Concept Plans to Re-construct the Amphibian Pond at Malcolmson Eco-Park into Functioning Vernal Pools

Submitted to fulfill the requirements of the term project for Ecosystem Restoration (ENVR 9147) at Niagara College, 2021.

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Executive Summary

The term project outlines a concept plan designed to enhance the existing Amphibian Wetland within Malcolmson Eco-Park and amend it into a functioning vernal pool ecosystem. This document includes fundamental site background information about the Malcolmson Eco-Park site, results of site baseline inventories and physical characteristics, as well as all the necessary components of a restoration plan as determined by a recovery wheel analysis. Improvements upon the sites hydroperiod, topography and species composition are suggested, and all necessary resources and permits required to complete the project are outlined. A long-term monitoring and management plan are also included for the site, in order to ensure the long-term success of the project and make the effort placed towards the restoration of this ecosystem worthwhile.

Vernal pools are vital ecosystems that provide habitat for endemic species which require ephemeral pools for breeding and egg-laying. With climate change, these microhabitats are in decline as a result of warming. Species that require these ecosystems for protection during the spring and winter months are being threatened due to the drying and disruption of vernal pools. Management and monitoring for vernal pools in the Carolinian zone have become a prominent discussion in the restoration community and would therefore be a prominent addition to the suite of ecosystems present within Malcolmson Eco Park

Contents

1.0 Background Information

1.1 Malcolmson Eco-Park and Vernal Pools

Malcolmson Eco-Park is a 14-hectare public park in the north side of St. Catharine's, Ontario (Figure 1). The site, west of Welland Canal and East of Lake Ontario, was historically used as a construction ground in the early 1900's during the construction of the Welland Canal (Wilson, 2002). Today, the park is used as a natural education center for the public to enjoy themselves and to learn about the natural landscape. The park and has a unique design which divides it into different community types to promote education on ecosystem diversity. The land surrounding the park includes residential areas, the Welland Canal, and a wastewater treatment plant.

One of the habitats currently found within the park is the Amphibian Wetland/Pool habitat. The amphibian pool is located towards the south side of Malcolmson park, adjacent to the tall grass prairie ecozone can be accessed by a walking path that is commonly used by the public (17T, 644916.34E, 4786440.07N). In 1998, the site was dug up further in the hopes of retaining water all through the summer. In summer of 1999, the pool dried up, but retained water the following summer, which was most likely caused by a wet season. As seen between Figure 2 and Figure 3, the site has lost its water holding capabilities over the course of a few years. In 2002, as seen in Figure 4, the pool covered 200 meters of the property, however in recent years, the water cover of the property has decreased. There is limited information to the reason the water holding capabilities have decreased in this specific area, but there is some indication that it may be a result of substrate and warming, as well as a water main which used to be broken but has since been repaired.

As a result of this loss of water within the Amphibian Wetland, a clear need for restoration work is indicated within the site. The current ecosystem is not functioning as it should, and some interventions are required in order to restore the ecosystem to a functioning state which supports amphibian populations within Malcolmson Eco Park. It is our desire to amend the current Amphibian Wetland into a vernal pool ecosystem.

The importance of vernal pools is becoming a greater concern in the restoration and science communities due to climate change and influx of terrestrial species (Dean, et al., 2009). Increased temperatures shift inundation periods and contribute to further drying of the

Vernal pools, otherwise known as ephemeral pools or seasonal pools, are wetland depressions located in forested habitats. In Ontario, vernal pools are typically found in the Carolinian zone formed near wooded areas, forests, alvars or sand dunes (Dean, et al., 2009). They are often formed in floodplains close to other water sources but do not maintain a flow creating stagnant waters and fishless habitats.

Pools typically maintain a hydroperiod of approximately 12-35 weeks (Rothenberger & Baranovic, 2021) during spring and winter months. Water is collected during these months through inundation or rainfall and will dry during drought periods in summer and fall (Rothenberger, et al., 2019). Clay to heavy clay soils is necessary for pool impermeability and inundation. Hydrophobic soils are typically substrate for vernal pools as it has water holding capacity required for these ecosystems (Collins, 2013).

Vernal pools are a recent focus for restoration as they create physical microhabitat requirements necessary for amphibians. The unique ecosystems support a wide range of fauna including frogs, salamanders, and benthic invertebrates. Due to the absence of fish species and other large predators, viability for these species is improved (Dean, et al., 2009).

Vegetation in these communities should maintain moderate canopy cover as it is used to create protection and cool temperatures in the pool (Collins, 2013). Herbaceous and shrub vegetation can often be found surrounding vernal pools as a result of flooding. Vegetation communities create deadfall and layers of organic material providing shelter for breeding and egg laying for species that require ephemeral habitats (Rothenberger & Baranovic, 2021).

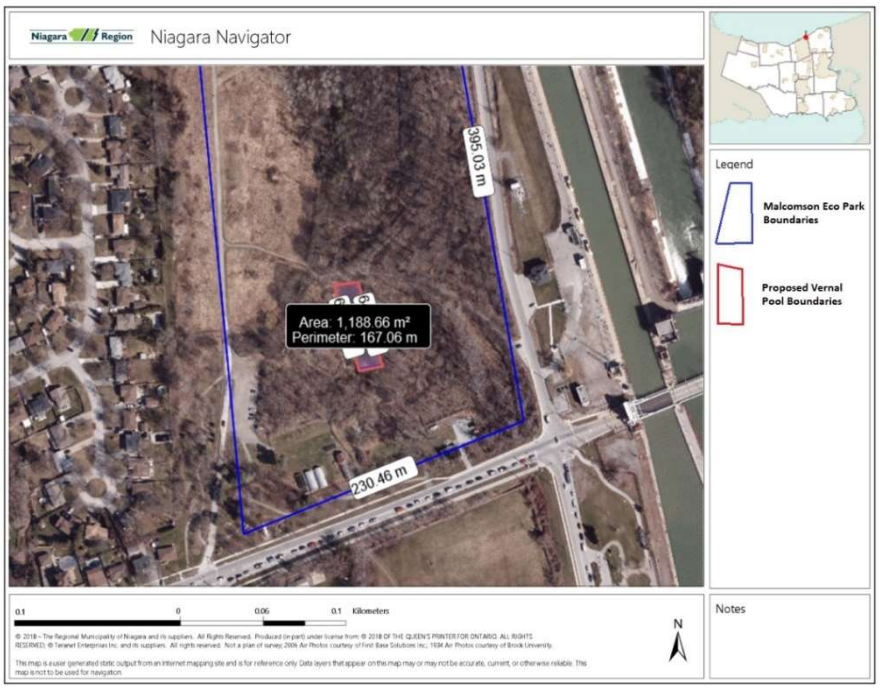


Figure 1: Malcomson Eco-Park and Amphibian Wetland Site Boundaries. Created using Niagara Navigator, 2021.

Figure 2: Amphibian Wetland at Malcolmson Park 2018. Created using Niagara Navigator, 2021.

Figure 3: Amphibian Wetland at Malcolmson Park, 2010. Created using Niagara Navigator, 2021.

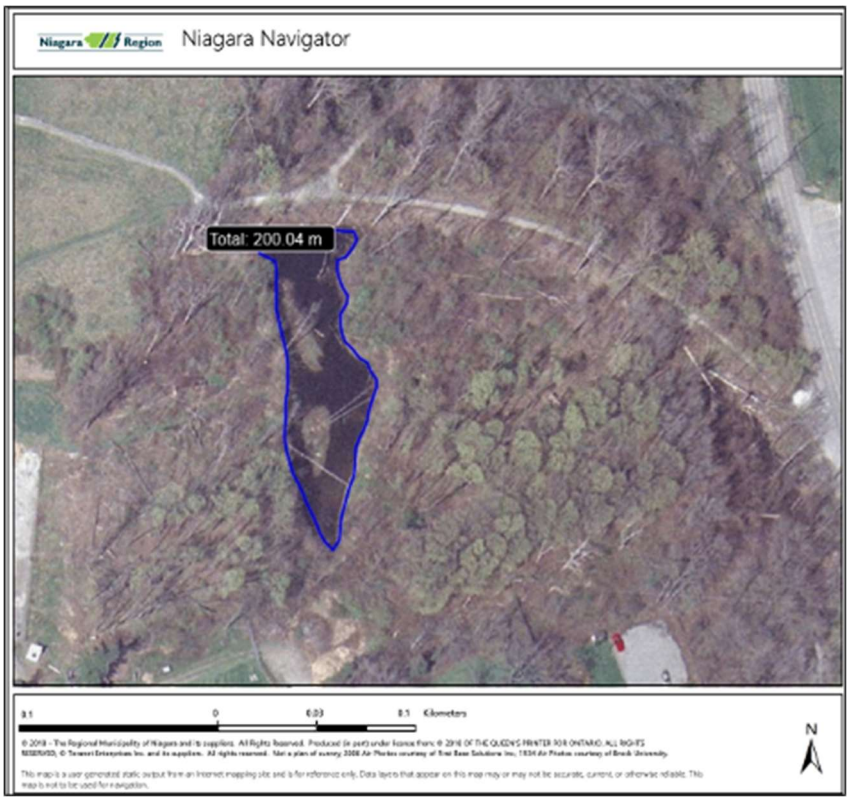


Figure 4: Amphibian Wetland at Malcolmson Eco-Park, 2002 with site perimeter (meters). Created using Niagara Navigator, 2021.

2.0 Site Physical Conditions and Inventory

2.1 Prominent Site Features

Several site visits were conducted in order to assess current site conditions and surrounding areas and assess community health and threats. The site itself is approximately 1017.63m^3 (Figure 1). Upon inspection of the site, a few prominent features were identified. It is an area with low canopy cover (>20%) and contains the remnants of an Amphibian Pond, including a large depression which is absent of water. The soil is unable to hold water for a long enough time frame for amphibian species to successfully reproduce and will therefore require to be amended. There is an existing weir on the site that has sustained some damage, as well as a piezometer which is not functional and will need to be removed. There is a considerable amount of leaf litter present at the site, as well as some existing deadfall logs that can be used as adult amphibian habitat. Vegetation is growing within the depression area due to the absence of water. There are also several button bushes plants which were seemingly abandoned in the site or possibly have been upturned from the soil frost heave. Specific plants within the site have been recorded in detail in Section 4.0, Site Inventory.

2.2 Soils

Soil augering and background research was conducted within the site in order to investigate soil conditions. As seen in Table 1, the three soil orders that are present in the soil are 63% Luvisolic, 20% Brunisolic and 17% Gleysolic. Luvisolic soils are dominant in forested landscapes underlain by loamy tills and typically consist of calcium and magnesium (Canadian Society of Soil Science, 2020). Brunisolic soils are also dominant in forested landscapes and often have slightly acidic or basic pH. Gleysolic soils are a result of prolonged water saturation of the soil profile (Canadian Society of Soil Science, 2020). This saturation is often associated with oxygen-depleted conditions resulting in mottles which is the result of iron being oxidized and gley, where iron is reduced (Canadian Society of Soil Science, 2020). However, no mottles were found in the soil sample and therefore, the soil might not be saturated long enough. The main soil types within the site were silty loam and clay loam. Results of soil sample augering are recorded in Table 2.

Table 1: Soil Orders within the Amphibian Pond Site

Soil Landscapes of Canada ID (v. 2.2 and 3.1)	56600131
Luvisolic %	63
Brunisolic %	20
Gleysolic %	17
Chernozemic %	0
Cryosolic %	0

Organic %	0
Podzolic %	0
Regosolic %	0
Solonetzic %	0
Vertisolic %	0

(Soils of Canada, 2021)

Table 2: Soil Sample Results

Sample Number	Colour	Munsell Value	Mottles	Length of Ribbon (cm)	Soil Type
1	Light Brown	2.5 YR 6/14	Absent	4	Silty Loam
2	Light Brown	2.5 YR 6/14	Absent	3	Silty loam
3	Light Brown	2.5 YR 6/14	Absent	5	Silty loam
4	Light Brown	2.5 YR 6/14	Absent	>5	Clay loam
5	Light Brown	2.5 YR 6/14	Absent	>5	Clay loam
6	Light Brown	2.5 YR 6/14	Absent	>5	Clay loam

The Soils of Pelham-Thorold-Welland map in the *Soils of Niagara* booklet has this area listed as *not mapped* (Ministry of Agriculture and Food, n.d.), so there are no official reports on what type of soil is on the site. However, it is known that water is moving through the soil quickly, which is supported by the results of at least the first three samples, which were found to be silty loam.

As no water was readily available during our site visits, we were not able to run any tests for water quality in the field or the lab. We were also unable to determine precisely how long water remains at the site, however, visitors to the site report seeing water only at some points following rain events, but not for more than a couple of days.

2.3 Plants/Vegetation Inventory

A baseline plant inventory was conducted during an initial site visit where a working list of plant species at the site was identified (Table 3). The presence of wetland plants supported the previous use of the site as an Amphibian Pond, and indicated that the site has previously held water, although there was evidence of succession occurring due to a recently transformed hydroperiod. Note that this is not an exhaustive list of species, and only reflects species which we were able to document in our initial assessment. A historic list of plant species within Malcomson Park can be seen in Appendix A. Several invasive species were identified on the site, which are indicated by an asterisk (Table 3). The biggest concerns are the Common Reed (*Phragmite australis)*, Common Buckthorn (*Rhamnus cathartica),* Norway Maple (*Acer platanoides)* and Purple Loosestrife (*Lythrum salicaria).* These are of greater concern because they spread quickly and easily, overtaking native plant species.

Table 3. Current existing plants in and around the vernal pool area.

Initial Site Visit Plant Inventory	
Common name	Latin name
Poison Ivy	*Toxicodendron radicans*
Swamp Rose Mallow	*Hibiscus moscheutos*
Virginia Creeper	*Parthenocissus quinquefolia*
Common Buckthorn*	*Rhamnus cathartica**
Staghorn Sumac	*Rhus typhina*
Norway Maple *	*Acer platanoides**
Red Maple	*Acer rubrum*
Purple Loosestrife *	*Lythrum salicaria**
Swamp Milkweed	*Asclepias incarnata*
Silver Maple	*Acer saccharinum*
Curly Dock *	*Rumex crispus**
Basswood	*Tilia americana*
Red/green Ash	*Fraxinus pennsilvanica*
Common Reed*	*Phragmite australis**
Common Buttonbush	*Cephalanthus occidentalis*
Red Osier Dogwood	*Cornus sericea*
White Willow*	*Salix alba**
Riverbank Grape	*Vitis riparia*
Maple-leaved Viburnum	*Vibernum acerifolia*
Dogwood spp.	*Cornus spp.*
Sedge spp.	*Carex spp.*
Tickfoil sp.	*Desmodium spp.*
Beggar-ticks spp.	*Bidens spp.*
Lesser Burdock	*Arctium minus*
Gypsywort	*Lycopus Europaeus*
Common Groundsel	*Senecio vulgaris*
Pennsylvania Smartweed	*Persicara pensylvanica*
Sweetflag	*Acorus calamus*
Yellow Flag Iris*	*Iris pseudacorus*

2.4 Animal Community

Currently, there is no known community of vernal pool-specific animals that use the vernal pool site, but several mammals and reptile species have been observed within the area (Brock University, Tourism Niagara, n.d.), as well as a variety of birds (Black, n.d.). Some species noted

by Brock University and Tourism Niagara to be in the area include coyotes, skunks, wild turkeys, deer, reptiles and various insects (Brock University, Tourism Niagara, n.d.). A full list of bird species that live in or near the park can be found in Appendix B.

There are several key species which commonly use or depend on vernal pools (Table 4). Benthic invertebrates comprise a large portion of these animals, and include crustaceans such as fairy shrimp, snails, fingernail clams, flatworms, caddisflies, water mites, water beetles, dragonflies, damselflies, mayflies, mosquitoes, springtails and other various aquatic insect species (Michigan Vernal Pools Partnership [MVPP], 2021). Another key group of vernal pool users are spring peepers, gray treefrogs, wood frogs, chorus frogs, blue-spotted salamanders, and spotted salamanders (MVPP, 2021). Several species of turtles have also been known to inhabit vernal pools, such as the spotted turtle, Blanding's turtle, and wood turtle (MVPP, 2021), all of which can be found in Niagara, although they are rare (Bruce Trail Conservancy, 2020). Some other regular visitors to vernal pool areas include eastern garter snakes, green frogs, great blue herons, wood ducks, red-shouldered hawks, and raccoons as they are known to feed upon the residents of these pools (MVPP, 2021).

Table 4: Common Vernal Pool Species Spawning Time Period

Common Name	Spawning Months	Reference
Spring Peepers	March – June	(Largett, et. al, 1999)
Green Frog	May – July	(Gillilland, 2000; Connecticut Wildlife, n.d.)
Eastern Gray Treefrog	May – July	(Marshall University, n.d.)
Western Chorus Frog	March – April	(Landry, 2018)
Wood Frog	March – April	(Connecticut Wildlife, n.d.)
Blue-Spotted Salamander	April – May	(Nature North, n.d.)
Spotted Salamander	March – April	(USDA, n.d.)
Eastern Fairy Shrimp	April - May	(Chesapeake Bay Program, n.d.)

3.0 Reference Site: Garner Road Slough Forest

In order to complete a recovery wheel for the Amphibian Pond site, a reference site was needed to compare ecosystem attributes. The reference site chosen to help guide our restoration planning is a slough forest located along the edge of Garner Rd near Hendershot Blvd. This ecosystem is observed to have several examples of persistent inundation throughout the extent of the site boundaries (vernal pools). These observations were made in early November, well into the fall season which experiences greater precipitation and overall moisture content. This site is not without its disturbances as it shares a border with Garner Rd and surrounding residential property. Excavated soil from neighboring homes was dumped along the periphery of the slough forest, likely from swimming pool installations. This is what resulted in such a low assessment of landscape flows in the recovery wheel analysis included below in Figure 5. This recovery wheel was included to allow for a more immediate visual comparison with the recovery wheel conducted for our proposed restoration site. Although this habitat is not a pristine model for all aspects of our analysis, it serves as a shining example of what an ideal hydro-period and topographic regime might look like for our envisioned vernal pool.

Our decision to use the Garner Road slough forest as a reference site is further supplemented after recording the observed vegetation type at the site (Table 5). The area exhibited a robust variety of native plants known to be indicator species of successful forested wetland habitats. Examples of these species can be found in table 5 including Bristly Greenbrier, commonly found in swamps and wet woods and less commonly Swamp Dewberry. An exciting revelation was made with the discovery of a Roundleaved Greenbrier specimen, as this is a threatened species in Ontario indicating the slough forest is providing an ideal habitat for our target ecosystem. These species are not all reminiscent of the habitat at Malcomson Eco Park but can serve as a benchmark to better understand the intended trajectory for our ideal vegetation community.

(See Appendix F for Images of Reference Site)

Table 5. Reference site plant community.

Common Name	Scientific Name
Shagbark Hickory	*Carya ovata*
White Elm	*Ulmus americana*
Red or Slippery Elm	*Ulmus rubra*
Rock Elm	*Ulmus thomasii*
Pin Oak	*Quercus palustris*
Swamp White Oak	*Quercus bicolor*
Bur Oak	*Quercus macrocarpa*
Swamp Maple	*Acer x freemanii*
Rough-leaved Goldenrod	*Solidago rugosa*
Common Blackberry	*Rubus allegheniensis*
Wild Red Raspberry	*Rubus idaeus ssp. melanolasius*
Swamp Dewberry	*Rubus hispidus*
White Wood Aster	*Eurybia divaricata*
Large-leaved Aster	*Eurybia macrophylla*
Carrion Flower	*Smilax herbacea*
Bristly Greenbrier	*Smilax hispida*
Roundleaved Greenbrier	*Smilax rotundifolia*
Black Gum or Tupelo	*Nyssa sylvatica*
Buttonbush	*Cepalanthus occidentalis*
Poison Ivy	*Rhus radicans ssp. negundo*
Sensitive Fern	*Onoclea sensibilis*
Jumpseed	*Polygonum virginianum*
Fowl Manna Grass	*Glyceria striata*

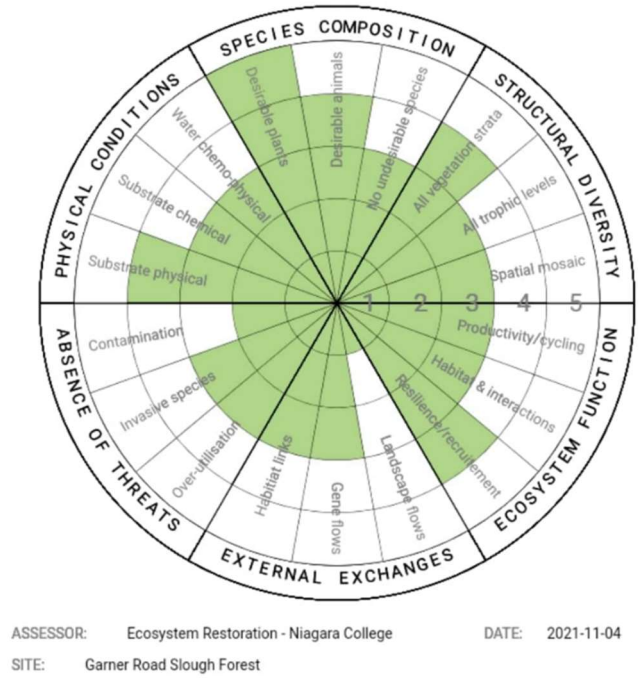


Figure 5: Recovery Wheel for Garner Road Slough Forest (reference site).

4.0 Recovery Wheel Assessment for Macolmson Eco Park Amphibian Wetland/Vernal Pools

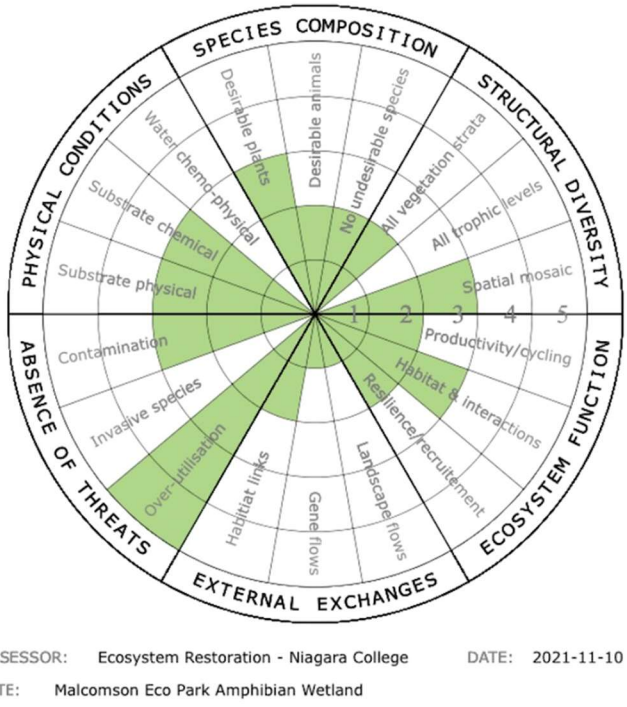


Figure 6: Recovery Wheel for Malcolmson Amphibian Pond/Vernal Pool.

Table 6. Recovery Wheel Analysis

Attribute	Rating	Rationale
1.Absence of Threats		
Over Utilization	☆☆☆☆☆	Over utilization of the site is not an apparent issue, if anything, the site is underutilized. No threats to overutilization present.
Invasive Species	**0**	Numerous invasive species are established at the site, most concerning of which is a stand of phragmite. These species must be managed before restoration can occur. Since there is no prevention of further deterioration in place, zero (0) stars were awarded.
Contamination	☆☆☆	No apparent contamination is present or increasing on the site, however, since there are no preventative measures in place for contamination, the site was given a rating of 3 stars.
2.Physical Conditions		
Substrate Physical	☆☆☆	Substrate chemical and physical properties are supportive of plant species which are characteristic of a vernal pool/wetland, including swamp rose mallow, sedges, buttonbush. However, soil conditions (clay loam/silty loam) do not support maintenance of water within the pools, unlike reference system soils.
Substrate Chemical	☆☆☆	
Water Chemo-physical	**0/NA**	No water is present within the site, preventing testing at the present time. Groundwater monitoring well is blocked with debris. Rating was not possible for the site, although it may be possible to test at other times of the year with higher moisture.
3.Species Composition		
Desirable plants	☆☆☆	Key native species present due to previous restoration efforts and use of the site as an amphibian pond (buttonbush, swamp rose mallow, sedges), however, more species should be present.
Desirable animals	☆☆/ **NA**	Desirable animals (amphibian species) were difficult to quantify due to lack of water within the site, however, once hydrology is adjusted, there are few apparent barriers to establishment of desired species.
No undesirable species	☆☆	Undesirable species were classified as those that are native or non-native and are not posing an active threat to the ecosystem but are not characteristically present within the desired ecosystem (since invasive species were accounted for in the "Absence of Threats" attribute). Some undesirable species are present within the vernal pools due to lack of standing water, but these will be removed during construction and are unlikely to persist once a suitable hydroperiod is restored.

4.Structural Diversity		
All Strata Present	☆☆	Some strata present, although missing some key aspects such as a higher canopy cover, shrub layer and water within the vernal pool. Low ratio of aquatic to terrestrial strata.
All Trophic Levels	**0**	Some key trophic levels which characterize the desired ecosystem are missing, i.e., interactions of amphibian vernal pool species. Trophic complexity is very low in the vernal pool itself.
Spatial Mosaic	☆☆☆	Mosaic present, however, not well defined and much room for improvement. The aquatic aspect is missing from the mosaic as well as vegetation cover layers.
5.Ecosystem Functioning		
Productivity, cycling	☆☆	Cycling occurring within the ecosystem, however, not on the desired spectrum and key aquatic elements missing. Site is within a functioning forest; however, goal is a vernal pool which is accompanied by its own forms of cycling and productivity which are not present.
Habitat Interactions	☆☆☆	Many habitat aspects are present (I.e., woody debris, leaf litter), although key aquatic elements are missing. Provision of habitat for species is happening but not currently involving desired amphibian species.
Resilience, recruitment	☆☆	Again, some evidence of potential for species resilience and recruitment, but without a proper hydroperiod these aspects are not yet possible within the ecosystem.
6.External Exchanges		
Landscape flows	☆	High potential for exchanges of water, species with surrounding landscape, however, water is moving through the system too quickly, and not being maintained for an ideal time period to allow for species exchange.
Gene flows	☆	Some suitable habitats for amphibians on-site, but there is a disconnect from current site due to lack of water and therefore no way to facilitate gene flow.
Habitat links	☆☆	Surrounding habitat is conducive to amphibian species, however, lack of water in the vernal pool is limiting key habitat aspects contributing to species establishment.

5.0 Target, Goals and Objectives

Target: To convert the historic amphibian pond into a functional vernal pool with surrounding native vegetation, suitable topography and seasonal water pooling for desired amphibian species.

Goals and Objectives:

1.Establish a more hospitable vegetation community within 30 meters of the vernal pool within 1 year

- Reduce invasive species abundance within a 30-meter buffer of the proposed vernal pool to less than 5% within the first year of the project.
- Plant 10 native shrub and herbaceous species within a 10-meter radius along the banks of the vernal pools in order to enhance wildlife habitat, within the first year, preventing further spread of invasives and stabilize the soil.
- Plant at least 4 native tree species near peripheral areas from in order to promote a thicker canopy cover (greater than 60%) to increase shade over the vernal pools within the first year.
- Prevent herbivory and monitor health of planted species for at least three years post planting.

2. Construct a more suitable landscape that provides increased accessibility along with an adequate hydro-period needed for various stages of vernal species' life cycle within 1 year

- Regrade the bank edges to a slope no greater than 25% (1:4 gradient) to allow easier access for smaller vernal pool species within the first year.
- Use excavated soil from regrading to fill in the existing depression which is too deep for the intended reference site conditions within the first year.
- Line the base of the proposed pool area with heavy clay to decrease permeability by 30%-50%, assisting in water retention throughout seasons within the first year.
- Repair the existing weir to ensure the water level in the pool does not exceed 1 meter in depth within the first year.

3.Enhance species diversity of amphibians within the vernal pools and surrounding 30-meter radius within 5 years.

- Increase suitable habitat features for amphibians within 3 years, supplementing the site with features such as woody debris, leaf litter and vegetation cover.

4.Set up monitoring protocol to ensure long term success of the restoration initiative for 5+ years post restoration

- Install a staff gauge and level logger after the construction phase (first year) in the vernal pool to record water levels throughout the year, ensuring appropriate hydrologic conditions
- Develop short term and long-term monitoring strategies with periodic site visits (biweekly) to provide group-truthing on instrument readings and record species inventories (monthly), spanning at least 5 years post construction

6.0 Restoration Plan Rationale, Priorities and Limitations

6.1 Rationale

As briefly stated earlier, we have decided to reconstruct what was previously known as the "Amphibian Wetland" into two functioning vernal pools. After consulting the restoration decision tree provided by the Society for Ecological Restoration, amending the current ecosystem was deemed to be the optimal option within reasonable constraints (Gann et al., 2019). This was decided after a baseline site assessment determined that the conditions of the degraded area including existing vegetation and hydrology were no longer conducive to an amphibian pond but are more appropriate for the target ecosystem of a vernal pool. The intended ecosystem for this restoration is a deciduous forest vernal pool with canopy cover greater than 60% which is rich in native understory shrub and herbaceous species within the riparian and peripheral zones. It was decided that the vernal pool would be created in the area of the existing amphibian pond, in order to use the area to its full potential and minimize the disturbance to other ecosystems within the park. This will also allow accessibility for public viewing. Vernal pools are crucial wetland ecosystems that support the habitat requirements for a diverse variety of biological communities, and they are one of the most commonly lost or degraded ecosystems due to their seasonal hydroperiod. As stated earlier, vernal pools are home to a unique suite of amphibian and invertebrate species that are not able to persist in areas where water pooling is permanent. This vernal pool must be able to maintain appropriate water levels throughout the wet and dry seasons and allow ideal accessibility and habitat conditions for amphibian species.

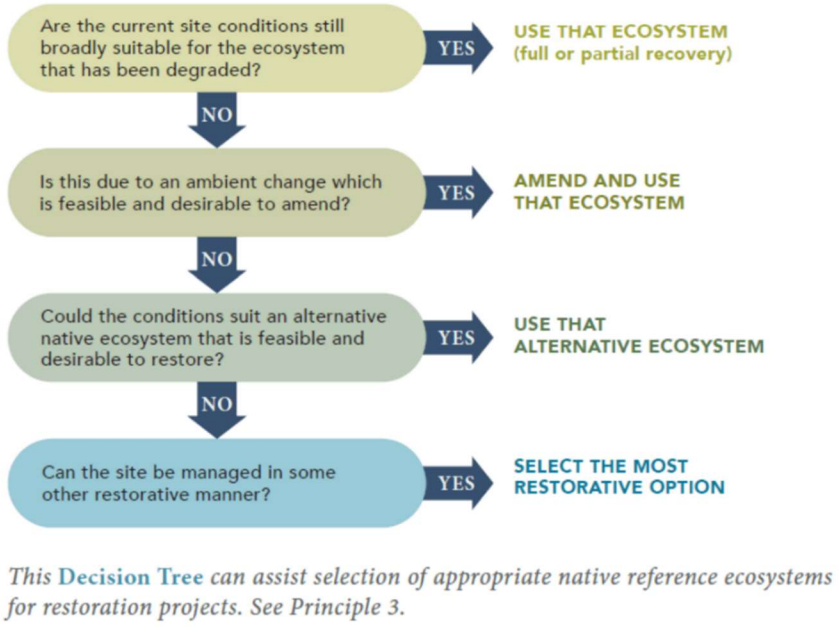


Figure 7: Restoration decision tree, Society for Ecological Restoration (2019).

In its current state, the primary stressor which the proposed vernal pool site is lacking is periodic flooding. Historically, the site held water for most of the year, however, in recent years this has been altered and the hydroperiod for the site is insufficient to support a vernal pool ecosystem. In order to be restored and reconstructed into a functioning vernal pool, the stressor of periodic flooding will need to be reintroduced. Limiting factors to the site includes the small area of the site, and the use of the park as a recreational area. The project will need to be limited in its scope since the park cannot be closed for extended periods of time. There are also numerous public access points to the site which will need to be addressed when heavy machinery is being used. The park itself is also situated within a busy urban area with nearby residential areas. Limitations also exist for the creation of vernal pools, as water must not be allowed to persist permanently or increase to a depth of greater than 1 meter (Government of Nova Scotia, 2017).

The primary site condition that needs to be repaired pertains to the topographic characteristics of the site's landscape along with the adjacent land uses and their functions. The state in which the degraded site exists does not allow adequate pooling of water which disrupts the ideal hydro-period needed for a functional vernal pool and establishment of amphibian populations. Not only is the soil composition inadequate for sustained water retention, but the depression itself is too deep as it stands with edges that are beyond an acceptable slope that would allow a stress-free exit for juvenile amphibians.

Following the primary physical landscape features of concern, canopy cover is another feature that is lacking for the vernal pool in its existing state. Since ephemeral water within vernal pools needs to remain cool to provide a hospitable environment for amphibians and other aquatic species, overexposure to sunlight poses a threat to the vernal habitat. Reduced canopy cover can also be translated to a reduction of detritus production and cycling within the pool. Leaf litter is a vital component in nutrient and energy cycling in these delicate habitats, also providing protective cover from predatory species.

6.2 Conceptual Planning

Maintaining transparency and a coherent line of communication with the City of St. Catherine's Parks and Facilities division is of the utmost importance on this project, serving as one of the driving motivations for this proposal itself. Constraints that have not been mentioned yet include the source of labour, specific details of the available budget, and a potential timeline including any deadlines for intended restoration activities. Funding would ideally be sourced from the City of St. Catharine's Parks and Facilities division as is subject to further discussions with the Parks manager. Budget limits have not been definitively set though the aim of our equipment and resource investigations has been to minimize costs as much as possible. There is no apparent requirement for a deadline since Malcomson Eco Park is public property and as such does not demand any temporal stipulations on restorative initiatives.

A detailed summary of the restoration timeline is included below in Table 8. Any required labour will chiefly be the task of our conservation team. If any essential equipment for the construction phase requires advanced certification that is not held by a member of our team, outside sources with the necessary certification will be consulted to execute the task in question. Finally, the Friends of Malcomson Eco Park will be notified of the restoration project in order to recruit

potential volunteers for the planting phase of the site preparation. This will be used to accelerate the process while reducing labour loads on our conservation team. Volunteer efforts are appreciated and will be used as a supplementary effort; however, they will not be considered a dependable or primary labour source.

6.3 Preliminary Tasks

Important preliminary tasks that have been outlined thus far in our proposal include a baseline recovery wheel analysis delineating key deficiencies and mechanisms of disturbance, the establishment of a reference ecosystem, and the development of objectives to complement our intended goals for the restoration project. At this stage, we have decided to appoint Taylor Hamel as the project lead who will be directing the course of our efforts and will be the primary point of contact for any legal concerns or general inquiries from the City of St. Catharine's and its citizens. Budgeting for equipment and materials needed was conducted for both the vernal pool construction and the planting plan which will be elaborated upon in greater detail under the Resources, Equipment, and Budgeting section of this report.

Pre-project monitoring led to the assessment of our intended goals, site stressors/limitations and the creation of a baseline inventory of plant species that can be found in Table 3under the Plants/Vegetation Inventory section. Effectiveness of our possible restoration techniques has been confirmed by investigating successful case studies of vernal pool restorations. We also followed guidelines set forth by Calhoun et al., 2014 for successful vernal pool restoration. These case studies essentially applied very similar approaches to their restoration projects with adjustments to their specific needs. Additional research has been conducted into the species selected for the planting plan in order to achieve the most harmonious transition towards our idealized reference community. The final aspect that must be considered in the preliminary phase is beginning to imagine how the project will be carried out in situ. Due to the proposed use of heavy machinery required for the vernal pool construction, access points and necessary blockade locations have been outlined in figure 8. Any required training would be sourced through external parties if it was not within the expertise of our team (i.e. Heavy Equipment Operator training).

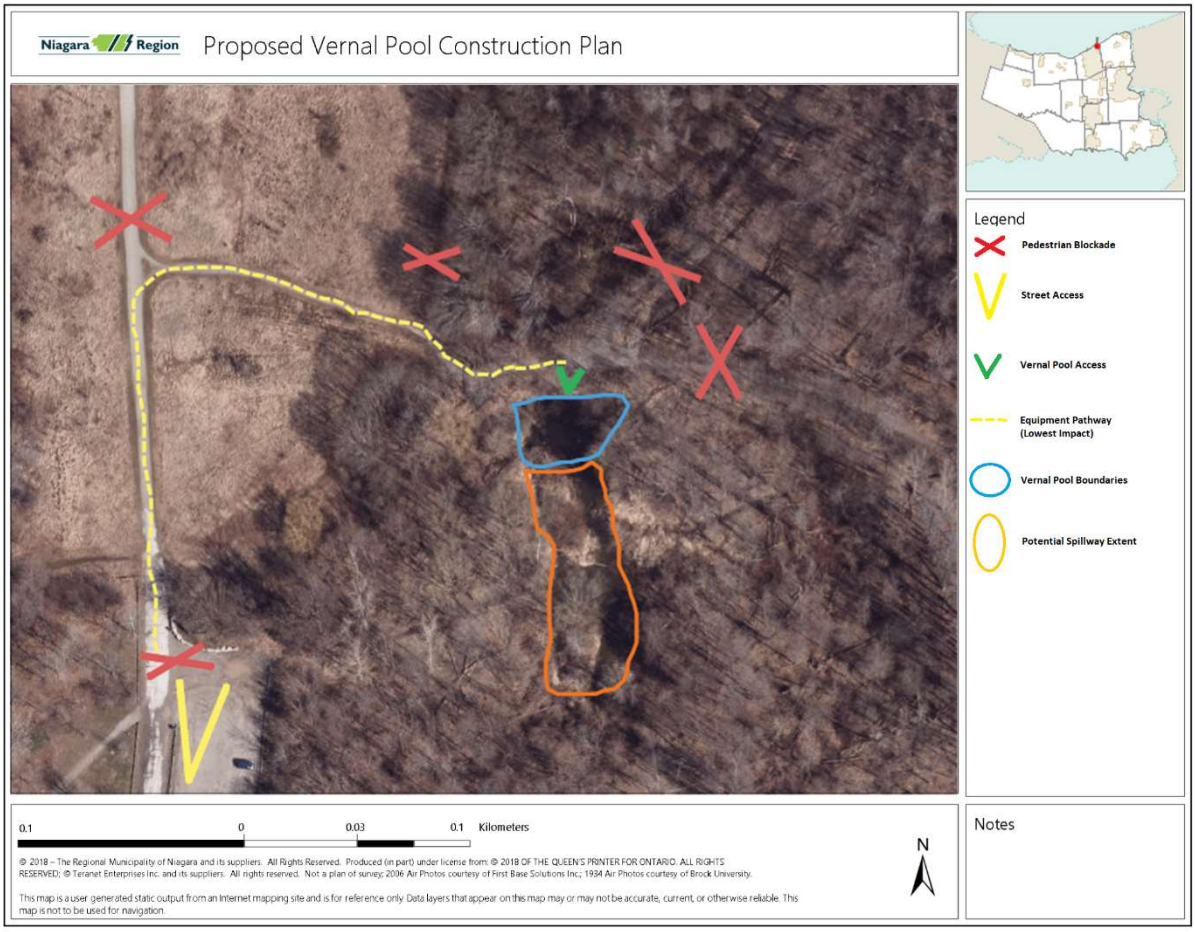


Figure 8: Conceptual diagram of the proposed vernal pool construction plan, including a path of lowest impact for heavy machinery.

7.0 Site Preparation and Implementation Strategy

This section will provide a detailed written description of the implementation of our restoration, including concrete tasks with accompanying timelines and labour considerations.

7.1 Invasive Species Removal

The first of the biotic interventions that needs to be addressed is the presence of invasive species threatening the existing and intended vegetation community. A small stand of *Phragmites australis* was noted during site assessments. These small clusters are already showing their dominance, however, since the stand is no greater than 10 m^2, the proposed removal will be a hand-pulling method. Herbicide use is not permitted in this case since standing water will be present on the site, and herbicide can threaten the sensitive vernal pool species. In case the stand spreads during monitoring, other management practices will be introduced. Buckthorn was also observed along the northern bank of the current site which has the potential to create dense thickets that will outcompete other shrub and herbaceous species. This will be removed using a weed wrench where possible. Additional herbaceous invasives that were identified include purple loosestrife, curly dock, and yellow flag iris. These have been deemed a lesser priority to

phragmites and buckthorn but will be hand-pulled wherever observed. Norway Maples and a White Willow tree were found growing within the boundaries of the site, yet these tree species could still provide considerable eco-services for the site through canopy cover and detritus production. Considering the size of the White Willow tree, removal would be inefficient and costly and is therefore not a target for removal within the scope of this project. Invasive species removal will mark the beginning of project implementation and will be completed during the first two weeks of August with a team of five staff members and Malcolmson Eco-Park volunteers whenever possible. This is the best time to remove phragmites without contributing to stand density, and the time where other invasives are easily identifiable and have not yet gone to seed (Natural Resources Conservation Service, n.d.).

7.2 Wier Repairs

The weir that is currently on site has been damaged over time therefore needs repair. The cap of the weir has been cracked and has filled with organic material. Extraction of organics will be by hand and a contractor will be brought in to quote the price of the weir repairs. The weir is necessary for water depth control and preventing water from overflowing into the floodplain. A piece of plywood with a V-notch will be installed to manage depth and flow volume.

7.3 Construction of new pools

As the existing pool is not holding water for long enough to support target species, we are proposing to redesign the current amphibian pond area into two new vernal pools. Based on the soil information in the site physical conditions section, the water is not being held there for long enough due to the current soil texture. What we are proposing is to excavate two new holes within the existing site that have dimensions of 2.6 meters long by 2.85 meters wide by 1.2 meters deep with an oblong shape. The holes will then be lined with 0.6 meters of material that can keep the water in place, such as clay. This will be accomplished using an excavator or a skid steer, and this machinery will also be used to remove the leaf litter, vegetation and debris existing in the vernal pool area.

There are a few different types of clay that are considerable for this project. The ideal option would be highly compacted bentonite clay, which has a permeability rate of 5×10^{-15} meters/second, however, this clay is very expensive because it must be imported from outside of the country and it is somewhat rare (Pusch, 1980). An alternate option would be to use heavy clay, which has a permeability rate of $>3.61 \times 10^{-7}$ meters/second (O'Geen, 2013). Heavy clay can be found in abundance locally, and a soil compactor can be used to tightly compact it. The costs associated with this are discussed in Section 9.1. Since the slope within the current amphibian pond area is quite steep, we are also proposing to use the excavated soil from the new pools to create a more gradual slope for easier access to the pools by amphibian species. This part of the project will be completed in the first two weeks of September.

7.4 Leaf Litter and Habitat Additions

Since current leaf litter and woody debris will need to be removed from the amphibian pond site prior to the excavation and lining of the new pools, these valuable habitat features will need to be reintroduced after construction of the pools is complete. Leaf litter will be collected from

surrounding areas and placed into the new vernal pools to begin the process of habitat creation within the pools, and woody debris will be distributed around the new vernal pools.

There are also various additions which can be made to the surrounding area in order to enhance habitat for vernal pool species. Some species of salamanders use woody debris to hide from the sun (Canadian Herpetological Society, n.d.). There are already some logs on the site for them, but they could be laid out more strategically around the area, within a 30-meter perimeter. In order to further enhance habitat, we recommend using fallen trees (possibly those that have fallen across trails and would already need to be cut up) from other areas of the park to supplement habitat for adult salamanders. Though the focus of this project is mainly to enhance salamander, frog and invertebrate species, there are habitat enhancements that exist which could be used to increase habitat for turtles if desired. For example, small boxes could be built or purchased and placed throughout the area for turtles to regulate their body temperature (Toronto Zoo, n.d.).

7.5 Planting Plan and Species List

A low abundance of plants will be located within the vernal pool itself, and focus will be placed on planting in the areas surrounding the proposed vernal pool to provide shade and sources of refuge and leaf litter used by vernal pool animal species (Calhoun et al., 2014). Table 7 outlines the proposed planting list. All these plants can be sourced from Verbinnen's Nursery Ltd (Verbinnen's Nursery Ltd, 2021). Some plants can be found on-site at Malcomson park as well and can either be transplanted to better locations or used to create cuttings to place where they are needed. A detailed planting map can be found in Figure 9.

Planting will take place over 1-2 days following the construction and lining of the vernal pools in order to avoid possible damage to the plants during construction. Ideally, the project team will undertake the planting with help from volunteers of Friends of Malcomson Eco Park, or students from Niagara College.

Table 7. Proposed planting list.

Common Name	Latin Name	Method? (Seed/cuttings/transplant/plugs)	Cost
Trees			
Black Willow	*Salix nigra*	1 gallon	1 gallon for $7.84 (x 5)
Swamp White Oak	*Quercus bicolor*	Seedlings/1gallon	100-125 cm for $10.32 (x5)
Tulip Tree	*Liriodendron tulipifera*	1 gallon	40-75cm for $7.49 (x 5)
Silver Maple	*Acer saccharinum*	2gallon	150-175cm for $16.20 (x 5)
Shrubs			
Black Raspberry	*Rubus occidentalis*	Plug	2x5" for $3.18 (x10)
Button Bush	*Cephalanthus occidentalis*	Transplant/Relocate/Properly Plant Existing	Malcolmson
Nannyberry	*Viburnum lentago*	Bare Root	$4.13 for 50-75cm (x5)
Red Osier Dogwood	*Cornus sericea*	Cuttings/Plug	Malcolmson / 2x5" for $3.05 (x 10)
Gray Dogwood	*Cornus Racemosa*	Bare Root	Malcomson/ 75-100cm for $3.60 (x 5)
Swamp Rose	*Rosa palustris*	Plug	2x5" for $3.18 (x10)
Perennials			
Great Blue Lobelia	*Lobelia siphilitica*	Plug	2x5" for $2.85 (x 10)
Swamp Milkweed	*Asclepias incarnata*	Plug	2x5" for $2.85 (x 10)
Swamp Mallow	*Hibiscus palustris*	Transplant/Plug	Malcomson/ 2x5" for $2.85 (x5)
Sedges/Grasses			
Fox's sedge	*Carex vulpinoides*	Plug	2x5" 2.42 (x25)

Figure 9: Proposed Planting Plan

7.6 Herbivory Prevention

Following planting, deer fencing will also be installed surrounding the plants in order to prevent herbivory from deer. This will be installed immediately following planting (same or following day) and should take 1-2 hours to complete by two people.

Table 8. Site preparation plan.

Active Management	August Week 1-2	August Week 3-4	September Week 1-2	September Week 3-4	October Week 1-2	October Week 3-4
Invasive Removal						
Repairing Weir						
Excavation/ Clay Instillation/ Grading						
Leaf Litter and Habitat Additions						
Vegetation Planting and Herbivory Prevention						
Extra Room Allotted for Unforeseen Delays						

8.0 Resources, Equipment and Budgeting Costs

8.1 Machinery Rentals

Since our site was already used as an Amphibian Pond, using machinery to dig up large amounts of soil is not necessary, but some soil will be excavated and re-graded in the back portion of the site. In addition to the soil, machinery will be needed to scrape the ground of all rocks, leaf litter, and debris in order to place any type of liner as well as assist in the removal of the Piezometer. The list of potential machines to do the job has been narrowed down to a mini excavator or skid steer loaders. Both machines are used to clear debris and rocks and can accommodate smaller spaces.

The costs for these machines are very expensive, so rentals are a good cost-effective choice. The cost of renting the mini excavator varies by size, but a 1-ton mini excavator costs $927 for one week or $309 for one day (Home Depot, 2021). Skid steer loaders cost $779 for a week and $335 for one day. While costs are very similar, only one will likely need to be used. The excavator focuses a lot on digging rather than trying to level the site, but it cannot go too far without needing fuel. The skid steer loader is mainly used to level the site, but they are likely to remove more soil and rocks than the excavator. In addition to removing the current rocky surface of the pool, we need to smooth down the soil and prepare to place a clay liner on top. A heavy-duty compactor can be rented nearby for $94 a day or $376 for one week (Home Depot, 2021). In addition, a contractor is not specified with rentals, but there are local machine operators that can work for $25-$35/hour.

Clay is heavy and costly. To put down a liner of heavy clay into the two pools, 12.34 tons will be needed. According to the latest statistics on the prices of clay, the going rate is $16 USD/ton (or $20.43 CDN/ton) (Garside, 2021). This means the total cost of clay would be $197.53, but to

account for any unforeseen circumstances where more clay is needed, a total of $500 will be allocated to cover this. The cost for the dump truck to deliver this soil would be $820 per day. Alternatively, Frank Ludwig, owner of *Digmore Excavating*, has stated he could provide the clay for free, but there would be a $100 - $150 cost for the delivery per truck. In order to verify that the correct clay is provided, we can perform sampling to identify the texture and also have a laboratory run tests to see if there are any contaminants present, including various metals, Benzene, toluene, ethylbenzene and xylenes (BTEX), pesticides, Polychlorinated biphenyls (PCBs), Semi Volatile Organic Compounds (SVOC), Volatile Organic Compounds (VOC), and fecal coliforms, total coliforms or *E. Coli* (Government of Canada, n.d.). The cost of those tests would be at least $900 (Government of Canada, n.d.). Additionally, there could be unexpected components of the soil which may not show up in these tests, such as invasive species within the seed bank of the soil.

8.2 Planting

The next step involved in our plan is planting native species around the pool and mulching exposed dirt. The purpose of mulching is to avoid erosion along the shoreline and can also improve soil fertility and support growing vegetation (Home Hardware, 2018). Healthistraw garden mulch can be purchased at any hardware store at $25.99/20 lbs (Home Hardware, 2018) bag. Before planting species, invasives (particularly the phragmites) in the pond area and the spillway must be removed. The Canadian Council on Invasive Species reported that phragmites removal costs $865-$1112 per hectare (Canadian Council on Invasive Species, n.d.). Tree and shrub removal by an arborist is on average $700-$750, but with respect to the invasive buckthorn, clearing several in the area can cost up to $500 (This Old House Reviews Team, 2021). Other methods of planting for specific species can be found in Table 7. The cost of deer fencing for herbivorous protection is also considered. For 200 m of fencing to surround the installed plants, the price would be $280.

All data is summarized in Table 9 including potential alternative prices for resources. This includes machinery, flora implementation, and post-implementation resources. Pre and post costs may vary as new information comes to light during the process, but the estimated cost of implementation is ~$3000.

Table 9: Estimated costs of all equipment and resources needed to build the vernal pool at Malcolmson Eco Park.

	Size	Costs	Alternate Costs/Sizes
Machinery Rentals			
Mini-Excavator	1.5-2 ton	$309/day	$927/week
Skid Steer Loaders	1700 lbs	$335/day	$779/week
Compactor	-	$94/day	$376/week
Machine Operator	-	$27/hour	$25-$35/hour
Flora Applications			
Straw Mulch	20 lbs.	$25.99	-
Plant Stock Costs*	Varies	$540.45	-
Removing Phragmites	1 hectare	$865-$1112	-
Removing Other Invasives	Average	$700-$750	Costs for plant removal varies between $150-$2500 depending on size, species, and quantity
Other			
Clay Liner	12.34 ton	$500	$900 in testing costs only (soil is free)
Dump Trucks	$10m^3$	$820/day	$100-$150
Deer Fencing	200m	$40.00 for 100 feet x7 (~200m) (Amazon) = $280.00	-
Post-Implementation**			
Water Quality Equipment	-	$325	-

* *Please refer to table 7 for specific plant prices*

** *Details regarding post-implementation are listed in* Long Term Management and Monitoring

9.0 Permits Required

Redevelopment of vernal pools in Malcolmson Eco-Park would first need permission under O. Reg. 155/06: Niagara Peninsula Conservation Authority: Regulation of Development, Interference with Wetlands and Alterations to Shorelines and Watercourses under the *Conservation Authorities Act R.S.O. 1990, c. 27*. Under section 4, subsection 1-7 of the regulation, it is required to fill out an application whereby the restoration plan is outlined and further approved. Should the restoration project be approved, the period of validity will be granted between 24-60 months depending on the reasonable time approved by the Ministry of Ontario.

Removal of Invasive Species

The removal of buckthorn and other small invasive trees will be required at the restoration site for landscape purposes. Obtaining a permit may be necessary for these advancements prior to the redevelopment of the property as per *the Tree Act*. *Phragmites australis* was also seen on site, should monitoring efforts record spread of species over time, removal will be necessary. The use

of herbicides may be used over time should the concern grow. Under the *Pesticides Act,* both license and permits are required for control of invasive species. Therefore, when concern for invasive species such as *Phragmites australis* increases, proceeding with application for permits will be necessary.

Clay deposit into Vernal Pool Site

Under the *Environmental Protection Act, O. Reg. 406/19,* clay depositing is required by permit only if the site is removing excess soil. In this case, the vernal pool site will deposit heavy clay soils into the site to create impermeable habitat. Should there be a need for removal and transferring of excess soil, the permit would then need to be obtained.

10.0 Long Term Management and Monitoring

Long-term management for the site will involve a monitoring plan and an adaptive management approach, as there is some uncertainty associated with the creation of new vernal pools. A monitoring plan is essential in order to ensure the long-term success of the project. It is standard for monitoring to occur for a minimum of five years following the completion of the installation, however, monitoring is encouraged to occur for an extended period (10+ years), as some species may take longer than five years to establish (Calhoun et al., 2014). Success of the project will be measured against completion of specific goals outlined in the conceptual plan, which will be represented by quantitative and qualitative measures. Due to the small size of the site, thorough monitoring is feasible. After the second year, a new recovery wheel assessment will be administered to identify and highlight successful improvements made within the site. This will be repeated after the 5-year mark, as well as the 10-year mark, should monitoring still be occurring at that time (highly recommended). It should be noted that monitoring for predators will not be part of the monitoring plan as they are necessary for population control. However, if the counts of indicators are very few every year, adding predator monitoring should be adjusted into the monitoring plan. Table 11 further below illustrates the time frame of monitoring and active management phases over a 10-year period.

10.1 Proposed Measures

Quantitative:

- Water depth (m)
- Water quality (pH, salinity, temperature, dissolved oxygen)
- Hydroperiod (time of continuous water presence in vernal pools)
- Success rate of native plantings (% survival)
- Amphibian Populations (Egg masses)
- Leaf litter (cm)
- Vegetation cover (%)

Qualitative:

- Presence of invasive species
- Presence of indicator species
    - Salamander Monitoring
    - Frog Monitoring
    - Aquatic Macroinvertebrate Monitoring
- Leaf litter decomposition stages

11.0 Implementation

Monitoring efforts and resources will be the highest in the first year and will decrease every year if required interventions are put into place in a timely manner. Ideally, monitoring efforts will be completed by two staff members, and should take approximately 2-3 hours per monitoring session, not including monitoring of individual indicator species. The site has been divided into 5 transects, which will be marked with flagging tape and used to complete several monitoring techniques. The remaining techniques will be completed within the vernal pools themselves, or within the entire site.

11.1 Hydrology/Hydroperiod

The site will be monitored intensely for the first year following installation of the vernal pool(s) in order to establish hydroperiod of the site and ensure water of sufficient depth is present at appropriate times. This will ensure that the desired amphibian species can be supported. Monitoring will commence in the winter, immediately following initial restoration steps which will mainly occur in the summer and fall. A staff gauge will be installed within the newly lined vernal pools to allow for rapid visual assessment of water levels, which will be measured biweekly. Level loggers will also be installed to continuously measure vernal pool water fluctuations. At biweekly site monitoring, water presence in the vernal pools will be noted. This will continue for the first year in order to obtain a baseline for hydroperiod of the pools, ensure they are holding water at the appropriate times and identify any alterations required for the vernal pool construction. Water level data will be compared to that of the reference site as well as against the requirements of desired species (see appendix E for sample field data sheet). Hydroperiod monitoring will measure success of objectives within Goal 2: Creating an adequate hydrological regime.

11.2 Water Quality

As soon as the presence of water is established within the vernal pool, water quality monitoring will commence biweekly in order to immediately identify any issues relating to water parameters. This will contribute towards measuring success of enhancing diversity of amphibians and creation of an adequate hydrological regime. Since the site was previously used as an amphibian pond it is unlikely that significant water quality issues will be identified, however, water quality is imperative for the establishment of desired species. Water quality parameters such as pH, conductivity, temperature and dissolved oxygen will be measured and recorded (see appendix E for sample field data sheet).

11.3 Invasive Species

Removal of invasive species is essential in order to establish a more hospitable vegetation community to support desired species within the site. Beginning in May of the year following site management implementation, the site will be actively monitored for re-emergence of invasive species. In order to effectively monitor for invasive occurrence, the site will be inspected bi-weekly beginning in May and ending in September for invasive occurrences (Table 10). The site has been divided into 6 transects, radiating from the reconstructed vernal pools (Figure 10). Each transect will be walked and any occurrence of invasive species will be tallied and marked with flagging tape. Should there be an occurrence recorded during monitoring, action will be taken within a timely manner to remove the vegetation so that the plant is unable to progress to unmanageable levels. Small plants (i.e. common buckthorn saplings) which can be easily pulled will be removed upon observation and tallied (see appendix E for sample field data sheet). Any necessary major *Phragmites* intervention will occur at the end of July/beginning of August.

Table 10: Invasive Species with known presence on the site.

Common Name	Latin Name
Common Reed	*Phragmites australis*
Common buckthorn	*Rhamnus cathartica*
Purple loosestrife	*Lythrum salicaria*
Curly dock	*Rumex crispus*
White Willow	*Salix alba*
Yellow flag iris	*Iris pseudacorus*

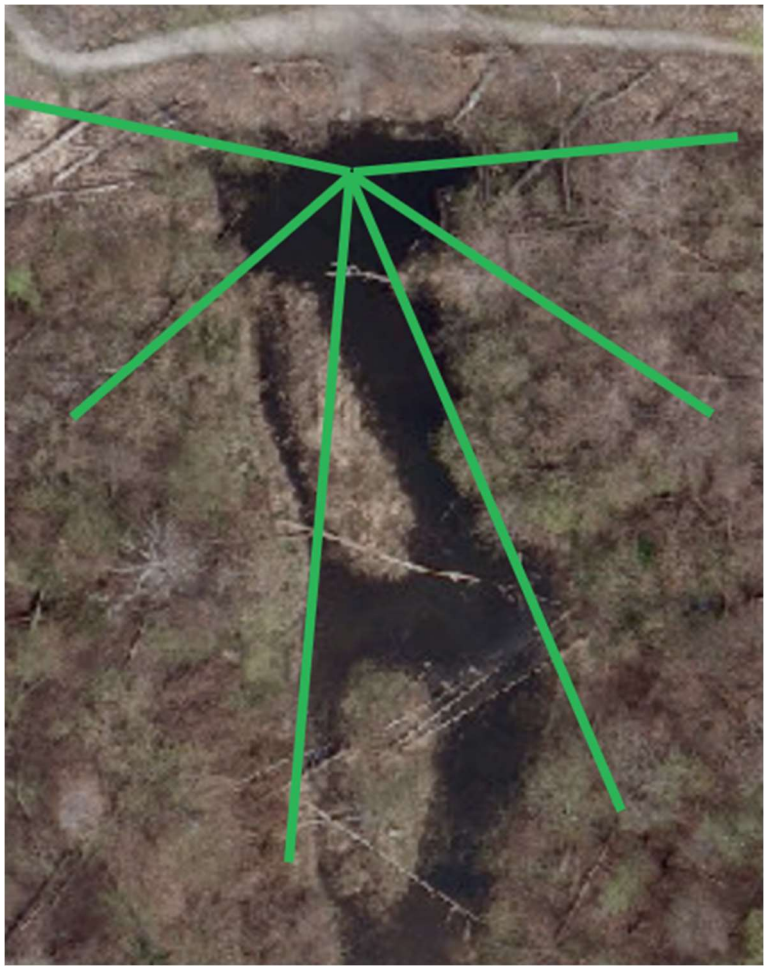


Figure 10: Vernal pool site with hypothetical transects.

11.4 Establishment of Planted Species

Planted areas will be monitored for dead/dying installed plants in order to quantify establishment success of planted species. This monitoring will occur simultaneously with invasive species monitoring; along the 6 site transects. Following the planting plan map, investigators will tally any obvious incidences of dead/dying plants which are included in the planted species list. Supplemental plantings will occur in the second year and beyond, in order to replace any lost plants. The survival of these planted native plants will be indicative of the establishment of a more stable vegetative community surrounding the vernal pool (see appendix E for sample field data sheet).

11.5 Amphibian Habitat Features

In order to monitor the amphibian habitat features within and surrounding the vernal pools, leaf litter depth and canopy cover will be monitored for the site in order to assess improvements in leaf litter build-up and shade cover for the site (shade cover effectiveness will also be reflected through water temperature). Cover will be estimated for the canopy layer as well as understory layer (see appendix E for sample field data sheet).

11.6 Presence of Indicator Species

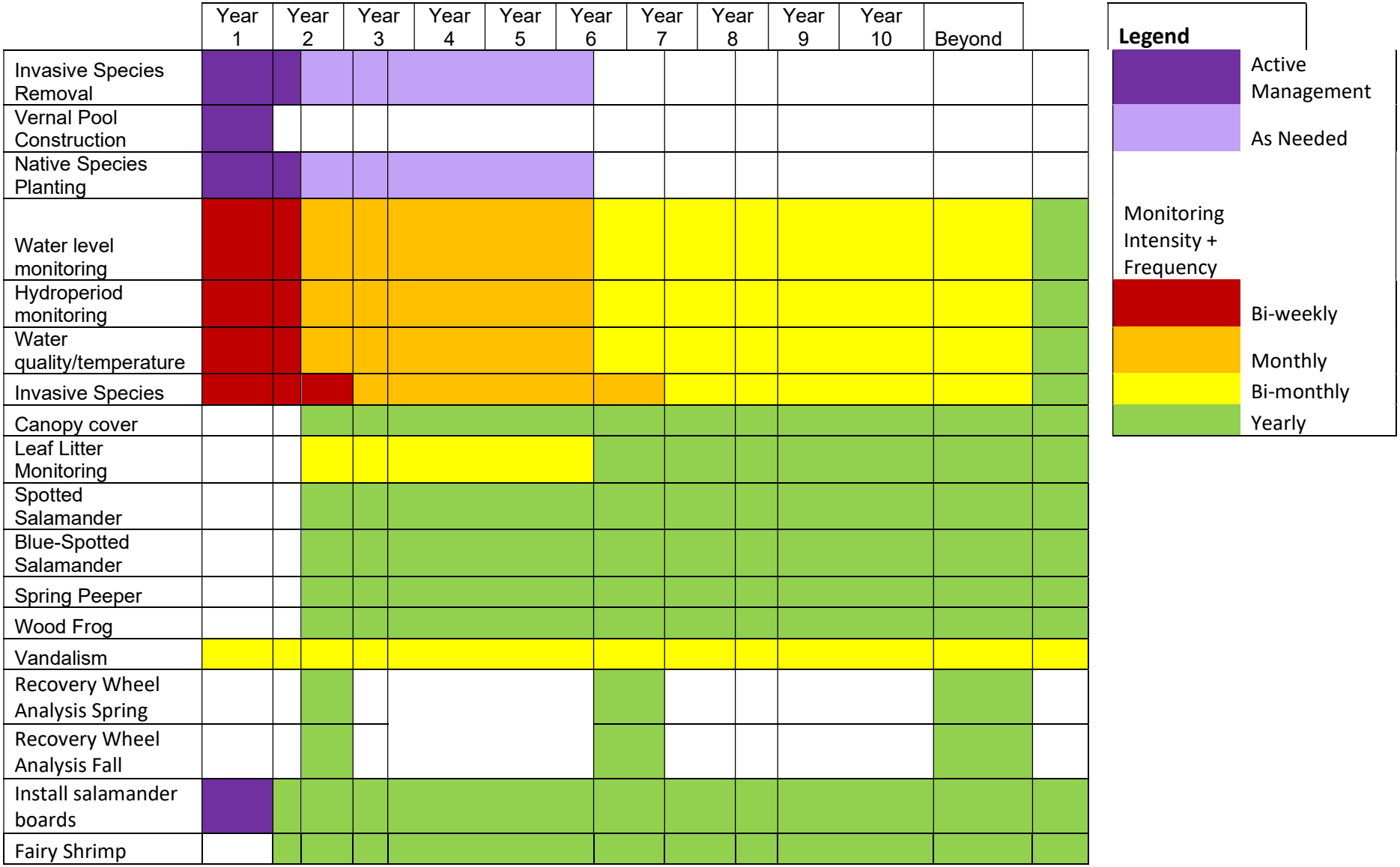
In order to indicate success of amphibian diversity enhancement within and surrounding the vernal pools, several indicator species will be monitored for their presence and evidence of reproduction within the reconstructed vernal pool. Fairy shrimp, yellow spotted and blue-spotted salamanders and wood frogs are all recorded species that occur within significant vernal pools (Calhoun et al., 2003). In order to confirm and document established populations of key vernal pool amphibian species, the pools will be monitored yearly beginning in year 3 for presence/evidence of these species, primarily through egg masses (Calhoun et al. 2003). This monitoring will be completed to verify the presence of these species and use of the vernal pool, as well as document baseline population estimates.

Monitoring for salamander and wood frog egg masses will be completed in the spring (March/April) and will consist of egg mass counts within the vernal pools. Counting egg masses is more indicative of vernal pool success than simply enumerating adults, since there is a demonstration of reproductive success occurring within the vernal pool (Calhoun et al. 2003).

Invertebrate monitoring will occur in the spring, as this is the time of year when fairy shrimp are most commonly present, and this species is an extremely important indicator of vernal pools (Thomas et al., 2010). Since invertebrate monitoring is being completed in order to document the presence of certain indicator species, the Ontario Benthic Biomonitoring Network (OBBN) protocol will be used, however with certain modifications which preserve the integrity of the vernal pool and its delicate species. For example, the coring method will be used to collect samples (not kick and sweep), and samples will be sorted in the field as opposed to in-lab to avoid mortality of sample species (Jones et al. 2007).

Additional monitoring of the site for other known amphibian species and users of vernal pools (spring peepers, leopard frogs, redback salamanders) may also be helpful, but is not essential. Initiatives such as FrogWatch outline protocols for monitoring frogs by their calls and can indicate which species may be present within a given site (Dean et al. 2008). Protocols also exist for monitoring of woodland salamanders (I.e. redback salamanders) through Environment Canada's Ecological Monitoring and Assessment Network (EMAN) (Dean et al. 2008).

Table 11: Gantt chart for long term management and monitoring.



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13.0 Appendix

13.1 Appendix A

Malcolmson Park Plant Inventory (Labelle, A., Brylowski, A., Chatelain, A., & Cox, C. (2003). A year-long study project of the amphibian wetland of Malcomson Park.)

MALCOLMSON PARK PLANT INVENTORY

(B = attracts butterflies) and (H = attracts hummingbirds)

Planted summer 1996

Grasses		
Switchgrass,	*Panicum virgatum*	
Indian grass,	*Sorgastrum nutans*	bronze fall colour
Little bluestem grass,	*Schizachyrium scoparium*	red fall colour
Big bluestem grass,	*Adropogon gerardii*	red fall colour
Canada wild rye,	*Elymus canadensis*	
Northern wheatgrass,	*Elymus trachycaulis*	
Flowers		
Flowering spurge,	*Euphorbia corollata*	white flowers
Showy tick-trefoil,	*Desmodium canadens*	magenta flower spikes (B)
Sky blue aster,	*Aster oolentangiensis*	bright blue (B)
Brown-eyed susan,	*Rudbeckia serotina*	yellow petals with brown center (B)
Round-headed bush clover,	*Lespedeza capitata*	white flowers
New England aster,	*Aster novae-angliae*	purple flowers with orange centres (B)
Hairy aster,	*Aster pilosus*	
Wetland Plants		
Blue vervain,	*Verbena hastata*	violet-blue flowers (B)

Planted 1996 and prior

Wetland Plants		
Swamp milkweed,	*Asclepias incarnata*	deep pink or rose flowers (B)
Joe-pye-weed,	*Eupatorium maculatum*	pinkish-purple (B)
Green headed coneflower,	*Rudbeckia laciniata*	yellow
Cup plant,	*Silphium perfoliatum*	yellow, seeds attract goldfinches
Foxglove beardtongue,	*Penstemon digitalis*	white (H)
Turtlehead,	*Chelone glabra*	pink (B)
Great blue lobelia,	*Lobelia siphilitica*	blue-violet (H)
Boneset,	*Eupatorium perfoliatum*	white (B)
Flowers		
Butterflyweed ,	*Asclepias tuberosa*	orange flowers (B)
Sweet ox-eye,	*Heliopsis helianthoides*	yellow
Wild bergamot,	*Monarda fistulosa*	lavender (B)
Virginia mountain-mint,	*Pycnanthemum virginianum*	white (B)
Groundnut,	*Apios americana*	light pink

Woodland sunflower,	*Helianthus divaricatus*	yellow
New Jersey Tea,	*Ceanothus americanus*	white
Azure aster,	*Aster azureus*	blue
Branched coneflower,	*Rudbeckia triloba*	
Dense Blazingstar,	*Liatris spicata*	rose-purple (B)
Pale blue Flag,	*Iris virginica*	pale blue
Cylindric blazingstar,	*Liatris cylindracea*	lavender (B)
Smooth aster,	*Aster laevis*	lavender-blue (B)

Grasses

Fringed brome grass,	*Bromus ciliatus*	

Sedges

Sedge,	*Carex species*	

Woodland Plants

Wild Columbine,	*Aquilegia canadensis*	red with yellow centres (H)
Bee-balm, (Oswego-Tea)	*Monarda didyma*	red (B) and (H)

Shrubs

Carolina rose,	*Rosa carolina*	pink
Spicebush,	*Lindera benzoin*	red fruit
Staghorn sumac,	*Rhus typhina*	crimson-red fruit
Red mulberry,	*Morus rubra*	red fruit

Trees
(spp. = species)

Tulip tree,	*Liriodendron tulipifera*
Flowering dogwood,	*Cornus florida*
Eastern red cedar,	*Juniperus virginiana*
Sweetgum,	*Liquidambar styraciflua*
Sugar maple,	*Acer saccharum*
Silver maple,	*Acer saccharinum*
Choke cherry,	*Prunus virginiana*
Hawthorn,	*Crataegus sp.*
Black cherry,	*Prunus serotina*
Pin oak,	*Quercus palustris*
Red oak,	*Quercus rubra*
Black oak,	*Quercus velutina*
Bitternut Hickory,	*Carya cordiformis*
Manitoba maple,	*Acer negundo*
White birch,	*Betula papyrifera*
American basswood,	*Tilia americana*

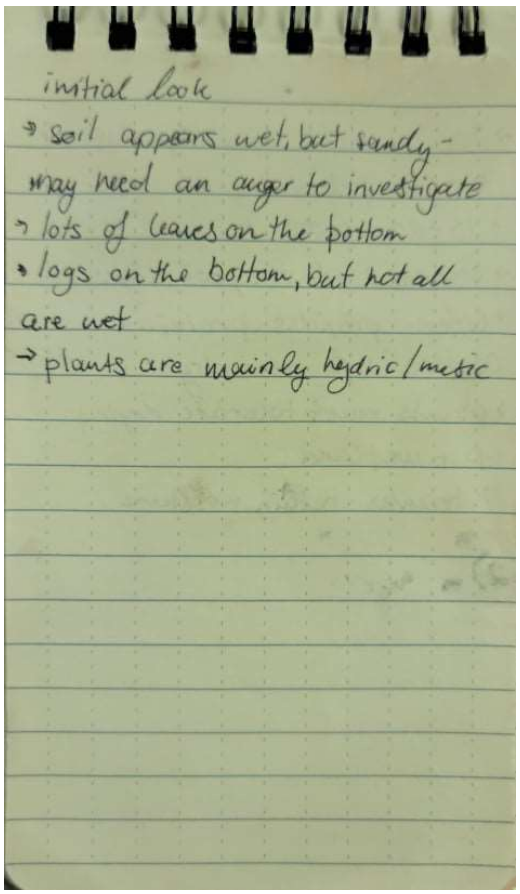
Red pine,	*Pinus resinosa*
Ironwood,	*Ostrya virginiana*
Tree of Heaven,	*Ailanthus altissima* (Exotic)
Honeylocust,	*Gleditsia triacanthos*
Black walnut,	*Juglans nigra*
Scots pine,	*Pinus sylvestra*
White pine,	*Pinus strobus*
Norway maple,	*Acer platanoides* (Exotic)
Trembling aspen,	*Populus tremuloides*
English oak,	*Quercus robur*
Butternut,	*Juglans cinera*
Northern catalpa,	*Catalpa speciosa*
Black locust,	*Robina pseudoacacia* (Exotic)
Carolina poplar,	*Populus x canadensis*
Sycamore maple,	*Acer pseudoplatanus*
Japanese maple,	*Acer palmatum*
Beech,	*Fagus spp.*
White willow,	*Salix alba x S. fragilis*
Elm,	*Ulmus spp.*
Jack pine,	*Pinus banksiana*
Fir,	*Abies spp.*
Mazard cherry,	*Prunus avium*
Larch (Tamarack),	*Larix spp.*
Chinese Elm,	*Ulmus pumila* (Exotic)

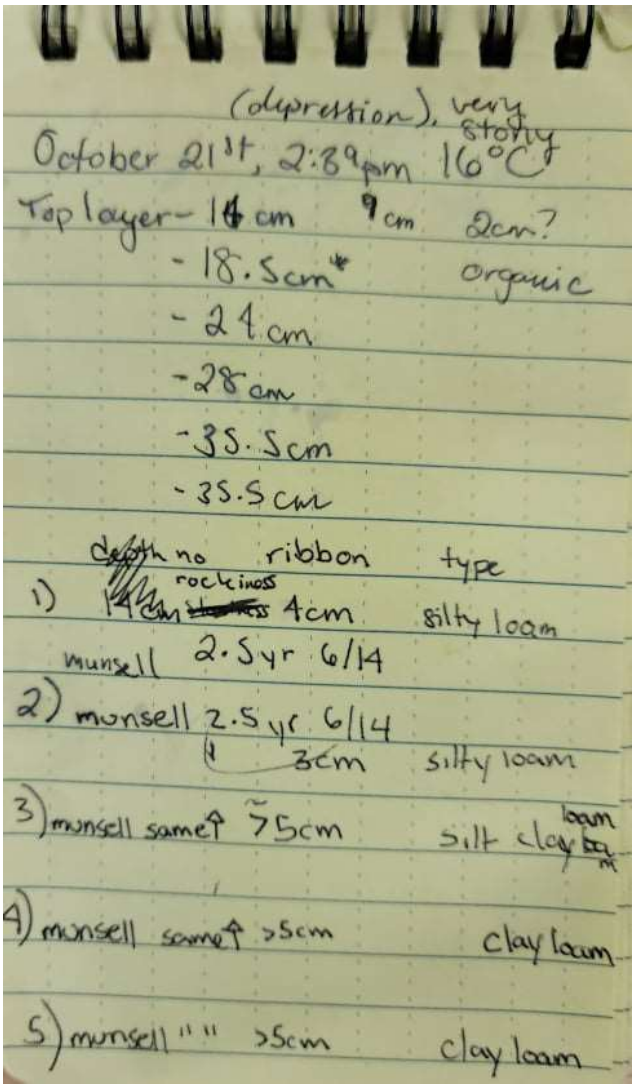
13.2 Appendix B

Table 12: Complete list of Bird Species that Live in or Near Malcolmson Eco-Park (Black, n.d.)		
Bald Eagle	American Goldfinch	Common Yellowthroat
Sharp-shinned Hawk	Evening Grosbeak	Hooded Warbler
Cooper's Hawk	Purple Martin	Wilson's Warbler
Northern Goshawk	Tree Shallow	Canada Warbler
Red-shouldered Hawk	Northern Rough-winged Shallow	Yellow-breasted Chat
Broad-winged Hawk	Bank Swallow	Double-Crested Cormorant
Red-tailed Hawk	Cliff Shallow	Ring-necked Pheasant
Horned Lark	Bobolink	Red-headed Woodpecker
Belted Kingfisher	Red-Winged Black Bird	Red-bellied Woodpecker
Canada Goose	Eastern Meadowlark	Yellow-bellied Sapsucker
Wood Duck	Rusty Blackbird	Downy Woodpecker
Green-winged Teal	Brown-headed Cowbird	Northern Flicker
Mallard	Common Crackle	Pileated Woodpecker
Common Pintail	Orchard Oriole	House Sparrow
Blue-winged Teal	Northern Oriole	Solitary Sandpiper
Common Merganser	Northern Shrike	Spotted Sandpiper
Chimney Swift	Loggerhead Shrike	Sanderling
Great Blue Heron	Common Black-headed Gull	Common Snipe
Green Heron	Bonaparte's Gull	American Woodcock
Black-Crowned Night Heron	Mew Gull	Red-breasted Nuthatch
Cedar Waxwing	Ring-billed Gull	White-breast Nuthatch
Turkey Vulture	Herring Gull	European Starling
Brown Creeper	Iceland Gull	Golden-crowned Kinglet
Killdeer	Lesser Black-backed Gull	Ruby-crowned Kinglet
Rock Dove	Glaucous Gull	Blue-gray Gnatcatcher
Mourning Dove	Great Black-backed Gull	Summer Tanager
Blue Jay	Caspian Tern	Scarlet Tanager
American Crow	Common Tern	Ruby-throated Hummingbird
Black-billed Cuckoo	Wild Turkey	Rock Wren
Yellow-billed Cuckoo	Gray Catbird	Carolina Wren
American Kestrel	Northern Mockingbird	House Wren
Merlin	Brown Thrasher	Winter Wren
Peregrine Falcon	Osprey	Marsh Wren
Northern Cardinal	Black-capped Chickadee	Eastern Bluebird
Rose-breasted Grosbeak	Tufted Titmouse	Veery
Indigo Bunting	Blue-winged Warbler	Gray-cheeked Thrush
Rufous-sided Towhee	Golden-winged Warbler	Swainson's Thrush
American Tree Sparrow	Tennessee Warbler	Hermit Thrush

Chipping Sparrow	Orange-crowned Warbler	Wood Thrush
Clay-coloured Sparrow	Nashville Warbler	American Robin
Field Sparrow	Northern Parula	Olive-sided Flycatcher
Vesper Sparrow	Yellow Warbler	Eastern Wood-Pewee
Savannah Sparrow	Chestnut-sided Warbler	Yellow-bellied Flycatcher
Grasshopper Sparrow	Cape May Warbler	Acadian Flycatcher
Fox Sparrow	Black-throated Green Warbler	Alder Flycatcher
Song Sparrow	Blackburnian Warbler	Willow Flycatcher
Lincoln's Sparrow	Pine Warbler	Least Flycatcher
Swamp Sparrow	Prairie Warbler	Eastern Phoebe
White-throated Sparrow	Bay-breasted Warbler	Great Crested Flycatcher
Darked-eyed Junco	Blackpoll Warbler	Eastern Kingbird
Lapland Longspur	Cerulean Warbler	Barn Owl
Snow Bunting	Black and White Warbler	Eastern Screech Owl
Pine Grosbeak	American Redstart	Great Horned Owl
Purple Finch	Prothonotary Warbler	Snowy Owl
House Finch	Worm Eating Warbler	White-eyed Vireo
Red Crossbill	Ovenbird	Solitary Vireo
White-winged Crossbill	Northern Waterthrush	Yellow-throated Vireo
Common Redpoll	Louisiana Waterthrush	Warbling Vireo
Hoary Redpoll	Connecticut Warbler	Philadelphia Vireo
Pine Siskin	Mourning Warbler	Red-eyed Vireo

13.3 Appendix C.
Field Notes


initial look
- soil appears wet, but sandy - may need an auger to investigate
- lots of leaves on the bottom
- logs on the bottom, but not all are wet
- plants are mainly hydric/mesic


(depression), very stony
October 21st, 2:39pm 16°C
Top layer- 14 cm 9 cm 2cm?
- 18.5cm* organic
- 24 cm
- 28 cm
- 35.5cm
- 35.5 cm
depth no ribbon type
rockiness
1) 14cm thickness 4cm silty loam
munsell 2.5yr 6/14
2) munsell 2.5 yr 6/14
4 3cm silty loam
3) munsell same ↑ ~5cm silt clay loam loam
4) munsell same ↑ >5cm clay loam
5) munsell " " >5cm clay loam

JOB MALCOMSON ECO PARK VERNAL POOLS

DATE OCT 14, 2021 PAGE 1

PLANT INVENTORY

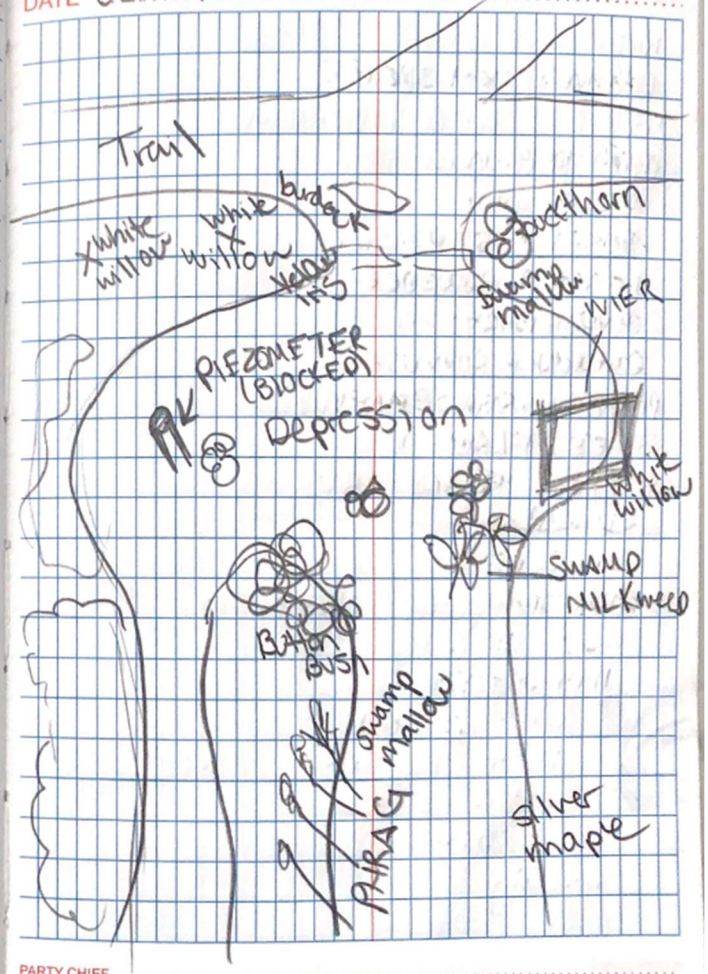
NORWAY MAPLE
POISON IVY
SWAMP ROSE MALLOW
VIRGINIA CREEPER
COMMON BUCKTHORN
STAGHORN SUMAC
PURPLE LOOSESTRIFE
SWAMP MILKWEED
SILVER MAPLE
RED MAPLE
CURLY DOCK
BASSWOOD
RED/GREN ASH
PHRAGMITES
COMMON BUTTON BUSH
- SEVERAL PLUGS PRESENT WHICH WERE IMPROPERLY PLANTED
RED OSIER DOGWOOD
WHITE WILLOW

PARTY CHIEF

WEATHER

JOB MALCOMSEN PARK VERNAL POOL

DATE OCT 14, 2021 PAGE 1



PARTY CHIEF

WEATHER

JOB MALCOMSEN PARK VERNAL POOLS
DATE OCT 14, 2021 PAGE 2

RIVERBANK GRAPE
BEGGARTICKS SPP
MAPLE-LEAVED VIBERNUM
Other DOGWOOD SP.
SEDGE sp.
TICKFOIL SPP
LESSER BURDOCK
GYPSYWORT
COMMON GROUNDSEL
PENNSYLVANIA SMARTWEED
SWEET FLAG
YELLOW FLAG IRIS.

*Downy woodpecker OBSERVED

SWAMP
SHOVER

PARTY CHIEF
WEATHER

JOB
DATE PAGE

PARTY CHIEF
WEATHER

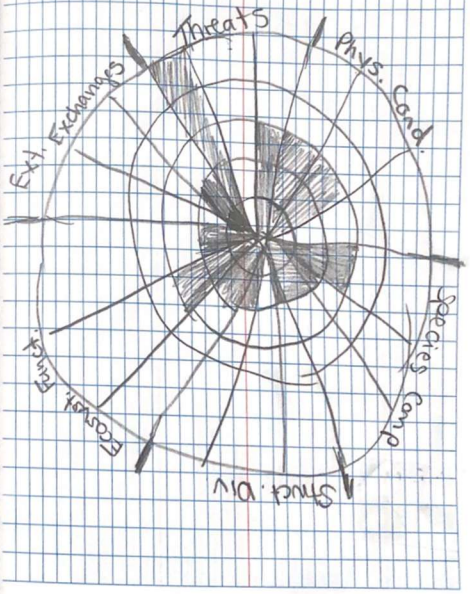
JOB MALCOMSEN PARK VERNAL POOLS
DATE NOV. 10, 2021 PAGE 3

RECOVERY WHEEL ANALYSIS

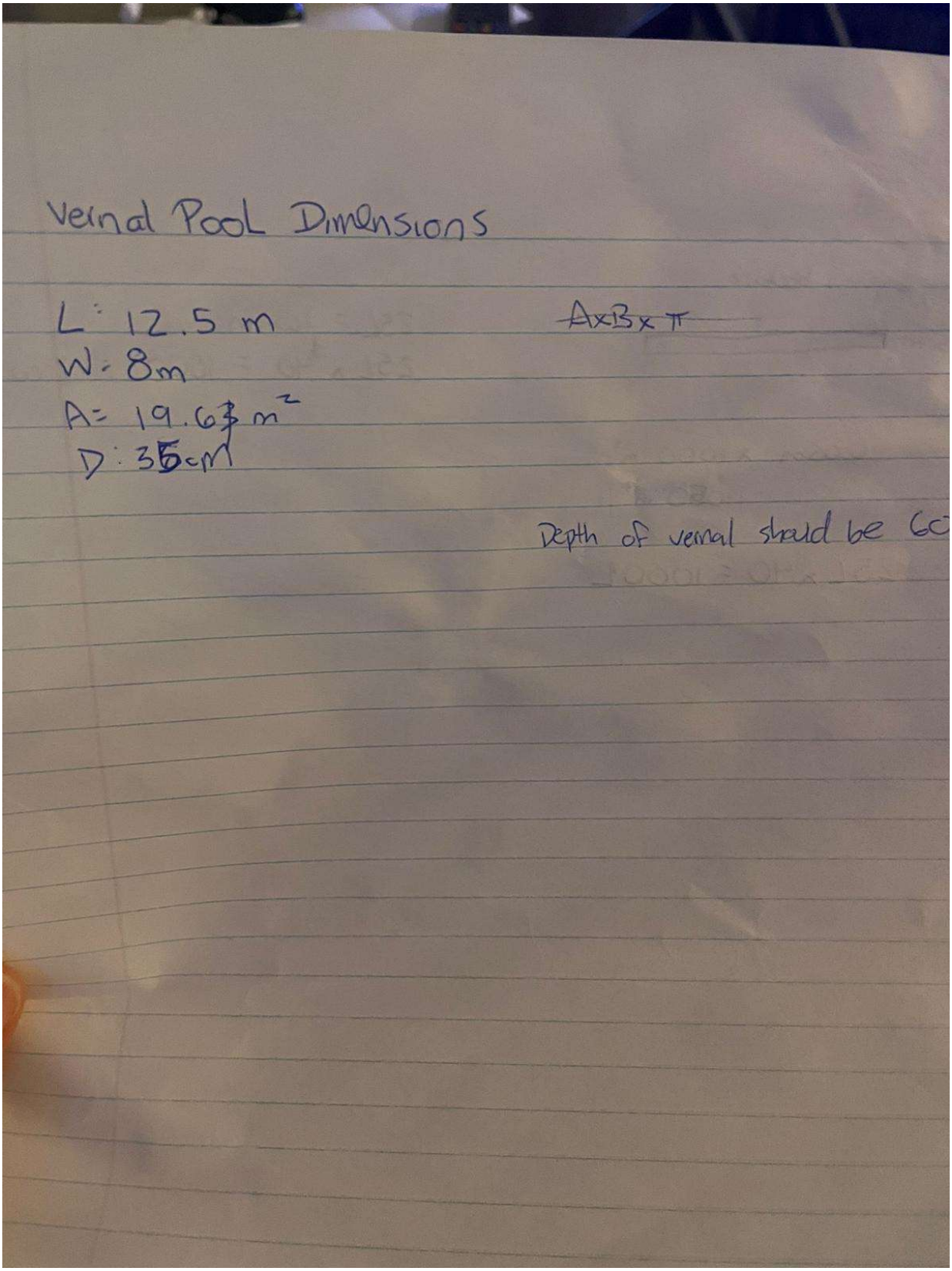
1. Threats
   - lots of invasives
   - no obvious contamination
   - not overutilized
2. Physical conditions
   Chem/phys
   - many characteristic plants present
   - check soil, no water
3. - no water, lacking desirable plants + animals
   - undesirable sp. are present, (weeds)
4. low canopy cover, no water needs more aquatic
5. High potential in area, evidence of water present sometimes needs to be more connected to aquatic aspect.
6. Steep slope, water moving through too quickly.

PARTY CHIEF
WEATHER

JOB Malcomson PARK VERNAL POOLS
DATE NOV 10, 2021 PAGE 3



PARTY CHIEF
WEATHER



Vernal Pool Dimensions

L: 12.5 m
W: 8m
A: 19.63 m^2
D: 35cm

~~A x B x T~~

Depth of vernal should be 60

13.4 Appendix D
Soil Auger Photos

13.5 Appendix E
Monitoring Datasheets

VERNAL POOLS FIELD MONITORING DATASHEET

Name_____ Date_____ Start Time_____ End Time_____Water Present? Y N

Staff Gauge (m)_____Level Logger Check ☐ Canopy vegetation cover % _____

Understory vegetation cover % _____ Vernal Pool Leaf Litter depth to bottom (cm) _____

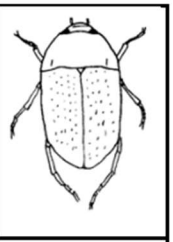
Decomposition % Discernable Leaves _____ Undiscernible Detritus % _____

Water Quality	
Temperature (C)	
Dissolved oxygen (mg/L)	
pH	
Conductivity (uS/cm)	

Invasive Species Tally						
Species	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
Common Reed *Phragmites australis*						
Common buckthorn *Rhamnus cathartica*						
Purple Loosestrife *Lythrum salicaria*						
Curly dock *Rumex crispus*						
Other						
Removed at time of observation						

Plant Survival Tally						
Species	Transect 1	Transect 2	Transect 3	Transect 4	Transect 5	Transect 6
Common Reed *Phragmites australis*						
Common buckthorn *Rhamnus cathartica*						
Purple Loosestrife *Lythrum salicaria*						
Curly dock *Rumex crispus*						
Other						
Removed at time of observation						

Ontario Benthos Biomonitoring Network Field Sheet-WETLANDS



Date:

Time

Agency:

Investigators:

Wetland Name:

Site #:

Location: centroid of 3 replicates; Lat/Long or UTM

Elevation (m asl):

Datum & zone:

Water Quality

Water Temperature (°C):

DO (mg/l):

Conductivity (uS/cm):

pH:

Alkalinity (mg/l as $CaCO_3$):

Site Description and Map

Draw a map of the site (with landmarks) and indicate areas sampled. Attach photograph (optional)
Show north arrow.

Benthos Collection Method (circle one):

- Traveling Kick & Sweep
- Jab & Sweep
- Coring
- Artificial Substrate
- Other (specify):

Gear Type (circle one)

- D-net
- Corer
- Rock Baskets
- Other

Corer/Artificial Substrate specifications:

Mesh Size: 500 micron (or specify)

Replicates	Sampling distance covered (m)	Time (min.)	Max. Depth (m)	# Pooled per replicate	Location (UTM or Lat./Long; note datum, zone)
Sample 1	TRAVELING KICK AND JABS ONLY			CORES OR JABS ONLY	
Sample 2					
Sample 3					

Substrate

Enter dominant substrate class and second dominant class for each sub-sample

	Sample 1	Sample 2	Sample 3
Dominant			
2nd Dominant			

Class	Description
1	Clay (hard pan)
2	Silt (gritty, < 0.06 mm particle diameter)
3	Sand (grainy, 0.06 - 2 mm)
4	Gravel (2 - 65 mm)
5	Cobble (65 - 250 mm)
6	Boulder (> 250 mm)
7	Bed Rock
8	Organic

Substrate Notes

Organic Matter-Areal Coverage		Sample 1	Sample 2	Sample 3
Use 1: Abundant, 2: Present, 3: Absent	Woody Debris			
and circle dominant type	Detritus			

Riparian Vegetative Community

Use: 1 (None), 2 (cultivated), 3 (meadow), 4 (scrubland), 5 (forest, mainly coniferous), 6 (forest, mainly deciduous)

Zone (dist. From water's edge)	Sample 1	Sample 2	Sample 3
1.5-10 m			
10-30 m			
30-100 m			

Aquatic Macrophytes and Algae (Use 1: abundant, 2: Present, 3: Absent. Circle dominant type)

Macrophytes	Sample 1	Sample 2	Sample 3	Algae	Sample 1	Sample 2	Sample 3
Emergent				Floating Algae			
Rooted Floating				Filaments			
Submergent				Attached Algae			
Free Floating				Slimes or Crusts			

Wetland Description (Circle)

• Marsh • Fen • Other
• Swamp • bog

Physiographic location

• Riverine, floodplain • Coastal (lakeshore)
• Riverine, headwater • Inland

Presence of Standing Water:

• Seasonal • Unknown
• Permanent

Wetland Morphometry (optional, will be calculated by OBBN Coordinator using OFAT)

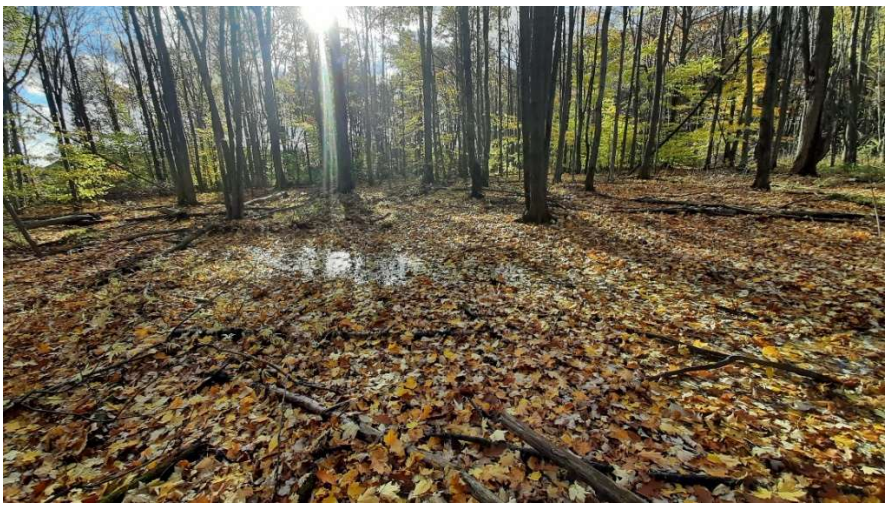
Surface area (m^2): Perimeter (m):

Notes (esp. related to land-use, habitat, obvious stressors)

Candidate reference Site - Minimally Impacted? (circle one) Yes No

General Comments

13.6 Appendix F
Reference Site Photos



13.7 Appendix G
Malcolmson photos