

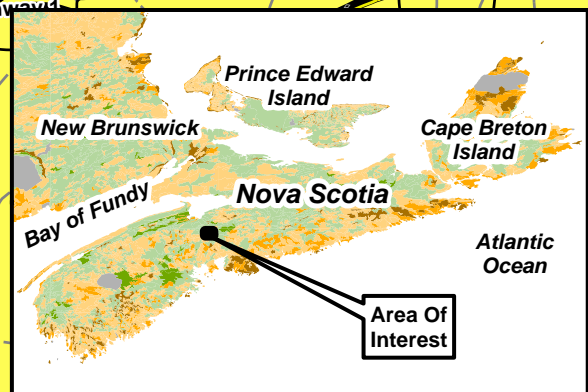
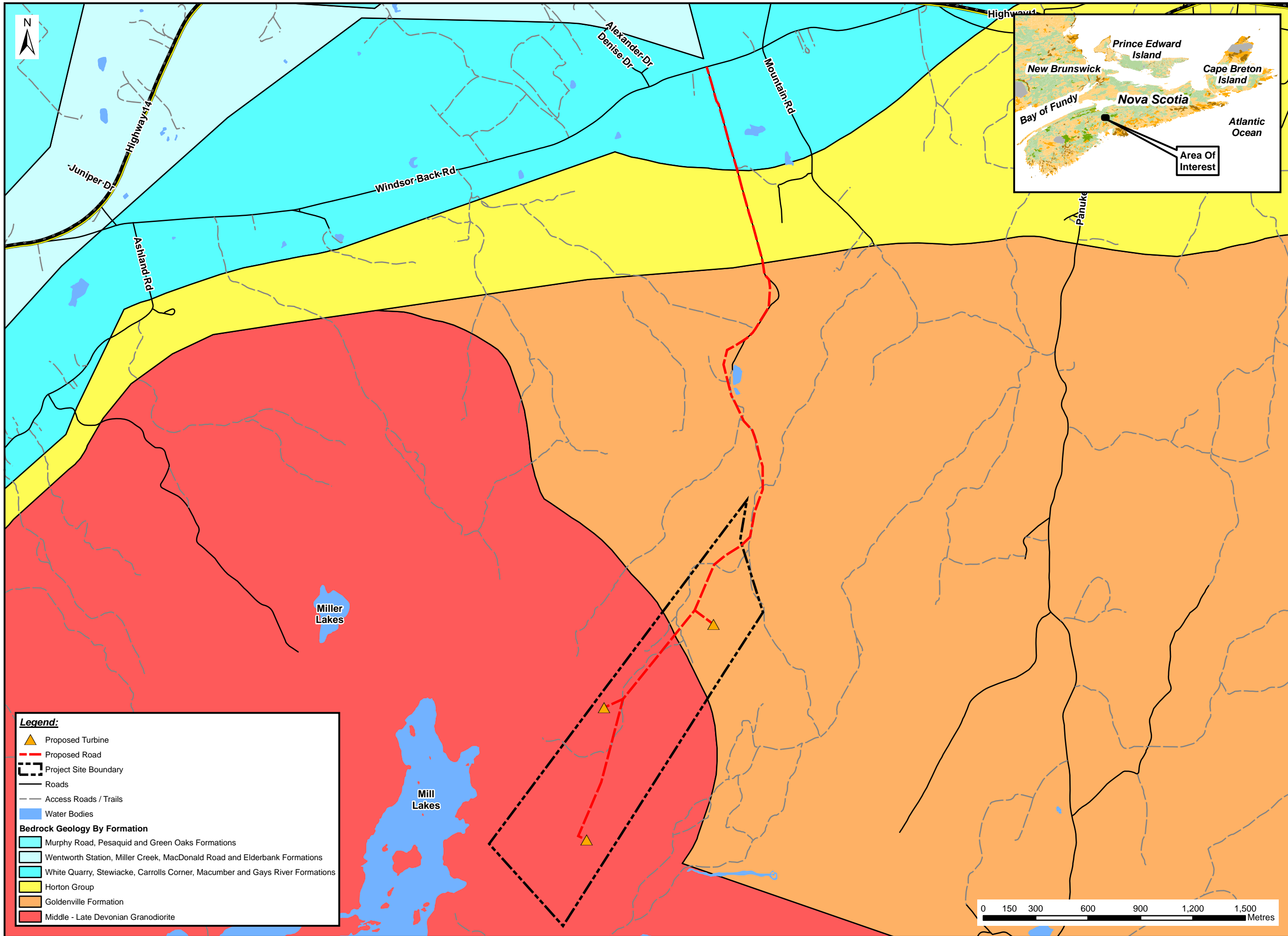
8.2.3 Bedrock Geology

Bedrock geology across the northern half of the Project site consists of Cambrian – Ordovician aged metamorphic rocks of the Goldenville Formation (Keppie 2000) (Drawing 8.2). The bedrock is typically composed of slate, greywacke and quartzite. The southern portion of the Project site is underlain by Middle – Late Devonian aged granodiorite bedrock consisting of slate, marble, schist, gneiss and amphibolite.

According to the NSE Well Log Database, there are no drilled wells located within a 1 km radius of the Project site (NSE 2012b). However, 16 wells were identified within 3 km of the Project site, ranging in depths from 15.5 m to 103.5 m. All 16 wells were drilled through varying surficial materials including clay, sand, boulders and gravel ranging from 3.0 m to 18.3 m in thickness, followed by slate, gypsum, quartzite, shale and sandstone bedrock.

Bedrock containing sulphide bearing minerals (e.g., pyrite, pyrrhotite, etc.) can potentially generate acid run-off if fresh surfaces are exposed to oxygen and water. The physical disruption of such bedrock leads to oxidation of iron-sulphide minerals and the generation of ARD (Fox *et al.* 1997). ARD can result in the acidification of surface and groundwater and promote the mobilization and leaching of toxic contaminants into the environment, including heavy metals. The likelihood of generating ARD within the Project site is low. The Goldenville Formation has been proven to contain only trace sulphide content, and therefore is less likely to contribute to ARD when exposed to oxidizing conditions (Fitzgerald and Goodwin 2004).

Based on a review of local surficial and bedrock geology, and in consideration of anticipated site use and development associated with the Project, the likelihood of encountering bedrock mineralogy that would be harmful to human health or the environment is low. Radon is present in some bedrock types similar to granite at this Project site; however, radon gas released from bedrock quickly becomes air borne and presents no risk. Though some radioactive shows have been recorded in bedrock similar to the type at the Project site, no shows or radioactive mineralogy above ambient levels are known within the boundaries of the Project site.



- Notes:**
1. Reference: Nova Scotia Department of Natural Resources, Minerals and Energy Branch, Map ME 2000-1, Geological Map of the Province of Nova Scotia, 1:500 000, Compiled by J. D. Keppie.
 2. Projection: NAD83(CSRS), UTM Zone 20 North.

Legend:

- Proposed Turbine
- Proposed Road
- Project Site Boundary
- Roads
- Access Roads / Trails
- Water Bodies

Bedrock Geology By Formation

- Murphy Road, Pesaquid and Green Oaks Formations
- Wentworth Station, Miller Creek, MacDonald Road and Elderbank Formations
- White Quarry, Stewiacke, Carrolls Corner, Macumber and Gays River Formations
- Horton Group
- Goldenville Formation
- Middle - Late Devonian Granodiorite



Bedrock Geology



Date: January 2013	Project #: 12-4402
Scale: 1:20,000	Drawing #: 8.2
Drawn By: H. Serhan	
Checked By: A. Walter	

8.2.4 Hydrogeology and Groundwater

Groundwater Quantity

Private water supplies near the Project site are generally derived from individually drilled wells. According to the NSE Well Log Database (NSE 2012b) of logs for wells constructed between 1920 and 2012, wells near the Project site have been reportedly installed through varying bedrock formations including: slate, gypsum, quartzite, shale and sandstone. A summary of the pertinent well properties included in these logs is presented in Table 8.1.

Table 8.1: Summary of Drilled Well Records Within Approximately 3 km of the Project Site

	Drilled Date (yr)	Well Depth (m)	Casing Length (m)	Estimated Yield (Lpm)	Water Level (m)	Overburden Thickness (m)	Water Bearing Fractures (m)
Minimum	1986	15.5	5.8	2.3	1.5	3.0	10.7
Maximum	2007	103.5	25.0	113.5	18.3	18.3	103.7
Average	1993	49.8	11.5	47.2	6.2	8.1	39.4
Geomean	1993	44.0	10.0	30.0	5.1	6.8	33.6
Number of well records	16	16	16	16	13	15	15

Source: NSE 2012b

Based on short term driller's estimates for the wells in Table 8.1, the average yield is approximately 47.2 Lpm (12.5 gpm) and average well depth is approximately 49.8 m (163.3 ft). These measurements represent very short term yields estimated by the driller at the completion of well construction. Fracture depths ranged from 10.7 m (35.1 ft) to 103.7 m (340.1 ft). The closest drilled well to the Project site is located approximately 1.8 km northeast of the site boundaries, along Panuke Road.

The NSE Pump Test Database (NSE 2012c) provides longer term yields for select wells throughout the province. Two regional wells, one drilled through the Goldenville formation and one drilled through the Windsor Group located within 12 km of the Project site, indicate long term safe yields (Q_{20}) of 95 Lpm (25.1 gpm) and 59.1 Lpm (15.6 gpm), and apparent transmissivity (T) values of 10.3 and 9.72 m²/d. Storativity values were not available from the two pump tests.

NSE maintains the Nova Scotia Groundwater Observation Well Network (NSE 2011b). The nearest observation well to the Project site is located approximately 26 km northwest, in Wolfville. This observation well was drilled to a depth of 17.7 m through sandstone bedrock of the Wolfville Formation and has been monitored since 1969. Water levels appear to have declined slightly over time, with a total water level drop since monitoring began of approximately 0.7 m. The reason for this decline has not been confirmed; however, it may be related to pumping at the Town of Wolfville's production wells, which are located within 750 m of this well.

Groundwater Quality

The water quality in the Goldenville Formation is expected to be good, with most parameters meeting the Canadian Drinking Water Guidelines (Health Canada 2012a). The presence of arsenic is a common naturally-occurring water quality issue, especially near anticline axis or gold districts. Other potential aesthetic problems such as iron, manganese and moderate hardness have

occasionally been reported. Groundwater in contact with granitic rocks tends to have higher alkalinity, hardness and TDS (Trescott 1968). Elevated concentrations of metals such as arsenic also occurs in some instances, associated with sulphides and base metal mineralization.

8.3 Freshwater Environment

8.3.1 Freshwater Habitats

The Project site lies on the border of two ecodistricts: the Rawdon/Wittenburg Hills Ecodistrict and the South Mountain Ecodistrict. The South Mountain Ecodistrict contains headwaters for some of the province's longest rivers, including the Tusket, Medway, Mersey, LaHave, Jordan, and Roseway (Neily *et al.* 2003). Approximately 7.5% or 486 km² of the ecodistrict is comprised of lakes and rivers. The Rawdon/Wittenburg Hills Ecodistrict rises notably above the surrounding valleys of the Stewiacke, Musquodoboit and Shubenacadie rivers in central Nova Scotia (Neily *et al.* 2003). In total, freshwater only accounts for 0.4% or 250 ha of this ecodistrict.

The Project site lies within the Avon River Watershed (1DE). The Avon River flows northerly and rises on the South Mountain, which is located to the southwest of Windsor. Near the rural community of Martock, the river enters a broad glacial river valley where it becomes tidal, creating an estuary for its remaining route to the Minas Basin several kilometres downriver from the Town of Hantsport. Tributaries to the Avon River include the Herbert, Cogmagun, Kennetcook, and St. Croix. Large water bodies in watershed include Card Lake, Panuke Lake, Falls Lake, Big St. Margaret's Bay Lake, and Mockingee Lake.

The Project site is located within the Mill Lakes Protected Watershed Area and approximately 330 m from Mill Lakes. The Mill Lakes Protected Watershed Area is protected by regulations set out in the *NSEA*. The regulations apply restrictions regarding usage of land and activities within the protected water area to manage potential threats to the water supply to the Town of Windsor and community of Three Mile Plains. Other nearby water bodies include Panuke Lake (3.2 km southeast), Miller Lake (1.3 km west), Palmer Lake (3.7 km southwest), and Mosquito Lake (2.0 km south).

Twelve lakes within Hants County are included in the Nova Scotia Lake Inventory Program (NSLIP), which determines the baseline biophysical attributes of lakes throughout the province. Data from the seven lakes located within 20 km of the Project site were reviewed, from sampling events completed in 1978 and 1984.

Water quality results were relatively consistent among the lakes with few apparent observations. Dissolved oxygen (DO) levels higher than 2 mg/L are considered optimal and were observed in the surface samples for all lakes. All lakes surveyed reported acceptable pH levels (guideline 5.0 – 9.0), surface DO levels, and secchi disk when compared to water quality guidelines for the protection of aquatic life (CCME 2009) and recreational use guidelines (Health Canada 2012b).

There are no mapped watercourses located at the Project site (NRCan 1996). The closest mapped watercourse is Fall Brook, which flows south to north, eventually draining into the Avon River. At its closest point, Fall Brook passes within 100 m of the eastern Project site boundary. Five additional watercourses were identified along existing access roads and/or within a 5 ha area centered on

proposed turbine locations during the July 2012 field surveys. The locations and characteristics of identified watercourses are listed in Table 8.2.

Table 8.2: Watercourse Characteristics

Watercourse ID	Bankfull Width (m)	Date of Observation	Observed Water Depth (cm)	Substrate	Drainage Direction
Fall Brook	10	July 18, 2012	30	Gravel and boulders	To the Avon River
Watercourse 1	1	July 18, 2012	Not running – intermittent standing water and saturated surface	Muck and fines	To Mill Lakes
Watercourse 2	1-1.2	July 18, 2012	Dry at the time of observation	Gravel and rock	To Fall Brook
Watercourse 3	0.7-1	July 19, 2012	Dry at the time of observation	Muck, gravel and boulders	To Fall Brook
Watercourse 4	2.5	July 19, 2012	Not running - intermittent standing water	Muck and boulders	To Fall Brook
Watercourse 5	0.5-0.7	July 19, 2012	Not running - intermittent standing water	Muck and boulders	To Fall Brook

8.3.2 Fish and Fish Habitat

For the purposes of the EA, all watercourses on the Project site have been assumed to be ‘fish bearing’ and will be treated as such throughout site development plans.

A review of the Atlantic Canada Conservation Data Centre (ACDC) database for fish species recorded within a 100 km radius of the Project site was completed. All species, including status rankings, are provided in Table 8.3.

Table 8.3: Fish Species Recorded within a 100 km radius of the Project site

Common Name	Scientific Name	NSDNR Status ¹	COSEWIC Status ²	SARA Status ³	NSESA Status ⁴
Atlantic Sturgeon	<i>Acipenser oxyrinchus</i>	Red	Threatened	Not Listed	Not Listed
American Eel	<i>Anguilla rostrata</i>	Green	Threatened	Not Listed	Not Listed
Atlantic Whitefish	<i>Coregonus huntsmani</i>	Red	Endangered	Not Listed	Endangered
Atlantic Salmon	<i>Salmo salar</i>	Red	Endangered	No Status	Not Listed
Atlantic Salmon - Inner Bay of Fundy pop.	<i>Salmo salar</i>	Red	Endangered	Endangered	Not Listed
Striped Bass	<i>Morone saxatilis</i>	Red	Threatened	No Status	Not Listed

Source: ACCDC 2012

¹ NSDNR 2010; ² COSEWIC 2012; ³ SARA 2012; ⁴ NSESA 2007

Atlantic Salmon

Atlantic salmon are native to the North Atlantic Ocean and coastal rivers (NSFA 2007). The species is anadromous, spending long migration periods in the ocean and returning to freshwater streams to reproduce. The species prefers rivers that are clear, cool and well oxygenated and that contain shallow riffles with gravel, rubble, rock or boulder bottoms (COSEWIC 2011a). Evidence suggests that historically, the Avon River (located approximately 5.8 km northeast of the Project site) had recorded populations of Atlantic salmon. A study completed in 2003 however, indicates that out of 2,000 fish caught in the Lower Avon River and Pesaquid Lake (above the Windsor Causeway), no salmonoid species were captured (Daborn *et al* 2004). None of the observed watercourses within the Project site provide suitable habitat for Atlantic salmon. The on-site watercourses exist as small tributaries, and are first order streams which drain areas of wetland habitat towards Fall Brook located to the east of the Project site. Although Fall Brook is hydrologically connected to the Avon River, it is unlikely to contain Atlantic salmon as the Water Treatment Plant incorporates a dam that spans the watercourse. This dam does not provide upstream fish passage (Beatty, pers. comm., 2012), and acts as a barrier to fish migration up Fall Brook. Any fish that may be present in the lower reaches of this watercourse would not be able to make it beyond this dam, and therefore are unable to access the upstream sections of Fall Brook that flow in proximity to the Project site.

Atlantic Salmon [Inner Bay of Fundy (iBoF)]

The iBoF population of Atlantic salmon require clean, cool, flowing water free from chemical or organic pollution and spawns in those rivers of Nova Scotia and New Brunswick that drain into the Minas Basin and Chignecto Bay (SARA 2012). Although the iBoF population of Atlantic salmon have been known to exist in the Avon River, the only anadromous species confirmed to still regularly ascend to the Upper Avon River are blueback herring (*Alosa aestivalis*) and alewife (gaspereau) (*Alosa pseudoharengus*), although brown trout (*Salmo trutta*) are occasionally observed (Isaacman and Beazley 2005). Furthermore, the salmon population in the Avon River is either thought to have extremely low abundance or to have been extirpated. Therefore, this species is unlikely to occur within the Project site.

Atlantic Sturgeon

Occurring in rivers and estuaries near North Atlantic shore environments, the Atlantic sturgeon requires a river with access to the sea, preferably with deep channels. The species spawns in

freshwater over rocky-gravel substrates at depths of 1-3 m in areas of strong currents, under waterfalls, and in deep pools (COSEWIC 2011b). The Atlantic sturgeon has been reported in the Minas Basin (as cited in Colligan *et al.* 1998), which is hydrologically connected to the lakes and watercourses within and surrounding the Project site. However, on-site watercourses are smaller and intermittently dry throughout the year, and generally consist of mucky beds and shallow channels. Therefore, this species is unlikely to occur at the Project site.

American Eel

The geographic range of the American eel extends from South America to Greenland in accessible freshwater systems that are connected to the Atlantic Ocean. This species spawns in salt water, and as juveniles the species drifts in ocean currents, eventually migrating inland through freshwater rivers and their tributaries. In later life stages, they persist in a variety of freshwater and estuarine habitats (COSEWIC 2006a). American eels are very common in Nova Scotia and may be found in the lakes and permanently flowing watercourses near and within the Project site.

Atlantic Whitefish

The Atlantic whitefish is typically anadromous and spawns in the deeper cool waters of Hebb, Milipsigate and Minamkeak Lakes in the Petite Riviere Watershed (MTRI 2008). Although recovery strategies are ongoing in southwest Nova Scotia (Bluenose Coastal Action Foundation 2011), it is unlikely that the species be present at the Project site.

Striped Bass

Striped bass are typically associated with estuaries and coastal waters. The species spawns in freshwater and occasionally brackish water. In Nova Scotia, the Annapolis River in the outer Bay of Fundy and the Shubenacadie/Stewiacke River system in the inner Bay of Fundy are known or believed to sustain spawning populations (Rulifson and Dadswell 1995). Therefore, it is unlikely that Striped bass are present in the lakes and watercourses near or within the Project site boundaries.

8.3.3 Watercourse Crossings

Based on the proposed Project layout, four watercourse crossings are expected along the access road. No watercourse crossings are expected in association with turbine pads; the closest distance between a watercourse and turbine location is approximately 170 m. As noted in Table 8.2, apart from Fall Brook (which shall be unaffected by the proposed development) all of the identified watercourses are small in size (i.e., none exceeded a bank full width of 2.5 m and lacked any flowing water) and potential impacts can be easily addressed through the provincial permitting process.

8.4 Terrestrial Habitats

8.4.1 General Habitats

The Project site falls within two Ecoregions: the southern two thirds is within the Western Ecoregion, while the northern third is within the Eastern Ecoregion (Neily *et al.* 2003). Habitats within the Western Ecoregion are influenced by its coastal proximity, which generally provides mild winters and warm summers. Fire is a common disturbance within this ecoregion, such that fire species including white pine (*Pinus strobus*), red pine (*Pinus resinosa*), and red oak (*Quercus rubra*) are characteristic of well drained sites on upper slopes and ridges (Neily *et al.* 2003). In these fire influenced forests,

the understory is often dominated by a dense growth of ericaceous shrubs including rhodora (*Rhododendron canadense*), lambkill (*Kalmia angustifolia*), and huckleberry (*Gaylussacia baccata*). In unburned, well-drained areas, stands of tolerant hardwoods such as yellow birch (*Betula alleghaniensis*), sugar maple (*Acer saccharum*), and American beech (*Fagus grandifolia*) occur.

The Eastern Eco-region is typically characterized by coniferous forests dominated by red spruce (*Picea rubens*) and black spruce (*Picea mariana*), particularly in lowland areas (Neily *et al.* 2003). On the upper slopes and drumlins, tolerant hardwood forests dominated by yellow birch and sugar maple persist. On the slate ridges rising above the Stewiacke, Musquodoboit, and Shubenacadie Rivers in central Nova Scotia, red spruce forests are common on hummocky terrain. Where moist, fine soils underlay hilly topography, mixed wood forests form a significant part of the landscape (Neily *et al.* 2003).

8.4.2 Project Site Habitats and Vegetation

The habitat types present in a given area are influenced by its biophysical character as well as the cultural attributes of the surrounding communities. Geology, soil type, and climate interact leading to the development of certain habitats and floral assemblages which are in turn altered by natural and human-induced disturbances. Human disturbances are largely dictated by the needs of the community and can include forestry, development, and mining, among others. Traditionally, habitat has been defined based upon the dominant vegetation cover. Forests, for example, typically grow in well-defined associations based upon local conditions, such that tree species that thrive under similar conditions tend to occur together (Davis and Browne 1996).

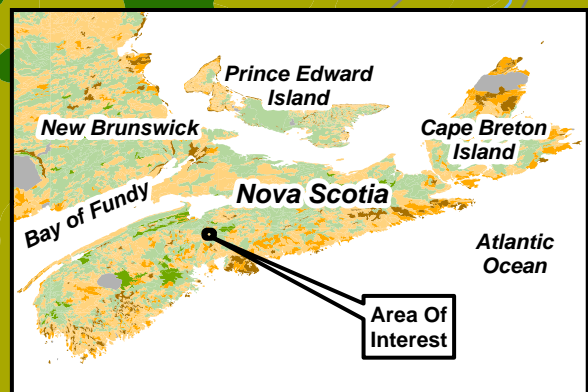
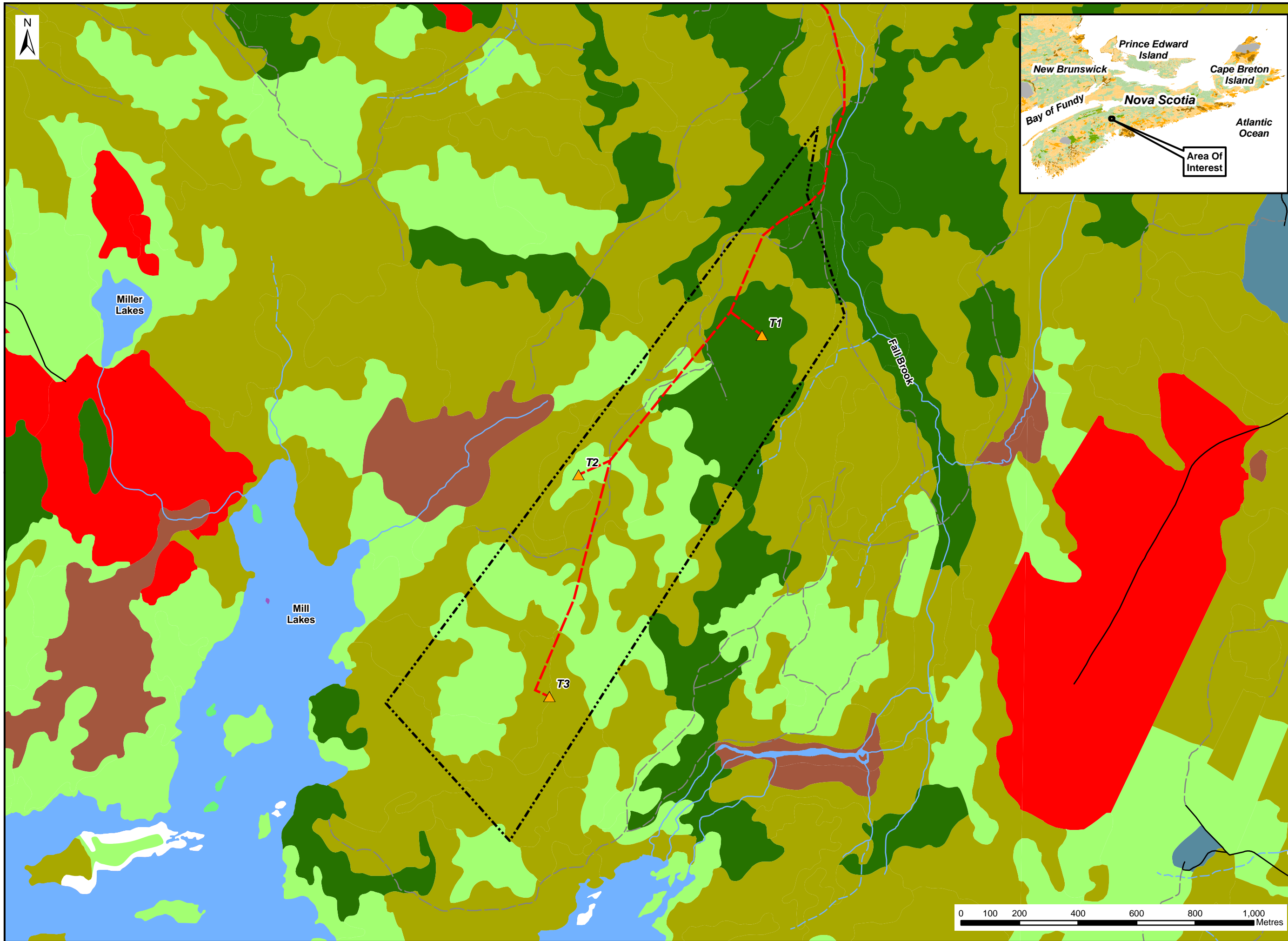
According to the Nova Scotia Forest Inventory (NSDNR 2012a), the entirety of the Project site is forested, with softwood, mixed wood, and hardwood stands occurring in substantial proportions (Table 8.4; Drawing 8.3).

Table 8.4: Habitat Types at the Project Site

Habitat Type	Area (ha)	Percent of Site
Mixed wood	55.75	47%
Softwood	36.64	31%
Hardwood	26.5	22%
Total	118.89	100%

Source: NSDNR 2012a

Site assessments were completed in July 2012 along the proposed access road and at turbine locations. Three main habitat types were identified. Northern portions of the assessment area were covered by mature hardwood forests with a canopy dominated by beech (*Fagus grandifolia*), birch (*Betula spp.*) and red maple. Central and southern regions of the assessment area were a mix of mixed wood forest and clusters of thick brush. The mixed wood areas occurred mostly on south-facing slopes and consisted of red maple, red spruce, and balsam fir. The brush areas were found in flatter areas that were often disturbed by windfall. They consisted mostly of balsam fir and red or black spruce regeneration.



Notes:

- Reference: Digital Topographic Mapping By Nova Scotia Geomatics Centre. Wetland Inventory and Forestry Inventory By Nova Scotia Department Of Natural Resources (NS DNR).
- Projection: NAD83(CSRS), UTM Zone 20 North.

- Legend:**
- Proposed Turbine
 - Proposed Road
 - Project Site Boundary
 - Roads
 - Access Roads / Trails
 - Existing Pipeline
 - Existing Transmission Lines
 - Water Bodies
 - Mapped Stream
 - Indefinite Stream
 - Softwood
 - Mixedwood
 - Hardwood
 - Brush
 - Clear Cut
 - Treed Bog
 - Lake
 - Inland Water
 - Urban
 - Gravel Pit
 - Powerline Corridor

Habitat Cover



Date: January 2013	Project #: 12-4402
Scale: 12,000	Drawing #: 8.3
Drawn By: H. Serhan	Checked By: A. Walter

