State of the Environment Report: Wainfleet Bog Ecosystem

Prepared by 8Trees Inc. March 11th, 2024.

8 Trees Inc.

We respectfully acknowledge that the land where we live and operate is sacred land which is situated upon the traditional territories of the Attiwonderonk (Neutral), Anishinaabeg, Mississauga, Ojibwe/Chippewa, and Haudenosaunee peoples. This territory is covered by the Upper Canada Treaties and is within the land protected by the Dish with One Spoon Wampum agreement. We are grateful to live on this sacred land.

8Trees Inc. is a Canadian owned and operated business based in the Niagara Region. 8Trees Inc., was founded in November 2016, and our primary mandate is ecological restoration and research, education, and mentoring. 8Trees began the species at risk population, habitat, and groundwater level monitoring project in 2017. From 1998 to 2016, the Ministry of Natural Resources and Forestry led the species at risk monitoring in partnership with the local Conservation Authority. All population data was compiled and summarized in this document. The data were collected under the authority of provincial and Conservation Authority regulations, permits and permissions.

Please note we intentionally did not include pictures of turtles to avoid showing locations of sensitive species. We also did not include habitat use mapping for any species at risk to avoid disclosing sensitive information. We have other reports and scientific articles compiled on this subject. Please contact us directly to discuss further.

This report contains the intellectual property of 8Trees Inc. This project is partially funded by the province of Ontario Species at Risk Fund, 8Trees Inc. and other partners. However, funding support from the province does not indicate the government's endorsement of our findings.

Comments, questions or concerns regarding the contents of this report can be directed through our web site www.8trees.ca or to support@8trees.ca .

Thank you.
Anne Yagi
President

Suggested Citation

Yagi A.R., K.T. Yagi and C. Blott. 2024. State of the Environment Report: Wainfleet Bog Ecosystem, prepared for the stewardship of species at risk. 25p. + APPENDIX 24p

"This project has received funding support from the Government of Ontario. Such support does not indicate endorsement by the Government of Ontario of the contents of this material."

Acknowledgements

When we started this project in 1998, the Massasauga and Spotted turtle were not yet listed as species at risk in Ontario or Canada. The Massasauga was an “urban myth” known to occur but had few, if any confirmed recent sightings. The Spotted Turtle project was first initiated by the public in the early to mid-1990s because they were concerned about pet trade poaching. During the study the USFWS and MNRF enforcement confirmed Wainfleet spotted turtles were part of the targeted pet trade. One of Wainfleet’s turtles was observed in a Milton Pond before it was intercepted at the USA/Canada Border, and about a year later it was returned to Wainfleet and monitored for annual survival over the next two years using radio telemetry. One Massasauga captured in 2007 was later DNA confirmed by Trent University as a suspected translocated snake from Georgian Bay.

In 2021, 8Trees Inc. formed a Delegation of Experts including Six Nations, universities and concerned individuals and presented to the Township of Wainfleet council to ask them to abandon a 1.5 km portion of the municipal drain that intercepts the Wainfleet Bog ecosystem and move the municipal drain back to its original location 300m south of the Wainfleet Bog for the stewardship and recovery of Species at Risk. The Township differed our request to the NPCA. The Delegation also met with the NPCA board in 2022 and as a result NPCA formed a public advisory committee to help manage this request. Please contact NPCA for further information.

We wish to acknowledge the following individuals for their contributions to the stewardship of species at risk within the Wainfleet Bog Ecosystem,

Rob Tervo, Devin Mills, David Denyes, Amy Parks, Kim Frohlich, Meisch Germaine, Mike Rose, Joad Durst, Don Pogue, Marc LaChaine, Mark Browning, Nelson Denyes, Susan Barbetti, Jillian Garrett, Cassandra Belmore, Michelle Karam, Nick Fattore, Anne Yagi, Katharine Yagi, R. Jon. Planck, Paulette Haché, Jacqueline Litzgus, Christina Davies, Brie-Anne Breton, Ron Arnold, Cathy Blott, Theresa Bukovics, Erica Yagi, Heather Yagi, Tom Eles, Yifeng Li, Brendan Park, Glenn Tattersall, Curtis Abney, Jonathan Choquette, Steve Marks, Liette Vasseur, Rick Vos, Andrew Lentini, Bob Johnson, Dr. Alistair Kerr (DVM), Shawn Bukovac, Nick Gervais, Wayne Weller, Adam Boudens, Rylee Goerlitz, Rebecca Anderson, Michael Babin, Justin de Vuyst, Cole Vandenberg, James Butler, Bill Mayes, Marcie Jacklin, Liz Benneian, Bethany Kuntz-Wakefield, Robin Vanstone, Flavia Papini, Lauren Jones, Kristen Bernard, Ed Struzik, Jen Hawse, James Patterson, Ryan Wolfe, Kyoko Gotanda, Paige Oau, Mathew Jung, Alanah Joyce, Byron Garcia, Calvin Dickens, Savannah Stuart, Mingxuan Su, Scott Sherk, Sharaya McCollum-Brown, Tiana Bilodeau, Luc Goulet and numerous volunteers.

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1.0 Introduction

The Wainfleet Massasauga population is likely the only remaining extant population within the Carolinian zone of Canada. The Wainfleet Massasauga population is considered endangered in Canada (COSEWIC, 2012). The last Ojibway observation was in 2019 and that site is likely extirpated (J. Choquette pers. com.). The Wainfleet population is considered genetically impoverished having the lowest effective population size (N_E) across the species range (Chiucchi and Gibbs, 2010). Recovery concerns for the Wainfleet subpopulation relate to improving our understanding of the effects of peat mining on habitat quality and juvenile survival (MECP, 2019). The Wainfleet population has also undergone recent population declines with a near extirpation event following a period of environmental stochasticity, the population persists today and is considered in a managed state of recovery (Yagi et al., 2020; Ontario, 2023).

Spotted turtles are endangered across their range in Canada (COSEWIC, 2004). The Wainfleet population is the largest of two extant sites in the Niagara Region (MNRF, unpublished data). The second site is approximately 20km to the east and has recently undergone some habitat loss (A. Yagi pers. observation). Due to its small size and isolation, the second site is not likely sustainable. Spotted turtle population declines and low rate of recruitment are the main recovery concerns (MECP. 2019). Population declines and habitat use changes likely reflect habitat quality changes within the central peat mined fields (CPA) and along the north edge of the provincial conservation reserve (Yagi and Yagi, 2018; Figure 1). Understanding site history, changes in habitat quality, species habitat use, and present management explains much of the changes in Massasauga and SAR turtle populations.

An ecological trap is a scenario where animals are attracted to use habitats that ultimately lower their fitness, which usually occurs in habitats that have been altered by human activity (Battin 2004). Reptiles respond to environmental cues such as temperature and moisture gradients to locate suitable habitats to complete their annual life cycle (Huey 1982; Litzgus at al.,1999; Blouin-Demers and Weatherhead, 2001; Carriere et al., 2008; Dubois et al., 2009). Additionally, many reptiles exhibit site fidelity to habitats previously used for hibernation, gestation, nesting, and incubation (Dodd and Seigel, 1991; Prior, 1997, Harvey and Weatherhead, 2006; Wastell and Mackessy, 2011; Refsnider et al., 2012). Anthropogenically altered habitats may mimic these cues and attract animals; however, habitat quality is not maintained for the duration of the animal or progeny's life span and therefore results in lower survival rates (Battin 2004). Ecological trap theory suggests that the continued presence of a trap will drive populations to extinction (Battin 2004).

All past and ongoing research collected to date (1998 to present) from radio telemetry (Yagi and Tervo 2005; Yagi and Litzgus 2012); mark-recapture (Yagi et al, 2020; COSEWIC In Prep; MNRF unpublished data), thermal ecology (Yagi and Litzgus 2013), bog hydrology (Browning, 2015), wintering habitat quality (Yagi, 2020; Yagi et al., 2020),

population trends and PVA (COSEWIC In prep; Ontario 2023) and field observations including wildfire and overwintering mortality (MNRF unpublished data; pers. obsv. M. Browning, A. Yagi, K. Yagi and C. Blott) lend support that the central mined peatland area (CPA) is acting as an ecological trap on two endangered populations, the Massasauga (***Sistrurus catenatus***) and Spotted Turtle (***Clemmys guttata***) (Parks Canada 2015; OMNRF 2016; Environment and Climate change Canada, 2018; MECP, 2020; MECP 2019; MECP 2018).

The Wainfleet Bog ecosystem has changed significantly since colonization. While natural changes are expected and wildlife are adapted to natural cycles such as the beaver-meadow cycle, and environmental stochasticity, harmful anthropogenic alterations affecting ecological functions such as habitat quality and resiliency are why sensitive native species are in decline world-wide. Habitat destruction, invasive species, overexploitation, illegal wildlife trade, pollution and climate change are listed as the top causes of biodiversity declines and population extinction.[1] The Wainfleet Bog ecosystem checks all these boxes. Ecosystems are interconnected by water, land, climate, air, wildlife, and people. The current directives of the IUCN are (Five R's) to **R**ecognise these connections, **R**etain our biodiversity, **R**estore ecological functions (populations and ecosystems), to invest in our natural **R**esources and to **R**econnect people by understanding connections and society's role in restoring ecosystem functions.

The purpose of this report is to assess the state of the environment as determined by the population trends of species at risk reptiles affected by the ecological trap (CPA) and the quality of refugia habitat represented by the provincial conservation reserve, Area of Natural and Scientific Interest (ANSI).

1.1 Background Site History

1.1.1 Ombrotrophic Bog Ecosystem (10,000 to 5,000 ybp)

The Wainfleet bog was formed about 5,000 ybp following the post glacial flood events when the Lake Erie shoreline breached and flooded most of the southern portion of the Niagara Region (Tinkler ,1994; Nagy, 1992). The Wainfleet bog is an ombrotrophic bog ecosystem meaning water input is from precipitation events only. Soils are organic and therefore hydrophilic to promote water storage function. The organic soils are underlain by a thick gley layer (jeddo clay) which functions as an aquitard sealing water above the bedrock layers within an organic basin (Yagi and Frohlich, 1998). There is a tendency over time for water stored within the organic soils to seep downward very slowly into the bedrock aquifer. Since the bedrock slopes toward the Niagara River the organic basin is also tipped in that direction and therefore there is a natural gradient for groundwater within the organic basin to flow in a northeasterly direction toward the Niagara River. As

[1] IUCN 2030, https://www.iucn.org/nature-2030

with most ombrotrophic bog ecosystems, water storage function is long-term with water output attributed to evaporation and some surface leakage from the edge during high-water conditions. Therefore, bog hydrology is naturally stable with very minor water level flux annually. The natural bog vegetation community is predominantly sphagnum moss and ericaceous low shrubs (MacDonald, 1992).

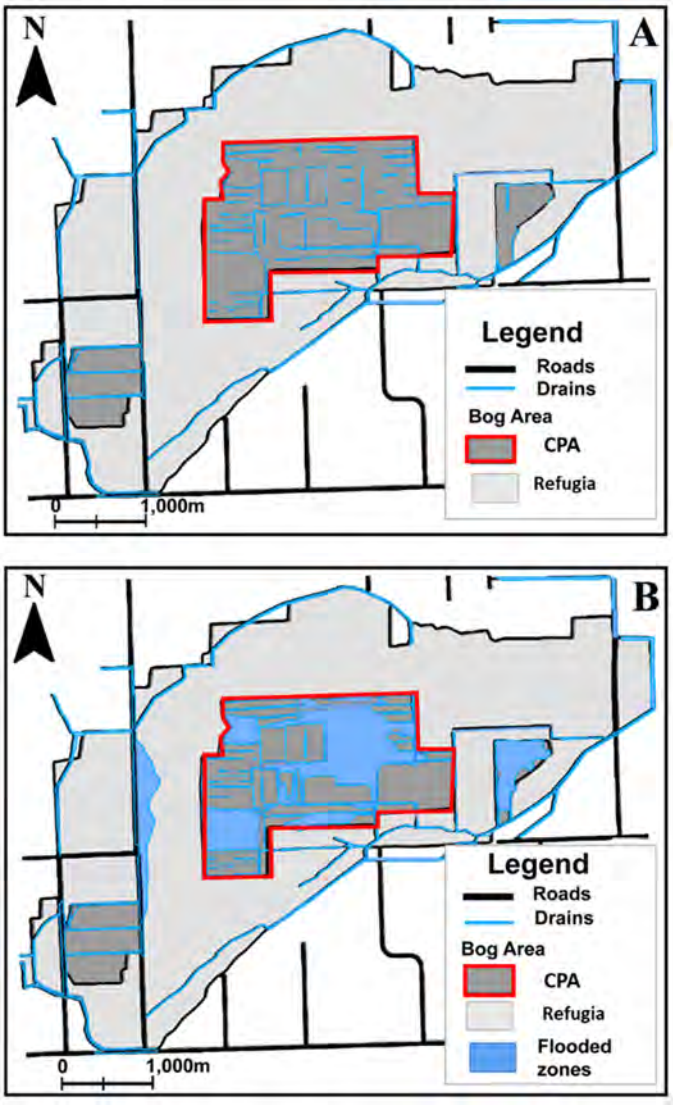

Fig. 1. Wainfleet Bog Ecosystem Study Area. A) Before first flood event B) At peak of first flood event in 2007-2010. The Central Peat Mined area (CPA) is the ecological trap area. However, drainage control affects the entire ecosystem including refugia areas which are kept drier than normal during the summer escalating ecological succession processes and the expansion of invasive species with loss of low shrub thicket and sphagnum moss community (Figure modified from Figure 2 in Yagi et al. 2020 with permission).

1.1.2 Drainage (circa 1940)

The Wainfleet bog was drained circa 1940s when a 1.5km section of the municipal drain was moved northward from the farm fields into the edge of the wetland. This action tied the drainage needs of the adjacent rural -farming community together with the drainage of the Wainfleet Bog ecosystem. The municipal drain was deepened and widened to improve water capacity. Interior canals or ditches were constructed which extended from the center of the peatland into the municipal drain (Fig.1). This began the "Drainage -Controlled State" of the Wainfleet Bog Ecosystem. Peat mining occurred within the "Drainage Controlled State". Once the organic soil was dried down, it was mined via soil stripping or suction dredge. Peat mining continued until the Nature Conservancy of Canada purchased a large portion of the feature for conservation purposes circa 1995.

1.1.3 Peat Mining Era (1940s to 1990s)

Within the central dome, peat mining activities removed the upper aerobic spongy sphagnum hummocky layer and left the site surface flattened and compacted. Surface water if present was contained below the ground surface in ditches or dugout ponds. The ability of the wetland to absorb storm events was impacted due to dryness and compaction and loss of microtopography. As a consequence, precipitation events were not likely retained very long within the feature and ran off the surface into the ditches and out to the municipal drain with a very shortened hydroperiod. Other ecological functions were also severely impacted such as habitat functions, especially hibernation habitat functions for resident reptiles. The site was also often on fire because it was kept dried down, in a flow through- drain managed state. There was also no site restoration initiated by the mining company. Large peat mined fields were left abandoned "as is" leaving an open, barren landscape. By the 1990's trees became established within dried down peatland edge communities and European White Birch became established within the Central peat mined area (CPA) and eventually found sparsely within refugia areas that were not peat mined (ANSI).

1.1.4 Post Peat Mining Era (1998 to 2016)

For about 60 years (1940s to 2000s) the Wainfleet bog was managed as a flow through "Drainage Controlled State". However beaver colonization and damming became an additional positive ecological factor (Yagi et al., 2010). According to MNRF wetlands database, beavers were first observed in the watershed near the Welland Canal in 1998. Beavers were nearly eliminated from the Niagara landscape except for "Bank" beavers inhabiting shoreline areas.

By the year 2000, Peat dams (n= 18) were constructed within some interior ditches as part of a research project to determine the effectiveness of higher water levels to re-store bog vegetation communities (Fig.2; Browning, 2015). These actions were supported by a bog committee under a conservation led management plan to raise water levels and restore sphagnum and other bog vegetation (NPCA 1997). These actions were also supported by a hydrological assessment of the bog done for NPCA by the

National Water Research Institute that concluded the bog water table could be raised 1m without affecting the surrounding tableland farming (Crowe et al, 2000).

From Oct 6th to 10th, 2006, a stochastic storm event containing mixtures of snow and rain flooded about 300-400ha of the CPA including a known Massasauga hibernation study area for the first time since peat mining ceased. Beavers re-colonized the bog and built and maintained three dams beginning in 2005 or 2006 (Fig. 2). Lodges were also built in the interior. Interior peat dams eventually became less effective at maintaining water levels than the beaver dams (Browning, 2015).

Water levels remained elevated in the CPA for 4 full seasons until beaver began extending their damming into the Municipal Drain. This period is when municipal drains were less effective at controlling water levels within the bog feature. This created a four-to-five-year period of sustained higher water levels “Beaver-Controlled State”.

Beaver dams were first removed from the Municipal Drain in Dec 2010, and the Wainfleet Bog drained and dried down again as a result returning to a “Drainage Controlled State”. In 2012 and again in 2016 during the “Drainage Controlled State” and coinciding with drought conditions, portions of the CPA caught fire and fire was suppressed in part using deep groundwater sourced from the adjacent limestone quarry.

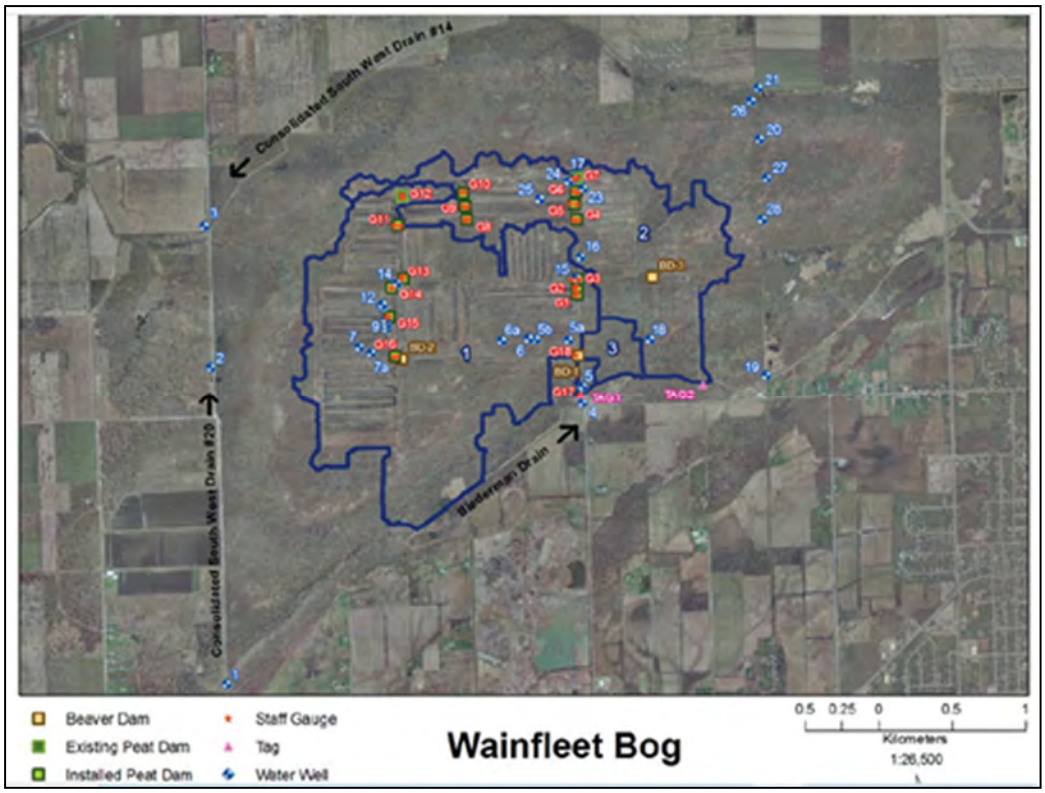

Figure 2. Well locations (blue), interior constructed peat dam locations (G1 to G18) and Beaver dam locations (BD1 to BD3) with an estimate of the sub watersheds at that time (Browning 2015).

1.1.5 Drainage Controlled State Continues (2011 to Present)

The history of drainage and peat mining damaged the wetland and impaired ecological functions across the entire ecosystem. The obvious damages from drainage and peat mining are especially evident within the Central Peat-Mined Area (CPA) with less obvious damage to the surrounding not-mined areas or refugia areas known as the provincial conservation reserve Area of Natural and Scientific Interest (ANSI; Fig.1). Drainage actions left the wetland in a dry state throughout the ecosystem.

Actions taken in early 2000 to raise water levels within the CPA using constructed interior peat dams have been assessed. Eleven of the original eighteen dams are either eroded or are no longer functioning today (Fig. 3). Since beavers re-colonized the bog, retaining water within the CPA interior is predominantly dependent on where beavers build and maintain their dams (Browning, 2015; Fig.4).

Recent water level monitoring now shows the entire ecosystem responds synchronistically to precipitation and drain maintenance cleanouts. Periods during beaver-dammed conditions over several consecutive seasons show improved storm absorption (smoother, longer duration storm peaks), and photo record shows ***Sphagnum*** growth is evident and extant. Periods during dried-down conditions show less storm absorption (taller spiked, short-duration storm peaks) and photo records show exposed turtle burrow holes and dormant, dry peat surfaces. Keeping beavers on the landscape is important to achieve a bog hydrology goal and for the survival of Species at Risk (Fig. 4; See 5.0 Appendix Site Photos spring 2019).

Today the bog hydrology cycles annually between a spring to fall “Drainage-Controlled State” into a winter to spring “Beaver-Controlled State”. Declining water levels in spring during the usual wet season is not normal hydrology for a bog ecosystem. Natural bog hydrology may only decline slightly during the summer dry season, but water storage function is long-term resulting in only a slight decline in groundwater levels thereby keeping the surface moist for sphagnum growth.

1.2 Detailed Discussion Water level (Figure 4)

The Wainfleet bog ecosystem is one hydrological system. Evidence that there is only one hydrologic system is from the ecosystem water level monitoring data collected since 2018 which shows a synchronous correlated pattern across the feature over time (Fig. 4). This data set is hourly data and is concurrent with manual water level measurements within the drains at four consistent locations and includes the timing of beaver dam removals from the Beiderman Drain and precipitation events (8Trees Technical Report 2021). What happens hydrologically within Beiderman Drain affects both the CPA and surrounding refugia areas including the provincial conservation reserve (ANSI; Fig.4).

Figure 4 represents the bog groundwater table elevation in mASL versus time at each monitoring location along the SW-to-NE transect across the bog from April 2018 to May 2022. The SW area (WW31) is the highest elevation and the lowest is WW20 to the northeast. The groundwater elevation data depicts a downward gradient toward the lower elevation northeast ANSI (WW20). Data is continuous from April 2018 to May 2022, capturing four full years of data.

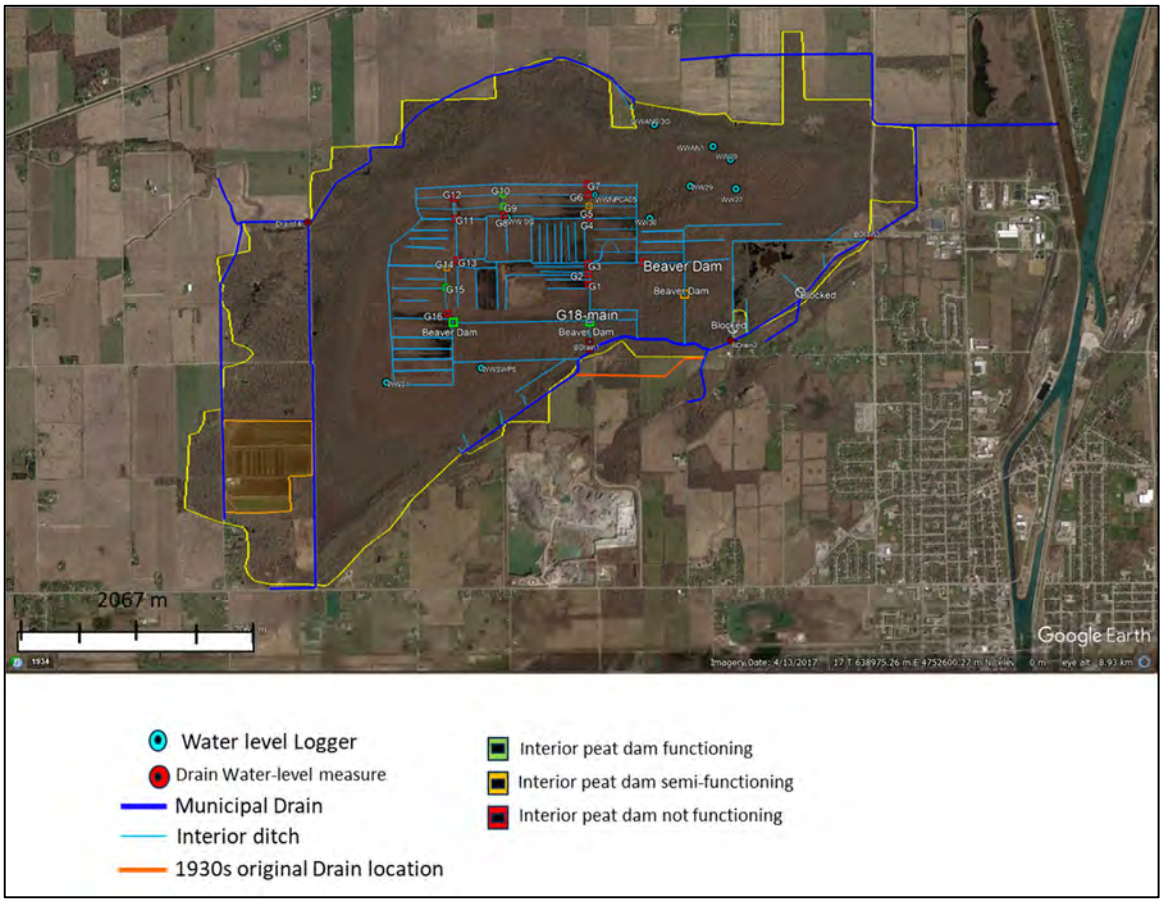

Figure 3. Locations of Water-level loggers managed by 8Tree Inc. and the location of manual water-level measurements within the Beiderman municipal Drain are indicated on the map. Interior Beaver Dams, interior ditches, and the locations of each constructed peat dam and their evaluated conditions as of 2021-2022 are also indicated.

The graph also represents the concurrent surface water level elevation in the Municipal Drain and notes the presence and timing of the removal of beaver dams and the drainage rate response. Blocked sections of time (Nov 2018 to July 2019; Nov 2019 to

mid-June 2020; Jan 2021 to May 2021; Oct 2021 to May 2022) represent periods when the beaver dams within the Municipal Drain have been left in place over several months during which time the bog has filled and stabilized. During these times the water table rises and remains relatively stable even following precipitation events.
Stars represent major dam removals. The sequence of dam rebuilding during the wet season and dam removal each spring, is the main driver that characterizes the bog water table regime, not precipitation.

The drainage of the ecosystem begins in the spring with the removal of beaver dams within the municipal drains to accommodate adjacent farmland drainage. Precipitation events are not retained as reflected by short high peaks and continuous drops in the hydrograph. Beaver dams are located within the Beiderman Drain along the southern edge of the NPCA lands, downstream of Townline Rd and at HWY 58. Beaver dams were extensively cleared from the entire municipal drain in the spring of 2020 including a large dam located at the HWY 58 crossing, causing the entire bog feature to drain (April 2020; Fig. 4).

1.3. Ecological trap

The drainage rate of the Wainfleet Bog ecosystem following beaver dam removals is ~ 1cm/day, which means a drop in water levels of 30cm within 30 days or 60cm within two months. This loss of water from the bog dries out the upper peat surfaces and prevents new growth. Much of the CPA is dusty-dry in summer when the bog is dried down. If this dried-down state coincides with a summer drought, the ecosystem becomes fire-prone. Summer wildfire is known to kill adult Spotted Turtles during aestivation.

Turtles overwinter inside a burrow within the banks of interior ditches within the CPA (PHOTO 29). From annual mark-recapture studies, not all ditches contain overwintering turtles. Midwinter water quality assessments indicate the highest dissolved oxygen and coldest temperatures (<0°C) are just below the ice surface and the poorest oxygen (< 2mg/L) and warmest temperatures (4–5° C) are in the bottom of the ditches (Yagi and Yagi, 2018). In a dried-down state, traditional Spotted Turtle hibernation areas have depleted or no surface water with groundwater if present close to the bottom clay layer. Turtles are either displaced to alternate sites or they attempt to hibernate in their traditional sites. If they remain close to the surface without the protection of groundwater, they risk mortality by freezing, alternatively they may dig down to the ground water table and they may asphyxiate. Water level increases overwinter should benefit turtles however water level depletions will harm turtles. In either scenario depending on their initial depth, turtles would need to reposition themselves within the burrow to maintain the best water quality. Furthermore, fast movement by reptiles during cold temperatures (< 5°C) is unusual requiring arousal and increased energy use. Overwinter mortality of adult turtles (Spotted Turtles, Snapping Turtles, and Midland Painted Turtles) is a regular occurrence of a few animals per winter. Overwinter mortality is evidence that the CPA is not supporting the ecological function of hibernation and is an ecological trap for turtles.

Snakes overwinter terrestrially or semi terrestrially in habitat that supports a life zone (Yagi et al., 2020). In a dried-down state, surface holes are exposed and open for snake use. If the holes remain dry during hibernation site selection, snakes will attempt to overwinter here. If the holes are also in a flood-prone area, such as portions of the CPA, that change in quality overwinter due to freezing or flooding, snakes will not survive. This is an ecological trap for snakes.

1.4 Proposed Beiderman Drain Water Elevation Target

If water levels are not drained down seasonally the ecological trap is mitigated, and the bog vegetation community becomes re-established across the feature. The corresponding surface water levels within the Beiderman municipal drain measured at the NPCA entrance are between **175.4 and 175.5 mASL** during this time**.** Since the bottom of the bog feature tilts downward toward the northeast, when water levels are held within the municipal drain at 175.5 mASL, this relates to groundwater level of 175.0 mASL within the ANSI, which is about 0.5m below existing ground surface (WW20). Under these conditions a life zone is maintained for Massasauga hibernation function in the ANSI and sphagnum moss was observed growing again on the ground surface withi the ANSI (e.g. spring 2019; Fig. 4).

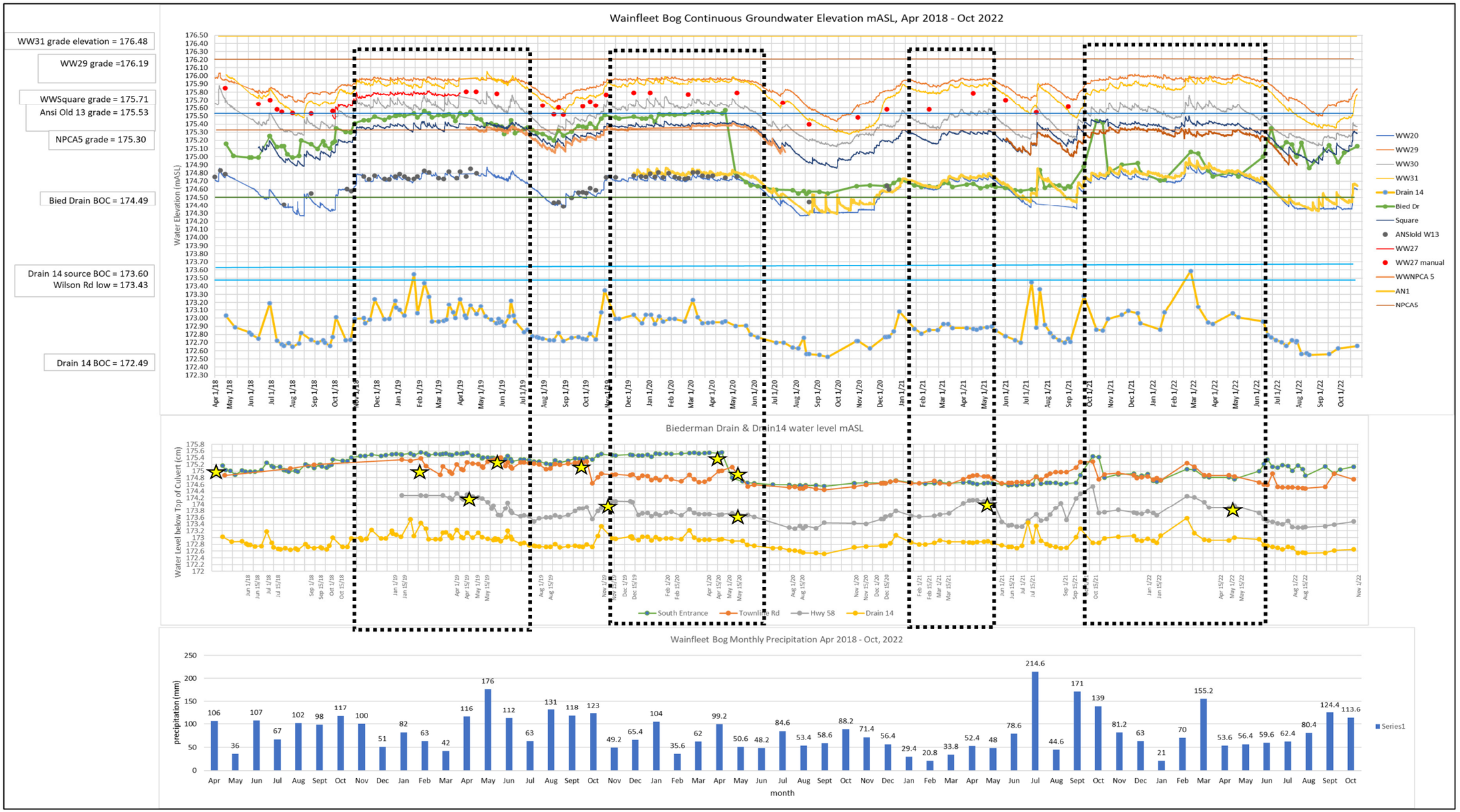
Wainfleet Bog Continuous Groundwater Elevation mASL, Apr 2018 - Oct 2022
WW31 grade elevation = 176.48
WW29 grade =176.19
WWSquare grade = 175.71
Ansi Old 13 grade = 175.53
NPCA5 grade = 175.30
Bied Drain BOC = 174.49
Drain 14 source BOC = 173.60
Wilson Rd low = 173.43
Drain 14 BOC = 172.49
Water Elevation (mASL)
WW20
WW29
WW30
WW31
Drain 14
Bied Dr
Square
ANSIold W13
WW27
WW27 manual
WWNPCA 5
AN1
NPCA5
Biederman Drain & Drain14 water level mASL
Water Level below Top of Culvert (cm)
South Entrance
Townline Rd
Hwy 58
Drain 14
Wainfleet Bog Monthly Precipitation Apr 2018 - Oct, 2022
precipitation (mm)
month
Series1

Figure 4. Water levels are measured hourly within the Wainfleet Bog ecosystem and manual measurements within the connected Municipal Drainage system. The actions within the drain (clean out) of beaver dams are reflected within the entire bog ecosystem (See ☆) There is resiliency (lag time) then the entire system responds downward at a rate of 1 cm per day until the wet season returns and beavers replace dams within the municipal drain. When the system is drained down storm events are not retained as seen by a flashy response within the drain. In contrast when beaver dams are in place storm events are absorbed within the ecosystem as seen by little change in the drain water levels. The most extensive drain clean-out occurred in April 2019. The dashed outlines are the periods with beaver dams in place. NOTE this figure is to be updated for May 2022 to Jan 2024.

2.0 Results to Date (Current State of Environment)

2.1 Overall Habitat Quality

Sphagnum hummocks are an important habitat for Massasaugas and Spotted Turtles inhabiting bog ecosystems (Yagi and Tattersall, 2018; Smolarz et al., 2018). Unfortunately, sphagnum hummock formation is impaired in this ecosystem. Sphagnum moss growth and hummock formation occur when water levels remain stable at an elevation that saturates the peat surface. Research suggests that sphagnum moss growth may be continuous throughout the year including winter, provided growing conditions are maintained (Küttim et al., 2020). This also means past sphagnum losses can be reversed with the correct water-level management. Sphagnum moss stops growing when water levels drop, and the peat surface becomes desiccated which happens in this ecosystem following beaver dam removals (See CPA PHOTOs). Since sphagnum hummock formation sustains Massasauga hibernation and refugia habitat quality, keeping beavers on the landscape to sustain water levels can assist and is necessary for the sustainability of this population. Similarly, the regrowth of sphagnum hummocks is important to maintaining Spotted Turtle hibernation and nesting habitat quality in the CPA.

Evidence of the importance of maintaining water levels year-round is provided by the assessment of ecological succession changes in the aerial extent of the sphagnum-low shrub community within the ANSI (refugia habitat) overtime. From 2006 to 2010 the rate of ecological succession slowed down (Fig. 5). This period coincides with elevated water levels created by the consistent presence of beaver dams over consecutive years. However, once beaver dams were removed from the municipal drain in Dec 2010 the rate of succession increased. Today the ANSI contains a small fraction of open low shrub habitat and no active growing sphagnum layer. Sphagnum hummocks if present are historic and not being replenished. The site is actively succeeding into a tall shrub- tree dominant community infested with invasive species Glossy Buckthorn and European White Birch. Scots pine was also found within the CPA indicating dry conditions are present sufficient to support their growth.

The removal of beaver dams exhibits control of the habitat quality for species at risk inhabiting the bog. This means if dams are removed during sensitive periods, species at risk may be harmed if not killed. The drainage cycle re-initiates the ecological trap and the potential for SAR reptile population declines. Although there is a regulatory role for both the Drainage Act and the Endangered Species Act, an ESA C permit (overall benefit permit) may be required for drain maintenance.

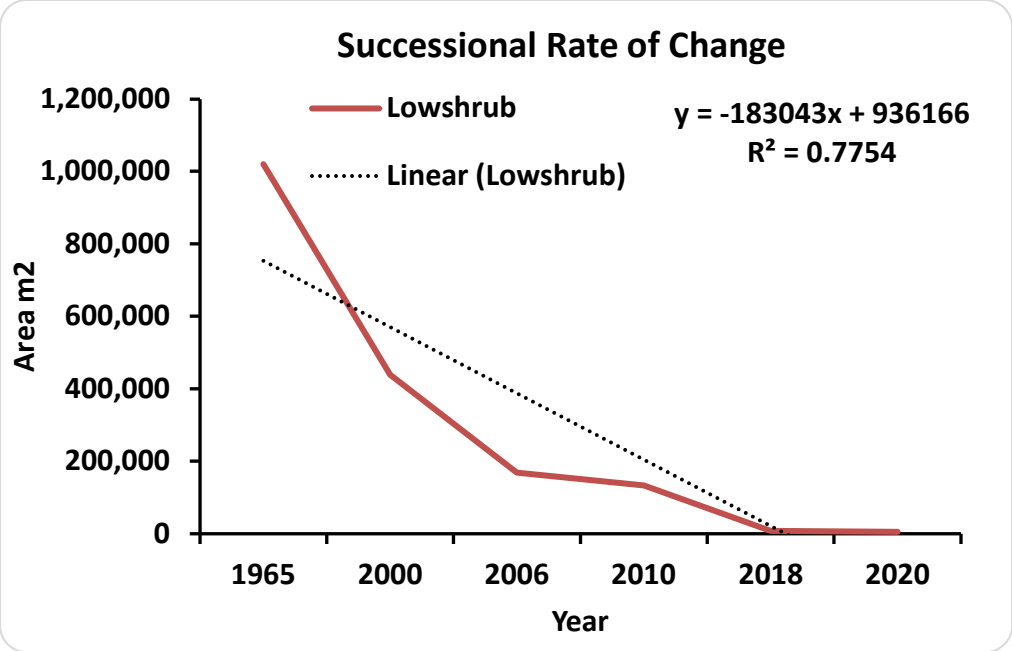

Figure 5. The aerial extent of low shrubs within the ANSI is estimated from historical aerial imagery. The ANSI was not peat mined, has the largest life zone for snake hibernation, and represents the refugia habitat for Massasaugas. It is also the provincial conservation reserve. Note from 2006 to 2010 water levels were raised continuously due to beaver dams being allowed to stay in place and the rate of succession slowed. Beginning in Dec 2010 the dams were removed regularly, and the rate of succession increased again. Today there is very little low shrub habitat remaining in the ANSI.

2.2 Current Spotted Turtle Population Trend

There have been no spotted turtles found in the ANSI since 2008. All remaining turtles are found within the CPA or along Willson Rd. In 2012, one adult spotted turtle was found several concessions to the West on Side Rd 20. The overall population trend is in decline (Fig. 6). Sources of known mortality relate to predation (confirmed via radio telemetry), wildfire (M. Browning and A. Yagi pers. obsv.) and overwinter mortality (confirmed in spring during mark-recapture surveys by MNRF and 8Trees).

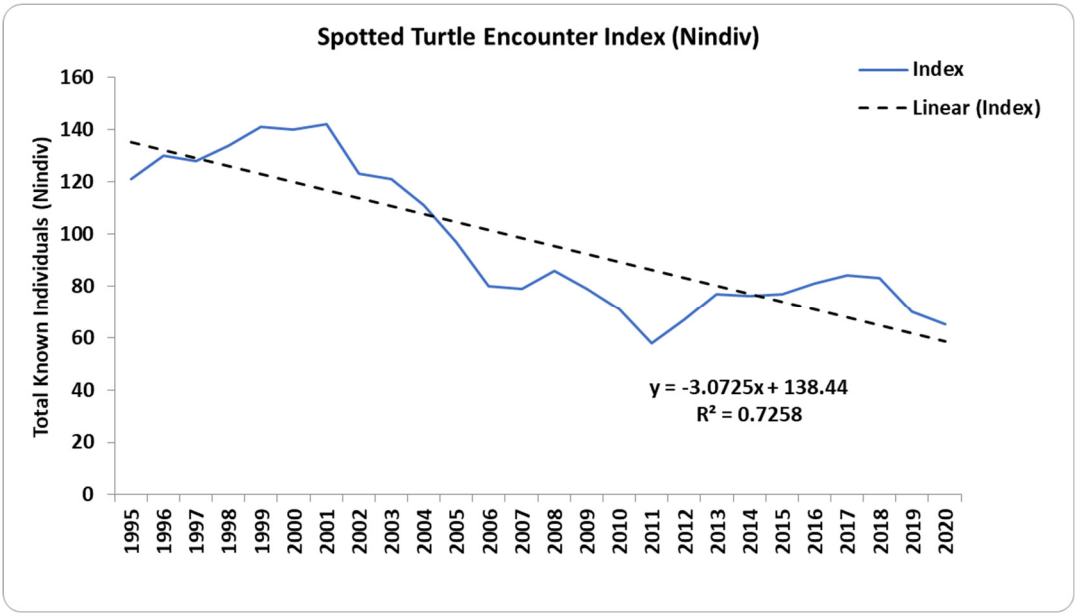

Figure 6. Spotted Turtle individual encounter index (NINDIV) overtime. Declines relate to mortality from predation, wildfire and overwinter. This graph includes all ages juvenile, subadult and adult.

2.3 Managed Recovery Massasauga Population Trend and PVA

The Massasauga population is in a “managed state of recovery” today due to targeted and successful mitigation of the ecological trap. Mitigation includes assisted hibernation to increase overwinter survival and gestation site habitat enhancement within the ANSI. Assisted hibernation has increased neonatal first-winter survival from < 25% to > 75%. This work has successfully turned a near-extinction event in 2008 into a recovery trend by 2023 (Figure 7; Ontario, 2023; COSEWIC In Prep).

The Massasauga population survived the 2006 to 2010 first stochastic flooding of the CPA because of refugia habitat. Survivors were from refugia areas (i.e. ANSI) surrounding the CPA. Massasauga encounter evidence from 2010 onward supports this conclusion with encounters only occurring within the ANSI. However, by 2013, when the ecosystem returned to a “Drainage-Controlled State” caused by frequent drain management, Massasauga observations returned to the dry CPA, which means the CPA returned to functioning as an ecological trap. Massasaugas are attracted to the CPA because it is open canopy and thermally attractive to gestating females.

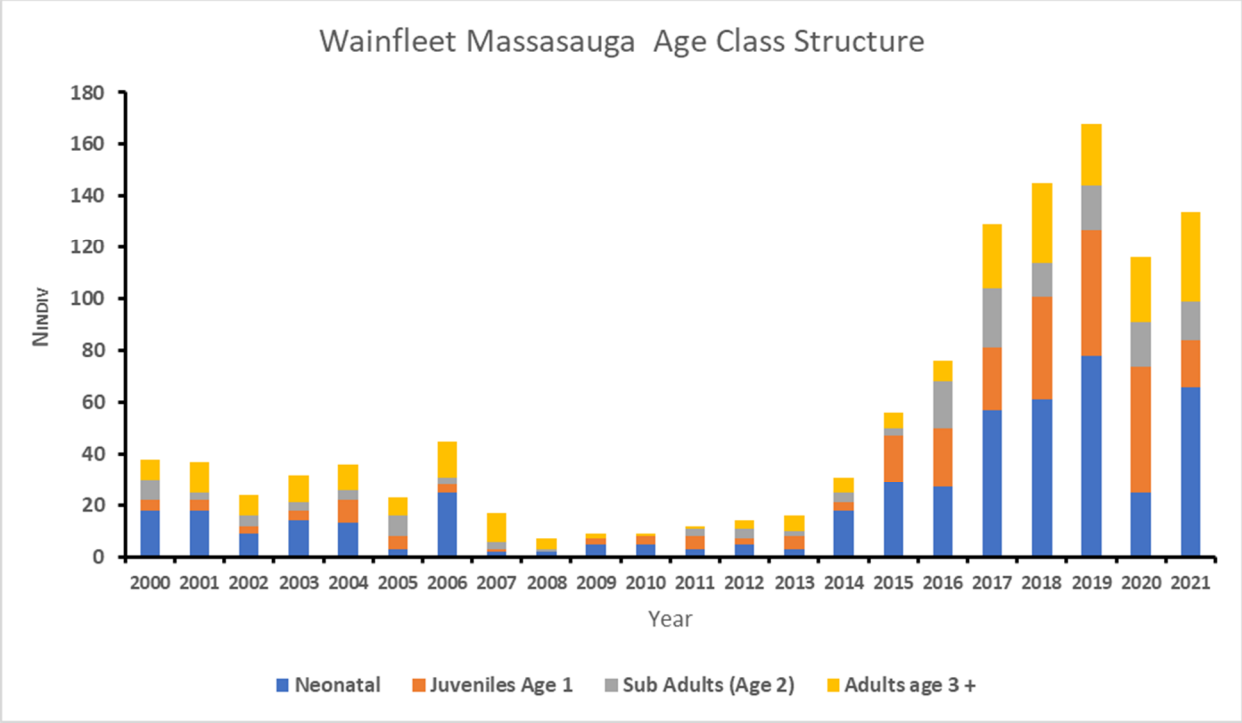

Figure 7. Wainfleet Massasauga Population Index (N_{INDIV}) and age-class structure derived from long-term mark recapture dataset. The population structure is about 25% adults supported by 75% neonatal, juvenile and subadult age classes. The trend is consistent with a "Managed state of recovery" induced by increased survival and site fidelity to refugia areas.

2.4 Evidence of Increasing Habitat Use of the CPA (Ecological trap Area) by Massasaugas

As the Massasauga population increases and the quality of habitat in refugia areas declines due to ecological succession, the number of observations of Massasaugas using the CPA during the active season is expected to increase over time. Evidence collected to date supports this hypothesis. From 2009 to 2023 the number of individual encounters (Age 1+) increased from zero to 19 (CPA N_{INDIV} index Fig. 8). The Massasauga population is once again becoming established within the CPA and showing fidelity to features especially for gestation, birthing, and increased survival (known neonate births = 47; recaptures = 2; Gravid Female recaptures = 3). Therefore, the overall population low in 2008 is likely to repeat itself, without threat mitigation, and until drainage is effectively mitigated. Population viability analysis (PVA) supports this conclusion. The PVA predicts extinction within 20 – 40 years unless the threat of the ecological trap is effectively mitigated (Fig. 9 and Fig. 10; COSEWIC in prep).

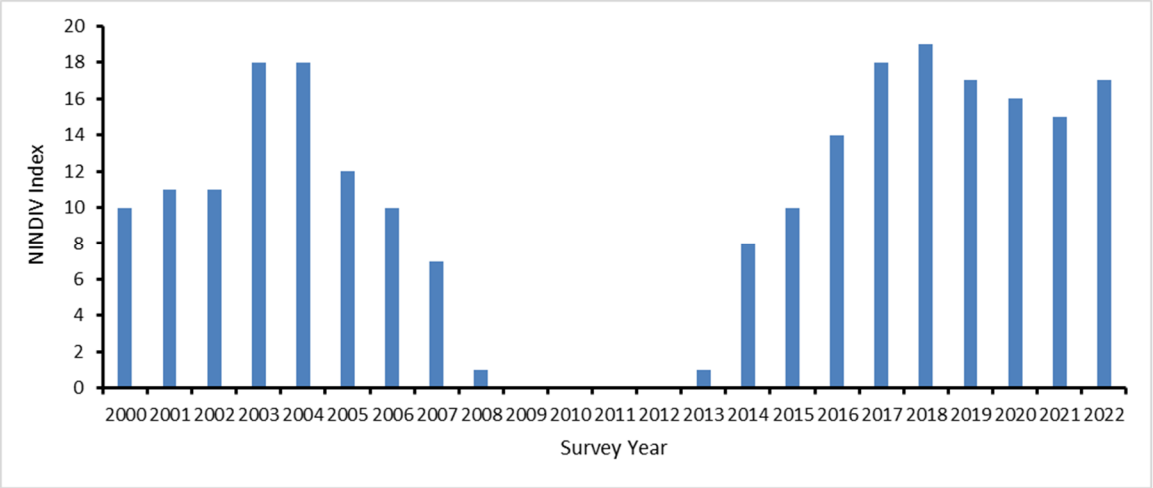

Figure 8. Massasauga individual encounter index (N_{INDIV}) for the CPA over time. This is an individual index of all encounters (New + Recap + Known undetected) per year of juvenile and adult life stages (Age 1+). Annual surveys by MNRF from 2009 to 2012 did not locate any Massasaugas within the CPA. From 2013 onward, during drainage control state, encounters have increased by 19 times. The Massasuga is once again showing fidelity to the CPA primarily for gestation and birthing. Therefore, there is an increasing likelihood for history to repeat itself without ongoing mitigation.

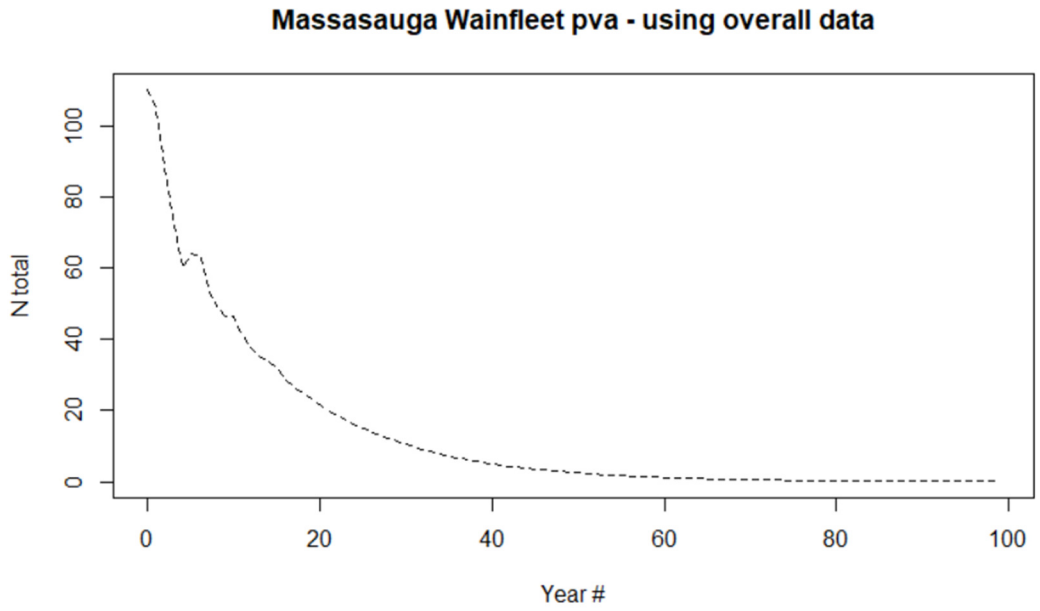

Figure 9. Population Viability Analysis (PVA) completed using data derived from long-term mark recapture dataset, lambda, fecundity and age specific survival from (2000 to 2020).

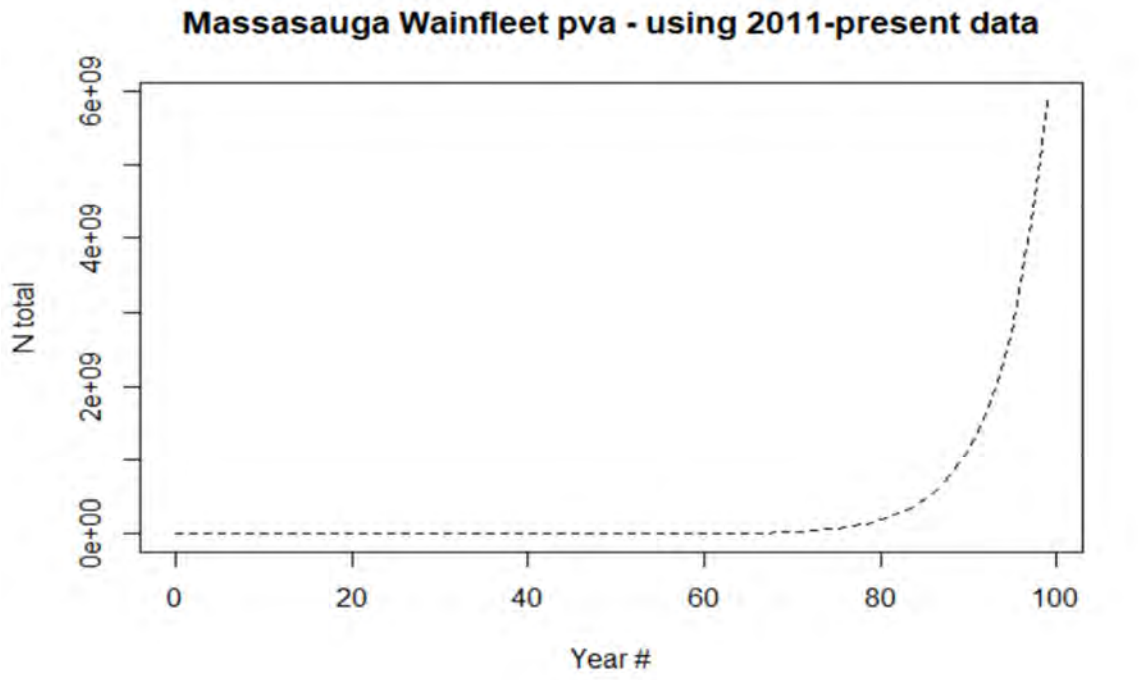

Figure 10. Population Viability Analysis (PVA) using data (population lambda, fecundity, and age specific survival) derived only from (2011 to 2020).

3.0 Management Recommendations (Next Steps)

As an interim measure, until farm-land drainage can be separated from wetland drainage 8Trees Inc. has recommended to the Drainage Authorities, to not remove beaver dams during the winter months, because stable winter water levels will help maintain habitat quality for both aquatic hibernators (turtles) and terrestrial hibernation (snakes) during this sensitive part of their life cycle. However, the breakage of dams is also initiated by other groups, individuals, and by storm events. Provided beavers are present in the ecosystem they will naturally maintain these breaks during the next wet cycle. Keeping flood-prone areas wet or saturated will help to collapse surface holes and prevent Massasaugas from hibernating in poor-quality habitat areas that do not maintain good hibernation habitat quality i.e. a life zone (Yagi et al., 2020). Given the declining trend for the Spotted turtle population more targeted mitigation is needed. In addition, an Endangered Species Act (ESA) C permit may be required for drain maintenance activities.

The best solution is a long-term one that separates drain maintenance from bog hydrology. We suggested moving 1.5 km of the municipal drain south 300m to its original location (before peat mining) and allowing beavers to occupy the current drain's location (Delegation Letter, 2021) This is not an expensive solution but seems to take time and political will to implement (See 6.0 Walter Fedy Proposed Drain Profile).

Therefore, the continuation of active mitigation of the ecological trap, in the short-term, is necessary until a long-term solution to the annual drainage cycle is successfully implemented. Mitigation includes monitoring when beaver dams are removed, continuous water level monitoring across the ecosystem, monitoring SAR populations, annual survival, improving Massasauga gestation habitat quality in refugia areas, and collecting gravid females from across the site to give birth in the lab with post-partum release, and finally, head starting neonates born in captivity and then assist hibernating them within refugia areas to control first winter hibernation site selection away from the CPA (i.e. ecological trap).

To address the low genetic diversity threat for this isolated population, the Wainfleet Massasauga population could receive surplus neonates from the Species Survival Plan (SSP) which contain both Georgian Bay and Wainfleet DNA. Individual neonates could be translocated using the assist hibernation methods established for this population (Yagi et al., In Prep 2024).

Finally, we recommend using the Society for Ecological Restoration methods for assessing restoration progress. Criteria for water quality, nutrients, pH, have not been developed but indirectly relate to the population trends being observed especially for Spotted Turtle (Photo 42 and 43).

Overall, the SER restoration criteria need to be adjusted because there is no single reference site for this ecosystem. A reference site for an ombrotrophic domed bog at this latitude that supports both Massasauga and Spotted Turtle populations does not exist. Further using the ANSI as a reference site for the CPA also does not work because this is one ecosystem, and the ongoing threats create issues across the entire site.

The current state of the Wainfleet Bog Ecosystem is cycling annually between a “Drainage-Controlled state” with a winter only “Beaver-Controlled State”.

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5.0 Appendix Site Photos

Photo 1: ANSI Low Shrub- Community Summer 2006.

Photo 2: ANSI Low Shrub-Community Oct 2005; same areas as Photo 1;

Photo 3: Left. ANSI Low Shrub area is now a tall shrub area by Aug 10, 2016 same area as previous.

Photo 4: Gestating Massasauga in ANSI Life Zone Study Area July 16, 2018

Photo 5: Assisted Hibernation and Life Zone Study Area ANSI August 2021, Note Glossy Buckthorn.

Photo 6: Assisted Hibernation and Life Zone study Area Aug 10, 2018, looking down on top of an old hummock see surface hole on left between exposed roots.

Photo 7: Assisted Hibernation and Life Zone Study Area May 2, 2018

Photo 8: Assisted Hibernation and Life Zone study area May 8, 2022

Photo 9 Top Left: Massasauga neonate ANSI Life Zone Study Area May 1 2018;
Photo 10 Top Right: Massasauga on old sphagnum hummock ANSI Life Zone Study Area May 19, 2019
Photo 11 Bottom Left: Adult Massasauga inside remnant sphagnum hummock Life Zone Study Area May 1, 2019;
Photo 12. Bottom Right: Massasauga neonate ANSI Life Zone Study Area Oct 8, 2020

Central Mined Peatland Area (CPA) PHOTOS

Photo 13 Left: CPA: April 22, 2017 Watersnake on top of a growing sphagnum hummock along interior ditch, before beaver dams removed from municipal drain.

Photo 14 Right: Massasauga neonate September 2019 south of Beiderman Drain under an unknown coverboard.

Photo 15 Left: CPA April 2018 before beaver dams removed from Beiderman Drain. Note green floating Sphagnum patches.

Photo 16 Right: Measuring 40 cm drop in interior ditch water levels Aug 8, 2018

Photo 17: CPA: Triangle Area, Turtle Aestivation Ares; post wildfire 2012

Photo 18: CPA just west of Triangle Area Sep 30, 2016 post wildfire 2016. All sphagnum re-growth in this area was burned off.

Photo 19: CPA, West Beaver Pond Oct 2012, post drainage. Note desiccated sphagnum at surface.

Photo 20: CPA West Beaver Pond Spring 2009, during water level peak, before beaver dams removed from within municipal drain in Dec 2010.


Photo 21: Spotted Turtle Hibernation Area Sep 30, 2016 during drained state. Site was popular hibernation area before 2016. Photo 22 (Right) same hibernation area taken March 26, 2010.

Photo 23: Spotted Turtle Hibernation areas open and exposed in the banks of ditches within CPA. Sep 30 2016; during drained state no water post wildfire season.

Photo 24: CPA interior meadow patch, Sep 2013; No Massasugas found.

Photo 25: CPA meadow patch; May 2015: no Massasaugas found.

Photo 26: CPA interior meadow area August 18, 2020. Massasuga confirmed.

Photo 27: First confirmed capture in interior meadow area “Bobit”, Adult Male missing rattle. Site increasingly more poplar each year thereafter.

Photo 28 and 29: Oct 3, 2018 CPA area West of main trail south of the northern most ditch. Top showing low shrub community and Bottom showing saturated peat conditions. These areas dry out in summer months and the surface of the ground becomes dusty.

Photo 30: August 2018 Peat surface dry, dusty and open

Photo 31: August 28, 2018 Scots Pine in same area as photo 29

Photo 32: CPA increasing marsh characteristics. Site is dry Oct 6, 2022.

Photo 33; CPA Same Are as photo 27. Site is Dry Oct 6, 2022

Photos 34 to 39 are some of the Massasauga encounters from the CPA (from 2017 to 2023) around the existing public trails and boardwalks. Management consideration of raised boardwalks will prevent accidental negative public encounters and will protect snakes from being accidentally impinged under a boardwalk that is just above the ground surface or in disrepair.

Photo 40 from CPA in June, 2018. This is a good example of the goal to recreate a sphagnum hummock surface in CPA and refugia areas once drainage control of water levels is mitigated.

Photo 41. CPA Note European White birch has fallen following the 2006 to 2010 extended high water level period. Photo taken Sep 24, 2013

Photo 42. Evidence of water quality impairment extensive red-green algae blooms in CPA May, 2010.

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Photo 43. Water quality of ditches in interior CPA are prone to red-green algae blooms.

6.0 Water Fedy Engineering Contract Results

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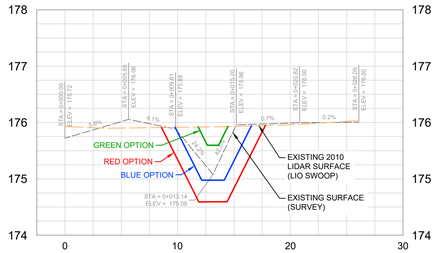

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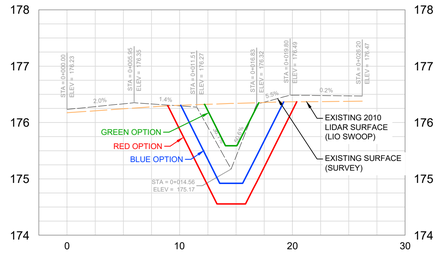

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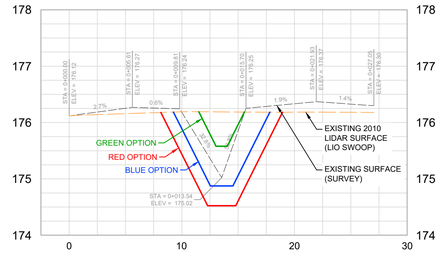

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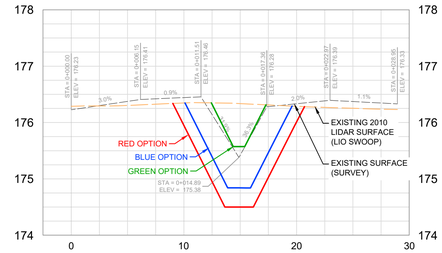

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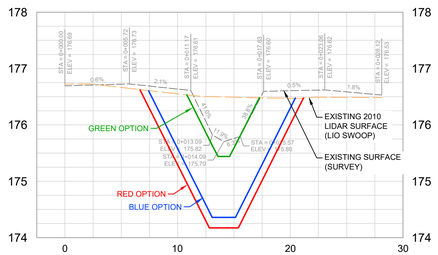

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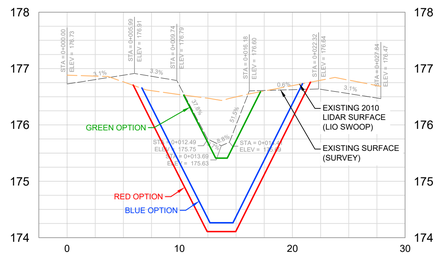

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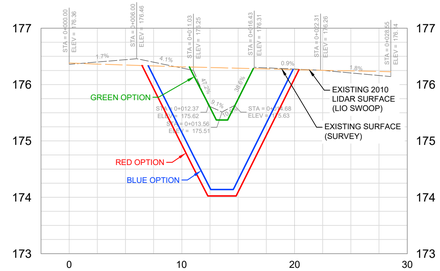

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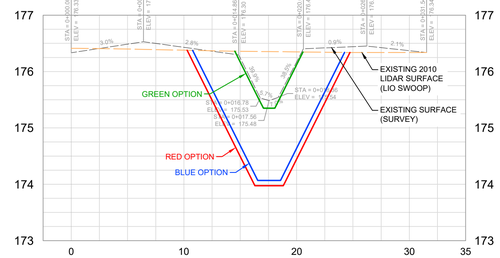

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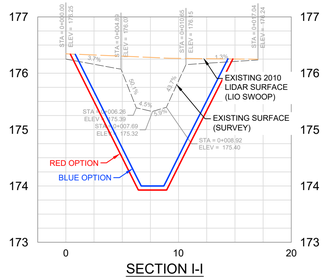

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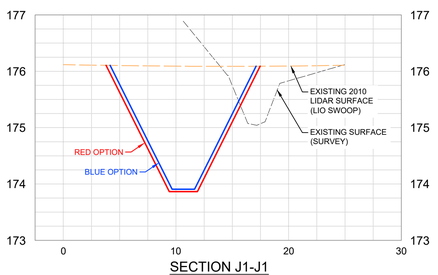

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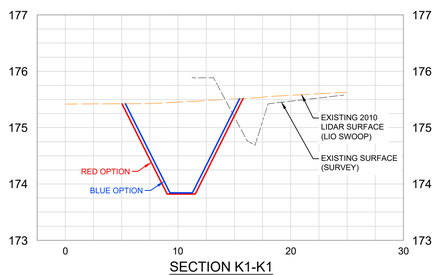

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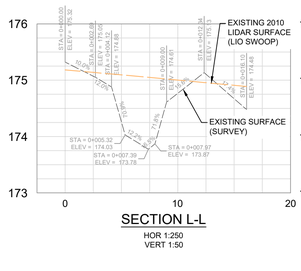

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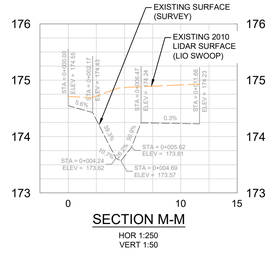
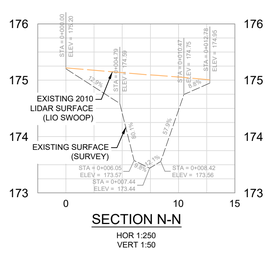
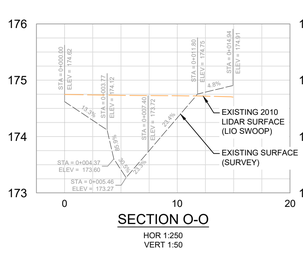


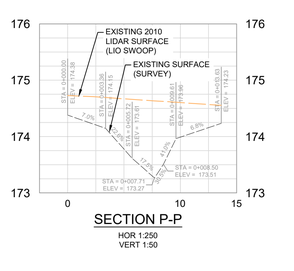
SECTION M-M
HOR 1:250
VERT 1:50



SECTION N-N
HOR 1:250
VERT 1:50



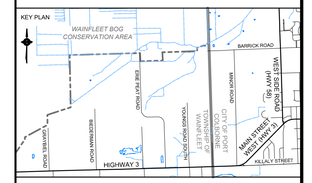
SECTION O-O
HOR 1:250
VERT 1:50



SECTION P-P
HOR 1:250
VERT 1:50

8Trees Inc.

KEY PLAN



DATE	ISSUANCE	NO.

CLIENT
8TREES INC.

FONTHILL, ONTARIO

PROJECT
WAINFLEET BOG

WAINFLEET, ONTARIO

TITLE
PROPOSED CROSS SECTIONS

WALTERFEDY
KITCHENER | HAMILTON | TORONTO
800.685.1378 walterfedy.com

SCALE:	HOR 1:250 VERT 1:50
DATE:	4/4/2022
PROJECT NO.:	2021-0791-10
DRAWN BY:	JJ
CHECKED BY:	NN

SHEET NO.:
PR-SEC

Design Alternatives Comparison Matrix
Wainfleet Restoration Plan
Wainfleet Bog Conservation Area
8Trees Inc.

Project objectives:

1. Remove mechanisims that allow water level flucuations within Wainfleet Bog.
2. Divert surface water runoff from adjacent quarry lands to prevent discharge to Wainfleet bog.
3. Maintain drainage for adjacent agricultural lands.

Option	Description	Meets project goals	Relative cost	Grading volume	Stakeholders	Pro	Con
Black	a. Install plug in existing Biederman Drain at Section N with crest elevation of 175.0m. b. No additional channel grading.	XX	$	X	- Niagara Peninsula Conservation Authority - Indigenous partners - 8 Trees - Farmer A - Farmer B	- Minimalist design concept with least cost. - Requires the least material and stakeholder input. - Requires an update to the operational manual utilized by the Conservation Authority.H4 - Halts the flow from Biederman Drain up to the plug crest elevation at 175.0m. This will increase the water surface in the drain about 0.2m at the upstream end and about 1.1m at the plug location. - No grading in agricultural areas. - Utilizes existing grades. - Creates a water level scenario within the bog similar to when the beaver dams are in place. - No impact to landowners. - No change in water balance.	- Does not direct runoff into the preferred/pre 1930 alignment. - All Biederman Drain water continues to flow into and through the bog.
Red	a. Install plug in existing Biederman Drain at Section N with crest elevation of 175.0m. b. Match existing channel invert at connection with main channel (174.61m) at Channel Station 0+007. c. Grade channel to drain downstream. Ties into existing channel at Channel Station 1+400. d. Remove trees in existing ditch that is congested with trees (Channel Station 0+007 to 0+190) to create positive drainage within the channel.	X	$$$$	XXXX	- Niagara Peninsula Conservation Authority - Indigenous partners - 8 Trees - Farmer A - Farmer B	- Drains adjacent agricultural fields to the greatest depth. - Intercepts and directs all flow around the bog. - Fully isolates the bog from the Biederman Drain. - Allows for field tile drains.	- The existing invert at the confluence with the Beiderman Drain and the upper end of the channel would remain as-is allowing the undesired bog draining scenario to continue. - Requires large earthen plugs installed in existing drain. - Requires the greatest grading within the woodlot. - Requires culverts at the Erie Peat Road, Enbridge gasline in the woodlot and multiple farm field crossings. - Allows water level to continue to fluctuate. - The propose channel alignment would have to be relocated north of the overhead power line from station 1+060 to 1+250. - Requires the greatest permit approval. - Requires the most grading volume. - Grading requirements impact agricultural lands and some loss of land able ot be cultivated will occur.
Blue	a. Install plug in existing Biederman Drain at Section N with a crest elevation of 175.0m. b. Invert at upstream connection with main channel to be 175.0m at Channel Station 0+012. c. Grade channel to drain downstream. d. Remove trees in existing ditch in that is overgrown (channel station 0+007 to 0+190) to create positive drainage in the channel.	XXX	$$$	XXX	- Niagara Peninsula Conservation Authority - Indigenous partners - 8 Trees - Farmer A - Farmer B	- Drains adjacent agricultural fields to the greater depths than the green option. - Provides a lot of channel capacity. - Allows for field tile drains.	- Requires large earthen plugs installed in existing drain. - Requires some grading within the woodlot. - The proposed channel alignment would have to be relocated north of the hydroline from channel station 1+060 to 1+250 - Allows some fluctuation of water levels in the bog to continue. - Requires culverts at the Erie Peat Road, the Enbridge gas line in the woodlot and multiple farm field crossings. - Grading requirements impact agricultural lands and some loss of land able ot be cultivated will occur
Green	a. Install plug in existing Biederman Drain at Section N with a crest elevation of 175.0m. b. Invert at upstream connection with Biederman Drain to be 175.6m at channel station 0+020. c. Grade channel to drain downstream. Ties into existing channel at channel station 0+980. d. Add fill to the existing ditch overgrown with trees (channel station 0+007 to 0+190 - remove trees or fill around them and they would die in a few years) to create positive drainage within the channel.	XXXX	$$	XX	- Niagara Peninsula Conservation Authority - Indigenous partners - 8 Trees - Farmer A - Farmer B	- Prevents most water level fluctuations in bog. - Current drainage for adjacent agricultural fields would continue. - Allows for existing field drains to continue to drain effectively. - Minimal grading is required. - No grading is required along overhead power line.	- Has limited flow conveyance capacity and may be subject to overtopping if filled with snow during spring snow melt events. - Limited field tile drainage opportunities. - Channel design isn't as deep as other options and therefore is most sensitive to sedimentation and may require more frequent maintenance. - Requires the least grading within the woodlot. - Requires culverts at the Enbridge gasline in teh woodlot and the western farm field crossing.
Interceptor Swale	a. Create a swale to intercept runoff from the concrete plant lands and direct it past the bog. b. The swale would be created on the south bank of the Biederman Drain and follow the existing alignment of the drain. c. The graded shallow swale would drain channel to drain downstream. Ties into existing channel at 0+980. d. Add fill to the existing ditch in that's full of trees (0+007 to 0+190 - remove trees or fill around them and they would die in a few years) to create positive slope.	N/A	N/A	N/A	- Niagara Peninsula Conservation Authority - Indigenous partners - 8 Trees - Farmer A - Farmer B		