APRIL 2017

WILDCAT BROOK SHALE PIT REMEDIATION & WETLAND EXPANSION PROJECT, PETITE RIVIÈRE WATERSHED

2016-17 PROJECT SUMMARY REPORT

BLUENOSE COASTAL ACTION FOUNDATION
coastalaction.org

Contents

Figures

Tables

Introduction

Bluenose Coastal Action Foundation

Bluenose Coastal Action Foundation is a community-based charitable organization with a mandate to address the environmental concerns along the South Shore of Nova Scotia. Coastal Action's goal is to promote the restoration, enhancement, and conservation of our ecosystem through research, education, and action.

The organization has been an established member of the Lunenburg County community since its inception in December 1993. Over the past 20+ years, Coastal Action has successfully completed a vast number of projects within the South Shore region of the province. One of Coastal Action's greatest ongoing concerns is healthy watersheds and we have experience in successfully conducting several fish habitat-related projects, along with water quality monitoring.

Project Overview

Wildcat Brook is part of the Petite Rivière watershed and located in Wileville, Lunenburg County, NS. Through Coastal Action's monthly sampling of the Petite Rivière watershed, Wildcat Brook has been identified as having abnormally low pH levels, causing acidic waters. The presence of low pH is presumed to be due to the exposed pyritic shale bedrock from several abandoned shale pits in the catchment area of Wildcat Brook.

Pooling rainwater in the smallest of the surrounding shale pits had an average pH of 4.20 during initial monitoring in the surrounding area. In heavy rainfall events, the pooling waters within the shale pits discharge into nearby Wildcat Brook causing acidic shocks to the stream system, which can be detrimental to aquatic life.

The Petite Rivière watershed is home to the last remaining wild population of the globally endangered Atlantic whitefish (*Coregonus hunstmani*), an endangered fish species listed through the federal *Species at Risk Act* as well as provincially through the *NS Endangered Species Act*. It is also contains the drinking water supply for the Town of Bridgewater.

Bluenose Coastal Action Foundation and partners, East Coast Aquatic Incorporated, have developed and executed a shale pit remediation and wetland expansion plan for smallest of the three abandoned shale pits (1.10 ha). The plan included remediation of the site by capping the exposed bedrock with organic wetland material and vegetation, which will limit the runoff of acidic waters into the adjacent Wildcat Brook, as well as creating wetland habitat for both aquatic and terrestrial wildlife.

Site Description – Pre-Restoration

The shale pit remediation site consisted of bare rock with very minimal amounts of soil and sparse shrub vegetation, surrounded by a mixed-wood forest stand. The eastern and western sides of the site (Figure 1) were lacking larger vegetation and collected rainwater in small low laying pools. All pools had low Ph readings (average pH of 4.20) and a lack of aquatic vegetation growth within them. The central and northern end of the site is at a higher elevation and larger vegetation was present. The larger vegetation has likely only established approximately 10 to 15 years ago, with White Pine (*Pinus strobus*)

and Gray Birch (*Betula populifolia*) being observed as the dominant vegetation which appeared sickly vand yellowing in colour. This was likely caused by the lack of nutrient rich soil found in these areas.

Figure 1: Arial view of the Wildcat Shale Pit Remediation Site shaded in pink with adjacent Wildcat Brook depicted with blue line.

Research & Methods

The 1.1 hactare restoration site was first surveyed for existing wildlife and vegetation. Pre-restoration water quality testing, benthic invertebrate sampling, and electrofishing was also completed in the adjacent Wildcat Brook prior to any restoration efforts. These surveys were completed to document a baseline of information of the conditions prior to restoration work.

In 2015, upon completion of initial ground-truthing, East Coast Aquatics Incorporated developed a restoration plan for the site. The Wildcat Restoration Plan document provides details on the existing conditions, pre-restoration, at the shale pit as well as the initial restoration plan. The document includes restoration objectives, scientific basis for restoration, design considerations, material options, and the physical restoration action plan.

Detailed results from Coastal Action's ground-truthing activities, including wildlife and vegetation surveys conducted as part of the baseline study, can be found in the report Appendices. These surveys involved documenting the presence of any wildlife and vegetation that existed at the site in pre-restoration conditions. The vegetation surveys were conducted under the direction of leading NS plant expert, Dr. Ruth Newell, and included recording a list of all vegetation found to determine the diversity

and density measurements of plant life using randomized 1 m^2 transects in four different sections of the shale pit.

The physical restoration of the 1.1 hectare shale pit site was completed by adding and spreading approximately 3,500 m^3 of organic wetland material and planting and seeding vegetation to cover the exposed pyritic shale bedrock preventing it from oxidizing. The bulk spreading of organics was completed with East Coast Aquatics' excavator and frontend loader tractor. The soil in the high-lying area, where more older growth vegetation existed, was spread by hand. This was completed with Coastal Action staff and volunteers. Soils were sourced from local development projects that were excavating and removing wetland/organic soils as well as from municipal compost.

The low-lying areas, eastern and western sides of the remediation site, received 3,000 m^3 of organic soil material, were flooded and planted with native wetland vegetation to encourage the formation of wetland habitat. The majority of the soil placed in the western side (0.35 ha) came from a development in Aspotogan, NS, which was approximately 80 km from the restoration site. The organic soil used in the eastern side of the restoration site (0.49 ha) came from Branch Tree Nursery, located only 2 km from the site.

Approximately 500 m^3 of municipal compost material was used in the high-lying areas of the northern end and central areas of the pit (0.16 ha and 0.10 ha respectively). The nutrient-rich organic soil will encourage and support a healthy growth of vegetation in the high-lying areas of the restoration site, whereas the low-lying areas are nutrient depleted. The high-lying areas will support larger types of vegetation such as large trees and shrubs rather than the wetland grasses, sedges, reeds, and flowers found in the low-lying areas of the site. The areas covered with compost material were seeded with a native reclamation grass mixture and already have some young tree development.

Weirs and berms were built in the eastern and western sides of the restoration site between the site and the adjacent Wildcat Brook. Weirs and berms were built using gabion rock and clay for the purposes of controlling the flow of water in and out of the site as well as to keep the organic soils flooded to maintain the resulting wetland habitat. Water levels within the site have been, and will continue to be, monitored with continuous data loggers. One data logger was placed in a monitoring well in the western side near a weir, while a second logger was placed in the northern side in a well near a weir. A third data logger was placed downstream from the restoration site in the adjacent Wildcat Brook to monitor the in-stream water levels as well.

To attract wildlife to the newly expanded and restored wetland, nest boxes were installed, including eight swallow boxes, two duck boxes, and two bat boxes. These were constructed by Coastal Action staff using the appropriate design standards. Swallow boxes were installed on posts with predator guards. Duck and bat boxes were installed at the appropriate height and distance from each other in the surrounding treed area of the restoration site.

Water quality monitoring has occurred throughout the project and, thereafter, in consultation with East Coast Aquatics. Point photos, macroinvertebrate sampling, vegetation surveys, wildlife surveys, and

electrofishing surveys were conducted pre-restoration and will also continue to occur post-restoration to monitor any habitat improvements in Wildcat Brook into the future.

Figure 2: (Left) Conducting ground-truthing & wildlife survey with Reg Newell, NS DNR Wildlife Biologist. Figure 3: (Right) Vegetation density measurements taken with 1x1 square grid.

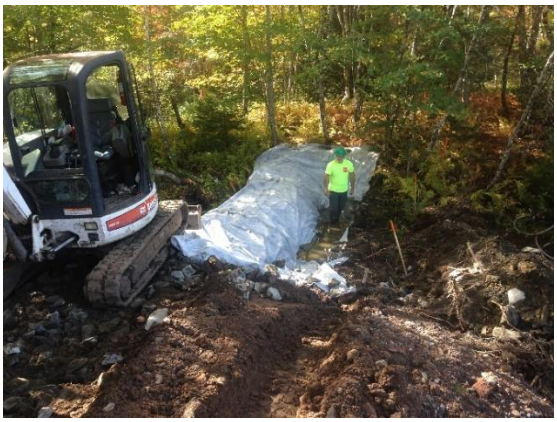


Figure 4: (Left) Dumping load of municipal compost. Figure 5: (Right) Constructing outlet weir in eastern side of restoration site.

Figure 6: (Left) Spreading and landscaping with excavator in western side of Wildcat Shale Pit Remediation Site. Figure 7: (Right) Hand spreading of compost in northern end of Wildcat Shale Pit Remediation Site.

Monitoring and Survey Results

Due to the nature of this project the results of the Wildcat Brook Shale Pit Remediation & Wetland Expansion are in a preliminary stage. Water quality, electrofishing, along with wildlife and vegetation surveys will continue to be monitored for several years after project completion. Details of surveys can be found in the Appendices of this report.

Before & After Pictures

The restoration of the western side of the shale pit remediation site began in 2015 and was fully completed in early 2016. The below photos (Figures 8 & 9) show the western side of the site prior to and after the spreading of organic soils and the planting of wetland vegetation. The post-restoration photos were taken during a dry spell across Nova Scotia in 2016, which will account for some of the discolouration of the vegetation seen in below photos.

Figure 8: (Left) Pre-restoration, September 2015, of the western side (Lower Pit) of Wildcat Shale Pit Remediation & Wetland Expansion Project. Figure 9: (Right) Post-restoration, October 2016., of the western side.

Restoration of the eastern side of the shale pit remediation site began in the spring of 2016 and was fully completed Fall 2016. The below photos (Figures 10 & 11) show the eastern side of the remediation site prior to and after the spreading of organic soils and the planting of wetland vegetation.

Figure 10: (Left) Pre-restoration, April 2015, of the eastern side (Lower Pit) of Wildcat Shale Pit Remediation & Wetland Expansion Project. Figure 11: (Right) Post-restoration, October 2016, of the eastern side.

Restoration of the northern end and central pit area began in the spring of 2016 and was fully completed Fall 2016. Below photos (Figures 12 & 13) show the northern end of the remediation site prior to and after the spreading of municipal compost over the exposed shale bedrock and the seeding of soil. The beginning of new vegetation growth is visible and will continue to grow and fill in over time.

Figure 12: (Left) Pre-restoration, May 2016, of the north end (Upper Pit) of Wildcat Shale Pit Remediation & Wetland Expansion Project. Figure 13: Post-restoration, October 2016, of the north end.

Vegetation Survey Results

Results of the pre-restoration vegetation density measurements showed there was approximately 25% of the remediation site covered by vegetation. This low percentage is likely due to the lack of available soil at the site. The lack of soil also limited the type of vegetation that could grow under these conditions. The first and second sections where vegetation density measurements were taken had an average vegetation percentage of 12%. These locations represented an area that consisted of more exposed rock, lacking in smaller vegetative cover and included the high-lying areas of the pit where

municipal compost was spread. The third and fourth sections had a higher average vegetation percentage with 38%. These areas contained wetter conditions and appeared to contain more soil along their perimeters. They represented the low-lying areas of the remediation site. In all four sections, a total of 103 plants were identified and recorded during the pre-restoration vegetation surveys.

The changes in vegetation at the site will continue to be documented post-restoration through point photos (seen above in Before & After section) and through field observations using vegetation density measurements.

Wildlife Survey Results

Results from the pre-restoration Wildlife Survey proved that there is wildlife presently using the surrounding area and that these species would benefit from having additional wetland habitat available to them. It is the hope that continued surveys will show that the newly restored and expanded wetland habitat will bring about and support more diverse and a larger amount of wildlife in the future.

Electrofishing was conducted over a 1 km stream length distance in Wildcat Brook in October 2015. This length of brook was situated between the 1.1 ha shale pit restoration site and another larger shale pit in the area. Only one fish species, chain pickerel (*Esox niger*), was found to inhabit this area of the stream. Chain pickerel is an introduced invasive species currently populating several watersheds throughout Nova Scotia. The species is known to be a significant threat to our native species and can persist in poor water quality conditions. Past surveys conducted by Coastal Action, along with anecdotal local knowledge, give reason to believe the more sensitive native species, such as trout and salmon, previously existed in areas above and below Wildcat Brook.

Water Quality Results

Monitoring of pH occurred at three different locations; within the pit itself, as well as instream both adjacent to the pit and below the pit at the outflow from the weir. Preliminary results of pH averages inside the restoration site and in Wildcat Brook are shown below (Table 1). The pre-restoration results were taken over a longer period from 2014 to 2016, whereas the post-restoration results were collected over a shorter period from October 2016 to March 2017. There was a visible change in pH between pre- and post-restoration at the site. It was also observed that the average pH in the outlet of the restoration site was significantly higher in pH than observed anywhere else. Average pH values within the Wildcat Brook remained similar pre- to post-restoration; the sampling site was located in Wildcat Brook downstream from the restoration site near the Lapland Road crossing.

Table 1: Preliminary results of average pH levels at the Wildcat Restoration Site and Wildcat Brook.

	Restoration Site (Inside wetland area)	**Outlet of Restoration Site**	**Wildcat Brook**
Pre-Restoration (monitoring from 2014 to 2016)	4.20	-	4.90
Post-Restoration (monitoring from Oct 2016 to Mar 2017)	4.90	5.20	4.60

Additional water quality results; including calculated parameters, inorganics, and metals; can be found in the Appendices of this report. The results indicate a baseline of information on the pre-restoration conditions inside the restoration site and surrounding drainage area. There are several metals; such as aluminium, cadmium, and iron; that exceed the recommended levels based on the Canadian Council of Ministers of the Environment (CCME). Results will later be compared to additional sampling which will be completed in the following years. These results will continue to be analysed by Coastal Action to observe water quality improvement, habitat changes, and recording success of restoration efforts at the site.

Water Levels

Water level loggers were installed in three separate locations to continuously monitor water levels in and adjacent to the restoration site. Data loggers were placed in monitoring wells in the eastern and western sides of the site as well as in Wildcat Brook. Monitoring of water levels began almost immediately after construction of the control weir above the outlet from the restoration site in the eastern side in mid-October. Results of the data collected from the water level loggers can be seen in the figure below (Figure 14).

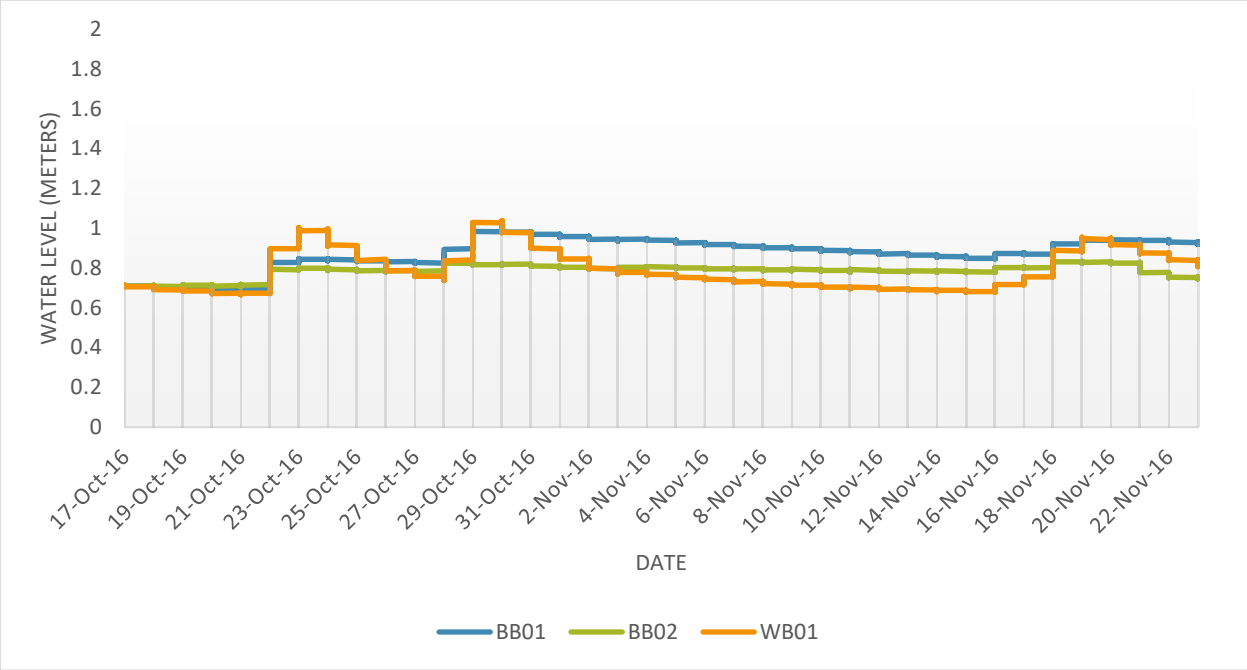


Figure 14: Water level readings taken from continuous data loggers in 15 min intervals at eastern side (BB01), western side (BB02), and Wildcat Brook (WB01).

Results show an increase in water level inside the restoration site, both in the eastern and western sides as well as in Wildcat Brook after mid-October. These increases likely reflect the excessive heavy rainfall events experienced last fall. Water levels deceased gradually and then increased again in late October. From late October on, the water levels slowly and steadily decreased, while maintaining a water depth around 80 to 100 cm within the restoration site and 60 to 80 cm in Wildcat Brook. Water level fluctuations in the brook appear more abrupt compared to those in the restoration site where levels shared the timing of fluctuations but maintained higher depths.

Discussion & Future Work

The preliminary results from this project show promising long term benefits for this expanded and newly restored wetland habitat. Vegetation growth in the restoration site at this point has been minimal, but there is promise for more growth in the following years. Nova Scotia was experiencing drought conditions during the summer months of 2016 when most of the physical restoration work at the site took place. This may have contributed to the lack of vegetation growth so shortly after the completion of the restoration efforts. Coastal Action is hopeful that future wildlife and electrofishing surveys will show additional native wildlife moving into the area. If water quality improves in Wildcat Brook, native fish such as trout and salmon, will be able to better compete against the invasive fish species, chain pickerel (*Esox niger*), and inhabit this area, effectively expanding available habitat that was previously lost due to the poor water quality conditions.

Water levels in the restoration site will continue to be monitored with continuous water level data loggers to ensure soils remain saturated, providing proper wetland habitat to native wetland plant species and providing an anoxic habitat which will reduce further acidification of waters in the adjacent Wildcat Brook.

There are two other larger shale pits in the surrounding area that Coastal Action would like to remediate in the future. Remediating these pits will ensure water quality improvements in the adjacent Wildcat Brook and will improve wildlife habitat. These remediation projects would be much larger in scale compared to the completed 1.1 ha restoration site, with the largest pit being just over 7.0 ha. This project would require significantly more organic soil to cover the exposed bedrock adequately.

Coastal Action has formed a new partnership with the Bridgewater Public Service Commission (PSC). The PSC's interests lay in improving water quality of Wildcat Brook, which enters directly into Hebb Lake very close to the main intake for the Town of Bridgewater's drinking water source. They are very keen to aide Coastal Action financially in the restoration of future shale pits in the surrounding area as it would lower their treatment costs and improve overall water quality in their municipal water supply. Coastal Action also formed another new partnership with Nova Scotia's Resource Recovery Fund Board (RRFB) through this project. This partnership has resulted in an opportunity for the use of municipal compost for future restoration projects that wish to promote the growth of healthy vegetation. The restoration efforts completed at the Wildcat Brook Shale Pit successfully demonstrated the fertility of the municipal compost used on-site as part of the restoration efforts and will continue to be documented by point photos and vegetation surveys into the future. These new partnerships will aide Coastal Action in planning and development of potential future restoration projects in the area.

Long-term monitoring of the completed restoration site will help Coastal Action with determining future remediation plans in the area. Coastal Action is optimistic that this project will continue to be successful in improving the water quality conditions in the adjacent Wildcat Brook and the overall health of the surrounding environment. Creating new and highly productive wetland habitat will attract additional wetland wildlife and native fish species into the area.

Acknowledgements

Bluenose Coastal Action Foundation's Wildcat Shale Pit Remediation & Wetland Expansion Project would not be possible without the generous support of our project partners, volunteers, and local community. Project activities in 2016 could not have been completed without the hard work and dedication of Coastal Action's field staff and project partners, East Coast Aquatic Inc. Much gratitude and many thanks to our 2016-17 financial partners, without your support there would be no project.

Appendix A

Ground-Truthing & Wildlife Survey

Wildcat Shale Pit Remediation & Wetland Expansion Project

Ground-Truthing & Wildlife Survey: April 28th, 2016

Team Coastal Action Staff: Emma Kinley, Sam Reeves, Shauna Barry, Melissa Rafuse, & Alisha Kelly

Volunteers: Reg Newell (DNR Wildlife Biologist) and Elijah Sawler (NSCC Natural Resources & Environmental Technology Program)

Site Description & Result of the 1-ha Shale Pit Wildlife Survey:

Current land use: Abandoned shale pit mining site – abandoned approximately 20 years ago

Current landscape features: Pit area consists of bare rock with very minimal amount of soil and sparse shrub vegetation. Lower lying areas, that likely have been excavated in the past, pool with rain water. Pools all read low acidity and lack aquatic vegetation growth within them which duck species rely on for shelter when young and for food. Surrounding the pit area is a mixture of softwood and hardwood forest varying in age but majority of growth around 20-30 years old. Shale pit site is adjacent to nearby Wildcat Brook. Standing mixed wood forest consisted of eastern white pine, red maple, eastern hemlock, white birch, grey birch, black spruce, balsam fir, and tamarack. Ground vegetation consisted of wild raisin, speckled and green alders, lambkill, leather leaf, bog cranberry, reindeer moss, straw berry, and dew berry. Regeneration vegetation consisted of balsam fir, red spruce, oak, and eastern white pine.

Habitat types present: Mixed wood forest (surrounding pit); riparian zone habitat (edge of stream); bare rock (within pit area) – snakes, turtles, and insects like to draw heat from; wet marsh/wetland habitat (edge of pit); old trees – cavities used for wildlife nests/downfall for cover/great for insects; and pond habitat – lacking vegetation but sightings of tad poles and frog eggs.

Wildlife present/sightings:

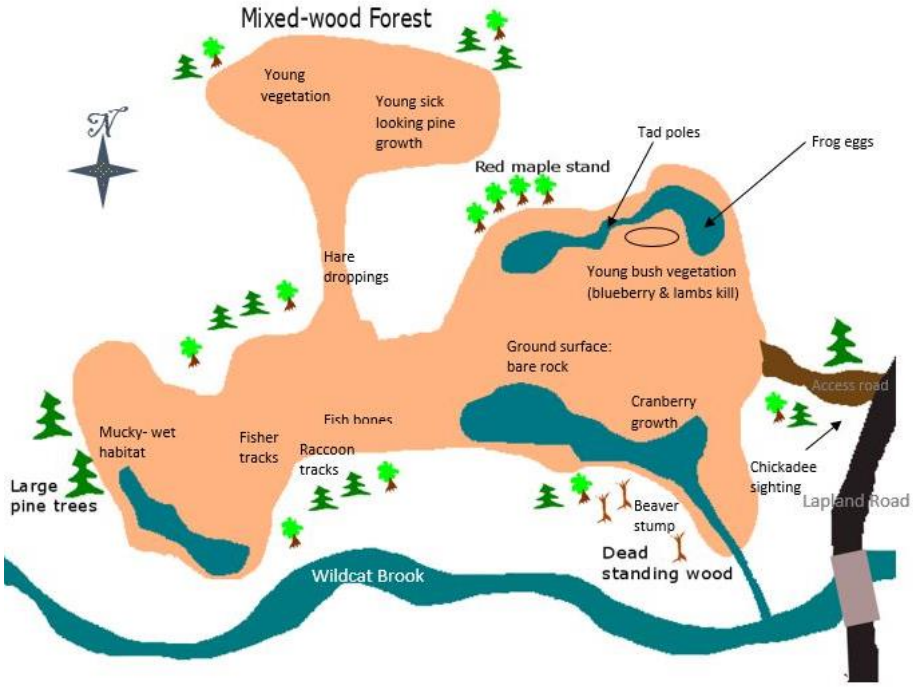
- Black Capped Chickadee – sighting
- Pileated Woodpecker hole
- Mallard duck – sighting
- Beaver stump
- Tad poles – sighting
- Hare scat
- Mustelidae family tracks and scat (scat found in larger pit)
- Racoon tracks
- Fish bones
- Coyote scat and tracts (found in larger pit)
- Deer tracks (found in larger pit)
- Unknown yellow bird – sighting

- Bird egg lining
- Insect damage on some old trees

Other Possible Species:

- The large white pine serves as good habitat for red-tailed hawk nesting and other raptor nesting, as well as barred owls, possibly great horned owl, and saw-whet owl.
- Smaller mammal species: shrews, red back moles included
- Bobcat, coyote, fox (likely not fox if coyotes are present)
- Pine grosbeak could be present during winter
- Deer could be present during winter, not the best feeding habitat during summer (little shrub vegetation to feed on)
- Warblers (like mixed forest)
- Grosbeak
- Woody, downy, and pileated woodpeckers
- Wood ducks
- Kinglets
- Goshawks
- Porcupines
- Fisher (possible tracks spotted in pit)
- Snakes
- Dragonflies
- Short tailed shrew (poisonous)

Other landscape features: The area is absent of any building structures within the surveyed area, but there is an ATV trail running through the western end of the pit and the access point to the pit on the eastern end is off the Lapland Road which has low residential traffic and some logging and other heavy machinery traffic as well. There are two other larger pits in the surrounding area. The closest of the two (7 ha pit) is positioned on the other side of the Wildcat Brook and was also visited the same day of the survey. This pit has more diversity in vegetation and better soils allowing for more vegetation growth.


Mixed-wood Forest
Young vegetation
Young sick looking pine growth
N
Tad poles
Frog eggs
Red maple stand
Hare droppings
Young bush vegetation (blueberry & lambs kill)
Ground surface: bare rock
Access road
Cranberry growth
Fish bones
Mucky- wet habitat
Fisher tracks
Raccoon tracks
Large pine trees
Chickadee sighting
Lapland Road
Beaver stump
Dead standing wood
Wildcat Brook

Appendix B

Vegetation Surveys: Density Measurements & Vascular Plant List

Density Measurements

Conducted by Coastal Action staff: Emma Kinley & Shauna Barry

Method: Remediation site was split into four sections (1-lower right, 2-upper right, 3-upper left, and 4-lower left) and each section sampled five times using a 1x1 square grid to measure randomized locations for presence of vegetation. * *These measurements do not account for large vegetation such as trees.*

Results:

Section:	Quadrate:	1	2	3	4	5	% Vegetation Average(s):
1	Q1	0	30	15	5	3	8.50%
	Q2	0	20	10	5	1	
	Q3	0	25	15	3	3	
	Q4	1	20	10	3	1	
2	Q1	2	15	75	5	3	15.60%
	Q2	1	7	60	3	2	
	Q3	1	10	20	1	2	
	Q4	2	5	75	20	3	
3	Q1	50	85	15	10	0	31.58%
	Q2	75	30	35	10	0	
	Q3	55	65	10	10	0.5	
	Q4	80	70	20	10	1	
4	Q1	5	10	80	95	60	43.55%
	Q2	5	5	65	75	70	
	Q3	2	7	50	80	50	
	Q4	2	10	50	80	70	
							Total Average: 24.80%

Vascular Plant List for Large Shale Pit adjacent to Shale Pit Restoration Site, Wileville, Nova Scotia – Completed on *August 15, 2016*. This list gives a baseline understanding of the diversity of the existing plant life pre-restoration and their current status.

Team: Coastal Action Staff: Emma Kinley, Blaire Slaunwhite, Shauna Barry, and Nicolas Wentzell

Volunteers: Dr. Ruth Newell (Professional Botanist), Reg Newell (DNR Wildlife Biologist), and Zackery Zwicker (Hobby Botanist).

Latin Name	Common	Nova Scotia General Status

		Name	Rank
1	Abies balsamea	Balsam Fir	4 Secure
2	Acer rubrum	Red Maple	4 Secure
3	Agrostis scabra	Rough Bent Grass	4 Secure
4	Anaphalis margaritacea	Pearly Everlasting	4 Secure
5	Anthoxantum odoratum	Sweet Vernal Grass	7 Exotic
6	Anus incana ssp. rugosa	Speckled Alder	4 Secure
7	Symphyotrichum lateriflorum	Calico Aster	4 Secure
8	Betula populifolia	Grey Birch	4 Secure
9	Bidens frondosa	Devil's Beggarticks	4 Secure
10	Brasenia screberi	Water Shield	4 Secure
11	Calopogon pulchellus	Grass Pink	
12	Carex canescens	Hoary Sedge	4 Secure
13	Carex lurida	Shining Sedge	4 Secure
14	Carex scoparia	Broom Sedge	4 Secure
15	Centaurea nigra	Knapweed	
16	Chamaedaphne calyculata	Leatherleaf	4 Secure
17	Comptonia peregrina	Sweet Fern	4 Secure
18	Cypripedium acaule	Pink Lady's-slipper	4 Secure
19	Danthonia compressa	Flattened Oat Grass	4 Secure
20	Danthonia spicata	Poverty Oat Grass	4 Secure
21	Dennstaedtia punctilobula	Hay-scented Fern	4 Secure
22	Drosera intermedia	Spoon-leaved Sundew	4 Secure
23	Drosera rotundifolia	Round-leaved Sundew	4 Secure
24	Dulichium arundinacium	Three-way Sedge	4 Secure
25	Eleocharis acicularis	Needle Spikerush	4 Secure
26	Eleocharis tenuis	Slender Spikerush	4 Secure
27	Epigaea repens	Mayflower	4 Secure
28	Epilobium ciliatum	Northern Willowherb	4 Secure
29	Erechtites hieraciifolia	Fireweed	4 Secure
30	Erigeron strigosus	Rough Fleabane	4 Secure
31	Eriophorum virginicum	Tawny Cottongrass	4 Secure
32	Euthamia graminifolia	Narrow-leaved Goldenrod	4 Secure
33	Fragaria virgininana	Wild Strawberry	4 Secure
34	Gaultheria hispidula	Creeping Snowberry	4 Secure
35	Gaultheria procumbens	Teaberry	4 Secure
36	Gaylussacia baccata	Huckleberry	4 Secure
37	Glyceria obtusa	Atlantic Manna Grass	4 Secure
38	Hieracium kalmii	Kalm's Hawkweed	5 Undetermined
39	Hieracium sp.	A hawkweed	7 Exotic
40	Hypericum canadense	Canada St. John's-wort	4 Secure
41	Hypericum perforatum	Common St. John's-wort	7 Exotic
42	Iris versicolor	Blue Flag	4 Secure
43	Juncus brevicaudatus	Narrow-panicled Rush	4 Secure
44	Juncus canadensis	Canada Rush	4 Secure
45	Juncus militaris	Bayonet Rush	4 Secure
46	Juncus pelocarpus	Brown-fruited Rush	4 Secure
47	Juncus effusus	Soft Rush	4 Secure
48	Juncus tenuis	Slender Rush	4 Secure

49	Kalmia angustifolia	Sheep Laurel	4 Secure
50	Kalmia polifolia	Bog Laurel	4 Secure
51	Larix laricina	Larch	4 Secure
52	Lechea intermedia	Pinweed	4 Secure
53	Ledum groendandicum	Labrador-tea	4 Secure
54	Leontodon autumnalis	Fall dandelion	7 Exotic
55	Lobelia inflata	Indian Tobacco	4 Secure
56	Lycopodiella inundata	Northern Bog Clubmoss	4 Secure
57	Lysimachia terrestris	Swamp Candle	4 Secure
58	Melampyrum lineare	Cow wheat	4 Secure
59	Muhlenbergia uniflora	Bog Muhly Grass	4 Secure
60	Myrica gale	Sweet Gale	4 Secure
61	Nuphar variegata	Cow Lily	4 Secure
62	Nymphaea cordata	Water Lily	4 Secure
63	Oenothera biennis	Common Evening Primrose	4 Secure
64	Oenothera perennis	Perennial Evening Primrose	4 Secure
65	Oxalis dillenii	Slender Yellow Wood Sorrel	7 Exotic
67	Dichanthelium depauperatum	Starved Panic Grass	4 Secure
68	Panicum lanuginosum	Woolly Panic Grass	4 Secure
69	Phalaris arundinacea	Reed Canary Grass	4 Secure
70	Picea mariana	Black Spruce	4 Secure
71	Picea rubens	Red Spruce	4 Secure
72	Pinus strobus	White Pine	4 Secure
73	Plantago major	Common Plantain	7 Exotic
74	Poa compressa	Canada Blue Grass	7 Exotic
75	Poa pratensis	Kentucky Blue Grass	4 Secure
76	Pogonia ophioglossoides	Rose Pogonia	4 Secure
77	Pontederia cordata	Pickerelweed	4 Secure
78	Potamogeton confervoides	Alga Pondweed	4 Secure
79	Potentilla sp.	a cinquefoil	4 Secure
80	Prenanthes trifoliolata	Three-leaved Rattlesnakeroot	4 Secure
81	Prunella vulgaris	Heal-all	7 Exotic
82	Pteridium aquilinum	Bracken Fern	4 Secure
83	Quercus rubra	Red Oak	4 Secure
84	Rhododendron canadense	Rhodora	4 Secure
85	Rhynchospora alba	White Beakrush	4 Secure
86	Rubus hispidus	Bristley Dewberry	4 secure
87	Sarracenia purpurea	Pitcher Plant	4 Secure
88	Scirpus atrocinctus	Black-girdled Woolsedge	4 Secure
89	Scirpus cyperinus	Common Woolsedge	4 Secure
90	Solidago juncea	Early Goldenrod	4 Secure
91	Solidago puberula	Downy Goldenrod	4 Secure
92	Solidago rugosa	Rough Goldenrod	4 Secure
93	Sparganium americanum	American Burreed	4 Secure
94	Spiraea alba var. latifolia	Meadowsweet	4 Secure
95	Spiraea tomentosa	Steeplebush	4 Secure

96	Spiranthes sp. (in bud; possibly S. ochroleuca)	a ladies-tresses	4 Secure
97	Triadenum fraseri	Fraser's Marsh St. John's-wort	4 Secure
98	Trifolium arvensis	Rabbit's-foot Clover	7 Exotic
99	Tsuga canadensis	Hemlock	4 Secure
100	Vaccinium macrocarpon	Large Cranberry	4 Secure
101	Veronica officinalis	Common Speedwell	7 Exotic
102	Viburnum cassinoides	Witherod	4 Secure
103	Viola lanceolata	Lance-leaved Violet	4 Secure

Appendix C

Water Quality Sampling Results

Water quality samples were taken at six sites on the November 18, 2014 and November 25, 2016 within the Wildcat Brook drainage area and analyzed by certified lab, Maxxam Analytics, for general parameters, inorganics, and metals. Parameters exceeding relevant water quality objective (WQO) are highlighted red.

WCB001 – Sampled in Wildcat Brook, approx. 20 m upstream from Lapland Road bridge (44°22'00.8" N,64°35'04.5" W)
WCB002 – Sampled at outlet of 1.1 ha restoration site (44°22'01.3" N, 64°35'07.2" W)
WCB003 – Sampled in 1.1 ha restoration site, eastern side (44°22'02.4" N, 64°35'08.2" W)
WCB004 – Sampled in 1.1 ha restoration site, western side (44°22'01.9" N, 64°35'14.7" W)
WCB005 – Sampled in 7.0 ha shale pit site in large pond in northern end (44°22'04.3 N, 64°35'29.3" W)
WCB006 – Sampled in Wildcat Brook upstream from shale pit sites (44°21'56.9" N, 64°35'53.4" W)

	UNITS	WCB001		WCB002		WCB003		WCB004		WCB005		WCB006		WQO	Reference
		2014	2016	2014	2016	2014	2016	2014	2016	2014	2016	2014	2016		
Calculated Parameters															
Anion Sum	me/L	0.230	0.370	0.430	2.64	0.410	2.61	0.240	2.15	0.360	0.780	0.210	0.230		
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Calculated TDS	mg/L	20	29	30	170	29	170	16	140	24	49	18	22		
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Cation Sum	me/L	0.360	0.450	0.440	2.28	0.430	2.37	0.220	1.81	0.280	0.450	0.320	0.390		
Hardness (CaCO3)	mg/L	5.2	8.4	4.6	61	4.9	63	2.3	47	6.0	11	4.4	6.7		
Ion Balance (% Difference)	%	22.0	9.76	1.15	7.32	2.38	4.82	4.35	8.59	12.5	26.8	20.8	25.8		
Langelier Index (@ 20C)	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC		
Langelier Index (@ 4C)	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC		
Nitrate (N)	mg/L	0.084	0.054	ND	0.62	ND	0.66	ND	ND	ND	ND	0.066	ND		
Saturation pH (@ 20C)	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC		
Saturation pH (@ 4C)	N/A	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC	NC		
Inorganics															

Acidity	mg/L	6.4	6.4	14	11	14	12	6.2	14	11	24	10	11		
Total Alkalinity (Total as CaCO3)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Carbonaceous BOD	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Chloride (Cl)	mg/L	8.0	9.4	11	26	9.8	26	4.9	19	3.6	3.3	7.2	8.0		
Colour	TCU	120	180	80	17	70	16	6.0	13	ND	ND	140	200		
Nitrate + Nitrite (N)	mg/L	0.084	0.054	ND	0.62	ND	0.66	ND	ND	ND	ND	0.066	ND		
Nitrite (N)	mg/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Nitrogen (Ammonia Nitrogen)	mg/L	0.054	0.14	0.082	0.26	ND	0.25	ND	0.095	ND	0.070	ND	0.18		
Dissolved Organic Carbon (C)	mg/L	9.3	11	7.3	4.9	6.7	6.5	1.5	6.6	0.67	1.3	11	11		
Total Organic Carbon (C)	mg/L	10	14	7.8	6.3	7.1	6.1	1.7	7.3	0.72	0.96	11	17		
Orthophosphate (P)	mg/L	ND	0.012	ND	ND	ND	0.010	ND	ND	ND	0.010	ND	0.011		
pH	pH	5.47	5.39	4.58	4.86	4.58	5.07	4.48	4.80	4.21	3.97	4.86	5.09	6.5-9	CCME*
Reactive Silica (SiO2)	mg/L	4.2	5.3	3.4	2.9	3.9	2.6	1.8	3.7	3.5	5.6	3.6	5.4		
Dissolved Sulphate (SO4)	mg/L	ND	4.8	6.4	89	6.5	88	4.8	77	12	33	ND	ND		
Turbidity	NTU	1.4	0.97	1.2	2.4	1.2	2.2	0.86	3.2	0.47	0.18	1.3	1.1		
Conductivity	uS/cm	40	51	62	290	58	300	35	240	60	110	36	45		
Metals															
Total Mercury (Hg)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	Not Tested	ND	ND	ND		
Dissolved Aluminum (Al)	ug/L	190	240	690	560	610	620	280	410	590	2100	200	240	5	CCME*
Total Aluminum (Al)	ug/L	240	270	720	650	660	710	340	450	620	2200	240	260	5	CCME*
Dissolved Antimony (Sb)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Antimony (Sb)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Arsenic (As)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	5	CCME*
Total Arsenic (As)	ug/L	ND	ND	ND	ND	ND	ND	ND	1.1	ND	ND	ND	ND	5	CCME*
Dissolved Barium (Ba)	ug/L	2.9	4.1	4.8	18	4.1	19	3.8	29	4.6	8.8	3.9	3.5	1000	BC**
Total Barium (Ba)	ug/L	3.0	4.6	4.7	19	4.4	20	3.7	31	4.6	9.1	2.7	3.7	1000	BC**
Dissolved Beryllium (Be)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Beryllium (Be)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Bismuth (Bi)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		

Total Bismuth (Bi)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Boron (B)	ug/L	ND	ND	ND	380	ND	380	ND	490	ND	ND	ND	ND		
Total Boron (B)	ug/L	ND	ND	ND	380	ND	400	ND	510	ND	ND	ND	ND		
Dissolved Cadmium (Cd)	ug/L	0.015	0.022	0.027	0.23	0.024	0.25	0.016	0.23	0.042	0.12	0.030	0.022	0.09	CCME*
Total Cadmium (Cd)	ug/L	0.019	0.020	0.032	0.24	0.032	0.26	0.021	0.24	0.052	0.14	0.019	0.021	0.09	CCME*
Dissolved Calcium (Ca)	ug/L	1000	1700	540	18000	600	19000	250	12000	1100	2100	860	1300	4000 to 8000	BC**
Total Calcium (Ca)	ug/L	1100	1800	510	18000	620	19000	240	13000	1100	2100	790	1300		
Dissolved Chromium (Cr)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	52	ND	1	CCME*
Total Chromium (Cr)	ug/L	ND	ND	3.6	ND	1.9	ND	ND	ND	ND	ND	3.7	1.1	1	CCME*
Dissolved Cobalt (Co)	ug/L	0.43	0.67	2.2	8.8	1.9	9.1	2.5	6.2	5.1	15	ND	ND		
Total Cobalt (Co)	ug/L	0.56	0.68	2.1	8.9	1.9	9.2	2.4	6.5	5.3	15	ND	ND		
Dissolved Copper (Cu)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	3.1	14	ND	ND	2	CCME*
Total Copper (Cu)	ug/L	ND	ND	ND	ND	ND	ND	2.4	ND	3.4	14	ND	ND	2	CCME*
Dissolved Iron (Fe)	ug/L	630	750	510	380	550	300	62	370	200	260	590	820	300	CCME*
Total Iron (Fe)	ug/L	850	920	620	890	680	670	140	1100	230	280	760	900	300	CCME*
Dissolved Lead (Pb)	ug/L	ND	ND	0.62	ND	0.51	ND	0.87	ND	ND	ND	ND	ND	1	CCME*
Total Lead (Pb)	ug/L	ND	ND	0.69	ND	0.60	ND	1.1	ND	ND	ND	ND	ND	1	CCME*
Dissolved Magnesium (Mg)	ug/L	650	990	790	3900	830	4100	420	3900	810	1300	550	820		
Total Magnesium (Mg)	ug/L	670	1100	760	4200	860	4300	430	4300	830	1500	540	850		
Dissolved Manganese (Mn)	ug/L	61	80	310	1100	360	1100	180	1300	310	560	42	59		
Total Manganese (Mn)	ug/L	64	85	300	1200	380	1200	180	1400	320	600	44	61		
Dissolved Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	73	CCME*
Total Molybdenum (Mo)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	73	CCME*
Dissolved Nickel (Ni)	ug/L	ND	2.4	4.1	14	3.6	15	2.6	3.8	10	32	ND	ND	25	CCME*
Total Nickel (Ni)	ug/L	ND	ND	3.6	14	3.9	15	2.8	3.9	10	32	ND	ND	25	CCME*
Dissolved Phosphorus (P)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Phosphorus (P)	ug/L	110	ND	ND	ND	100	ND	ND	ND	ND	ND	ND	ND		
Dissolved Potassium (K)	ug/L	500	520	290	9200	310	9700	160	10000	200	480	520	310	373000	BC**
Total Potassium (K)	ug/L	570	540	290	11000	290	11000	160	12000	210	550	430	340	373000	BC**

Dissolved Selenium (Se)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	CCME*
Total Selenium (Se)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	1	CCME*
Dissolved Silver (Ag)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	CCME*
Total Silver (Ag)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0.1	CCME*
Dissolved Sodium (Na)	ug/L	4800	5200	6600	18000	6400	19000	3200	13000	2100	2400	4300	4500		
Total Sodium (Na)	ug/L	4900	5600	6300	20000	6600	21000	3100	16000	2100	2900	4300	5100		
Dissolved Strontium (Sr)	ug/L	5.1	8.4	2.9	65	3.0	69	ND	48	4.6	8.6	4.7	7.3		
Total Strontium (Sr)	ug/L	5.0	8.9	2.5	68	2.8	70	ND	52	5.0	9.3	4.7	7.7		
Dissolved Thallium (Tl)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Thallium (Tl)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Tin (Sn)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Tin (Sn)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Titanium (Ti)	ug/L	2.4	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.4	ND	2000	BC**
Total Titanium (Ti)	ug/L	4.4	2.5	2.9	ND	ND	ND	ND	ND	2.4	ND	19	ND	2000	BC**
Dissolved Uranium (U)	ug/L	ND	ND	ND	ND	ND	ND	ND	0.12	ND	0.16	ND	ND		
Total Uranium (U)	ug/L	ND	ND	ND	ND	ND	ND	ND	0.16	ND	0.18	ND	ND		
Dissolved Vanadium (V)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Total Vanadium (V)	ug/L	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND		
Dissolved Zinc (Zn)	ug/L	ND	ND	9.7	29	9.9	32	7.1	28	11	24	6.0	6.1	30	CCME*
Total Zinc (Zn)	ug/L	5.6	5.3	8.9	31	11	33	7.6	30	11	27	ND	ND	30	CCME*

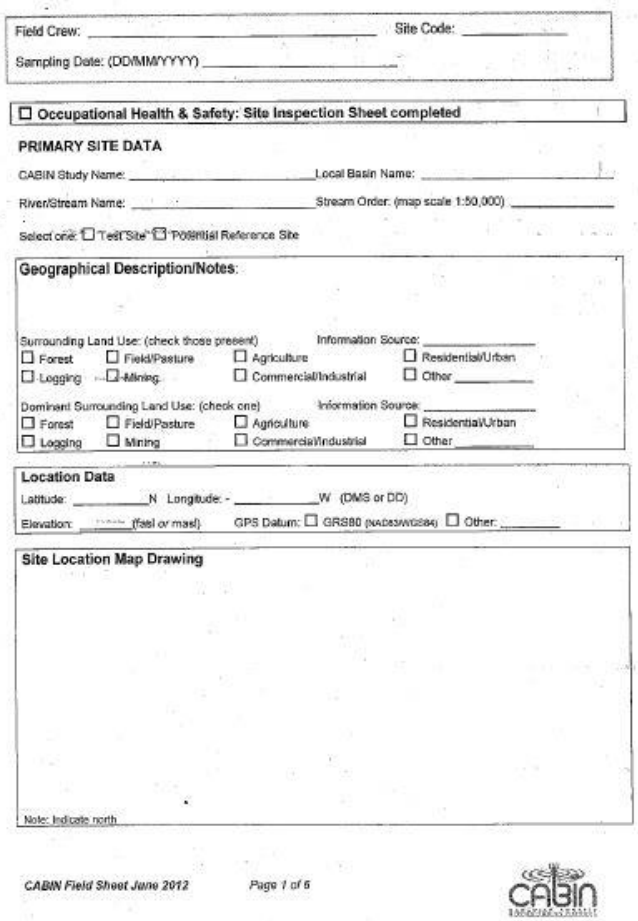
*CCME – Canadian Council of Ministers of the Environment (2016)

**BC – British Columbia Water Quality Guidelines (2006)

Appendix D

Macroinvertebrate Sampling Field Sheet

Macroinvertebrate sampling was completed using Environmental Canada's Canadian Aquatic Biomonitoring Network (CABIN) protocol. Sampling was completed in four sites in 2015 and again in 2016 in Wildcat Brook. Results have been entered and can be viewed online in the CABIN database (http://www.ec.gc.ca/rcba-cabin/default.asp?lang=En&n=4A1D6389-1).



Field Crew: _____ Site Code: _____

Sampling Date: (DD/MM/YYYY) _____

☐ Occupational Health & Safety: Site Inspection Sheet completed

PRIMARY SITE DATA

CABIN Study Name: _____ Local Basin Name: _____

River/Stream Name: _____ Stream Order: (map scale 1:50,000) _____

Select one: ☐ Test Site ☐ Potential Reference Site

Geographical Description/Notes:

Surrounding Land Use: (check those present) Information Source: _____

☐ Forest ☐ Field/Pasture ☐ Agriculture ☐ Residential/Urban

☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other _____

Dominant Surrounding Land Use: (check one) Information Source: _____

☐ Forest ☐ Field/Pasture ☐ Agriculture ☐ Residential/Urban

☐ Logging ☐ Mining ☐ Commercial/Industrial ☐ Other _____

Location Data

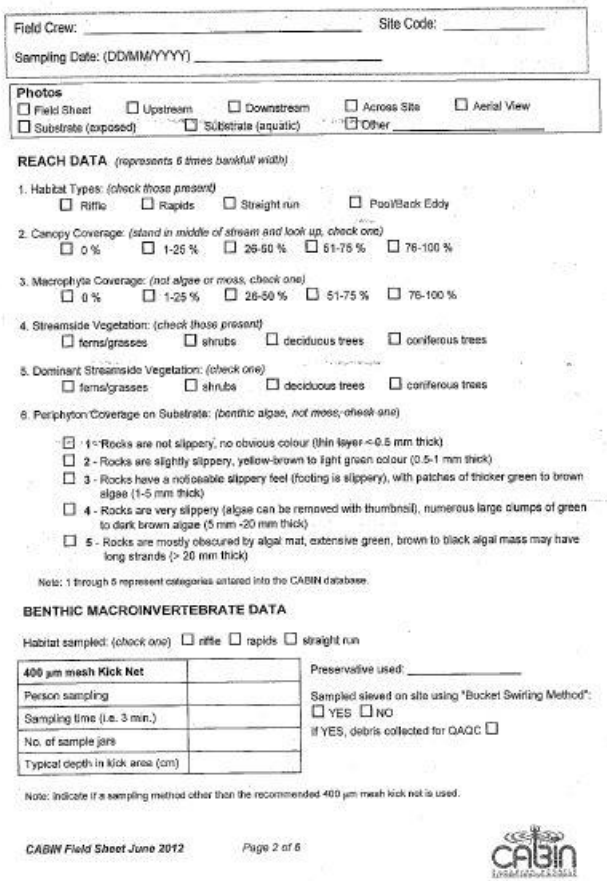
Latitude: _____N Longitude: - _____W (DMS or DD)

Elevation: _____(fasl or masl) GPS Datum: ☐ GRS80 (NAD83/WGS84) ☐ Other: _____

Site Location Map Drawing

Note: Indicate north

CABIN Field Sheet June 2012 *Page 1 of 6*



Field Crew: _____ Site Code: _____

Sampling Date: (DD/MM/YYYY) _____

Photos

☐ Field Sheet ☐ Upstream ☐ Downstream ☐ Across Site ☐ Aerial View

☐ Substrate (exposed) ☐ Substrate (aquatic) ☐ Other _____

REACH DATA *(represents 6 times bankfull width)*

1. Habitat Types: *(check those present)*
   ☐ Riffle ☐ Rapids ☐ Straight run ☐ Pool/Back Eddy
2. Canopy Coverage: *(stand in middle of stream and look up, check one)*
   ☐ 0 % ☐ 1-25 % ☐ 26-50 % ☐ 51-75 % ☐ 76-100 %
3. Macrophyta Coverage: *(not algae or moss, check one)*
   ☐ 0 % ☐ 1-25 % ☐ 26-50 % ☐ 51-75 % ☐ 76-100 %
4. Streamside Vegetation: *(check those present)*
   ☐ ferns/grasses ☐ shrubs ☐ deciduous trees ☐ coniferous trees
5. Dominant Streamside Vegetation: *(check one)*
   ☐ ferns/grasses ☐ shrubs ☐ deciduous trees ☐ coniferous trees
6. Periphyton Coverage on Substrate: *(benthic algae, not moss; check one)*
   ☑ 1 - Rocks are not slippery, no obvious colour (thin layer <0.5 mm thick)
   ☐ 2 - Rocks are slightly slippery, yellow-brown to light green colour (0.5-1 mm thick)
   ☐ 3 - Rocks have a noticeable slippery feel (footing is slippery), with patches of thicker green to brown algae (1-5 mm thick)
   ☐ 4 - Rocks are very slippery (algae can be removed with thumbnail), numerous large clumps of green to dark brown algae (5 mm -20 mm thick)
   ☐ 5 - Rocks are mostly obscured by algal mat, extensive green, brown to black algal mass may have long strands (> 20 mm thick)

Note: 1 through 5 represent categories entered into the CABIN database.

BENTHIC MACROINVERTEBRATE DATA

Habitat sampled: *(check one)* ☐ riffle ☐ rapids ☐ straight run

400 µm mesh Kick Net	
Person sampling	
Sampling time (i.e. 3 min.)	
No. of sample jars	
Typical depth in kick area (cm)	

Preservative used: _____

Sampled sieved on site using "Bucket Swirling Method": ☐ YES ☐ NO

If YES, debris collected for QAQC ☐

Note: Indicate if a sampling method other than the recommended 400 µm mesh kick net is used.

CABIN Field Sheet June 2012 *Page 2 of 6*

Field Crew: _____ Site Code: _____

Sampling Date: (DD/MM/YYYY) _____

WATER CHEMISTRY DATA **Time:** _____ (24 hr clock) **Time zone:** _____

Air Temp: _____(°C) Water Temp: _____(°C) pH: _____

Specific Conductance: _____(µs/cm) DO: _____(mg/L) Turbidity: _____(NTU)

Check if water samples were collected for the following analyses:

- ☐ TSS (Total Suspended Solids)
- ☐ Nitrogen (i.e. Total, Nitrate, Nitrite, Dissolved, and/or Ammonia)
- ☐ Phosphorus (Total, Ortho, and/or Dissolved)
- ☐ Major Ions (i.e. Alkalinity, Hardness, Chloride, and/or Sulphate) ☐ Other_____

Note: Determining alkalinity is recommended, as are other analyses, but not required for CABIN assessments.

CHANNEL DATA

Slope - indicate how slope was measured: (check one)

☐ **Calculated from map**

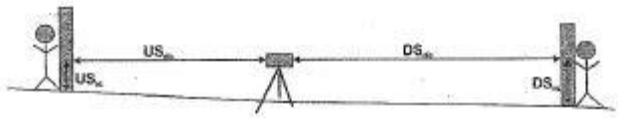
Scale: _____ (Note: small scale map recommended if field measurement is not possible - i.e. 1:20,000).
contour interval (vertical distance) _____ (m).
distance between contour intervals (horizontal distance) _____ (m)
slope = vertical distance/horizontal distance = _____

OR

☐ **Measured in field**

Circle device used and fill out table according to device:
a. Survey Equipment b. Hand Level & Measuring Tape

Measurements	Upstream (US)	Downstream(DS)	Calculation
*Top Hairline (T)			
*Mid Hairline (ht) OR [b]Height of rod			
*Bottom Hairline (B)			
*Distance (dis) OR *T-B x 100	*US_{dis}=T-B	*DS_{dis}=T-B	US_{dis}+DS_{dis}=
Change in height (Δht)			DS_{ht}-US_{ht}=
Slope (Δht/total dis)			



Field Crew: _____ Site Code: _____

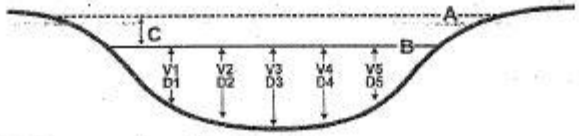
Sampling Date: (DD/MM/YYYY) _____

Widths and Depth

Location at site: _____(indicate where in sample reach, ex. d/s of kick area)

A - Bankfull Width: _____(m) B - Wetted Stream Width: _____(m)

C - Bankfull–Wetted Depth (height from water surface to Bankfull): _____(cm)



Note:
Wetted widths > 5 m, measure a minimum of 5-6 equidistant locations.
Wetted widths < 5 m, measure 3-4 equidistant locations.

Velocity and Depth

Check appropriate velocity measuring device and fill out the appropriate section in chart below. Distance from shore and depth are required regardless of method:

☐ **Velocity Head Rod (or ruler):** Velocity Equation (m/s) = $\sqrt{[2(\Delta D/100) * 9.81]}$

☐ **Rotary meters:** Gurley/Price/Mini-Price/Propeller (Refer to specific meter conversion chart for calculation)

☐ **Direct velocity measurements:** ☐ Marsh-McBirney ☐ Sontek or ☐ Other_____

	1	2	3	4	5	6	AVG
Distance from Shore (m)							
Depth (D) (cm)							
Velocity Head Rod (ruler)							
Flowing water Depth (D_1) (cm)							
Depth of Stagnation (D_2) (cm)							
Change in depth ($\Delta D = D_2 - D_1$) (cm)							
Rotary meter							
Revolutions							
Time (minimum 40 seconds)							
Direct Measurement of Velocity							
Velocity (V) (m/s)							

Field Crew: _____ Site Code: _____

Sampling Date: (DD/MM/YYYY) _____

SUBSTRATE DATA

Surrounding/Interstitial Material
Circle the substrate size category for the surrounding material.

Substrate Size Class	Category
Organic Cover	0
< 0.1 cm (fine sand, silt or clay)	1
0.1-0.2 cm (coarse sand)	2
0.2-1.6 cm (gravel)	3
1.6-3.2 cm (small pebble)	4
3.2-6.4 cm (large pebble)	5
6.4-12.8 cm (small cobble)	6
12.8-25.6 cm (cobble)	7
> 25.6 cm (boulder)	8
Bedrock	9

100 Pebble Count & Substrate Embeddedness

- Measure the intermediate axis (100 rocks) and embeddedness (10 rocks) of substrate in the stream bed.
- Indicate B for bedrock, S for sand/silt/clay (particles < 0.2 cm) and O for organic material.
- Embeddedness categories (E): Completely embedded = 1, 3/4 embedded, 1/2 embedded, 1/4 embedded, unembedded = 0

	Diameter (cm)	E	Diameter (cm)	E	Diameter (cm)	E	Diameter (cm)	E
1			26		51		76	
2			27		52		77	
3			28		53		78	
4			29		54		79	
5			30		55		80	
6			31		56		81	
7			32		57		82	
8			33		58		83	
9			34		59		84	
10			35		60		85	
11			36		61		86	
12			37		62		87	
13			38		63		88	
14			39		64		89	
15			40		65		90	
16			41		66		91	
17			42		67		92	
18			43		68		93	
19			44		69		94	
20			45		70		95	
21			46		71		96	
22			47		72		97	
23			48		73		98	
24			49		74		99	
25			50		75		100	

Note: The Wolman D50 (i.e. median diameter), Wolman Dg (i.e. geometric mean diameter) and the % composition of the substrate classes will be calculated automatically in the CABIN database using the 100 pebble data. All 100 pebbles must be measured in order for the CABIN database tool to perform substrate calculations.

Field Crew: _____ Site Code: _____

Sampling Date: (DD/MM/YYYY) _____

SITE INSPECTION

Site Inspected by: _____

Communication Information

☐ Itinerary left with contact person (include contact numbers)

Contact Person: _____ Time checked-in: _____

Form of communication: ☐ radio ☐ cell ☐ satellite ☐ hotel/pay phone ☐ SPOT

Phone number: ( ) _____

Vehicle Safety

☐ Safety equipment (first aid, fire extinguisher, blanket, emergency kit in vehicle)

☐ Equipment and chemicals safely secured for transport

☐ Vehicle parked in safe location; pylons, hazard light, reflective vests if necessary

Notes:

Shore & Wading Safety

☐ Wading Task Hazard Analysis read by all field staff

☐ Wading Safe Work Procedures read by all field staff

☐ Instream hazards identified (i.e. log jams, deep pools, slippery rocks)

☐ PFD worn

☐ Appropriate footwear, waders, wading belt

☐ Belay used

Notes: