In addition, there will be a 30 m buffer zone adjacent to each watercourse, where clearing will only occur in areas necessary for the RoW development. Extra efforts will be made to minimize instream activities during culvert and bridge installations. If instream work is required, this work will be conducted in the dry using cofferdams, temporary diversions, or pumping flow around the construction site. Details on these approaches are outlined in the *Watercourse Alteration Technical Guidelines* (NBDELG 2002b).

Runoff controls limit or contain soil movement from the construction site. Minimizing raindrop impact on the soil, reducing runoff volume, and decreasing runoff velocity are three of its main objectives. Diversion berms will be used on slopes to intercept sheet flow on exposed surfaces and to reroute flow into undisturbed areas. Erosion protection will be implemented at the berm outlets. Flow checks will be constructed in ditches, swales, or chutes to reduce hydraulic gradient and flow velocity, thus minimizing the potential erosion of the channel.

In the event of late season work (*i.e.*, after September 30), stabilization of exposed soils within the Work Area will be completed:

- within 5 days of disturbance within 30 m of a watercourse (using mulch or another approved late season stabilization material), or prior to any forecasted winter storm event and/or the onset of frozen ground conditions; or

- within 30 days of disturbance beyond 30 m of a watercourse as per Item 946 of the Standard Specifications (NBDOT 2003), or prior to any forecasted winter storm event and/or the onset of frozen ground conditions, when possible.

Erosion protection measures are used to reduce or eliminate the suspension and removal of soil particles by flowing water. These measures will be placed on or applied to the soil surface and in conjunction with runoff control and sediment interception measures as appropriate. Various geomembranes and geotextiles will be used to minimize erosion as appropriate. In addition, revegetation will occur on slopes and embankments for long term stabilization.

Soil loss from slopes may occur even with erosion and runoff control measures. To prevent this soil from entering a waterbody, mitigative measures will be implemented to intercept it. Methods that will be used to trap sediment include vegetated buffer strips, silt fences, filter berms and sediment traps. Monitoring of erosion control structures will be conducted to ensure the structures remain in place and operate effectively throughout the construction period. Specifically, all structures will be inspected prior to and following any rainfall event, and at least daily during prolonged periods of rainfall. Erosion control measures will not be removed until the exposed areas have been stabilized by vegetation.

During construction, a wet weather shut down policy will be in place to avoid soil disturbance during runoff periods. In addition, a watercourse monitoring program will be developed in consultation with DFO, which will include total suspended solids and pH (where the potential for sulfide bearing rock drainage exists).

The mitigation for minimizing the potential interaction between clearing and grubbing activities and sulfide bearing rock is described in Section 5.3.5.2.1 of Surface Water.

Based on consideration of the potential environmental effects of the individual activities required for RoW preparation of the proposed TCH and associated roads and facilities, the proposed mitigation [*e.g.*, EPP, EFG, site specific EPPs, *Watercourse Alteration Technical Guidelines* (NBDELG 2002b), and *Guidelines for the Protection of Fish and Fish Habitat – The Placement and Design of Large Culverts* (DFO 1999a) and the residual environmental effects significance ratings criteria, the environmental effects on fish and fish habitat by site preparation activities are considered not significant.

Roadbed Preparation

Blasting

Blasting will be avoided where possible but in some instances it may be unavoidable. Should blasting be required during construction in or near a watercourse, authorization will be required from DFO for the use of explosives (Section 32 of the *Fisheries Act)*. Blasting will be conducted in accordance with the EPP and EFG and *Guidelines for use of Explosives in Canadian Fisheries Waters* (Wright and Hopky 1998), and in full compliance with the requirements of DFO's authorization.

Environmental effects from blasting to fish and fish habitat can be minimized through use of these mitigative measures, which include but are not limited to:

- consultation with DFO Regional authorities during the planning process;
- exclusion of fish from the blasting area, where practical, using appropriate methods (*e.g*., noise generated with an air compressor discharge line);
- use of non-propagating explosives;
- use of time-delay blasting caps for detonation of multiple, smaller charges;
- no use of ammonium nitrate-fuel oil mixtures in or near water due to the production of toxic ammonia;
- recovery of all residual blasting components (*e.g*., shock tubes and detonation wire); and
- no explosive is to be detonated in or near fish habitat that produces, or is likely to produce, an instantaneous pressure change greater than 100 kPa in the swimbladder of a fish.

Construction (including blasting) in or near watercourses will be undertaken between June 1 and September 30, outside of the biologically sensitive period to avoid the sensitive and critical fish life stages, where possible.

The mitigation for minimizing the potential interaction between clearing and grubbing activities and sulfide bearing rock is described in Section 5.3.5.2.1 of Surface Water.

Based on consideration of the potential environmental effects of the individual activities required for roadbed preparation of the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g*., EPP, EFG, site specific EPPs, *Watercourse Alteration Technical Guidelines* (NBDELG 2002b), and *Guidelines for the Protection of Fish and Fish Habitat – The Placement and Design of Large Culverts*), and the residual environmental effects significance ratings criteria, the environmental effects on fish and fish habitat by roadbed preparation activities are considered not significant.

Watercourse Crossing Structures

A design exercise was completed for each watercourse crossing, regardless of watercourse size, along the proposed highway to evaluate the drainage area upstream of the proposed crossing, fish populations within the watercourse, and precipitation. The results will be use to spent Watercourse and Wetland Alteration Permit requirements, and review by DFO.

As part of the design process, a Watercourse and Wetland Alteration Permit will be obtained from NBDELG. Conditions associated with the permit will be met by NBDOT. Generally, watercourse crossings (if constructed with proper mitigation) do not violate the *Fisheries Act* and therefore do not require habitat compensation under DFO's *No Net Loss Policy*. However, final approval is required from DFO regarding the overall Project, and the proposed individual watercourse crossings. If DFO determines that there will be a harmful alteration disruption or destruction to fish habitat (HADD), then a habitat compensation plan will be required to ensure the policy is met. In addition, Coast Guard approval under the *Navigable Waters Protection Act* will be required for proposed crossings over navigable waters.

Mitigation for the potential HADD of fish habitat required by DFO for similar highway projects in New Brunswick includes:

- watercourse crossings in fish bearing watercourses will be designed in consultation with DFO;
- the area of disturbance will be limited to that which is absolutely necessary to complete the Project;
- all work will be done in strict accordance with conditions of approval;
- an onsite pre-construction meeting with DFO, NBDNR, and NBDELG to review conditions of authorization will be held;
- all streambeds and streambanks associated with the proposed work will be permanently restored as soon as possible following disturbance;
- a wet weather shut down policy will be in place and will include the minimum forecast intensity/duration rainfall event which will evoke the implementation of response measures;
- instream work or any work within 30 m of a watercourse will not be done outside of the period between June 1 and September 30 of each year without written permission from DFO and NBDELG;
- work conducted outside the June 1 to September 30 time period will be subject to conditions/requirements determined by DFO on a site-specific basis (*i.e.,* HADD authorization, NBDOT inspector to oversee work on a continuous basis);
- a fish salvage will be conducted by a qualified biologist prior to de-watering;
- a Compliance Monitoring Plan will be developed prior to commencement of any construction activity; and
- all culverts and temporary and permanent stream diversions associated with the project works allow for fish passage.

NBDOT is committed to address the issue of fish habitat compensation as required through the development of a "habitat bank". "Habitat banking" is the completion of compensation prior to authorization, whereby the proponent (NBDOT) creates or improves fish habitat for future use as compensation when the project is carried out. The creation of a habitat bank does not involve monies, nor does it "pre-approve" any future HADD authorizations. The value (in area units) of the compensation is determined at the time of the withdrawal. DFO regional staff and NBDOT have agreed to a maximum required ratio of 3:1 for offsite habitat compensation for this Project. This means that for each (1) unit of habitat requiring authorization, up to three units of habitat must be enhanced or created in consultation with and as authorized by DFO. Changes to the construction of watercourse crossings (*e.g.*, design, schedule, construction methodology) which require amendments to the *Fisheries Act* authorizations may also require additional habitat compensation.

Prior to initiation of the habitat banking process, a HADD compensation plan will be developed by NBDOT, and include:

- the process by which the requirement for compensation will be minimized;
- the process by which compensation projects will be selected;
- the process by which compensation will be carried out;
- a compliance monitoring plan;
- an effectiveness monitoring plan; and
- a schedule for the completion of sufficient compensation prior to authorization.

Monitoring required in the plan would include compliance monitoring to ensure that compensation is being carried out correctly, and effectiveness monitoring to ensure that compensation achieved a net gain in productive capacity.

Compensation, requiring an authorization under Section 35(2) of the *Fisheries Act,* for the loss of fish habitat required by DFO for similar highway projects in New Brunswick includes:

- identification of who will carry out work and if any landowners are involved;
- development of an approved compensation plan;
- the compensation plan must be implemented before the end of the authorization period;
- a post construction monitoring plan will be developed and implemented;
- all planted material will be maintained for the duration of the post production monitoring program;
- all planted material will be native to New Brunswick;
- all instream enhancement works will be maintained for the duration of the post production monitoring program;
- results from post construction plan will be summarized yearly and submitted to DFO; and
- as-built drawings for the channel re-alignments, culvert installations and compensation works will be provided to DFO within one year.

DFO has advised that in most cases, the installation of box or pipe culverts is the preferred approach to minimizing habitat loss. Section 2.2.3 describes the types of watercourse crossing structures that may be used, and the criteria for the selection of a particular type. The following watercourses may require a large structure (*e.g.*, arch or bridge):

- Big Presque Isle Stream (WC33);
- Little Presque Isle Stream (WC36 and WC37);
- River de Chute (WC18);
- Upper Guisiguit Brook (WC20);
- Lower Guisiguit Brook (WC24); and
- Hunters Brook (WC32).

A complete list of watercourse structures is included in Surface Water, Section 5.3.

All watercourse crossing structures will be installed in compliance with the conditions set in the site specific watercourse alteration permit. Bridge design and installation will be done in consultation with DFO and the Canadian Coast Guard (Navigable Waters Protection Program).

The installation of culverts will be done using dam and pump procedures or channel diversion. In either case, fish will be removed from the area of planned construction activities prior to construction commencing. This will be done by enclosing the area of planned construction activities with fine-mesh nets and removing the fish using DFO approved methods (*e.g.*, electrofishing or seine nets). Direct mortality of some fish can be expected at rates consistent with those typical for electrofishing and the use of barrier nets. Water pump intakes – used during dam and pump procedure – will be in compliance with the DFO *Freshwater Intake End-of-Pipe Fish Screen Guideline* (DFO 1995b).

During construction, an on-site monitor (environmental inspector) will ensure that the installations are conducted according to the planning process, meet the Conditions of Approval as described in the Watercourse and Wetland Alteration Permit and do not introduce suspended sediments or contaminants to surface waters.

Based on consideration of the potential environmental effects of the individual activities and physical works required watercourse crossing structures for the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g.*, habitat compensation), and the residual environmental effects significance ratings criteria, the environmental effects on the fish and fish habitat by these activities are considered not significant.

Surfacing and Finishing, and Ancillary Structures and Facilities Construction

The management of hazardous materials will be mitigated as described in Section 5.3.5.2.1 of Surface Water.

Based on consideration of the potential environmental effects of the individual activities and physical works required for surfacing and finishing and construction of ancillary structures and facilities along the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g.*, EPP, EFG), and the residual environmental effects significance ratings criteria, the environmental effects of construction of fish and fish habitat by these activities are considered not significant.

5.4.5.2.2 Operation

The following provides an evaluation of key potential project-VEC interactions for the operation phase of the Project as summarized in the environmental effects assessment matrix (Table 5.4.6). Operation of the proposed TCH will continue in perpetuity upon completion of the construction phase of the project. The main issues in this phase of the project related to fish and fish habitat are proposed TCH presence (long term erosion, sedimentation and runoff), and winter safety (*i.e.*, use of salt and sand for snow removal and providing traction). Further discussion follows the table.

Table 5.4.6 Environmental Effects Assessment Matrix for Fish and Fish Habitat (Operation)

Environmental Effects Assessment Matrix
Valued Environmental Component: FISH AND FISH HABITAT
Phase: Operation

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Winter Safety	Change in habitat quality (A)	• Develop and implement long term salt management plan	1	3	2/2	R	2
Proposed TCH Operation	Change in habitat quality (A) Change in habitat quantity (A)	• Proper design of cut and fills, and ditching • Follow EPP and EFG	1	3-4	5/6	R	2

Key:

Magnitude:
1 = Low: localized effect on specific group, habitat, or ecosystem, returns to pre-Project levels in one generation or less, within natural variation
2 = Medium: portion of a population or habitat, or ecosystem, returns to pre-Project levels in one generation or less, rapid and unpredictable change, temporarily outside range of natural variability
3 = High: affecting a whole stock, population, habitat or ecosystem, outside the range of natural variation, such that communities do not return to pre-Project levels for multiple generations

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10 - 50 km^2
4 = 50 - 100 km^2
5 = 100 - 1000 km^2
6 = >1,000 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 - 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Winter Safety

The application of salt and sand to improve safety during winter weather conditions will be mitigated as described in Section 5.3.5.2.2 of Surface Water.

Based on consideration of the potential environmental effects of the individual activities required for winter safety along the proposed TCH and associated roads and facilities, the proposed mitigation [*e.g.*, EPP, EFG, salt management plan], and the residual environmental effects significance ratings criteria, the environmental effects on fish and fish habitat by these activities are considered not significant.

Proposed TCH Presence

Erosion and sedimentation and runoff from the road surface will be mitigated as described in Section 5.3.5.2.2 of Surface Water.

Culverts and bridges can lose their ability to provide fish passage through accumulation of debris, or through erosion. Culverts and bridges will be inspected, cleaned and repaired on a regular basis, to help ensure proper fish passage, and to maintain the integrity of the structure. Watercourse Alteration Permits will be applied for any activities at these crossings. The maintenance or construction activities will be conducted according to the requirements specified in the Watercourse Alteration Permit. Section 5 of the EPP and Section 6 and 7 of the EFG protection measures will be implemented. Erosion control measures shall be installed as required, and removed material from the watercourse will be disposed of in such a way as to prevent material from re-entering the structure.

Based on consideration of the potential environmental effects of the individual activities and physical works associated with the presence of the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g.*, EPP, EFG, salt management plan), and the residual environmental effects significance ratings criteria, the environmental effects on fish and fish habitat by these activities are considered not significant.

5.4.5.2.3 Maintenance

Routine highway maintenance that may potentially interact with fish and fish habitat includes ditching, vegetation control and watercourse crossing structure repairs. Further discussion, by Project phase, follows Table 5.4.7.

Table 5.4.7 Environmental Effects Assessment Matrix for Fish and Fish Habitat (Maintenance)

Environmental Effects Assessment Matrix
Valued Environmental Component: FISH AND FISH HABITAT
Phase: Maintenance

Project Activity (See Table 4.1.1 for list of specific activities and works)	**Potential Environmental Effects**	**Mitigation**	**Magnitude**	**Geographic Extent**	**Duration/Frequency**	**Reversibility**	**Ecological/Socio-Cultural and Economic Context**
Proposed TCH Maintenance	Change in habitat quality (A)	• Follow EPP and EFG • Follow requirements of Watercourse Alteration Permits • Follow necessary erosion control measures • Maintain buffer zone within 30 m of watercourse	1	3	5/6	R	2
Vegetation and Wildlife Management	Change in habitat quality (A)	• Follow EPP and EFG • Apply for Watercourse Alteration Permits, follow requirements • Maintain buffer zone within 30 m of watercourse	1	3	5/6	R	2

Key:

Magnitude:
1 = Low: localized effect on specific group, habitat, or ecosystem, returns to pre-Project levels in one generation or less, within natural variation
2 = Medium: portion of a population or habitat, or ecosystem, returns to pre-Project levels in one generation or less, rapid and unpredictable change, temporarily outside range of natural variability
3 = High: affecting a whole stock, population, habitat or ecosystem, outside the range of natural variation, such that communities do not return to pre-Project levels for multiple generations

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10 - 50 km^2
4 = 50 - 100 km^2
5 = 100 - 1000 km^2
6 = >1,000 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
2 = 11 - 50 events/year
3 = 51 - 100 events/year
4 = 101 – 200 events/year
5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Proposed TCH Maintenance

Ditching may be required to improve water flow, erosion or excessive vegetative growth. The primary issue of concern is the release of sediment into surface water bodies. NBDOT has identified this issue in their EPP (Section 6.1.4) and EFG (Section 4.4), and detailed protection measures to protect surface waters. The end of ditching should not come within 30 m of a watercourse. Ditches should be directed into surrounding vegetation where possible, rather than entering directly into a natural watercourse. Sediment-laden water entering fish bearing waters will comply with the *Canadian Water Quality*

Guidelines for the Protection of Aquatic Life (CCME 1999). A Watercourse Alteration Permit will be applied for any activities within 30 m of a watercourse.

Based on consideration of the potential environmental effects of the individual activities associated with the maintenance of the proposed TCH and associated roads and facilities, the proposed mitigation [*e.g.*, EPP, EFG], and the residual environmental effects significance ratings criteria, the environmental effects on fish and fish habitat by these activities are considered not significant.

Vegetation and Wildlife Management

Vegetation control will be conducted by mechanical clearing during highway operation on the RoW (*e.g.,* road shoulders and interchanges). As stated in the NBDOT EPP, there will be no herbicides used for vegetation control. For vegetation control activities within 30 m of a watercourse, when required, a Watercourse Alteration Permit will be obtained before initiation of activities. Slash shall not be allowed to enter any watercourse.

Any increase in watercourse nutrient levels from hydroseeding would be temporary as the applications are infrequent and these nutrient forms are readily absorbed by sediments or taken up by plants.

Based on consideration of the potential environmental effects of the individual activities associated with the vegetation and wildlife management along the proposed TCH and associated roads and facilities, the proposed mitigation (*e.g*., EPP, EFG), and the residual environmental effects significance ratings criteria, the environmental effects of maintenance on fish and fish habitat by these activities are considered not significant.

5.4.5.2.4 Accidents, Malfunctions and Unplanned Events

The following provides an evaluation of key potential project-VEC interactions for accidents, malfunctions and unplanned events as summarized in the environmental effects assessment matrix (Table 5.4.8). The main issues related to fish and fish habitat are hazardous materials spills, fire and bridge/culvert washout. These accidents are possible during all Project phases. Further discussion of each accident type follows the table.

Table 5.4.8 Environmental Effects Assessment Matrix for Fish and Fish Habitat (Accidents, Malfunctions and Unplanned Events)

Environmental Effects Assessment Matrix
Valued Environmental Component: FISH AND FISH HABITAT
Phase: Accidents, Malfunctions and Unplanned Events

Project Activity (See Table 4.1.1 for list of specific activities and works)	Potential Environmental Effects	Mitigation	Magnitude	Geographic Extent	Duration/Frequency	Reversibility	Ecological/Socio-Cultural and Economic Context
Hazardous Materials Spill	Change in habitat quality (A) Direct mortality (A)	• Follow EPP and EFG procedures and provincial and federal regulations should be followed for storage and handling of materials • Contingency Plan • Employee training	1-3	3-5	1/1	R	2
Erosion and Sediment Control Failure	Change in habitat quality (A) Direct mortality (A)	• Follow EPP and EFG preventative measures • Contingency Plan	1-2	1-5	1/1	R	2
Bridge or Culvert Washout	Change in habitat quality (A) Direct mortality (A)	• Follow EPP and EFG preventative measures • Contingency Plan	1-2	1-2	1/1	R	2
Fire	Change in habitat quality (A) Direct mortality (A)	• Follow EPP and EFG preventative measures • Contingency Plan	1-2	4-5	1/1	R	2

Key:

Magnitude:
1 = Low: localized effect on specific group, habitat, or ecosystem, returns to pre-Project levels in one generation or less, within natural variation
2 = Medium: portion of a population or habitat, or ecosystem, returns to pre-Project levels in one generation or less, rapid and unpredictable change, temporarily outside range of natural variability
3 = High: affecting a whole stock, population, habitat or ecosystem, outside the range of natural variation, such that communities do not return to pre-Project levels for multiple generations

Geographic Extent:
1 = <1 km^2
2 = 1-10 km^2
3 = 10 - 50 km^2
4 = 50 - 100 km^2
5 = 100 - 1000 km^2
6 = >1,000 km^2

Duration:
1 = <1 month
2 = 1 - 12 months
3 = 13 - 36 months
4 = 37 - 72 months
5 = >72 months

Frequency:
1 = <11 events/year
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5 = >200 events/year
6 = continuous

Reversibility:
R = Reversible
I = Irreversible

Ecological/Socio-cultural and Economic Context:
1 = Relatively pristine area or area not adversely affected by human activity.
2 = Evidence of adverse environmental effects.

N/A = Not Applicable
(A) = adverse
(P) = positive

Hazardous Materials Spill

Known hazardous materials that will be used during the construction and operation of the Route 2 Bypass include fuels, lubricants, solvents, windshield washer and antifreeze. There is also a possibility that a large quantity of other various unidentified hazardous materials will be transported along this route. There is a possibility that these materials could be accidentally introduced into fish habitat through a spill of these materials. These materials could temporarily degrade water quality and have subsequent environmental effects on freshwater fish. In addition, contaminants can accumulate in sediments and be mobilized slowly over time. If a major spill of a highly toxic and soluble material were to occur at one of the watercourse crossings, the geographic extent would include both the tributary and areas downstream in the watershed, potentially downstream as far as the confluence with the Saint John River depending on the quantity and the toxicity of the material spilled. Mortalities could potentially occur at all fish life stages within the affected area. Changes in water quality could also affect other trophic levels, resulting in drift or direct mortalities of benthic organisms. Sublethal environmental effects could include avoidance behaviour and disruption of feeding and migration patterns.

The magnitude of the environmental effect of a spill would be dependent on a number of factors, which are difficult to predict. Reversibility of physical environmental effects is high, due to the dynamic nature of lotic water systems. The high spring flows and high bedload transport will effectively flush the system during the spring following the event. Reversibility of environmental effects on fish populations will depend on the species involved, and the proportion of the watershed affected. Resident fish would re-establish within the affected area.

NBDOT has spill response contingency procedures identified in Section 8.1 of the EPP and Section 5.7 of the EFG. In the unlikely event of a hazardous material spill, the spilled material will be controlled and contained, and NBDOT will assist with the clean up. Materials to facilitate a rapid containment and clean up of hazardous materials spills will be available on site during construction in or near watercourses and wetlands.

Areas NBDOT considers to be environmentally sensitive are identified in Section 7.0 of the EPP and may be particularly sensitive to pollutant spills. Watercourses, Wetlands, Rare Plants, Archaeology Sites, Wildlife Habitat, etc., are indicated by location on the various Figures included in the Comprehensive Study Report. The protective measures required to ensure the protection of sensitive areas in the case of an accident or spill are identified in Section 5.7 of the EFG. This section outlines seven steps to be taken when a spill occurs and also describes and illustrates how to control and contain spills. The seven steps include the following.

1. Identify the material involved and make a quick assessment.
2. Stop the flow of product, if it can be done safely.
3. Call the Coast Guard Environment t Emergency Number (1-800-565-1633: 25 hours). This is a legal requirement.
4. Call CANUTEC: 1-613-996-6666 (24 hours).
5. Notify DOT District Engineer or other designated representative.
6. For spills at fuelling facilities contact the DOT Supervisor, Vehicle Management Agency, Maintenance and Traffic Branch, and the local Fire Prevention Authority.
7. Control and contain spilled product until expert help arrives, if it can be done safely.

Section 8.1 of the EPP also outlines protection measures incase of a fuel or chemical spill. A brief description of the procedures to take are as follows:

- First group on the scene assumes a worst case scenario, and cordon off the area to others;
- Safely attempt to retrieve shipper's emergency telephone number from the driver or the order papers to identify the materials involved and make a quick assessment;
- Report all information at hand to headquarters or dispatcher (*i.e.,* respective of the first group on the scene) as applicable; and
- Determine if the coast Guard (1-800-565-1633) has been notified; if not, ensure that coast gu7ard is notified giving all information at hand, so they can activate the response from DOE and the Emergency Measures Organization.

Section 4.19 of the EPP also identifies protection measures to prevent spills and accidents from occurring. Site-specific EPPs will be developed for work near environmentally sensitive areas and these will address preparedness measures that are necessary to ensure effective emergency response in the event of spills is reflective of the level of sensitivity.

The transportation of dangerous goods is discussed in Section 5.2.5.2.4. Assuming that emergency spill response plans are in place and carried out effectively, it is considered extremely unlikely (almost no chance of occurrence) that a spill event capable of producing a high magnitude environmental effect (Table 5.4.8) would occur during the life of the Project (in perpetuity). Therefore, a significant environmental effect from a large scale spill is considered possible, but extremely unlikely.

Based on consideration of the potential environmental effects of an accident, malfunction, or unplanned event, involving the release of a hazardous material into fish habitat along the proposed TCH and associated roads and facilities, the proposed mitigation, and contingency plans, most of the environmental effects of hazardous material spills are considered unlikely and not significant. However, because of the possibility (albeit very low) of a substantial hazardous material spill of a toxic substance directly into a watercourse, the environmental effects of an accidental hazardous material spill on fish and fish habitat are considered significant, but not likely.

Erosion and Sediment Control Failure

There is a potential during heavy precipitation events or flash floods for erosion control structures (*i.e.*, check dams) to fail. To reduce the possibility of this occurring, protection measures will be followed as described in Section 4.5 of the EPP. Specifically, erosion control structures will be monitored regularly and maintained in a functional condition until the grass on seeded slopes is sufficiently established to be an effective erosion deterrent. All check dams will be inspected before and after each rainfall and at least daily during periods of prolonged rainfall. All check dams found to be damaged will be repaired immediately. Sediment deposits retained by structures will be removed when the level of sedimentation is within 100 mm of the top of the structure.

Based on consideration of the potential environmental effects an accident, malfunction, or unplanned event, involving erosion and sediment control failure along the proposed TCH and associated roads and facilities, the proposed mitigation, and contingency plans, the environmental effects of erosion and sediment control failure on fish and fish habitat would not likely result in the decline of a fish community that would not recover in one generation and are therefore considered not significant.

Bridge or Culvert Washout

There is a potential during high flood events for portions of the highway, or bridge or culvert installations to be washed out. This could temporarily degrade water quality due to increased sedimentation, or affect habitat quantity by deposition of debris material into the stream (concrete debris, bridge/culvert materials) that could affect fish passage. Factors influencing the magnitude, duration and geographic extent of the environmental effect include amount and duration of flooding, type and size of washout, natural terrain surrounding watercourse and location within the watershed. The extent of the environmental effects of such a road failure or washout on fish is predicted to be low due to the small area of a watershed which is covered by the watercourse crossing. Reversibility potential is high due to the dynamic nature of stream high spring discharges and high spring bedload transportation.

Roads are most susceptible to washouts during the high flow period during and immediately following spring snow melt. Road design will focus on protection of the aquatic environment by incorporating buffer zones, drainage and erosion control features and very conservative culvert and bridge design criteria. Watercourse crossings (bridges and culverts) will be designed with a hydraulic capacity to handle at least the 1 in 100 year peak discharge event, and will follow the *Watercourse Alteration Technical Guidelines (*NBDELG 2002b*).*

Watercourse crossing structures (including culverts) will be inspected at regular intervals and repairs will be made as required as per Section 6.3 of the EPP and Section 6 and 8 of the EFG.

Based on consideration of the potential environmental effects of an accident, malfunction, or unplanned event, involving a bridge or culvert washout along the proposed TCH and associated roads and facilities, the proposed mitigation, and contingency plans, the environmental effects of a bridge or culvert washout or failure on fish and fish habitat would not likely result in the decline of a fish community that would not recover in one generation and are therefore considered not significant.

Fire

A forest fire could alter water quality within streams, resulting in subsequent environmental effects on the population of freshwater fish. Fire within the Assessment Area of the highway could occur during any phase of the Project due to lightning or human activities. It is assumed, for the purposes of this assessment, that the affected area for such an event would extend to all areas downstream of the area affected by fire. Factors influencing the severity and duration of environmental effects include time of year, extent of fire damage and type of fire. Risk of forest fire along the road route is possibly higher than in non road areas due to the presence of human activity along the road route, which may be recreational or commercial in nature.

A fire during late summer or early fall could interfere with migration and spawning of salmonid species if the interaction was of long duration. During early life stages (*i.e.*, eggs, alevins), salmonids are more sensitive to the deposition of ash and sediment through runoff and have limited avoidance ability. Therefore, fires during the fall (spawning) and winter (incubation) present a greater risk to salmonid populations. If the forest fire affects a large proportion of the stream and occurs during the late fall, the magnitude of the environmental effect of such a fire could be medium for salmonids. Atlantic salmon are not known to spawn in watercourses within the watercourses crossed by the proposed TCH. Reversibility of physical environmental effects is high, but would occur over a number of years. Spring flows and high bedload transport will effectively flush the system during the spring following the event, however, erosion within the watershed would continue to contribute sediments to the stream system for a number of years. Changes to groundwater patterns and contribution to baseflow in the stream may be altered during this period due to changes in evaporation and infiltration rates. Restoration of bank stability and cool temperatures would rely on the re-establishment of riparian communities through vegetative succession. The environmental effects on the population of resident and migratory fish are reversible. Benthic drift from upper portions of the brook will re-establish food resources. For fish populations, individuals from other portions of the watershed would recolonize the areas of environmental effects.

The potential for Project-related fires during Construction and Maintenance will be mitigated through equipment maintenance (*e.g.*, power saw mufflers and vehicle exhaust systems) and proper vigilance working with power equipment in forested areas, as per Section 8.4 of the EPP. Also, any burning of vegetative debris will require permits from NBDNR and NBDELG as per Section 4.8.3 of the EFG. All Construction activities will be done in compliance with regulations contained within the *Forest Fires Act*.

The potential for Project-related fires during Operation will be mitigated through vegetation management (*e.g.,* mowing and brush cutting) as per Section 6.1.6 of the EPP.

In the event of a fire occurring as a result of Construction and Maintenance activities, NBDOT personnel shall be prepared (*i.e.*, will have access to round point shovel or fire extinguisher) to control and fight any fires in and about the work area, as per Section 7.4 and 8.4 of the EPP, and the *Forest Fires Act*. All fires will be reported to NBDNR. Forest fires not related to the Project will be managed by NBDNR.

Based on consideration of the potential environmental effects an accident, malfunction, or unplanned event, involving a fire contacting fish habitat along the proposed TCH and associated roads and facilities, the proposed mitigation, and contingency plans, the environmental effects on fish and fish habitat would not likely result in the decline of a fish community that would not recover in one generation and are therefore considered as not significant.

5.4.5.3 Determination of Significance

Table 5.4.9 evaluates the significance of potential residual environmental effects resulting from the interaction between Project activities and fish and fish habitat, after taking into account any proposed mitigation. The table also considers the level of confidence of the study team in this determination and the likelihood of potential environmental effects. The residual environmental effects are considered not significant for all Project phases. Potential hazardous material spills for the Project are considered significant for hazardous material spills, but unlikely.

Table 5.4.9 Residual Environmental Effects Summary Matrix for Fish and Fish Habitat

Residual Environmental Effects Summary Matrix
Valued Environmental Component: FISH AND FISH HABITAT

Phase	Residual Environmental Effects Rating	Level of Confidence	Likelihood	
			Probability of Occurrence	Scientific Certainty
Construction	NS	3	3	3
Operation	NS	3	3	3
Maintenance	NS	3	3	3
Accidents, Malfunctions and Unplanned Events	S	3	1	3
Project Overall	NS	3	3/1	3

Key
Residual Environmental Effect Rating:
S = Significant Adverse Environmental Effect
NS = Not-significant Adverse Environmental Effect
P = Positive Environmental Effect

Level of Confidence
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence

Probability of Occurrence: based on professional judgement
1 = Low Probability of Occurrence
2 = Medium Probability of Occurrence
3 = High Probability of Occurrence

Scientific Certainty: based on scientific information and statistical analysis or professional judgement
1 = Low Level of Confidence
2 = Medium Level of Confidence
3 = High Level of Confidence
N/A = Not Applicable
*As determined in consideration of established residual environmental effects rating criteria.

Based on consideration of the Project-related environmental effects, it is concluded that the fish and fish habitat resources in the vicinity of the Project have the capacity to meet the needs of the present and those of the future.

5.4.6 Monitoring and Follow-up

The primary residual environmental effect of the Project on fish and fish habitat is the potential for the sedimentation of watercourses. The loss of fish habitat from installation of watercourse crossing structures will be mitigated by ensuring no net loss of fish habitat through habitat compensation. Watercourse crossing structures will be designed to allow for fish passage as required by DFO, where possible.

The fish and fish habitat monitoring will consist of both compliance and effectiveness monitoring. During construction, compliance monitoring will ensure that all applicable environmental protection and permitting requirements for work within 30 m of a watercourse are followed, and that remedial action, if necessary, is successfully implemented. Remedial action may involve fish rescue for de-watered sections of streams and/or near blasting areas. The fish and fish habitat compliance monitoring will be the same as that described in Section 5.13.3.3 for surface water monitoring.

Effectiveness monitoring for fish and fish habitat has the following four objectives:

- verify that mitigative strategies used during construction and operation have been effective;
- determine the total amount of HADD that occurred as a result of the Project;
- verify that habitat compensation, completed as part of the habitat bank, is operating effectively; and
- identify the need for, and carry-out, any additional habitat compensation.

The exact specifications of the fish and fish habitat and surface water monitoring program will be developed in consultation with DFO and NBDELG. The monitoring program will be subject to approval by DFO as part of the HADD authorization process and NBDELG as a part of the Watercourse and Wetland Alteration permitting process. This work will be undertaken in selected streams as determined through the authorization/permitting processes. The fish and fish habitat (and surface water) effectiveness monitoring will consist of the following core elements for comparison with pre-development baseline conditions:

- assessment of fish population and diversity (short term and long term);
- assessment of fish habitat;
- assessment of invertebrate population and diversity (short term); and
- a substrate and embeddedness study.

In addition, a fish passage study will also be conducted on a small number of watercourses to verify that design strategies for fish passage were effective.

The fish habitat assessment will use the NBDNR/DFO fish habitat assessment methodology (Hooper *et al.* 1995). The fish habitat assessment will also include measurements of pH and salinity in those watercourses identified, in consultation with DFO and NBDELG, as sensitive to these parameters.