Highway 125 - Sydney Wetland 5
2015 (Year 3) Monitoring Report

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Prepared for:

Nova Scotia Department of Transportation and Infrastructure Renewal

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Executive Summary

The Nova Scotia Department of Transportation and Infrastructure Renewal (NSTIR), as part of the twinning of Highway 125 in Cape Breton Regional Municipality, anticipated that Sydney Wetland 5 would be altered through construction activities. CBCL (2011) prepared the wetland alteration application for this wetland on behalf of NSTIR. East Coast Aquatics Inc. (ECA) was retained by NSTIR to undertake post-alteration monitoring of Sydney Wetland 5 to determine the actual alteration area and if there were any additional unanticipated impacts to the remaining wetland area as a result of the alteration.

ECA has completed monitoring at Sydney Wetland 5 over the period of 2013 to 2015. This monitoring incorporated vegetation, soils, ground surface elevation and surface water quality at the wetland. Experienced wetland scientists and botanists completed the annual surveys of the wetland. The results of the vegetation monitoring were compared against thresholds to determine if an ecologically significant change had occurred at the wetland.

CBCL (2011) reported the wetland area, prior to alteration, to be 2.67 ha. It was predicted that the twinning of Highway 125 would result in the alteration of 1.26 ha (47%) of habitat at Sydney Wetland 5, with this being confined to the northern margin of the wetland. At the time of ECA's 2013 field surveys, an interchange to Highway 125 was under construction immediately to the west of Sydney Wetland 5. NSTIR was responsible for the construction of the bridge over the Highway 125, with Membertou First Nations responsible for the construction of the approaches and on/off ramps to the Highway 125 (I. MacCallum, pers. com.).

ECA conducted a perimeter delineation of the wetland in August 2013 and December 2015, finding the remaining area to be 0.74 ha (instead of the predicted 1.41 ha). Based on the 2013 and 2015 field delineations by ECA, the review of the wetland boundaries in the wetland alteration report (CBCL, 2011), and examination of air photos, the actual alteration at Sydney Wetland 5 is estimated to be 1.86 ha (70% of original wetland area). The larger than predicted alteration footprint was principally due to the new east-bound lane on-ramp from the Membertou Interchange which passes through the wetland. This construction feature was not part of the original highway twinning program and hence was not addressed in CBCL (2011). Interchange construction also resulted in the near-total loss of Transect 2 (parallel to the highway) and approximately 20% of Transect 1 (perpendicular to the highway prism).

Based on the diversity and abundance of plants species sampled by ECA, hydrophytic species were found to be dominant on all vegetation transects. The vegetation surveys did not identify any species at risk or species of conservation concern at the wetland. No invasive alien species were documented through the surveys. Soil cores confirmed the presence of hydric soils. For transect SydW5T1, no significant change in the vegetation community was observed in terms of the Bray Curtis Similarity Index and Prevalence Index. As noted above, Transect SydW5T2 was mostly covered by infill from the ramp following the sampling of vegetation in 2013, and ECA staff staked out a new transect location in 2014 to be ready for the Year 3 survey.

Monitoring conducted by ECA documented a number of unanticipated impacts to the wetland during the 2013 interchange construction period, including sedimentation of surface waters. While these transitory impacts were not observed during the 2015 visits to the site, it was noted that the impact

footprint to the wetland was considerably larger than predicted. Highway construction activities were finished at the time of the December 2015 visit to the site, with the edges of the road prisms largely re-vegetated.

Qualitatively, the re-established Transect 2 revealed changes within the vegetation community at the eastern end of the wetland. This conclusion is supported by visual observations made by ECA staff over the 2013 to 2015 period. It is not possible to state definitely that no further significant changes to the ecological character of the wetland will occur in the short to medium term. Therefore we recommend extending the monitoring at the wetland for a Year 5 survey (2017).

No additional remedial measures for the wetland are recommended at this time.

Introduction

Wetland alteration proposals were prepared by Nova Scotia Department of Transportation and Infrastructure Renewal (NSTIR) for 17 wetlands potentially to be affected by the upgrading of Highway 125 in Cape Breton Regional Municipality (CBRM) (Table 1) (CBCL, 2011). The subsequent approval by NS Environment (2011-076058) required long-term ecological monitoring and restoration plans to detect any further changes or unforeseen alterations to the wetlands. NSTIR undertook a post-construction monitoring programme for a representative subset of these altered wetlands (Wetlands 5, 6, 10, 12 and 17).

East Coast Aquatics was commissioned to conduct the wetland vegetation surveys (belt transects) in the designated key plant communities, as well as develop a long-term ecological monitoring and restoration plan at each of the selected wetlands. This report describes the second round of monitoring at Sydney Wetland 5, which was conducted between August and December 2015 (Year 3). The methodologies employed were based on the Nova Scotia Wetlands Delineation Manual (MCFT, 2009) and followed those described in further detail by East Coast Aquatics (2013).

The objectives of the project, as articulated in the Request for Proposals, were: (a) to provide detailed descriptions of sampling methods, locations of transects and other sampling sites, and databases with the collected field information, (b) to provide confirmation of direct wetland alteration areas, (c) to undertake soil, vegetation and hydrology characterization, and (d) to provide clear recommendations for any changes to future monitoring programs or restoration requirements.

The layout of this report corresponds to the above objectives. Part 1 describes the results of the 2015 monitoring. Part 2 provides an analysis of change between 2013 and 2015, with Part 3 addressing conclusions concerning the status of the wetland and recommendations for future monitoring.

Table 1: Summary of wetland alterations and monitoring associated with the twinning of Highway 125 in Cape Breton Regional Municipality

NS Environment Approval #	Wetland ID	Wetland Type	Monitoring Started	Fish Habitat Present	Original Size (ha)	Predicted Alt. Area (ha)	Predicted Alt. Area (%)
2011-076058	SydW1	Treed/shrub swamp with open water and marsh inclusions		*Sibou Bk	4.09	0	0
2011-076058	SydW2	Wooded swamp		No	0.16	0.024	15
2011-076058	SydW3	Wooded/shrub swamp, wet meadow and shallow water		*Prime Bk	15.82	0.23	2
2011-076058	SydW4	Wooded swamp		No	0.14	0.036	25
2011-076058	SydW5	Wooded/shrub swamp and wet meadow	2013	*Reservoir Bk from main reservoir	2.67	1.26	47
2011-076058	SydW6	Wooded/shrub swamp and shallow water	2013	No	1.09	0.30	27
2011-076058	SydW7	Treed/shrub swamp and shallow water		*Reservoir Bk from Skating Pond)	2.30	0.49	21
2011-076058	SydW8	Swamp		No	0.31	0.27	88
2011-076058	SydW9	Swamp		No	0.0030	0	0
2011-076058	SydW10	Wooded/shrub swamp	2013	No	7.17	0.29	4
2011-076058	SydW11	Swamp		No	0.13	0.046	35
2011-076058	SydW12	Swamp	2013	No	0.53	0.32	60
2011-076058	SydW13	Swamp		No	1.83	0.019	1
2011-076058	SydW14	Swamp		No	0.12	0.12	96
2011-076058	SydW15	Treed/shrub swamp		Sibou Bk	0.27	0	0
2011-076058	SydW16	Treed/shrub swamp and shrub fen complex		Reservoir Bk	2.95	0	0
2011-076058	SydW17	Treed/shrub swamp	2015	Reservoir Bk	0.16	0.030	19

* DFO HADD authorization 11-HMAR-MA7-00171 for four of the wetlands

Part 1: 2015 (Year 3) Monitoring of Sydney Wetland 5

Sydney Wetland 5 Description

CBCL (2011) described Sydney Wetland 5 as a wet meadow, shrub swamp and wooded swamp complex in continuity with Reservoir Brook. Two branches of Reservoir Brook merge to the south of the existing Highway 125, before passing under the highway and to the north. CBCL (2011) reports that prior to the construction of Highway 125, Sydney Wetland 5 was likely contiguous with a sizable wetland situated to the north of the highway (Wetland 16). CBCL (2011) noted a number of important functions provided by the wetland, including surface water storage, stream flow maintenance, nutrient recycling and fish habitat. Of the seventeen wetlands examined by CBCL (2011) in conjunction with the Highway 125 twinning, Sydney Wetland 5 was noted as one of the five most valuable, given the number of wetland functions, diversity of the plant community and association with a fish-bearing stream.

In 2013, construction of a new Membertou Interchange immediately west of Wetland 5 generated additional impacts to those identified by CBCL (2011). Infill for the eastbound on-ramp between the September 3, 2013, start of Year 1 Monitoring, and October 23, 2013, completion of field work, resulted in the loss of one quadrat on Transect 1 and five of the six quadrats on Transect 2 (ECA 2014). ECA staff surveyed and staked a new Transect 2 in 2014 to be ready for Year 3 surveys in 2015.

Possible Sources and Directions of Impacts on the Wetland

CBCL (2011) reported the wetland area, prior to alteration, to be 2.67 ha. It was predicted that the twinning of Highway 125 would result in the alteration of 1.26 ha (47%) of habitat at Sydney Wetland 5, with this being confined to the northern margin of the wetland (Table 2).

Table 2: Direct and indirect predicted impacts on the Sydney Wetland 5

Wetland	Area lost (ha)	Area lost (% of total)	Possible Impacts Arising From Alteration Wetland Direct	 Indirect
Sydney Wetland 5	1.26	47	Loss of habitat	− disruption of drainage features, - introduction of weeds, - decrease in hydrologic function (surface water retention) - disturbance of sensitive species.

Given the past assessments of the site by ECA staff, additional unforeseen impacts to Sydney Wetland 5 were expected as a result of the twinning of Highway 125 and new interchange construction. These impacts would include direct loss of habitat and indirect impacts in the form of sedimentation or altered hydrology. It was anticipated that any unforeseen impacts would diminish to the south (upstream) from the road alignment (Figure 1). The locations of both the predicted direct and the unforeseen impacts were considered in placement of monitoring transects.

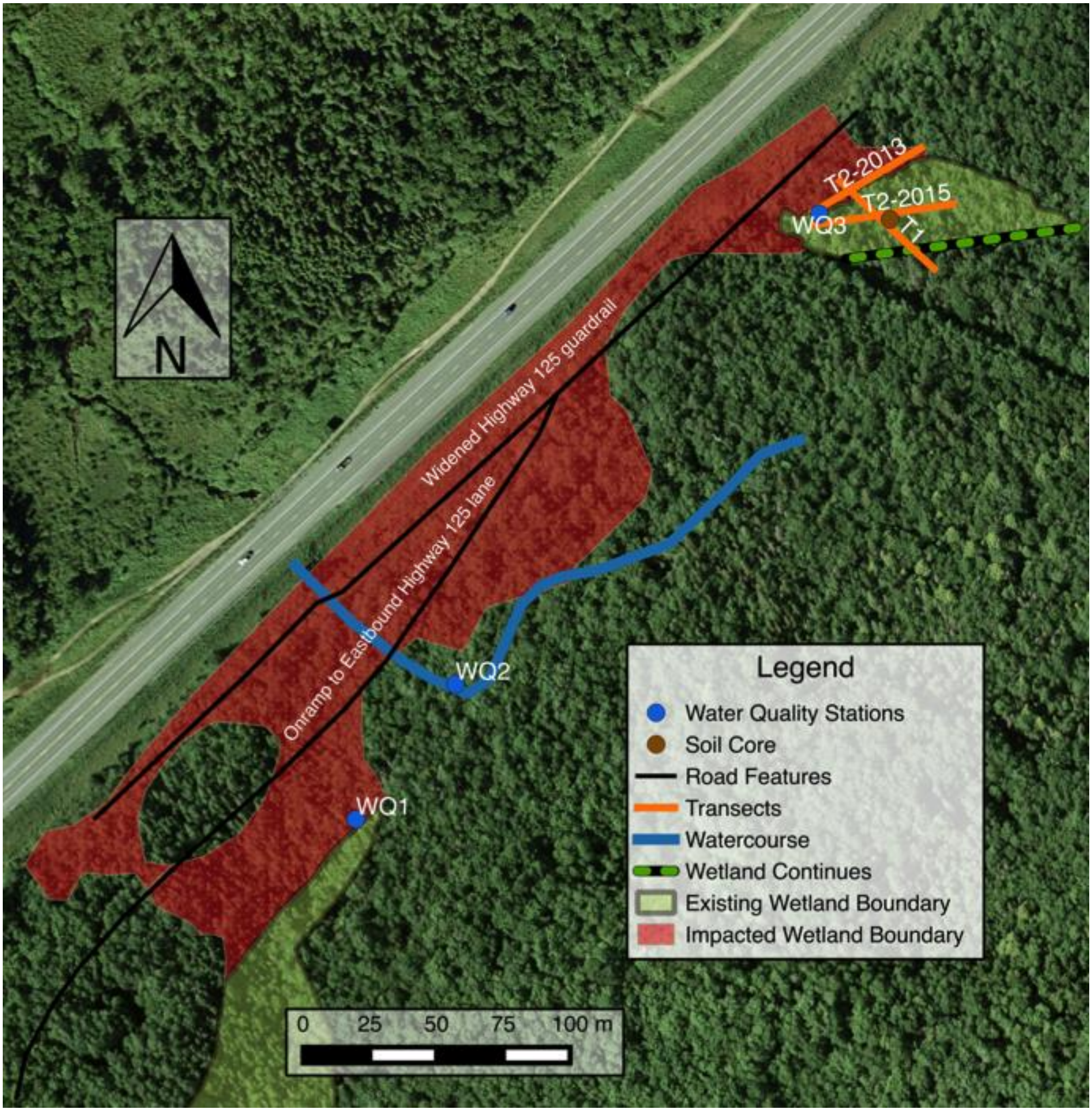

Figure 1: Sydney Wetland 5 showing orientation of vegetation transects and associated features. Impacted wetland boundary based on field surveys by ECA in 2013 and 2015, wetland alteration report (CBCL, 2011) and inferred from air photo. Predicted wetland alteration: 1.26 ha. Actual wetland alteration: 1.86 ha (70% of original wetland area).

Methodology

The methodology utilized in 2015 consisted of the survey of belt transects in the wetland, allowing for the representative and reproducible placement of monitoring quadrats. The percent abundance of wetland vegetation at the herb, shrub, sapling and tree strata was recorded at each quadrat. A description of the detailed methodology employed is contained in Appendix 1.

The methodology employed for the 2015 field monitoring drew on current NSE guidance and specifications for wetland delineations and reporting (MCFT (2009) and ECA (2013)). The ECA team was composed of Mike Parker (study design and field surveys), Tom Neily (botanical assessments) and Andy Sharpe (project management and field surveys) maintaining consistency within personnel since the Year 1 monitoring and thus limiting practitioner variability within the reported results.

A total of two transects were established at Sydney Wetland 5 by ECA in 2013. Both transects were located in the eastern portion of the remnant wetland post-construction. Transect SydW5T1 was perpendicular to the axis of Highway 125, 47 m in length with six quadrats over one wetland zone. Transect SydW5T2 was parallel with Highway 125, 50 m in length with six quadrats over one zone. Subsequent to the establishment of Transect 2 and sampling of vegetation in 2013, additional infilling of the wetland occurred due to ongoing highway construction, leading to the burial of most of Transect 2. A new transect was established in 2014, approximately 10 m further into the wetland. The purpose of the perpendicular and parallel transects was to evaluate if a gradient exists for any of the measured impacts across the site. The vegetation communities of two transects were re-surveyed in 2015.

As part of the survey methodology, ECA established a number of Quality Assurance/Quality Control (QA/QC) measures to verify the consistency and accuracy of the results, and to help quantify the magnitude of change that is likely detectable by the methods employed. These methods and QA/QC results are described in greater detail in Appendix 2.

Ground surface profile surveys were completed in 2015 (Year 3), in accordance with the survey methodology. Coordinates for the benchmark, water quality monitoring locations, and transects are presented in Appendix 3, together with ground surface profiles.

Substrate characteristics in each quadrat were recorded as part of the monitoring program and are reported in Appendix 4. These measures characterize the amount of moss, water, muck, and stone associated with the plant communities. Field data sheets are presented at Appendix 5 and site photographs at Appendix 6.

Vegetation Monitoring

The dominant herbs along transect SydW5T1 were *Abies balsamea*, Graminoid seedlings, *Juncus effusus*, *Osmunda cinnamomea*, and *Thelypteris noveboracensis* (Table 3). The dominant shrub along the transect was *Abies balsamea* (Figure 2). The dominant saplings were *Abies balsamea*, *Acer rubrum* and *Betula alleghaniensis*. The dominant tree species were *Abies balsamea* and *Picea mariana*.

Table 3: Dominant plant species, transect SydW5T1

Zone	**1**
Zone width (m)	**47**
No. of Quadrats	**6**
Herbs	*Abies balsamea* (Balsam Fir), Graminoid seedlings (Grasses), *Juncus effusus* (Soft Rush), *Osmunda cinnamomea* (Cinnamon Fern), *Thelypteris noveboracensis* (New York Fern)
Shrubs	*Abies balsamea* (Balsam Fir)
Saplings	*Abies balsamea* (Balsam Fir), *Acer rubrum* (Red Maple), *Betula alleghaniensis* (Yellow Birch)
Trees	*Abies balsamea* (Balsam Fir), *Picea mariana* (Black Spruce)

The substrate cover for transect SydW5T1 consisted of stone and mineral soil at quadrat 2 (30% cover) and moss (quadrats 3 to 6 – 10 to 70% cover). A total of 26 plant species were recorded on the transect. No invasive alien species were documented, although the exotic *Gnaphalium uliginosum* (Low Cudweed) was recorded with a total absolute abundance of 4%. No species at risk or species of conservation concern were recorded on the transect.

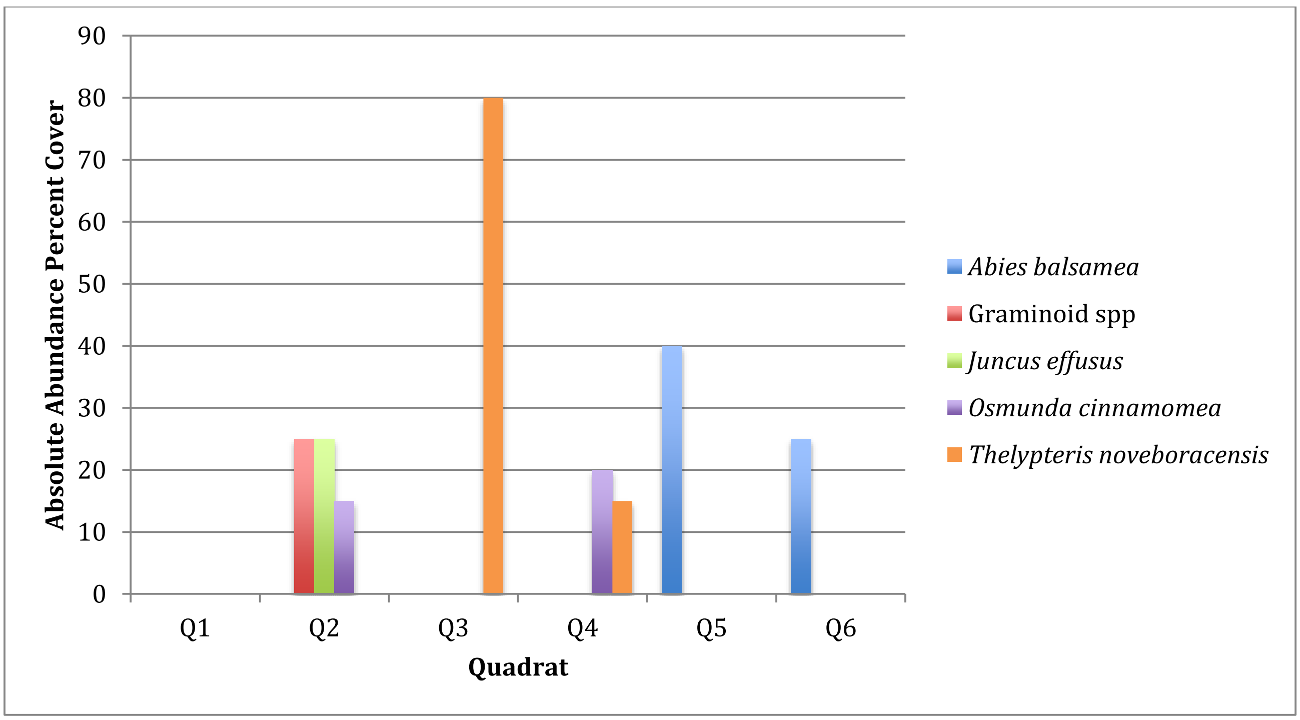

Figure 2: Dominant herb and shrub species, transect SydW5T1

A total of six quadrats were surveyed along transect SydW5T2, across one wetland zone. The transect was positioned parallel to the axis of Highway 125. Table 4 presents the dominant herbs, saplings and trees for transect SydW5T2 in 2015.

Table 4: Dominant plant species by zone, transect SydW5T2

Zone	**1**
Zone width (m)	**50**
No. of Quadrats	**6**
Herbs	*Sparganium americanum* (American Bur-Reed), *Thelypteris noveboracensis* (New York Fern)
Shrubs	*Picea mariana* (Black Spruce)
Saplings	*Abies balsamea* (Balsam Fir), *Betula alleghaniensis* (Yellow Birch)
Trees	*Picea mariana* (Black Spruce)

The dominant herbs along transect SydW5T2 were *Sparganium americanum* and *Thelypteris noveboracensis*. The dominant shrub along the transect was *Picea mariana* (Figure 3). The dominant saplings were *Abies balsamea* and *Betula alleghaniensis*. The dominant tree species was *Picea mariana*.

The substrate cover for transect SydW5T2 consisted of moss (5 to 45% cover) and muck (quadrats 4 to 6 – 20 to 90% cover). A total of 24 plant species were recorded on the transect. No invasive alien species or exotic species were documented, nor any species at risk or species of conservation concern along on this transect.

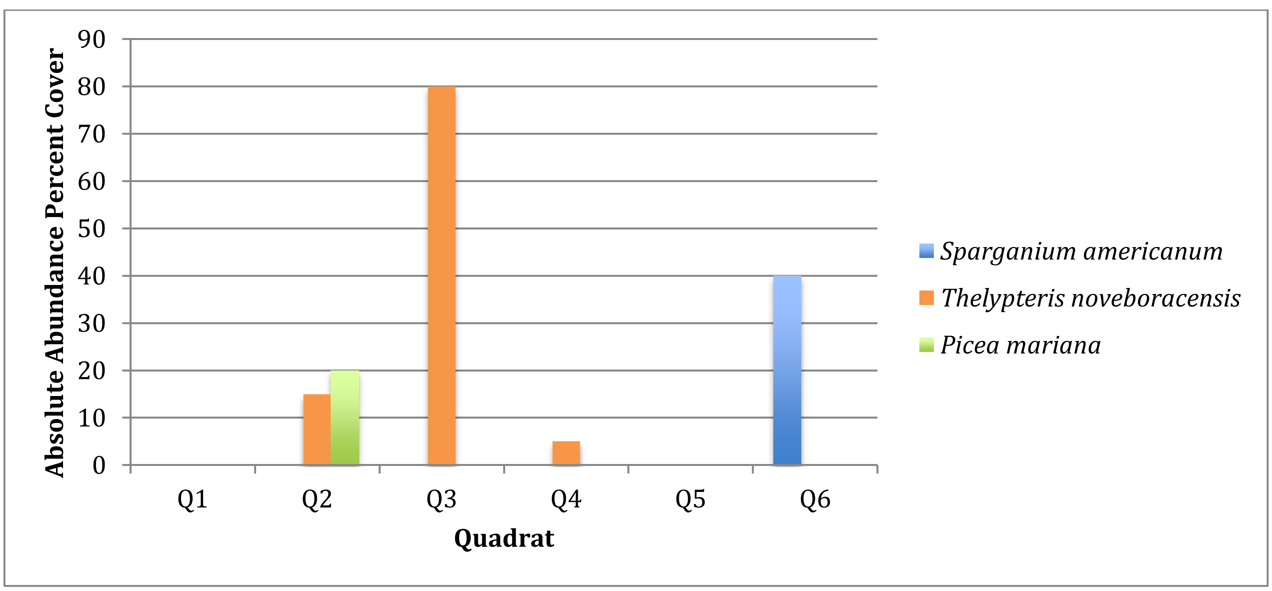

Figure 3: Dominant herb and shrub species, transect SydW5T2

Water Quality Monitoring

Water quality measurements were recorded at three locations at the Sydney Wetland 5 on December 7, 2015 at 07:15 am (Table 5).

Table 5: Water quality observations for Sydney Wetland 5

Location	Temp. (°C)	Spec. Cond. (µS/cm)	DO (mg/L)	DO (% sat)	pH	TDS (mg/L)	Turbidity (NTU)
WQ1: Ditchline draining to Reservoir Bk from West	1.7	47.3	8.3	60	6.12	55.25	2.56
WQ2: Reservoir Bk upstream of culvert beneath on-ramp	2.2	35.0	15.1	113	6.29	39.65	1.60
WQ3: Eastern end of wetland – surface outflow	5.2	219.05	2.2	17	6.03	218.05	2.68

Water chemistry observations were recorded to serve as both an indicator of change within the wetland and to assist in the identification of the cause of any unforeseen impacts upon the wetland. For example, change in specific conductivity could indicate road salt impacts. Dissolved oxygen levels can be altered through changes in vegetation communities or contamination, while pH and temperature provide information on changes to the hydraulic regime within a wetland. Elevated turbidity may indicate natural or anthropogenic sedimentation.

There are limited published guidelines for water quality in wetland settings for the protection of wetland plants. No water quality measurements were recorded as part of the wetland alteration permitting process prior to construction, so no site baseline is available for direct comparison. The Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME, 2007) indicate a pH guideline of 6.5 to 9.0 and a guideline for dissolved oxygen of 5.5-9.5 mg/L for freshwater.

The water quality measurements for Sydney Wetland 5 were recorded at three locations: (WQ1) a ditchline adjacent to the east-bound onramp and flowing into Reservoir Brook; (WQ2) Reservoir Brook upstream of the new Highway 125 east-bound on-ramp, and (WQ3) near the eastern extent of the wetland. During the 2013 sampling period, construction was ongoing at the site with heavy sediment flows into the standing water at WQ1. By 2015, this area had stabilized to a significant extent, with the 2015 turbidity levels at WQ1 being 2.56 NTU, compared to the 2013 value of 434 NTU. Surface waters in Reservoir Brook (WQ2) had high levels of Dissolved Oxygen with pH values within the CCME guideline range and low turbidity. Shallow surface (<15cm) waters adjacent to transects 1 and 2 (WQ3) had low Dissolved Oxygen levels, which is not unusual for non-flowing depressions within wetlands and consistent with the 2013 observations. Abundant orange floc and fine organic sediment was present in the shallow water at WQ3, making the collection of undisturbed sample difficult. Overall, surface water quality has improved significantly between 2013 and 2015, in the case of WQ1, or remained approximately the same, in the case of WQ2 and WQ3.

Wetland Soils

Soils at Sydney Wetland 5 had previously been examined by ECA on October 23, 2013. They were almost completely decomposed organics (Oh9) from 0 to 40 cm. Base material occurred at 40+ cm, with refusal of the soil auger. Standing water was observed in the pit at a depth of 11 cm, with full saturation occurring to ground level.

Soils within the wetland were sampled on December 7, 2015 approximately 1m east of intersection of the two vegetation monitoring transects and adjacent to the elevation benchmark (Table 6). The ground surface was heavily covered with leaf and needle litter, with almost no live moss cover. Decomposed organics (Oh9) occurred from 4 to 30 cm below the ground surface. This was underlain by sandy loam to at least 37 cm below the surface. Standing water was observed in the pit at a depth of 9 cm, with full saturation occurring to ground level.

Table 6: Soil profile for Sydney Wetland 5, 1m east of elevation benchmark

Horizon	Depth Range	Matrix		Redox Features				Texture	Remarks
	(cm)	Colour (moist)	%	Colour (moist)	%	Type[1]	Location[2]		
	0-4								Surface duff (leaves and root mass)
O1	4-30		100	N/A	N/A	N/A	N/A	Oh9	Almost completely decomposed organic
M1	30-37+	10Y-5GY 4/2	100	N/A	N/A	N/A	N/A	Sandy loam	No redox features

[1]Type: C=concentration, D=depletion, RM=reduced matrix, CS=covered or coated grains

[2]Location: PL=pore lining, M=matrix

CBCL (2011) encountered decomposed peat at several of the pre-alteration soil sample locations within the wetland, with standing water at or near the ground surface. Hydric soil conditions have continued to persist though at this location over the 2013 to 2015 monitoring period, with no significant changes observed.

Part 2: Analysis of Change 2013 to 2015

The overarching goal of the Highway 125 wetland monitoring program was to evaluate if the overall ecological integrity of post-alteration wetlands was intact or further altered. ECA has proposed a number of preliminary criteria in order to evaluate if a significant change has occurred in a wetland over the monitoring period (ECA, 2011). These criteria sought to establish thresholds for changes in the plant communities within a wetland, including the presence of invasive alien species. These thresholds were based in part on the level of resolution available from the survey methods employed, taking into account natural and practitioner variability that was quantified through the QA/QC programme. The review of the 2012 to 2015 field data has provided the opportunity for these criteria to be further evaluated, revised and expanded. The development of these criteria is viewed as an iterative process, requiring assessment of the criteria under different settings followed by revision.

Below, ECA presents several metrics for evaluating change in wetlands. This list draws on those presented in ECA (2011) and ECA (2013) and the work of others, including the Credit Valley Conservation Authority and its evaluation of wetlands in the Toronto area (Credit Valley Conservation, 2010) and U.S. Army Corps of Engineers (2009). The following approach seeks to use a variety of metrics and assessments to evaluate change within a wetland. This approach recognizes that no single indicator can capture the complexity of impacts and responses that may occur in post-alteration wetlands, therefore relying on a suite of measures to provide a composite picture.

As was described in ECA (2011), the monitoring program was established to provide a multi-year assessment of change relative to Year 1 within the post-altered wetland. A full plant, surface elevation, soils and water quality survey was undertaken in the initial year. In the final year of monitoring, vegetation surveys and water quality observations were repeated, together with a repeat of the surface elevation survey and the examination of wetland soils.

Indicators

Indicator 1: Bray Curtis Similarity Index

ECA (2011) proposed that a change in the vegetation community was indicated when the Bray-Curtis Similarity Index of all herb and shrub species within a zone was less than 0.6 for the comparison of Year 1 to the current year data (Table 7). In cases where the herb stratum has low percent cover, the next two most abundant strata are used instead in this comparison. The BCI threshold was developed through the examination of replicate and duplicate transects. Based on the addition of the 2013-15 duplicate data to that collected between 2010 and 2012, the BCI threshold of **0.6** has been used in this report (Appendix 2). This value was felt to fairly reflect the level of change that can be routinely detected by the methods employed while taking into account natural and practitioner variability.

Indicator 2: Invasive Alien Plants

ECA (2011) recommended that an indicator for invasive alien plants should be incorporated into the monitoring program. A change in the vegetation community was indicated when the occurrence of alien invasive plants increased significantly. This indicator was satisfied when either of the following criteria are achieved: (a) The absolute percent cover of invasive alien species (IAS) increases by more than 20% within a single zone of a single transect, from the Year 1 value, or (b) the number of invasive alien species present within a single zone of a single transect increases by two or more between any two consecutive years of monitoring (Table 8).

Indicator 3: Prevalence Index

The Prevalence Index (PI) for each zone within a transect was calculated using the species-specific wetland codes and the respective absolute abundance of each species. The Prevalence Index uses the methodology described by the U.S. Army Corps of Engineers (2009). It draws on the concept of a Wetness Index proposed by Credit Valley Conservation (2010) and serves as a tool to evaluate change in vegetation communities (Spieles *et al*, 2006). The Prevalence Index incorporates plants occurring in the herb and shrub strata only.

The Prevalence Index sought to capture in a numerical value the overall "wetness" or "dryness" of the plant community within a zone, and as such was also a surrogate hydrology indicator. Plants of the herb and shrub strata were used since they were likely to be the first to exhibit changes resulting from altered hydrology and were almost always found in significant density (unlike sapling and tree stratum). An increase in the numerical value of the Prevalence Index indicated a greater proportion of plants which tend to occur in dryer conditions. The Prevalence Index would equal 1 where 100% of the plants within a zone were obligate wetland plants and 5 where 100% of the plants were upland plants.

Over the period of 2010 to 2015, a total of 15 duplicate vegetation transect pairs have been examined in five different wetlands, being drawn from the Highway 101 (Kings and Hants counties), the Highway 104 (Pictou and Antigonish) and Highway 125 (Sydney) projects. The PI has been calculated for each of these pairs to better understand the variability of the metric within identical plant communities (Appendix 2). Within this data set, the relative percent difference (RPD) of the PI between identical plant communities was found to range from 0 to 27%, and the initial threshold for change was established at 30%. The addition of the 2013-15 duplicate data has allowed for the re-analysis of this threshold as the now larger data set allowed for greater confidence in the observed results. Therefore, a year to year change in the PI greater than **20%** was considered an indicator of change, warranting further consideration. This threshold level was viewed as conservative and should be reviewed in the future as more duplicate analysis becomes available.

Table 9 presents the Relative Percent Difference (RPD) of Prevalence Index values over the monitoring period. A positive RPD, denoted by a (+), indicates an increase in the PI over time, suggesting a change in the plant community to one more typically found in dryer conditions. A negative RPD, denoted by a (-), indicates a decrease in the PI over time, suggesting a change in the plant community to one more typically found in wetter conditions.

Indicator 4: Visual Assessment of Wetland

Experienced wetland scientists conducted all annual monitoring of the post-alteration wetlands. Making use of photographic documentation, surface profile surveys and professional judgement, a qualitative assessment of changes to the wetland was made. This information was examined within the context of any quantitative changes observed. In undertaking the visual assessment of the wetland, surveyors were cognisant of overall changes in the wetland's vegetation composition, hydrology, wetland class, adjacent land uses, wildlife usage and recent disturbances.

This indicator also includes an assessment of the predicted post-alteration size of the wetland relative to the actual post-construction field measured boundary. This assessment focused on only the altered boundaries of the wetlands closest to the alteration, which were recorded using a hand held GPS. These records were compared with those predicted in the original wetland alteration application (where available) to assess whether there have been additional, unpredicted spatial alterations to the wetland.

Analysis

Indicator 1: Bray-Curtis Similarity Index

The 0.65 BCI value for transect SydW5T1 during the 2013 to 2015 monitoring period was not below the 0.6 threshold of change, suggesting no significant change. This value was determined assuming the *Juncus* spp observed in 2013 was the same as the *Juncus effusus* recorded in 2015. A moderate increase in *Thelypteris noveboracensis* was observed, with an increase in absolute abundance along the transect of 15 to 95% over the 2013 to 2015 period.

In transect SydW5T2, the BCI value was below 0.6, suggesting significant change over the 2013 to 2015 period. However, transect SydW5T2 was covered by additional highway construction infill following the sampling of vegetation in 2013, with a new transect location being staked in 2014. Therefore, the quadrats compared by the BCI were not physically in the same location. Over the period of 2010 to 2015, ECA has examined BCI values for 11 pairs of replicates, with the transects being established in visually identical wetland plant communities. The BCI values for these replicates ranged from 0.25 to 0.82, representing differences in wetland plants in visually identical communities. Therefore, the low BCI value of 0.36 for SydW5T2 may be been in part due to relocation of the transect following the 2013 infill. Edge effects extending from the infill into the wetland were observed, including ponding of water and sediment runoff. Based on these factors, it is not possible to state definitively whether or not the low BCI value represents a significant change in the plant community over the 2013 to 2015 period.

Table 7: Bray-Curtis Similarity Index (BCI) comparison of herb and shrub species: 2013 and 2015

Threshold of change: BCI <0.6

Transect	Transect Orientation	Zone 1
SydW5T1	Perpendicular	0.65
SydW5T2	Parallel	**0.36***

***Transect re-established at new location following 2013 infill**

Indicator 2: Invasive Alien Plants

No invasive alien species (IAS) were observed at Sydney Wetland 5 over the 2013 to 2015 monitoring period. Therefore, there was no increase in IAS percent cover or number of species and the thresholds of change were not exceeded.

Table 8: Invasive Alien Species (IAS) comparison: 2013 and 2015

Threshold of change: Percent Cover increases by >20% or Number of Species increases by 2

Transect	Transect Orientation	Zone 1	
		Change in IAS Cover	**Change in number of IAS**
SydW5T1	Perpendicular	0	0
SydW5T2	Parallel	0	0

Note: A (+) denotes an increase in the reported value, while a (-) denotes a reduction in the report over the monitoring period.

Indicator 3: Prevalence Index

The relative percent difference of the Prevalence Index for the 2013 to 2015 period in Sydney Wetland 5 ranged from +10 to +50%. The threshold of change (> +/-20%) was not exceeded for transect SydW5T1. While the threshold of change was exceeded for transect SydW5T2, this value must be qualified on two points. The Prevalence Index indicator requires that at least 80% of the plant species be identified to species level. In the case of SydW5T2, only 74% of the plants could be identified to species level in 2013 due to the absence of key taxonomic features. Furthermore, the re-establishment of the transect, noted above, introduced the possibility of variability into the dataset. PI values calculated from the QA/QC replicate pairs ranged from 0 to 67%. Therefore, it is possible that the change in PI between the 2013 and 2015 sampling events for transect 2 may have been due, in part, to the relocation of the sample quadrats.

Table 9*:* Relative Percent Difference (RPD) of Prevalence Index (PI) for Herb and Shrub Strata: 2013 to 2015

Threshold of change: Absolute RPD >20%

Transect	Transect Orientation	Zone 1
SydW5T1	Perpendicular	+10%
SydW5T2	Parallel	**+50%***

Note: A positive RPD, denoted by a (+), indicates an increase in the PI over time, suggesting a change in the plant community to one more typically found in dryer conditions. A negative RPD, denoted by a (-), indicates a decrease in the PI over time, suggesting a change in the plant community to one more typically found in wetter conditions.
***Transect re-established at new location following 2013 infil**l

Indicator 5: Visual Assessment of Wetland

A visual survey of Sydney Wetland 5 was undertaken as part of the 2015 field work. Construction activities associated with highway twinning and the new overpass adjacent to the wetland were largely concluded by the time of the 2015 surveys. Exposed soils on slopes, evident during the 2013 surveys, had been extensively re-vegetated by 2015. Standing water was present at the western end of transect SydW5T2 in both 2013 and 2015, possibility due to the outflow culvert beneath the twinned Highway 125 being set too high. The diminished condition and die-back of trees at the western end of transect SydW5T2 was noted in 2015, possibly due to the presence of standing water in this area. No additional post-construction alterations were observed to the wetland in 2015.

Part 3: Conclusions and Recommendations

Conclusion

Year 3 post-alteration monitoring was completed at Sydney Wetland 5 between August and December 2015. This monitoring documented the vegetation community using a series of transects and quadrats together with water quality, soils and ground surface elevations. A summary of the indicators of change are presented in Table 10. Two vegetation transects were examined, one perpendicular to the Highway 125 right-of-way, with a second transect parallel to the highway alignment. The wetland plant community was sampled at a total 12 quadrats, over a cumulative transect distance of 97 m.

Table 10*:* Indicators of change summary table, Sydney Wetland 5 - 2013 to 2015

Transect	Bray Curtis Similarity Index	Invasive Alien Species	Prevalence Index	Visual Assessment	Transect Summary
SydW5T1	Threshold not exceeded	Threshold not exceeded	Threshold not exceeded	No evidence of change	**No indication of change**
SydW5T2	Not able to determine	Threshold not exceeded	Not able to determine	Presence of standing water	**Not able to determine**
Wetland summary	**No indication of change**	**No indication of change**	**No indication of change**	**Possible indication of change**	**N/A**

CBCL (2011) reported the wetland area, prior to alteration, to be 2.67 ha. It was predicted that the twinning of Highway 125 would result in the alteration of 1.26 ha (47%) of habitat at Sydney Wetland 5, with this being confined to the northern margin of the wetland. At the time of the 2013 field surveys, an interchange to Highway 125 was under construction immediately to the west of Sydney Wetland 5. NSTIR was responsible for the construction of the bridge over the Highway 125, with Membertou First Nations responsible for the construction of the approaches and on/off ramps to the Highway 125 (I. MacCallum, pers. com.).

ECA conducted a perimeter delineation of the wetland in August 2013 and December 2015, finding the remaining area to be 0.74 ha. Based on the 2013 and 2015 field delineations by ECA, the review of the wetland boundaries in the wetland alteration report (CBCL, 2011), and examination of air photos, the actual alteration at Sydney Wetland 5 is estimated to be 1.86 ha or 70% of the original area. The larger than predicted alteration footprint was principally due to the new east-bound lane on-ramp which passes through the wetland. This construction feature was not part of the original highway twinning program and hence was not addressed in CBCL (2011).

One of the two transects established at Sydney Wetland 5 was inadvertently infilled by highway construction between August and October 2013. Transect 2 was re-established in early 2014 within the remnant portion of the wetland. While the re-established transect was surveyed in 2015, it was not possible to drawn any quantitative conclusions concerning the change in the vegetation community along the transect over the 2013 to 2015 period due to the different quadrat locations. However, professional judgement by ECA would qualitatively suggest that a measurable change likely did occur over the 2013 to 2015 time frame in the vicinity of transect 2, likely through a combination of additional light, ponding of surface water and sediment runoffs from the adjacent infill.

Based on the diversity and abundance of plants species sampled, hydrophytic species were found to be dominant on all transects in 2015. The vegetation surveys did not identify any species at risk or species of conservation concern at the wetland. No invasive alien species were documented through the surveys. The soil core confirmed the presence of hydric soils. For transect SydW5T1, no significant change in the vegetation community was observed in terms of the Bray Curtis Similarity Index and Prevalence Index.

During the 2013 sampling period, construction was ongoing at the site with heavy sediment flows into the standing water at Water Quality Station #1. By 2015, this area had stabilized to a significant extent, with the 2015 turbidity levels at the station being 2.56 NTU, compared to the 2013 value of 434 NTU.

Post-Construction Wetland Monitoring and Remediation Recommendations

Monitoring at Sydney Wetland 5 over the period of 2013 to 2015 has evaluated the vegetation community composition, surface water quality, soils, ground surface profile and post-alteration wetland boundaries. The monitoring documented the persistence of hydrophytic plant species and hydric soils within the wetland. Monitoring conducted by ECA has documented a number of unanticipated impacts to the wetland during the 2013 construction period, including sedimentation of surface waters. While these transitory impacts were not observed during the 2015 visits to the site, it was noted that the impact footprint to the wetland was larger than predicted. Highway construction activities were finished at the time of the December 2015 visit to the site, with the edges of the road prisms largely re-vegetated.

Qualitatively, the re-established Transect 2 suggests that changes may have occurred within the vegetation community at the eastern end of the wetland. This conclusion is supported by visual observations made by ECA staff over the 2013 to 2015 period. It is not possible to state definitely that no further significant changes to the ecological character of the wetland will occur in the short to medium term. Based on this, there is merit in extending the monitoring at the wetland in order for a more definitive conclusion to be drawn. Hence, we recommend a Year 5 survey in 2017,

No additional remedial measures are recommended at this time.

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Appendix 1: Detailed Methodology

Belt transects have been placed at locations where it is predicted that unforeseen residual impacts may be the greatest. Two or more transect were oriented at an angle perpendicular to the highway road prism, with the expectation that monitoring results would document a gradient from greatest potential to least potential for alteration. A minimum of one transect was orientated parallel to the highway road prism so as to better understand the spatial extent of any impact gradients.

Transects were at least 50 m in length, unless site conditions dictated otherwise. A continuous 50 m tape was used for quadrat placement, to reduce layout error. The beginning and end of each transect were permanently staked in the field, with the location of each quadrat also staked on two corners to facilitate future monitoring and proper placement of the monitoring quadrat. Beginning and end points of each transect were documented with a handheld GPS. The bearing of each belt transect was also documented. Wetland zones along each transect were then visually identified, measured from the point of origin, and flagged, based on the qualitatively observed generalizations of wetland vegetation composition. Establishment of zones created a stratification of the existing wetland classification. A series of 1 m x 1 m quadrats were located in each zone. The target number of quadrats within each zone was as least three, in order to provide a more meaningful representation of the zone being assessed. In some cases, if the zone was very narrow, it is not feasible to place multiple quadrats in the narrow zone, and less than three were employed. Quadrats were sited within a zone by dividing the zone length by the number of quadrats, ensuring that they were equally spaced across the zone.

A standard naming convention was used for transects and quadrats. A three or four letters abbreviation denoted the wetland name, followed by a capital “W” and the individual wetland number. This was followed by a capital “T” and the individual transect number. For example, transect CoalW3T2 was the second transect at the Coalburn Wetland 3. Quadrats were numbered in ascending order, beginning at the end of the transect closest to the road prism, in the case of perpendicular transects. For parallel transects, the beginning of the transects was indicated on the data sheet. Thus CoalW3T1Q4, is the fourth quadrat on transect 1 at Coalburn wetland 3.

Following the establishment of the wetland zones and quadrat points, vegetation composition was analyzed at each quadrat. Herb and shrub stratum were assessed by documenting all species and their absolute percent cover within a 1 m x 1 m quadrat. A rigid 1 m x 1 m sampling frame was used to clearly delineate the boundaries of the quadrat. Sapling stem counts were made within an estimated 5 m radius of the quadrat sampling position. Trees were counted via a prism count from each quadrat sampling location. These methods directly tie to NS Wetland Delineation methods. The vegetation cover in and immediately around each quadrat was documented with a digital photograph.

Experienced staff were utilized in conducting field assessments and data analysis. The same field staff were used annually in conducting all botanical assessments, in order to ensure consistency, and reduce variance associated with practitioner bias. In addition to NSE methodologies, ECA recorded environmental characteristics of the substrate for each quadrat, including percent water, muck, moss, and exposed stone or mineral soil. Finally, average shrub/herb plant height and water depth in each quadrat were recorded. All field collected data was entered on a standardized field data collection sheet for later entry into a custom-designed database. All data collected through the wetland monitoring project is available in spreadsheet format (Excel) from NSTIR.

For the herb, shrub, sapling and tree strata, the dominant species within each wetland zone was determined using the 50/20 rule (MCFT, 2009). The indicator status of wetland plants was assigned based on the Nova Scotia Wetland Indicator Plant List (Nova Scotia Environment, 2011) with Zinck (1998) used as a taxonomic reference.

ECA utilized a survey level, tripod and survey rod to record surface elevation change across each transect. In order to improve consistency of observations, the survey rod is placed in the same position at each quadrat (within the quadrat and immediately adjacent to the right-hand initial corner stake, when facing towards the end of the transect). The estimated accuracy for this survey method has been estimated to be +/- 2 cm for sighting distances up to 80 m. While effort was made to ensure consistent placement of the survey rod in consecutive surveys, a relatively small change in rob placement (e.g. on a hummock or root) could result in reduced repeatability between the surveys. A local benchmark was establish for each transect (e.g. concrete culvert) to allow for year-to-year comparisons. Local benchmarks were assigned an arbitrary elevation of 10.00 m.

Water quality measurements were recorded in open water areas at each wetland using a YSI ProPlus multiprobe water meter, calibrated as per the manufacturer's instructions. Parameters recorded included pH, Dissolved Oxygen (mg/L), Dissolved Oxygen (Percent Saturation), Water Temperature (°C) and Specific Conductivity (μS/cm). Turbidity measurements were made in the field using a LaMotte 2020i turbidity meter.

Alien invasive species present in the wetland were identified using a list compiled from several sources: Hill and Blaney (2009), CARP (2007), Nova Scotia Weed Control Act (Revised 1989), Brazner (2011) and ISANS (2011).

Appendix 2: Quality Assurance and Quality Control Measures Implemented

One of the central objectives in the post-alteration monitoring of wetlands was to determine if residual or unpredicted effects were causing ongoing impacts to the wetland. Central to achieving this objective was the ability to determine when an ecologically significant change has occurred. Monitoring programs must encompass the natural variability of the system under investigation as well as variability inherent within the monitoring methodology.

ECA implemented a quality assurance/quality control (QA/QC) program throughout the post-alteration wetland monitoring program in order to ensure the accuracy and precision of the results. The QA/QC program included a series of controls within the methodology in order to limit variability, as well as duplicate and replicate surveys to assess the reliability and reproducibility of the data collection methods. The implementation of the QA/QC program has both reduced methodological variability to a minimum while allowing a meaningful estimate of ecological change to be determined.

Consistent QA/QC methods were employed in the post-alteration monitoring of wetlands along Highway 101 in Kings and Hants counties from 2010 to 2012, Highway 104 in Pictou and Antigonish counties from 2011 to 2015 and Highway 125 in Sydney in 2013 and 2015. As both the field methodology and QA/QC approach from the Highway 101, 104 and 125 programs were consistent; the results are incorporated here to increase the breadth of the evaluation and sample size. The broader examination of QA/QC results across multiple years and sites has allowed a more comprehensive picture to emerge of temporal and spatial variability within the data set. While the datasets from the three monitoring programs are combined here, the results have also been examined individually to ensure consistency.

During the 2015 monitoring season, three duplicate vegetation surveys were conducted at: Antigonish Wetland 11 (transect 1), Antigonish Wetland 13 (transect 1) and Sydney Wetland 6 (transect 3). As well, two replicate surveys were conducted at Antigonish Wetland 21 (transects 6 and 7) and Sydney Wetland 6 (transects 1 and 2).

Methodological Controls

ECA employed a number of quality assurance measures throughout the field program to ensure reliability of the results. The purposes of these measures were to reduce methodological error and variability to the lowest extent possible. These measures are summarized in Table A1.

Table A1: Quality Assurance Measures Employed

Type of Variability	Controls Employed
Spatial variability within the vegetation community	1. Both ends of each transect geo-referenced, with the location of each monitoring plot recorded. 2. Opposite corners of each monitoring plot staked. 3. All plots labeled with unique identifier code. 4. Use of a rigid 1m x 1m sampling frame.
Taxonomic and data recording variability	5. Consistent use of the same experienced botanist in year to year surveys.

	6. Consistent use of the same experienced field staff. 7. Written procedure for the implementation of field surveys. 8. Use of pre-printed wetland-specific data sheets, to minimize data gaps and coding errors. 9. Management of field day length to control crew fatigue. 10. Water quality and other instruments calibrated immediately prior to each field survey and in accordance with the manufacturers directions. 11. Elevations of hydrology monitoring wells surveyed at both logger deployment and retrieval.
Seasonal Variability	12. Field surveys conducted during the same time period (typically the same week) each year.
Data Management and Analysis	13. Field data held in a custom designed database, providing off-site backup. 14. Automated generation of summary analysis by zone and transect. 15. Peer review of data analysis and conclusions.

Replicate Surveys

In order to better understand the level of spatial variability within wetland plant communities at the scale of 1 to 10 meters, ECA has made use of replicate surveys within the plot-based vegetation monitoring. The term replicate is used here to describe where two transects are placed in visually identical vegetation communities (parallel transects separated by 10 m) and surveyed using the same personnel on the same day. The purpose of the replicate is to better understand the heterogeneity and spatial variability in wetland plant communities and hence the basic assumptions made as part of the sampling methodology.

During the 2010 to 2015 period for the Highway 101, 104 and 125 projects, ECA surveyed 11 replicate pairs across four wetland types. The results of this analysis are presented in Table A2.

Table A2: Summary Survey Metrics for Eleven Replicate Pairs

Metric	Mean	Worst	Best	Notes
BCI of Herbs and Shrubs	0.60	0.25	0.82	BCI=1 for identical communities; BCI=0 for completely dissimilar communities
RPD of Herb & Shrub Species Richness	16%	40%	0%	Species richness = total number of identified species
RPD of Total Herb Abundance	18%	38%	0%	Absolute abundance used
RPD of Prevalence Index	17%	67%	0%	PI calculated using absolute abundance and plant status codes
RPD of number of dominant herbs and shrubs	31%	111%	0%	Dominance determined using the 50/20 rule

BCI – Bray Curtis Index
RPD - Relative Percent Difference

The Bray Curtis Index analysis of the data suggests that, on average, the replicate pairs have a similarity of 0.60, where 1.0 is identical and 0.0 completely dissimilar. Comparisons of Species Richness, Herbaceous Abundance and Prevalence Index across the replicate pairs all have similar mean relative percent difference values. Comparison of the number of dominant herb and shrub species has a mean difference of 31% across the eleven replicate pairs.

The data presented in Table A2 suggests that a moderate level of spatial variability exists within visually identical wetland plant communities. From this, it can be concluded that the placement of transects may have a significant influence on the vegetation species observed. Given the goal of monitoring post-construction change in wetlands, it would appear to be critical for successive vegetation surveys to occur on exactly the same transects and quadrats, otherwise the vegetation "signal" may be lost in the background noise caused by a shifting transect location. This variability has been recognized from the outset of the post-alteration wetland monitoring program, and is controlled for with sample quadrats being permanently staked and a 1 m x 1 m sampling frame being used to ensure that consistent areas are being surveyed year to year.

Duplicate Surveys

In order to better understand the level of internal error within the plot-based methodology (botanical identification and abundance estimates, data recording and encoding, systematic biases etc) ECA has made use of duplicate surveys within the wetland vegetation surveys. In this context, the term duplicate is used to describe where vegetation communities on a single transect are surveyed a second time, using the same personnel. The interval between the first and second surveys was typically 6 to 24 hours. With this interval, it can be safely assumed that the vegetation community has not changed. Any differences between the two surveys are thus due to observer bias or other methodological limitations. The purpose of the duplicate is to better understand variability entering the data as a result of methodological errors and taxonomic mis-identifications. This is also referred to as practitioner variability.

During the 2010 to 2015 period for the Highway 101, 104 and 125 projects, ECA surveyed 15 duplicate pairs across five wetland types. The results of this analysis are presented in Table A3.

Table A3: Summary Survey Metrics for 15 Duplicate Pairs

Metric	Mean	Worst	Best	Notes
BCI of Herbs and Shrubs	0.74	0.29	0.95	BCI=1 for identical communities; BCI=0 for completely dissimilar communities
RPD of Herb & Shrub Species Richness	18%	60%	0%	Species richness = total number of identified species
RPD of Total Herb Abundance	10%	31%	0%	Absolute abundance used
RPD of Prevalence Index	8%	27%	0%	PI calculated using absolute abundance and wetland plant status codes
RPD of number of dominant herbs and shrubs	22%	67%	0%	Dominance determined using the 50/20 rule

BCI – Bray Curtis Index
RPD - Relative Percent Difference

The Bray Curtis Index analysis of the data suggests that, on average, the duplicate pairs have a similarity of 0.74, where 1.0 is identical and 0.0 completely dissimilar. These results are shown graphically in Figure A1. From Figure A1, it is evident that BCI values for the duplicate pairs are largely consistent, over the 2010 to 2015 monitoring period. If the initial three results from the first year of the monitoring program and three outliers are removed, the resulting dataset, representing the best 75% of the BCI values, provides a good estimate of practitioner variability within the methodology.

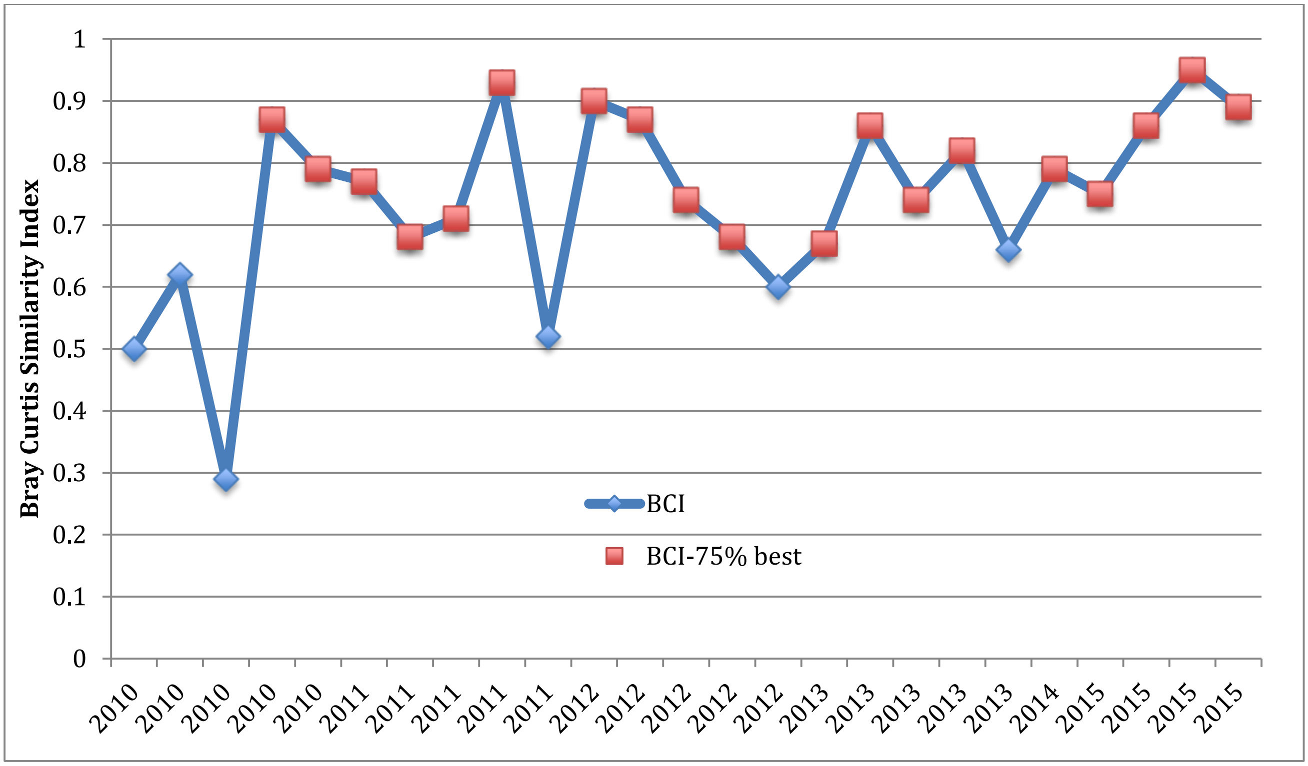


Figure A1: Bray Curtis Index values for duplicate pairs

Figure A2 presents the relative percent difference (RPD) values of Prevalence Index across the duplicate pairs. If the best 75% of these values are considered, this provides a reasonable estimate of practitioner variability for this metric.

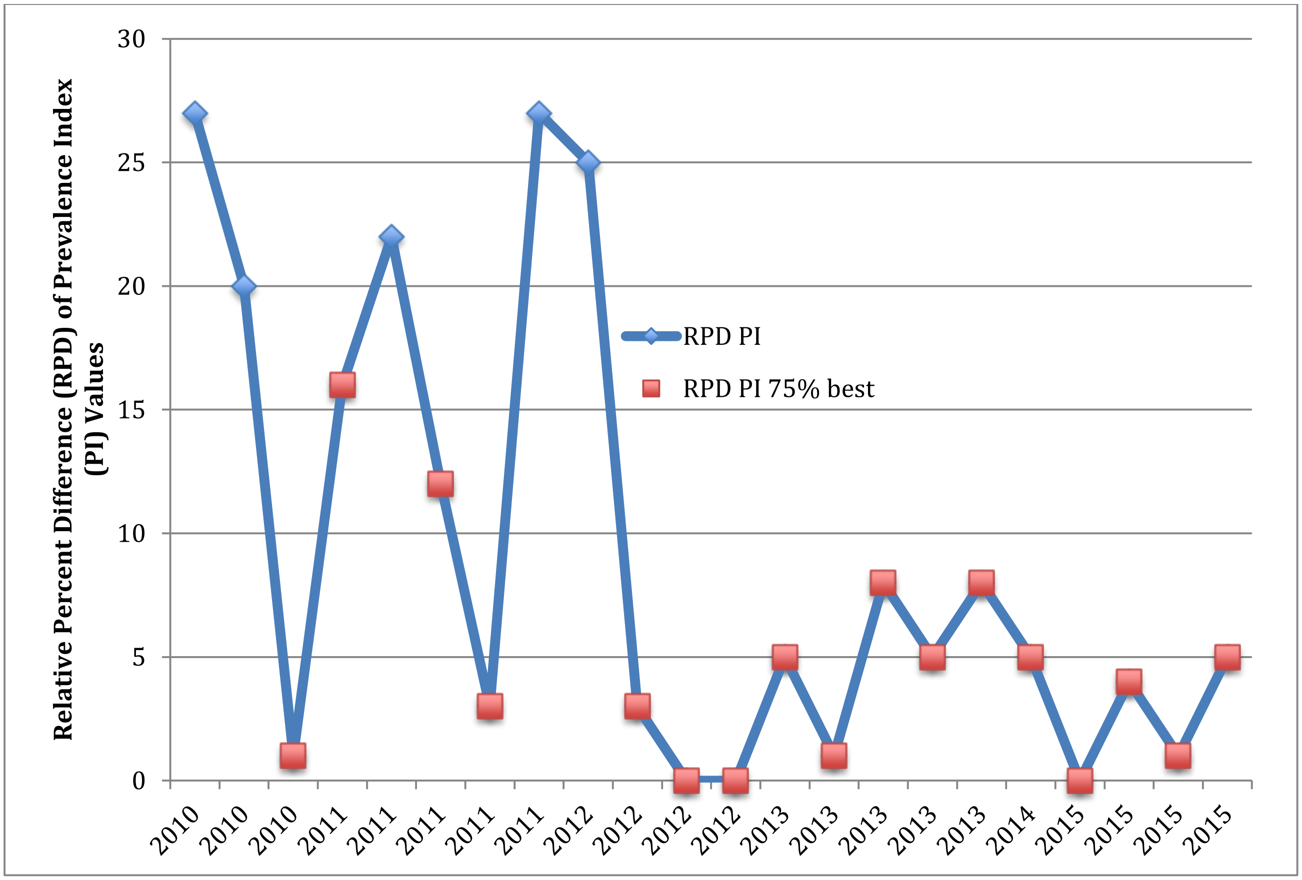


Figure A2: Relative Percent Difference of Prevalence Index values for duplicate pairs

The comparisons of Species Richness, Herbaceous Abundance and Prevalence Index in Table A3 across the duplicate pairs all have similar mean relative percent difference (RPD) values. Comparison of the number of dominant herb and shrub species has a mean difference of 22% across the 15 duplicate pairs. The level of variability between the duplicate pairs was lower for all metrics than that observed for the replicate analysis. This outcome is expected as the replicate pairs incorporated both spatial and methodological variability, whereas the duplicate pairs incorporated only methodological variability.

The data presented in Table A3 suggests that a consistent level of practitioner variability exists within the plant data, even when different wetland types are examined, across several years. This variability most likely originates within the sampling methodology used, with possible sources being mis-identification of plant species and inconsistency in estimating plant abundances (observer bias), as well as recording errors and data inputting errors. The duplicate analysis establishes the minimum threshold level of post-alteration change that can be detected and attributed to an actual ecological impact.

Elzinga *et al* (2001) reports several studies where observer bias within botanical surveys (percent cover of all species) has been documented in the range 23 to 25%. In comparisons between two trained observers, differences of up to 39.5% are reported. The ECA duplicate results reported in Table A3 are consistent with these literature values. While ECA utilizes competently trained individuals and makes every effort to employ consistent methods with error checking, the data presented in Table A3 suggests that inherent variability exists within the dataset. It is highly likely that the repetitiveness of the surveys and fatigue on the part of the botanist, coupled with long field days under demanding conditions is a are contributing factors to the observer bias. This variability must therefore be incorporated in any interpretation of the data.

Elevation Surveys

The post-alteration wetland monitoring methodology makes use of ground-surface elevation surveys to document local topography within the wetland. ECA utilizes a survey level, tripod and survey rod to record surface elevation change across each transect. In order to quantify variability in elevation observations, a duplicate set of observations were recorded across a transect in 2013. These results are presented in Figure A3.

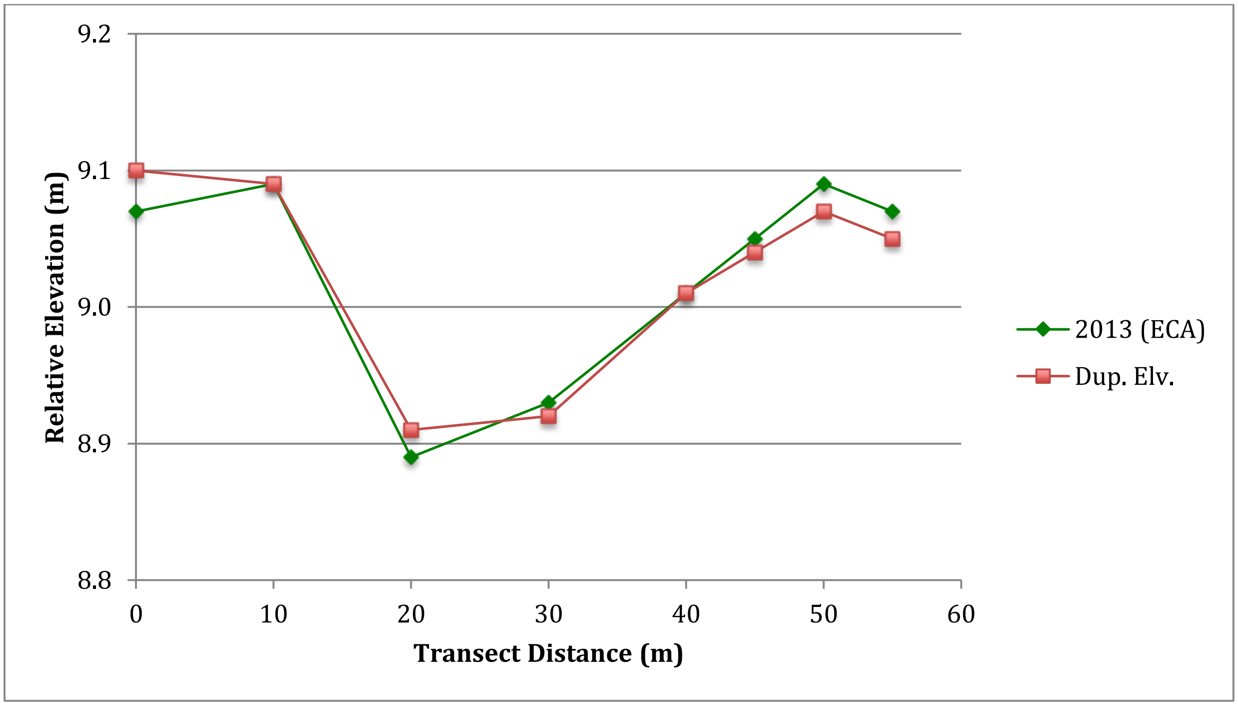
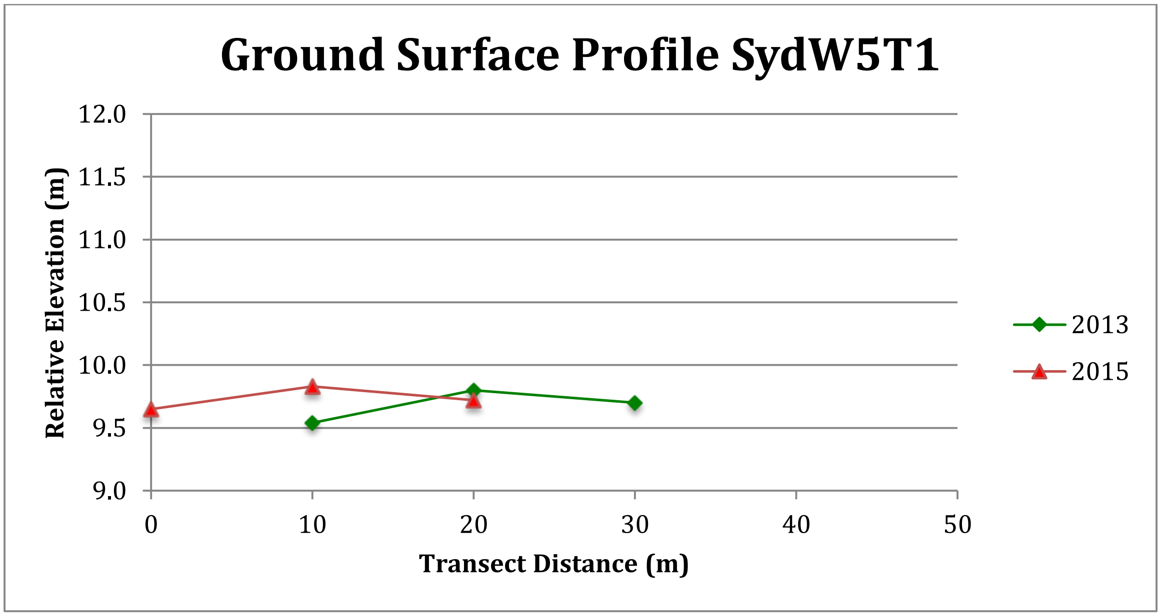


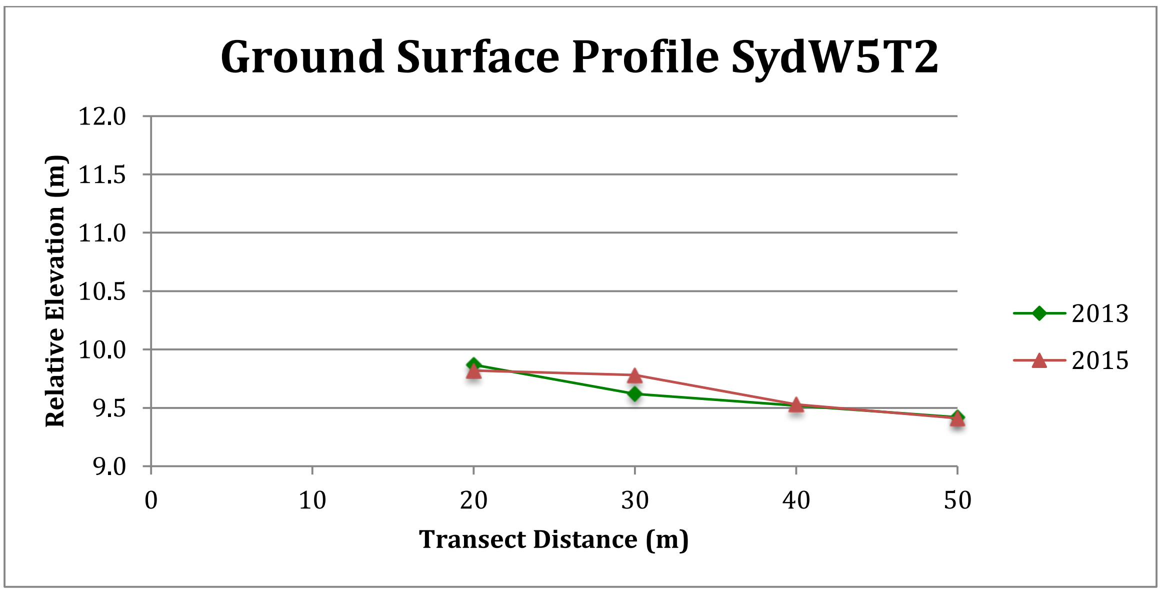
Figure A3: Duplicate Elevation Survey

In order to improve consistency of observations, the survey rod is placed in the same position at each quadrat (within the quadrat and immediately adjacent to the right-hand initial corner stake, when facing towards the end of the transect). Due to the natural undulating microtopography within wetlands, even a small shift in the rod placement can reduce the repeatability of the results. The duplicate elevation survey results shown at Figure A1 suggests that there is no significant positive or negative bias in the results. For this duplicate pair, the mean elevation difference was 0.014 m. This magnitude of error is considered to be insignificant within the context of the typical microtogographic undulations observed in wetlands.

Appendix 3: Transect Location Data and Ground Surface Profiles

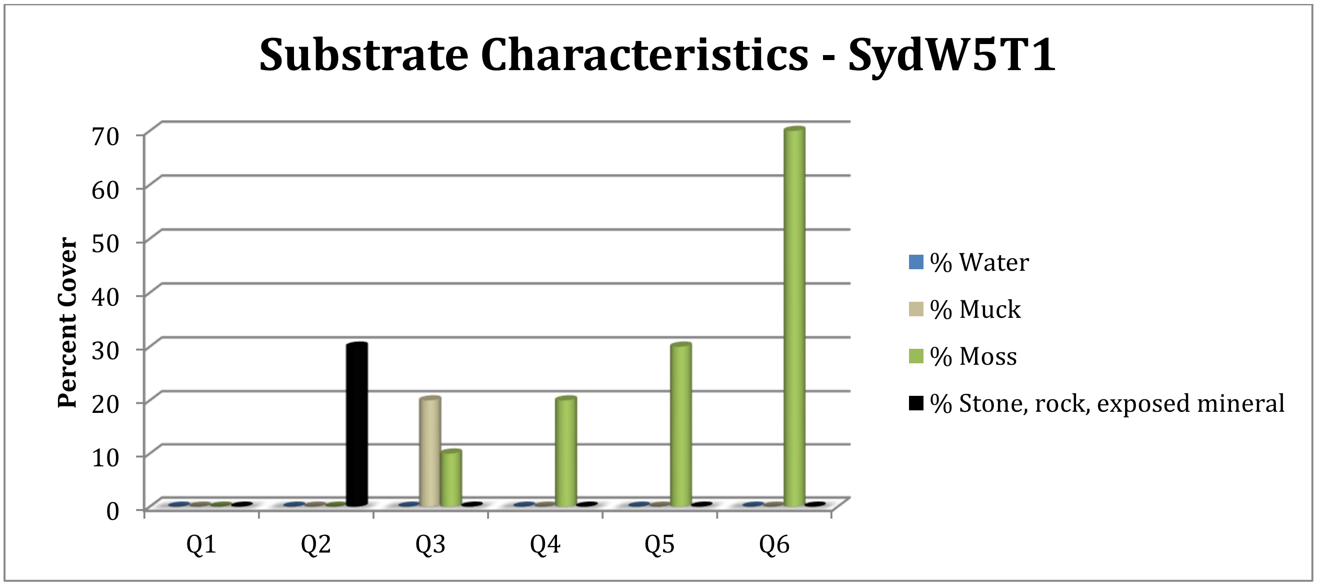
Waypoint Description	Coordinates
Start of transect SydW5T1	20 T 717857 5109881
End of transect SydW5T1	20 T 717872 5109835
Start of transect SydW5T2-2013	20 T 717889 5109877
End of transect SydW5T2-2013	20 T 717843 5109876
Start of transect SydW5T2-2015	20 T 717896 5109852
End of transect SydW5T2-2015	20 T 717839 5109871
SydW5 Water Quality site 1	20 T 717582 5109761
SydW5 Water Quality site 2	20 T 717641 5109787
SydW5 Water Quality site 3	20 T 717841 5109870
Local benchmark used for Sydney Wetland 5	20 T 717867 5109863

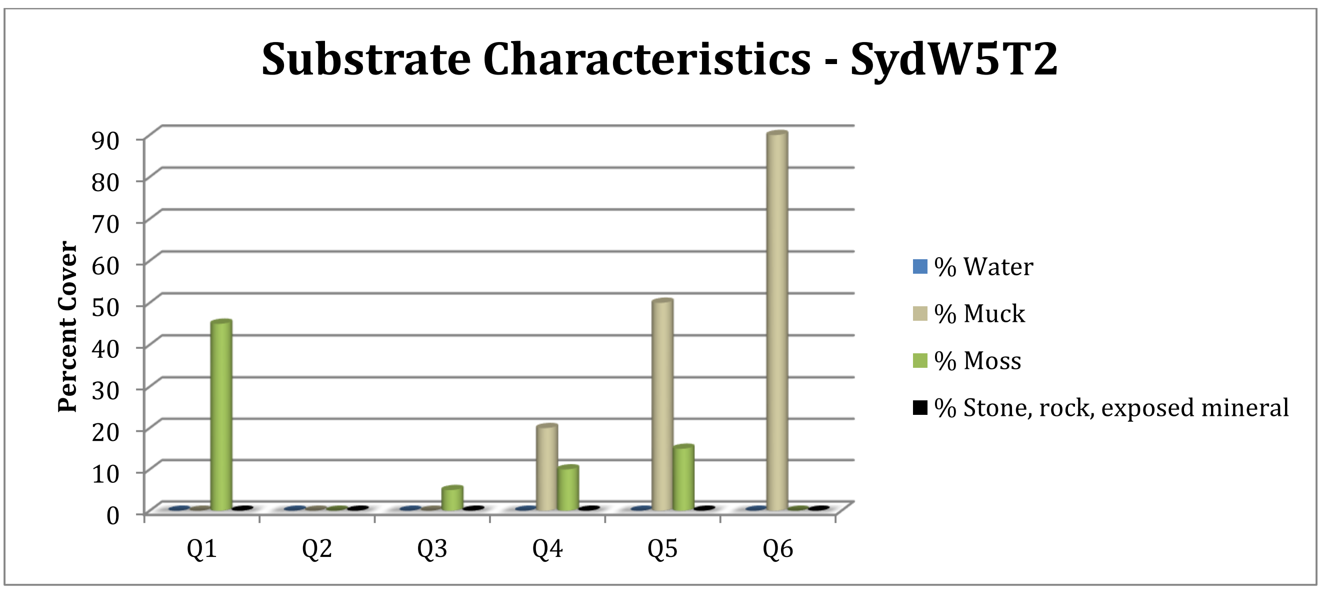




Note: Elevation measures could not be recorded at all quadrats due to dense vegetation conditions.

Appendix 4: Substrate Characteristics





Appendix 5: Belt Transect Field Data Sheets

Project: NSTIR Monitoring — Location: Sydney Wetland 5 — Date: 2015-08-25
Investigator(s): Sharpe-Neily — BELT Site: SydW5T1 — BELT Bearing: 164
Zone: 20T — Origin UTM: 0717857 5109881 — End UTM: 0717872 5109835
E. Region: Northumberland Bras Dor — Eco District: Bras Dor Lowlands — Eco Site: WMHO-IMHO
Wetland Type: Wooded shrub swamp, wet meadow — Map Datum: NAD83
Notes: South side of Hwy 125, Perpendicular. 2015 Q2 start 0717857 5109873 End 0717876 5109841; Q4 to Q6 undisturbed intact moss substrate; Q1 infilled, could not be located; T1Q3 same as T2Q4; possible run off of sediment for spoil pile to E limited veg cover; outlfow culvert may be set too high, causing ponding of water at outflow; mud/open/wet patches

Zone	Begin	End	Length(m)	# of Q	Q spacing(m)
1	0	47	47	6	10

	Zone1						
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	
Hor. Distance(m) from origin	0	10	20	30	40	47	
% Water	0	0	0	0	0	0	
% Muck	0	0	20	0	0	0	
% Moss	0	0	10	20	30	70	
% Stone, rock, exposed mineral	0	30	0	0	0	0	
Avg Height shrubs/herbs (m)	0	0.4	0.2	0.3	0.3	0.3	
Herb Stratum	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Totals**
Abies balsamea	0	0	0	0	20	25	45
Acer rubrum	0	0	0	0	0	5	5
Betula alleghaniensis	0	0	0	0	10	5	15
Carex disperma	0	0	5	0	0	0	5
Carex trisperma	0	0	0	0	0	20	20
Clintonia borealis	0	0	0	5	0	0	5
Coptis trifolia	0	0	0	0	5	0	5
Cornus canadensis	0	0	0	5	0	15	20
Doellingeria umbellata	0	0	4	0	0	0	4
Equisetum arvense	0	4	0	0	0	0	4
Gnaphalium uliginosum	0	4	0	0	0	0	4
Graminoid spp	0	25	0	0	0	0	25
Juncus effusus	0	25	0	0	0	0	25
Linnaea borealis	0	0	0	0	10	0	10
Maianthemum canadense	0	0	4	5	0	0	9
Osmunda cinnamomea	0	15	0	20	0	0	35
Oxalis montana	0	0	0	5	0	0	5
Polygonum sagittatum	0	4	0	0	0	0	4
Scirpus cyperinus	0	15	0	0	0	0	15
Sorbus americana	0	0	0	0	10	4	14
Thelypteris noveboracensis	0	0	80	15	0	0	95
Trientalis borealis	0	0	5	0	4	0	9
Typha latifolia	0	20	0	0	0	0	20
Viburnum nudum	0	0	0	0	0	15	15
Shrub Stratum	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Totals**
Abies balsamea	0	0	0	0	20	0	20
Sapling	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Totals**
Abies balsamea	0	1	6	11	4	6	28
Acer rubrum	0	7	9	3	1	2	22
Betula alleghaniensis	0	6	11	4	3	2	26
Betula papyrifera	0	1	1	0	0	0	2
Picea mariana	0	0	0	0	0	2	2
Tree Stratum	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Totals**
Abies balsamea	0	0	1	3	0	1	5
Acer rubrum	0	0	0	1	2	0	3
Picea mariana	0	1	1	0	3	3	8

Project: NSTIR Monitoring
Location: Sydney Wetland 5
Date: 2015-08-25
Investigator(s): Sharpe-Neily
BELT Site: SydW5T2
BELT Bearing: 272
Zone: 20T
Origin UTM: 0717889 5109877
End UTM: 0717842 5109876
E. Region: Northumberland Bras Dor
Eco District: Bras Dor Lowlands
Eco Site: WMHO-IMHO
Wetland Type: Wooded shrub swamp, wet meadow
Map Datum: NAD83
Notes: Parallel to Hwy 125. East end of W5, about 5m south of toe of slope. Start 0717890 5109853; End 0717841 5109872
Q4 @ bolt in tree elevation BM; Q4 to Q6 open mucky patches - trees poor condiiton good - possible die back;
Note: under tree stratum Q5 - one of the two black spruce trees almost dead

Zone	Begin	End	Length(m)	# of Q	Q spacing(m)
1	0	50	50	6	10

	Zone1						
	Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	
Hor. Distance(m) from origin	0	10	20	30	40	50	
% Water	0	0	0	0	0	0	
% Muck	0	0	0	20	50	90	
% Moss	45	0	5	10	15	0	
% Stone, rock, exposed mineral	0	0	0	0	0	0	
Avg Height shrubs/herbs (m)	0.3	0.3	0.3	0.2	0.2	0.3	
Herb Stratum	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Totals**
Carex disperma	0	0	0	5	0	0	5
Carex lurida	0	0	0	0	10	0	10
Carex scoparia	0	0	0	0	10	0	10
Coptis trifolia	5	0	0	0	0	0	5
Doellingeria umbellata	0	0	4	0	0	0	4
Gaultheria hispidula	5	0	0	0	0	0	5
Graminoid spp seedling	5	0	0	0	15	0	20
Juncus canadensis	0	0	0	0	0	5	5
Juncus effusus	0	0	0	0	10	15	25
Linnaea borealis	0	0	4	0	0	0	4
Maianthemum canadense	0	0	4	0	0	0	4
Oclemena acuminata	4	0	0	0	0	0	4
Osmunda cinnamomea	15	15	0	0	0	0	30
Sparganium americanum	0	0	0	0	0	40	40
Thelypteris noveboracensis	0	15	80	5	0	0	100
Trientalis borealis	0	0	0	5	0	0	5
Shrub Stratum	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Totals**
Picea mariana	0	20	0	0	0	0	20
Sapling	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Totals**
Abies balsamea	8	12	5	6	3	0	34
Acer rubrum	0	0	0	9	6	3	18
Betula alleghaniensis	4	8	9	11	8	1	41
Betula papyrifera	0	0	0	1	0	0	1
Nemopanthus mucronatus	1	0	0	0	0	0	1
Picea mariana	0	2	2	0	1	1	6
Viburnum nudum	2	2	0	0	0	0	4
Tree Stratum	**Q1**	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Totals**
Abies balsamea	0	2	1	1	0	0	4
Acer rubrum	0	2	0	0	1	1	4
Betula alleghaniensis	0	0	0	0	1	0	1
Larix laricina	0	0	0	0	1	1	2
Picea mariana	2	1	1	4	2	2	12

Appendix 6: Site Photographs

October 23, 2013

December 7, 2015

Photographs 1 and 2: Flooded treed swamp south of onramp to East-bound Highway 125 lane. Location for Water Quality station #1.

October 23, 2013

August 25, 2015

Photographs 3 and 4: View to the west along the Highway 125, with Sydney Wetland 5 on the left. Stakes marking the end of Transect 2 are visible in the 2013 photo, as is standing water.

Photograph 5: Sydney Wetland 5, Transect 1, adjacent to Highway 125 and the area infilled following the establishment of transects in 2013. Photo August 25, 2015.

Photograph 6: Sydney Wetland 5, Transect 2, adjacent to Highway 125 and the area infilled following the establishment of transects in 2013. Photo August 25, 2015. Note standing water, which was also evident in photo 3.

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