ROYAL BOTANICAL GARDENS
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Wetlands Conservation Plan 2016-2021

Includes RBG contribution to the HHRAP as it pertains to the restoration of the wetlands

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Document Description:
This document summarizes operating strategies, projects, and needed resources for RBG marsh restoration and management between 2016 and 2021. Recommendations and an action plan are included, which will be pursued by RBG pending relevant approvals, compatibility with broader RBG strategies, funding, and support from outside organizations and the public.

Executive Summary

Wetland Restoration Goal: While maintaining system connectivity restore the underlying conditions for biodiversity recovery and sustainability, quantified as a mesoeutrophic environment in the deltas and a mesotrophic environments in the sheltered bays.

The 2010-2015 Wetland Restoration plan activities (Project Paradise) advanced the recovery of Cootes Paradise and Grindstone Marsh significantly. Aquatic vegetation doubled to 131 hectares (target 270ha.), and water clarity in Cootes Paradise Marsh improved from an average of 35cm to 60cm (target 100cm). However, fish and wildlife populations have not responded in relation to the improved marsh conditions. For example fish counted at the Fishway have only slightly increased from an already extremely impaired level. Research projects have been initiated with partners to assess potential unknown sources (i.e. pesticides and pharmaceuticals). Also for fish, the adjacent harbour's summer loss of oxygen in the deeper water, and recent research that found loss of oxygen under the ice in the western basin during the last two winters clearly impacts the fish populations. The cause of this problem is expected to be resolved once the Hamilton Waste Water Treatment Plant (WWTP) upgrades are completed (2021). Similar research in the western Desjardin Canal in Cootes Paradise (below the King St. WWTP), found this area also loses its oxygen under ice cover. These low oxygen conditions favour a system dominated by low-oxygen-tolerant carp and goldfish.

This restoration plan summarizes items including the role of RBG in the HHRAP, the strategy looking forward independent of the HHRAP, resources required, partnerships, research opportunities, specific projects and locations. The plan is in parallel with the 2021 expected completion of the Hamilton Harbour Remedial Action Plan (HHRAP), bringing the wetlands to a recovered state. An important role for RBG in this process is providing water quality-based communications on the state of the wetlands, and the most important factor for wetland sustainability – supporting the partner initiatives to improve inflowing waters.

In summary, the Wetland Restoration Plan addresses large-scale degradation, Species at Risk protection and recovery, and invasive species management. These themes (below) align with provincial and federal biodiversity strategies. RBG's planned wetland management actions between 2016 and 2021 are dominated by four principle themes that are threaded through 13 separate project initiatives; their associated summaries are found in the Project Descriptions section. In addition to these themes, specific partner projects in the western section of the Desjardins Canal upstream of West Pond (owned by the City of Hamilton), and the wastewater treatment at the head of the canal, will be key steps on the road to achieving wetland sustainability.

Wetland Restoration Themes 2016-2021

1. Exclusion and removal of Common Carp from the marsh areas.
2. Emergent marsh planting to ameliorate Lake Ontario water level regulation.
3. Removal and repair of historically armoured shorelines in Cootes Paradise Marsh.
4. Meadow Marsh restoration through invasive plant management with potential alignment with pollinators.

To complete the plan, staff compliment is forecasted to be the same as current. The most significant expense after staffing will be plants for restoration work, estimated at $500,000 total (220,000 plants). There is also potential for RBG volunteers to assist with propagation. This volunteer contribution can be helpful in leveraging partner funding, with this already noted to both the volunteers and RBG propagation. Basic infrastructure of boats, the boathouse and vehicles (x2) will need to be renewed.

Financial contributions to RBG between 2010 and 2015 to support the HHRAP work within the marshes by the lead agencies Environment Canada and Ministry of Environment and Climate Change were a critical partnership in advancing the projects. Partnerships with both these agencies are expected to continue going forward to the completion of the HHRAP. Partnerships with the Ontario Ministry of Natural Resources and Forestry are expected to grow under the Species at Risk and invasive species management themes. RBGs Project Paradise Fund still holds $240,000 but will be depleted within the next couple years. Notable RBG funding raising opportunities will occur in the coming years including, the Cootes Paradise Fishway 20th anniversary celebration (2017), and supporting the propagation of plants. Opportunities will also present themselves as restoration success with individual wetland species such as turtles, eagles and wild rice occurs.

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RBG 2016-2021 Strategic Plan

ACHIEVING EXCELLENCE IN:

1. THE RBG GUEST EXPERIENCE
2. FINANCIAL SUSTAINABILITY
3. ENVIRONMENTAL LEADERSHIP
4. GOVERNANCE AND LEADERSHIP

In the natural areas, we will continue to align with the provincial Biodiversity Strategy undertaking projects to inventory and protect endangered species, as well as developing and implementing plans to manage invasive species. Our wetlands restoration initiatives will continue to be our flagship environmental management project, working with local and government partners to monitor and recover the health of two of the largest remaining Lake Ontario coastal wetlands, Cootes Paradise and Grindstone Marsh. These marshes represent a third of RBG natural areas and the project aligns exactly with the objectives of the new Great Lakes Protection Act. Complementing the environmental projects, trail system infrastructure renewal will continue, ensuring trails remain open, safe, inspiring, and facilitate environmental protection and educational programming.

Natural Lands Biodiversity Goal

To manage Royal Botanical Gardens' conservation lands as integrated sanctuaries in the context of their international and local significance, both ecologically and culturally by enhancing, restoring, and maintaining habitats and linkages in balance with the public's need for spiritual renewal and exploration.

Wetland Restoration Goal

While maintaining system connectivity, restore the underlying conditions for biodiversity recovery and sustainability, quantified as a mesoeutrophic environment in the deltas & mesotrophic in the sheltered bays.

Longer Term Objectives

1. with partners, recover inflowing water quality to meet provincial/federal water quality objectives
2. restore natural water cycle patterns of Spencer Creek and Lake Ontario
3. remove non-native species dominating the system

Key Partner Water Quality Related Plans

- Great Lakes Water Quality Agreement
- City of Hamilton Stormwater Master Plan
- City of Hamilton Wastewater Master Plan
- Conservation Authorities Watershed Plans – various

As noted in the previous 2010-2015 wetland restoration plan, a significant driver of the success of the dominant harbour fish, Common Carp (*Cyprinus carpio*), and the overall unbalanced fish populations is the ability to survive anoxia in Hamilton Harbour. This anoxia is a direct result of the Woodward Ave. Wastewater Treatment Wastewater Plant, and so despite the fact its water does not flow directly into RBG wetlands, upgrade of this plant is critical for the long term sustainability of the marshes.

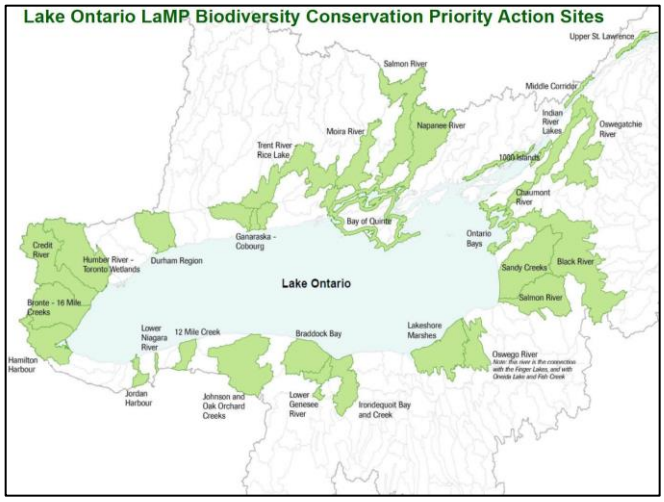
Looking Forward

During the period of this plan, a transition from RBG activities driven by the Great Lakes Recovery initiative (HHRAP) to the Great Lakes Biodiversity Strategy will occur as the HHRAP and the wetlands are to be delisted by 2021. At RBG, this transition began during the course of the previous five years with initiatives specific to both Species at Risk and Invasive Species (other than carp) being undertaken. This was highlighted by the completion of an RBG Turtle Site Specific Plan and a *Phragmites* Management Plan. Given the biota of the wetlands, there are in excess of 20 partner level strategies RBG could align with (Appendix A). Moving forward, both Species at Risk and invasive species will become dominant drivers of future activities, with pollinators currently emerging as a potential new dimension. In addition, local cooperation will shift from the

HHRAP to the Lake Ontario Management Plan, Cootes to Escarpment Ecopark System, and Niagara Escarpment World Biosphere Initiatives.

Key Partner Plans

- Great Lakes Water Quality Agreement (State of the Lake Ecosystem Conference - SOLEC)
- Federal and Provincial Biodiversity Strategies with focus on Species at Risk, invasive species & pollinators
- Provincial Great Lakes Protection Act and Lake Ontario Management Plan (LaMP)
- Federal North American Migratory Waterfowl & Shorebird Management Plans
- Great Lakes Wetlands Conservation Action Plan
- Nature Conservancy Great Lakes Conservation Blue Print
- Lake Ontario Water Level Regulation Plan 2014
- Ontario Invasive Species Strategy / Act



The International Joint Commission (IJC) recommends 16 ecosystem indicators composed of 41 measures as the best indicators in assessing progress under the GLWQA. The State of the Lakes Ecosystem Conference (SOLEC) also has a suite of indicators to measure the health of the Great Lakes. The SOLEC and IJC indicators are compared in chart form in Table 15 in Appendix A. From these, RBG will focus on improvements to the extent, composition, and quality of Coastal Wetlands. RBG on its own, or in partnership with appropriate agencies, will also continue to monitor various Great Lakes indicator species including the plant communities, migratory waterfowl, and fisheries, as well as support the Hamilton Harbour Remedial Action Plan (HHRAP) delisting criteria.

A currently unexplored dimension of the property management goals is with the North American Waterfowl and Shorebird Management Plans. Understanding these plans and determining what specific alignments can be made will be part of planning. International interest in Great Lakes wetlands will continue to grow, and in the case of Lake Ontario, will be of particular interest as a new water level regulation plan is expected to be implemented (Plan 2014). The International Lake Ontario-St. Lawrence River Study performed by the IJC has investigated water level regulation plans and their associated impacts on the Environmental Performance Indicators, show in Table 16 in the Appendix A. Implementation of the proposed Plan2014 would benefit key indicators of the Wetland Meadow Marsh Community (by 1.44 times over the current regulation plan) and the muskrat populations (by 2.59). These indicators line up with RBG's six year plan to improve the quality of meadow marsh community in RBG wetlands and the quality of marsh habitat that will support native wildlife populations, including muskrats.

An extensive list of background reports has been generated over the years to inventory biota and explore the various issues affecting the marsh. This list of the most relevant reports is located in the reference reports section, but is by no means an exhaustive list of reports pertaining to Cootes Paradise and Grindstone Marshes.

The Primary Restoration Issue

The primary issue to resolve is the historical loss of the entire wetland plant community and biota in areas flooded for periods longer than 1 month (Cootes Paradise Marsh= 208 ha. This is a result of extremely high Eurasian Common Carp (*Cyprinus carpio*) densities (800 kg/ha), connected to water pollution. The high density of carp caused a collapse of ecosystem function through destruction of the marsh channels, allowing formerly contained inflowing contaminants to disperse throughout the marsh. The feeding action of carp resulted in this fish being the primary source of suspended sediment and associated phosphorus in the water column. Through experience with carp exclusion, RBG finds measurable impacts occur at densities over 20

kg/ha. The success of the carp is a product of multiple factors noted under the section "Invasive Species" later in the document.

Secondary Issues
Degraded inflowing water supplies, water level regulation, and system dominance by various non-native species comprise fundamental challenges for RBG wetlands. Inflowing water quality issues are highlighted by bacteria, phosphorus, sediment, nitrogen compounds, and potentially pesticides. This has resulted in 3 areas of sediment impairment including the interior of Westdale Inlet, the Desjardins Canal upstream of West Pond, and Chedoke Bay. Outer Carroll's Bay shows metal contaminants impairment, but it is unknown if this is limiting biodiversity and is in need of further study. In 1994, non-native species represented >90% of the biological system with the chief invaders comprised of Common Carp, Eurasian Manna Grass (*Glyceria maxima*), Common Reed (*Phragmites australis*), and Mute Swan (*Cygnus olor*). In addition, water level regulation of Lake Ontario has maintained summer water levels high enough to prevent natural emergent marsh reestablishment from seedlings (nursery conditions) since the inception of the restoration. As a result, 11.5 km of shoreline within the marshes remains without emergent plants and virtually all new vegetation sites are a result of active planting by RBG staff and volunteers.

Issues Summary

- Physical destruction of plant communities and impairment of water quality by carp
- Turbidity preventing light penetration to the bottom for plant growth derived from carp, urban and rural runoff, and eutrophication
- Hypereutrophic inflowing phosphorus water sources, well exceeding guidelines for aquatic life
- Localized sediment contamination from sewage and urban watersheds
- Modified water cycles - both Lake Ontario and inflowing rivers
- Historical Ditching of Lower Spencer Creek and Chedoke Creek
- Dominance of several Eurasian non-native species
- Extirpation of native species
- Localized accumulation of inflowing litter and debris smothering and trapping biota

The Key Performance Indicators for RBG Wetlands

Measurement of the following list of topics will be used to track the state of the wetlands and the rate of progress of recovery. More details on the monitoring programs are provided in the monitoring section.

- Area of submergent marsh
- Area of emergent marsh
- Area of meadow marsh
- % wetland native plants
- Water clarity or water quality index
- Biomass of common carp
- Winter muskrat lodges present
- Yellow Perch population

Integration with the HHRAP

The HHRAP is triggered by the Great Lakes Water Quality Agreement, with both pre-dating federal and provincial Biodiversity Strategies. The HHRAP does not pertain to the entire area of RBG wetlands, focusing only on the highly impaired area as identified in1992 HHRAP Stage 1 Report. These areas included the seasonally flooded habitats of meadow marsh and emergent marsh, and the permanently flooded submergent marsh. The initial habitat targets for Cootes Paradise and Grindstone Marshes were never actually calculated, but the spirit was to restore the missing wetland and aquatic vegetation back to historical conditions (with no reference to species makeup). As such, target numbers originally identified to be restored have since been refined by RBG with detailed Geographic Information System mapping (ARCGIS).

The current HHRAP targets for the marshes are;

- Cootes Paradise Marsh - 230 hectares of vegetation
- Grindstone Marsh – 40 hectares of vegetation

The Grindstone Marsh habitat target has proven to be challenging as total area of habitat lost in Grindstone Marsh continued to increase following the onset of the initial HHRAP. This was further confounded by the lack of initial habitat measurements of the area, resulting in a HHRAP target that under represented the missing vegetation by 1999. As of 1999 the missing vegetation had reached 46 ha.

Significant progress has been made during the course of the HHRAP, such that meadow marsh restoration is no longer part of the HHRAP (based on HHRAP criterion that is solely based on area of vegetation and not species composition). However, all HHRAP reporting will still include this area since it is still contributing area towards the habitat delisting target. The current challenge in the meadow marsh areas is that it is almost entirely composed of a Eurasian plant species making the habitat quite ineffective in supporting native insects and wildlife. Meadow marsh management now falls under federal and provincial biodiversity strategies linked with both Invasive Species and Species at Risk.

HHRAP Targets

Within the HHRAP there are 11 Beneficial Use Impairments (BUIs), for which 5 are directly measured within RBG properties and several that rely on the health of the properties. One of the 12, BUI v, is currently listed as requiring further assessment to properly summarize its condition.

v - Bird or Animal Deformities or Reproduction Problems (measured by Environment Canada – reassessment)
vi - Degradation of Benthos (marsh criteria currently not established, no lead assigned)
viii - Eutrophication or Undesirable Algae
xi - Degradation of Aesthetics (no criteria currently established)
xiv - Loss of Fish and Wildlife Habitat

HHRAP BUIs with a direct link to RBG marshes.
iii - Degradation of Fish Population (measured by DFO in the harbour)
iii - Degradation of Wildlife Populations (measured by EC – colonial waterbird populations)
x- Beach closing and water contact sports (restricted to beach measurement)

The objectives pertaining to RBG marshes and the BUIs under the HHRAP can be summarized as:

1. Achievement of water quality targets through restoration of inflowing water and exclusion of Common Carp (*Cyprinus carpio*).
2. Restoration of plant coverage through elimination of Common Carp and rebalancing of Canada goose population.
3. Remediate onsite physical/chemical damages of historical impairment, including collapsing shorelines and localized sediment impairments at the western Desjardins Canal, Chedoke Bay, and Westdale Inlet.

To measure the progress towards recovery of the HHRAP each of the BUIs has targets (delisting targets). The delisting targets, as available, are listed in Table 1. Several of the delisting targets are relative to comparison

sites, while the measure of aesthetics has yet to be resolved. Both benthos and wildlife deformities have baseline data available; however, the actual HHRAP target is not chosen. In addition, RBG strives to achieve environmental conditions consistent with provincial and federal guidelines and in support of biodiversity. Two challenges have risen as RBG targets and alignment with federal and provincial guidelines/objectives do not always align with the initial HHRAP targets laid out in 1992. The challenges are two fold;

1. The HHRAP water quality targets for the marshes are not reflective of current federal and provincial guidelines/objectives for aquatic life, while the harbour targets are.
2. Several factors (i.e. pesticides, pharmaceuticals, and nitrates) have no HHRAP measures and yet are negatively affecting the marsh ecosystem.

The above two factors have confounded the City of Hamilton's ability to determine capital infrastructure needs to mitigate wastewater and urban runoff pollution. Resolving the HHRAP water quality targets are currently the subject of the Cootes Paradise-Grindstone Marsh Water Quality Subcommittee.

Table 1. HHRAP delisting targets for RBG wetlands

Measure	**BUI**	**Final Objective**	**Cootes Paradise 2015 Average**	**Grindstone Marsh 2015 Average**	**Pre Restoration (1990)**
**Vegetated Area	iii	270 hectares	133 ha	20 ha	60 hectares
* Water Clarity	viii	>100 cm	60 cm[+]	33 cm	<30cm
* Total Phosphorus	viii	<50 ug/l	78 ug/l	117 ug/l	270 ug/l
* Total Suspended Sediment	viii	<25 mg/l	21 mg/l	33 mg/l	65 mg/l
* Chlorophyll a	viii	TBD	N/A	N/A	N/A
* Unionized ammonia	viii	<0.02 ug/l	0.024 ug/l	0.15 ug/l	<0.02 ug/l
* Dissolved Oxygen	viii	>5mg/l	>5 mg/l	>5 mg/l	>5 mg/l
Aesthetics	xi	TBD	TBD	TBD	No determination
Benthos	vi	Relative to unimpaired site	In process	In process	Impaired
Wildlife deformities	v	Relative to unimpaired site	In process	In process	Impaired

*measured at monitoring stations CP2 and GC1.
**Improved wetland mapping revised the initial HHRAP target with 230ha in Cootes Paradise marsh and 40ha in Grindstone Marsh.
[+] 12 out of 24 samples had a Secchi reading that was greater than depth. In this case, depth was used to calculate the average.

Background Summary & Status

Royal Botanical Gardens has been providing protection, stewardship, and restoration of its wetland holdings since the 1940's. This has included many projects from wetland planting programs, to hydrological manipulations, to carp exclusion, and to species re-introduction. Inflowing water quality has also always been at the forefront. Local municipalities that discharge wastewater into the properties have always maintained the highest quality effluent standards in the region. Under the Great Lakes Water Quality Agreement of 1970s, the two remaining wetlands retained within RBG property holdings gained additional interest with the formation of the HHRAP and the unveiling of Project Paradise in 1993. Project Paradise was structured to set a restoration course and generate funds for RBG to contribute to projects. Project Paradise will discontinue as part of this plan and the restoration project will be rebranded as an RBG wetland biodiversity conservation project and part of the Niagara Escarpment World Biosphere. Focus will be placed on recovery of rare species, meadow marsh invasive plant species, migratory birds, and fish.

The goal of the Hamilton Harbour Remedial Action Plan (HHRAP) is the restoration of a degraded Great Lakes area (Area of Concern) as identified by the International Joint Commission (IJC) under the Great Lakes Water Quality Agreement (updated 2012). At RBG, the area covered includes the two river mouth coastal marsh complexes of Cootes Paradise Marsh and Grindstone Marsh (bounded by the 75.5msl contour). Overall these wetlands extend up multiple watersheds, totaling approximately 400 hectares in size, and include over 30 km of shoreline and 25 subwatersheds. RBG owns all of Grindstone Marsh and nearly all of Cootes Paradise Marsh. West of Cootes Drive is owned by Hamilton Conservation Authority and portions of the old Desjardins Canal are owned by the City of Hamilton. Locally these areas represent 99% of the remaining undisturbed harbour shoreline and greater than 95% of the remaining wetland habitats. These are also the largest wetlands in the western half of Lake Ontario and the only coastal marshes protected within the Niagara Escarpment World Biosphere Reserve. The marshes are directly connected to the Lake Ontario water level. Lake Ontario water cycle variations can result in all or none of the marsh area flooded, and the typical annual cycle moves across 1/3 of the marsh area (~70 cm annual fluctuation). Dominant watersheds are Spencer Creek (270 km^2) and Grindstone Creek (89 km^2). Although impaired, these watersheds are two of the healthier watersheds remaining on Lake Ontario, with over 95% of the Spencer Creek watershed contained within the Greenbelt.

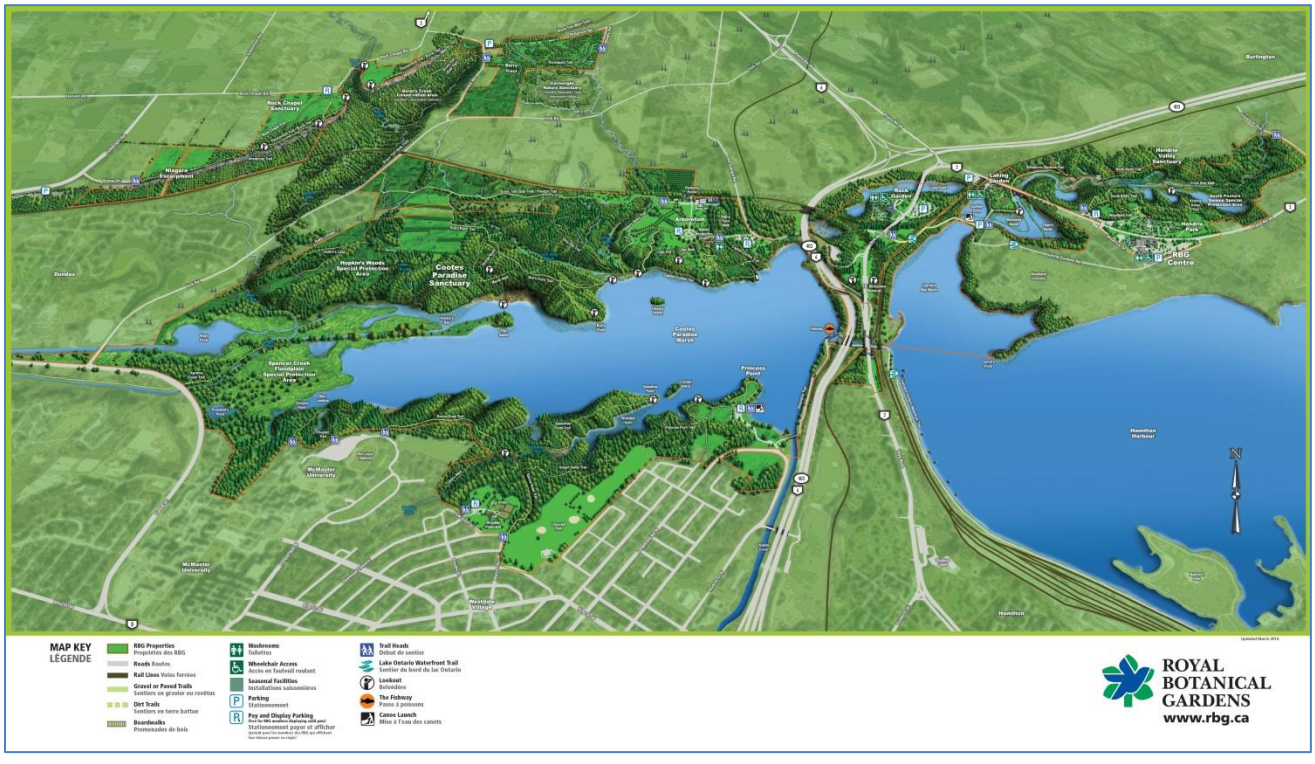


Figure 1. Map of RBG properties with Cootes Paradise Marsh as the central water feature

Current Wetland Status

By the end of 2015, significant progress had been made toward restoration goals. Water quality and clarity in Cootes Paradise Marsh improved from an annual average off 35cm (2009) to 60cm clarity (2015). Emergent plants expanded each year and from 2010 to 2015, complimented by planting, added an additional 4.5 ha. No emergent seedlings naturally established during this period due to above average summer water levels. The total area missing at the onset of the HHRAP was 208ha. and is now less than 100ha. In 2012, low fall water levels allowed for almost all remaining carp to be removed triggering subsequent wetland improvements. Wild Rice and submergent plants responded to the increased water clarity, with submergent plants increasing annually to now cover more than half the marsh surface area. Carp continue to be a challenge, and since the end of 2012 when the marsh was temporarily drained by low water, an additional 3,250 have been removed from the marsh. These carp are a result of their reluctance to leave the shallow cold marsh for the winter holding in water <15cm deep, and combined with ongoing carp from reproductive success in the marsh. Their reproductive success reflects the lack of other native predators and competitors. Overall the marsh continues to be eutrophic and annually, in late summer, declines to hypereutrophic conditions resulting in extensive algae blooms and considerable collapse of the submergent plant community. Fish and wildlife populations which are mostly based in Hamilton Harbour have not responded in accordance with the improvements in marsh habitat, with studies currently underway to further understand the situation. As an example, less fish passed through the Fishway in 2015 than 2009, with only native Bluegill populations improving and Eurasian Goldfish and Rudd also increasing.

In Grindstone Marsh (58 hectares) conditions have also improved with total vegetation 2009 = 14 ha and 2015 = 20 ha. At the outset of the HHRAP an estimated 40 ha of marsh vegetation was missing and worsened to 46 ha by 1999. The original 40 ha is only estimated from aerial photos and the experience of one of the authors (Theysmeyer pers. obs.) as it was not quantified in the field in the early 1990s. While more than half is still missing, the vegetated area has increased in the carp protected areas and deceased in Carroll's Bay (not carp protected). During the past 5 years, relocation and rebuild of carp exclusion berms reclaimed 0.75 ha of additional marsh area from the creek for restoration. Pond 1, although small in area, shows a measurably improved plant community and Ponds 2-4 remain in an essentially restored condition, but require ongoing carp removal. Issues with flooding (poor quality water) of restoration areas and carp exclusion are slowing recovering, with multiple projects implemented to improve the situation. Long Pond, the second largest area after Carroll's Bay Marsh, remains a challenge to access to complete work, while Carroll's Bay Marsh continues to be overrun with carp. Inflowing Grindstone Creek water quality is improved, a result of two major projects in the watershed by the municipalities. The outer bay area of Carroll's Bay (the actual location of the bay historically) does contain some aquatic vegetation but currently is not quantified.

RBG projects in the previous 5 years also included a variety of public access and aesthetic improvements; public education programs; public education signage; extensive wetland replanting; carp barrier and carp removal operations; and goose management. In Cootes Paradise, a total of 57,000 cattails and 1,500 water lilies were planted as well as an annual program to re-establish wild rice. Newly planted reeds are currently protected with 1.5 km of temporary fencing. In Grindstone Marsh, three of the four carp exclusion berms have been rebuilt, and four of the five carp exclusion structures have been upgraded from temporary experimental structures to more permanent metal barriers. In addition, the wetlands were mapped in detail providing RBG with high quality base maps and historical aquatic plant community data. Databases continue to be updated for the various monitoring programs; the Fishway database the most extensive, containing over 84,000 records.

RBG worked with multiple partners to complete projects on site and supported major capital projects to improve water flowing into the property. In partnership with the Bay Area Restoration Council, annual volunteer planting contributing 2,000+ new emergent plants to Cootes Paradise Marsh every year, plants which continue to multiply and expand and now cover about a half a hectare. Within Grindstone Marsh, the City of Burlington rebuilt a broken storm drain leading from Plains Road to one of the marshes, redirecting the flow to the creek and improving the water quality with an updated storm scepter. Grindstone Creek was measurably improved as the City of Hamilton closed down the Waterdown Wastewater Plant (WWTP), ending a long history of discharge to the creek; the water is now redirected to the main Woodward Ave plant.

The City of Hamilton began operating the McMaster CSO tank, located on Ancaster Creek (a tributary of Spencer Creek), dramatically improving inflowing water quality to the back of Cootes Paradise. The operation of the Main/King and Royal CSO tanks was improved dramatically reducing the number of overflows. Also, the King Street WWTP (located in Dundas) had the sand filters replaced restoring effluent quality to the original characteristics achieved in the 1980s, although still at levels that create hypereutrophic conditions in West Pond. On Spencer Creek, the Hamilton Conservation Authority removed Crooks Hollow Dam, a historical mill dam which created an algae filled impoundment flowing to Cootes Paradise Marsh.

Figure 2. Cootes Paradise's Rat Island in the Spencer Creek delta, 2011 (lower photo) and 2015 (upper photo)

Invasive Species

Eurasian invasive species are a significant challenge in the RBG natural areas. During the period of 2010-2015, the invasive species dimension of the provincial biodiversity strategy emerged as a significant provincial priority, culminating in the passage of the Ontario Invasive Species Act in 2015. Federally aquatic invasive species also emerged as a priority with the management work expanded to include Asian Carp (excluding Common Carp). Prior to 2010, Common Carp was the species of focus through the HHRAP. However, between 2010 and 2015, initiatives for several other species have occurred, particularly in relation to Species at Risk protection. The implications of the new legislation for RBG are yet to be determined, but it can be anticipated as a future source of funding support both on the management and monitoring front. In recognition of this RBG is drafting an invasive species management strategy to summarize the top priorities going forward. As of 2015, Common Carp and *Phragmites* have RBG management plans, with Eurasian Manna Grass *(Glyceria maxima)* soon to follow. Both Phragmites and European Manna Grass principally occupy the meadow marsh habitat, a habitat that is also a Lake Ontario Health wetland health indicator. The list of non-native invasive species of concern identified in the RBG wetlands is found in Table 3 below. Of the listed species, mute swans, goldfish, rudd, and flowering rush are identified as emerging issues adding to the already challenging list of species. As part of the invasive species strategy, a target threshold level triggering management action for non-native species abundance will need to be established.

In theory, Eurasian species such as the Common Carp would not be expected to out-compete native species, unless the habitat was altered to disfavour the native species or a suitable natural predator did not exist in North America. This is demonstrated elsewhere on the Great Lakes were unpolluted wetlands are not dominated by carp. Altered/impaired water quality allowed Common Carp to reached 90% of the fish biomass, equivalent to an estimated 800 kg/ha in Cootes Paradise. This resulted in the loss of most native species across all biological community levels, including plants, invertebrates, fish, birds, mammals, and multiple Species at Risk. RBG has found that associated issues begin at densities of over 20 kg/ha. Carp arrived in the late 1800's and were locally established as a dominant species by the 1940's. Most of RBG wetland loss occurred between 1937 and 1950. Key drivers of carp population include eutrophication of the marsh, anoxia and ammonia issues adjacent Hamilton Harbour, watershed sediment input, and alteration of the natural marsh water cycle.

Table 2. Identified factors contributing to the historical success of Common Carp (*Cyprinus carpio*).

Life History	Issue	Strategy
Reproduction	Favoured by the regulation of Lake Ontario – typical regulated peak seasonal shoreline flooding aligns with reproductive habitats (June spawning – flooded vegetation)	1. Long term - Return variability to seasonal water level peak, and return peak period to May. 2. Short term - Exclude carp from reproductive habitats
Summer Habitat	Favoured by turbid open water river mouth marshes and backwaters.	1. Reduce turbidity of inflowing water, nutrients and fine particulate. 2. Short term – exclude carp from river mouth habitats with barriers and by returning of Old Desjardins Canal remnant to wetland depth
Wintering habitat	Favoured through tolerance to elevated ammonia and depressed dissolved oxygen levels in Hamilton harbour.	1. Address ammonia and dissolved oxygen issues in harbour.
Feedback loop 1 – *Vacant niche*	Open niche created by loss of wetland vegetation in the wetland areas.	1. Exclude carp from wetlands 2. Restore inflowing water quality 3. Reestablish natural water cycle patterns
Feedback loop 2 – *Lack of Predators*	Lack of predators to maintain a balanced system.	1. Restore wetland fish habitat, with marsh species expect to eat young carp. 2. Bald Eagle, Mink, Northern Pike & Muskellunge for moderate sized carp.

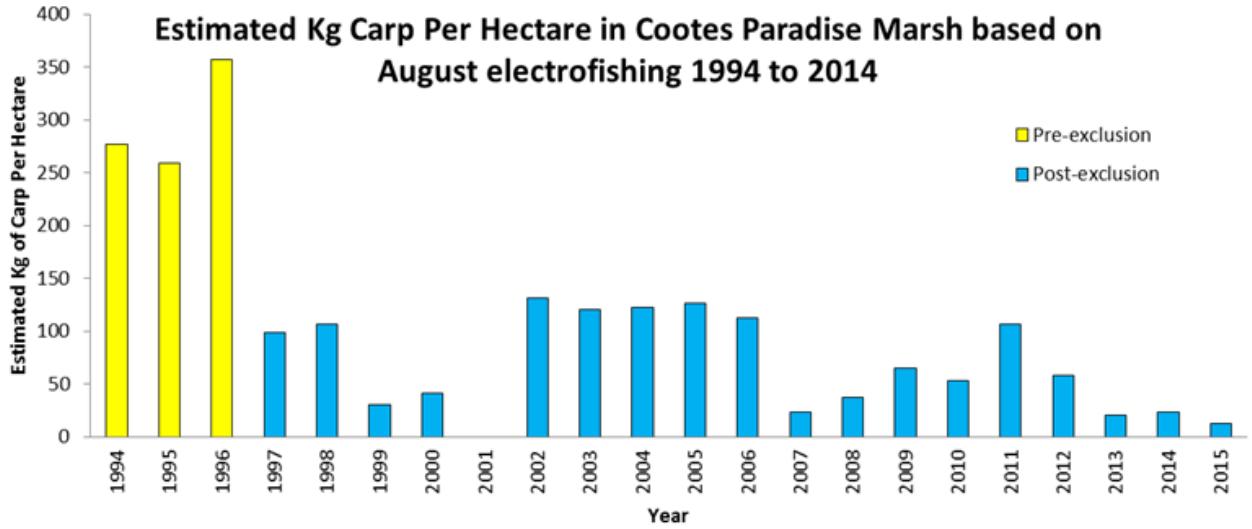


Figure 3. Trends in carp abundance at Cootes Paradise from August electrofishing monitoring (22 transects).

Table 3. Summary of abundant invasive species found within RBG wetlands.

Species	**Status**
Eurasian Manna Grass (*Glyceria maxima*)	Covers 90% of the meadow marsh habitats as monocultures
Giant Reed Grass *(Phragmites australis)*	Localized monocultures cover less than 5 hectares
Red Canary Grass (*Phalaris arundinacea*)	Localized, suppressed by Eurasian Manna Grass
Purple loosestrife *(Lythrum salicaria)*	Sporadic and controlled by previously introduced beetles (1994)
Flowering Rush *(Butomus umbellatus)*	Localized, but emerging as a potential problem
Crack Willow *(Salix fragilis)*	Dominant wetland tree species
Yellow Iris *(Iris pseudoacorus)*	Localized, but emerging as a potential problem
Common Carp *(Cyprinus carpio)*	Became dominant in the 1950s, 800kg/ha as of 1994
White perch *(Morone americana)*	Currently declining, in the 1990's a very abundant fish species
Round Goby *(Neogobius melanostomus)*	Locally abundant in Grindstone Creek and Carroll's Bay marsh.
Goldfish (*Carassius auratus*)	Increasing, recently reached status as a common species
Rudd *(Scardinius erythropthalmus)*	Increasing, recently reached status as a common species
Red-ear slider *(Trachemys scripta elegans)*	Abundant near public access areas
European Mute Swan *(Cygnus olor)*	A dominant breeding waterbird

Species at Risk

RBG's Species at Risk (SAR) program objectives include providing regular status updates (every 3-5 years) for all SAR species that occur on RBG lands. This process is evolving with the ever-increasing list of species under threat. As of the end of 2015, 28 listed SAR have been observed in association with the wetlands in the preceding decade (see Table 4). With the transition away from the Hamilton Harbour Remedial Action Plan, efforts supporting SAR biodiversity strategies in the wetlands will emerge as significant. This process has started with the creation of the Site Specific Plan for SAR turtles and with background research on SAR freshwater mussels. In the past, funding was secured for Prothonotary Warbler and Least Bittern habitat projects, as well as most recently for aerial insectivore bird surveys. In addition, the populations of two SAR at Royal Botanical Gardens (Red Mulberry and Few-flowered Club-rush) represent the critical remaining populations in Canada, and as such are the focus of research and management initiatives. The status updates identify issues to focus future management actions, which subsequently feed into the creation of Site Specific Plans. To provide additional protection for concentrations of SAR, RBG has branded specific off-trail areas as Special Protection Areas. This further minimizes off-trail activities and emphasizes the unique nature of the property. The areas currently include two locations in Cootes Paradise Sanctuary and one location in Hendrie Valley Sanctuary, with two consisting primarily of wetland habitat.

Key Species at Risk that we anticipate will assist with obtaining funding support include:

- Northern Map Turtle and Blanding's Turtle (general wetland habitat)
- Lilliput Mussel, potential for Eastern Pondmussel and Mapleleaf Mussel (aquatic habitat)
- Least Bittern (emergent marsh habitat)
- Prothonotary Warbler (swamp forest habitat)
- Eastern Ribbonsnake (wetland and swamp forest habitat)

We anticipate Southern Wild Rice (*Zizania aquatica*), a dominant plant in the restored RBG wetlands, will be added to the Species at Risk list within the next six years, following COSWEIC/COSARO assessment. Royal Botanical Gardens appears to be the province's primary information organization on this species, with only Lakehead University also taking an interest in the past. Southern Wild Rice spontaneously reappeared in Grindstone Marsh in 1998, and has since generated reintroduction research and projects.

Reintroducing SAR species extirpated from RBG has the potential to strategically align with similar efforts for currently extirpated, but listed, species. If other agencies undertake related initiatives, and wetland and overall aquatic conditions recover to a stable healthy environment, current opportunities can include:

- Grass Pickerel (potential for natural recolonization) (Special Concern federally and provincially)
- Redside Dace (Special Concern federally, Endangered provincially)
- Bridle Shiner (Special Concern federally and provincially)
- Lake Sturgeon (current subject of OMNRF reintroduction work in Lake Ontario) (Great Lakes population assessed by COSEWIC as Threatened federally, Threatened provincially)
- Jefferson Salamander (can potentially naturally recolonize from nearby/upstream populations)
- Hills Pondweed (potential for natural recolonization) (Special Concern federally and provincially)

Aerial insectivore birds are also of rising interest in biodiversity protection; population trends showing rapid decline have resulted in several recently being added to the Species at Risk list. Due to the migratory bird staging significance for these species at RBG, they are relevant as breeding residents, foraging area residents, and as staging migrants (which currently occur in the thousands). These birds are also connected to the marsh's invertebrate populations, which in turn also support other insectivorous SAR birds, namely the Acadian Flycatcher, Olive-sided Flycatcher, and Canada Warbler. Aerial insectivore birds relevant to the marsh include:

- Chimney Swift (Threatened federally and provincially)

- Bank Swallow (assessed as Threatened by COSEWIC, Threatened provincially)
- Barn Swallow (assessed as Threatened by COSEWIC, Threatened provincially)
- Common Nighthawk (Threatened federally, Special Concern provincially)
- Eastern Whip-poor-will (Threatened federally and provincially)

Species at Risk surveys conducted in 2015 to update the status of RBG's known Bank Swallow colonies found that they are now no longer nesting on RBG land. Black Terns, though not classed as an aerial insectivore, can rely heavily on insects and will nest only in hemi marsh conditions (50% open water and 50% emergent vegetation). During the past 3 years (2012-2015), Black Terns have been observed foraging at Cootes Paradise Marsh.

Table 4. Wetland-related Species at Risk at RBG, and their current wetland use status.

Common Name	Scientific Name	SARO	SARA/ (COSEWIC)	Wetland use at RBG	Last seen at RBG
Bald Eagle	*Haliaeetus leucocephalus washingtoniensis*	SC	NAR	migratory, breeding	2015
Prothonotary Warbler	*Protonotaria citrea*	END	END	migratory, breeding	2013
Least Bittern	*Ixobrychus exilis*	THR	THR	migratory, breeding	2015
American Eel	*Anguilla rostrata*	END	(THR)	permanent	2015
Eastern Pondmussel	*Ligumia nasuta*	END	END	permanent	2010
Lilliput	*Toxolasma parvus*	THR	(END)	permanent	2015
Mapleleaf Mussel	*Quadrula quadrula*	THR	THR	permanent	2015
Eastern Musk Turtle	*Sternotherus odoratus*	THR	THR	permanent	2009
Blanding's Turtle	*Emydoidea blandingii*	THR	THR	permanent	2015
Northern Map Turtle	*Graptemys geographica*	SC	SC	permanent	2015
Snapping Turtle	*Chelydra serpentina*	SC	SC	permanent	2015
Hooded Warbler	*Setophaga citrina*	-	THR (NAR)	migratory, breeding	2009
Acadian Flycatcher	*Empidonax virescens*	END	END	migratory, breeding	2015
Bank Swallow	*Riparia riparia*	THR	(THR)	migratory, breeding	2015
Barn Swallow	*Hirundo rustica*	THR	(THR)	migratory, breeding	2015
Chimney Swift	*Chaetura pelagica*	THR	THR	migratory, breeding	2015
Common Nighthawk	*Chordeiles minor*	SC	THR	migratory, breeding	2015
Spotted Gar	*Lepisosteus oculatus*	THR	THR	permanent	2006
Red Knot	*Calidris canutus rufa*	END	END	migratory	2012
Yellow Rail	*Coturnicops noveboracensis*	SC	SC	migratory	2012
American White Pelican	*Pelecanus erythrorhynchos*	THR	NAR	migratory	2015
Canada Warbler	*Cardellina canadensis*	SC	THR	migratory	2015
Golden Eagle	*Aquila chrysaetos*	END	(NAR)	migratory	2015
Horned Grebe	*Podiceps auritus*	SC	SC	migratory	2015
Rusty Blackbird	*Euphagus carolinus*	NAR	SC	migratory	2015
Olive-sided Flycatcher	*Contopus cooperi*	SC	THR	migratory	1975; 2015
Eastern Ribbonsnake	*Thamnophis sauritus*	SC	SC	permanent	1985; 2014 (unconfirmed)

Common Name	Scientific Name	SARO	SARA/ (COSEWIC)	Wetland use at RBG	Last seen at RBG
Black Tern	*Chlidonias niger*	SC	NAR	migratory (bred here historically)	late 1960s, 2015
Atlantic Salmon (Lake Ontario population)	*Salmo salar*	-	EXT	migratory, breeding	historical
Grass Pickerel	*Esox americanus vermiculatus*	SC	SC	permanent	historical
Redside Dace	*Clinostomus elongatus*	END	SC	permanent	historical
Blue Racer	*Coluber constrictor foxii*	END	END	permanent	historical
Gray Ratsnake	*Pantherophis spiloides*	END	END	permanent	historical
Timber Rattlesnake	*Crotalus horridus*	EXP	EXP	permanent	historical
Eastern Whip-poor-will	*Antrostomus vociferous*	THR	THR	migratory	1965
King Rail	*Rallus elegans*	END	END	migratory, breeding	1981
Jefferson Salamander	*Ambystoma jeffersonianum*	END	THR	permanent	1984
Eastern Spiny Softshell Turtle	*Apalone spinifera spinifera*	THR	THR	permanent	1984
Cerulean Warbler	*Setophaga cerulea*	THR	SC (END)	migratory, breeding	1996
Northern Brook Lamprey	*Ichthyomyzon fossor*	SC	SC	permanent	1997
Short-eared Owl	*Asio flammeus*	SC	SC	migratory, breeding	1999
Silver Shiner	*Notropis photogenis*	SC	SC	permanent	1999
Louisiana Waterthrush	*Parkesia motacilla*	SC	SC	migratory, breeding	2003
Wood Turtle	*Gleptemys insculpta*	END	THR	permanent	1994 (suspected pet release)

SARO – Species at Risk in Ontario List (https://www.ontario.ca/environment-and-energy/species-risk-ontario-list)
SARA – Species at Risk Act (2003) (http://www.registrelep-sararegistry.gc.ca/sar/index/default_e.cfm)
(COSEWIC) – Committee on the Status of Endangered Wildlife in Canada; rank is in brackets when SARA/COSEWIC differ, or if species does not yet have federal status on SARA schedules but has been assessed as at-risk by the Committee
SC – Special Concern; THR – Threatened; END – Endangered; EXP – Extirpated; EXT – Extinct; NAR – Not at Risk
Historical – not observed on RBG land in over 10 years.

Restoration Strategies and Actions

The strategies and actions integrate invasive species management and Species at Risk protection within them. In alignment with the HHRAP, the projects target recovery of wetland area first, and wetland plant community quality second. The primary objective for the wetlands is restoring wetland plant coverage to Cootes Paradise and Grindstone Marshes, with this total area (270 hectares) a HHRAP delisting criteria. The interior bay water quality goal in particular, a mesotrophic environment, supports plant diversity objectives. These wetlands contribute to numerous other beneficial use impairments (BUI's) and delisting targets of the HHRAP.

Four principle themes dominate RBG's on site wetland management actions between 2016 and 2021. These themes are threaded through 13 separate project initiatives with their associated summaries found in the Projects Description section of this document. Aside from the below, the King St Waster Water Plan and the Desjardins Canal upstream of West Pond to the WWTP (City of Hamilton land) negatively affecting the pond, lower Spencer Creek, and the western half the marsh will require a project to reduce contaminants. In addition to these projects RBG will provide communications to support partner efforts to improve inflowing waters.

1. Exclusion and removal of Common Carp from the marsh areas
2. Emergent marsh planting to overcome Lake Ontario water level regulation
3. Removal and repair of historically armoured shorelines in Cootes Paradise Marsh
4. Meadow marsh restoration through invasive plant management with potential alignment with pollinators

Table 5. Wetland project titles and timelines

Project	2016	2017	2018	2019	2020	2021
The Cootes Paradise Fishway	x	x	x	x	x	x
The Spencer Creek Delta Project	x	x	x			
Cootes Paradise Shoreline Repair	x	x	x	x	x	x
Cootes Paradise Inner Bay Project	x	x	x	x	x	x
Wild Rice and Deep Water Plants	x	x	x	x		
Meadow Marsh Invasive Plant Removal	x	x	x	x	x	x
Stream Habitat improvement	x	x	x			
RBG Center Urban Runoff Management		x	x	x		
Sunfish Pond & Long Pond Project	x	x	x	x	x	x
Chedoke Bay Project		x	x			
Grindstone Marsh Delta (the elbow)	x	x	x	x	x	x
Hendrie Valley Floodplain Ponds	x	x	x	x	x	x
Carroll's Bay Marsh	x	x			x	x

Actions

1. Maintain Common Carp densities to <20 kg/ha through the use of 6 fish barriers, while maintaining system connectivity with fishways.
2. Carp removal from Long Pond and other locations as needed.
3. Replacement of the decaying Grindstone Marsh carp barrier structure at Sunfish Pond.
4. Accelerate restoration of marsh river channels as biofilters and corridors, with targeted restoration emergent marsh planting projects along Spencer Cr, Grindstone Cr, and Chedoke Cr.
5. Recontour the Chedoke Creek delta to reestablish a natural levee, also acting as a water quality protection barrier to the adjacent Cootes Paradise sheltered bay.
6. Stabilization of island shorelines through bioengineering plantings.
7. Removal of old shoreline erosion armour stone and restoration with bioengineering plantings.
8. With CN rail reestablish a natural shoreline along the west side of Carroll's Bay.
9. Introductions of several late summer submergent plant species as well as water lily species.
10. Ongoing reintroduction and propagation of Southern Wild Rice.
11. Recovering inflowing water quality through
    i. support/input to Wastewater, Stormwater and Conservation Authority Watershed Plans.
    ii. community involvement activities to educate about the relavence of these plans.
12. Mitigation of RBG Centre stormwater runoff.

13. Creation of the Cootes Paradise Marsh Inner Bay migratory waterfowl protection area.
14. Management of invasive species including, *Phragmites*, Eurasian Manna Grass, and Mute Swans.
15. Integration Species at Risk habitat projects with focus on Presidents Pond (Cootes Paradise).
16. Training young professionals in the field of environmental stewardship.
17. Monitoring to provide the evidential basis for remedial action efforts of both RBG and partner agencies undertaking activities on the waters that flow into our wetlands.
18. Monitoring – to provide updates on the status of the delisting criteria.
19. Recovery of natural water cycles through direct input to the St. Lawrence Board of Control.
20. Supporting organizations implementing projects that improve water quality flowing into our wetlands.
21. Providing support to partner agency research and monitoring programs.
22. Community engagement and education focused at the Fishway, Nature Centre programs, public speaking engagements, and volunteer opportunities.
23. Volunteer opportunities to allow citizens to experience the wetlands, as well as better understand the issues affecting the wetlands.
24. Educational opportunities through wetland school programs, interpretive signage, RBG website, open houses, and communication of monitoring results.
25. Participation of selected HHRAP technical committees.
26. Continue to implement and support trash cleanup programs on the shorelines of RBG watersheds, with groups such as the Stewards of Cootes Watershed and McMaster student clubs.

Staffing

To execute the plan RBG will continue to require the existing staff complement as well as volunteers

- Head of Natural Lands
- Aquatic Ecologist
- Monitoring Ecologist
- Species at Risk Biologist
- Biotechnician
- Aquatic Intern
- Summer Students (x2)
- Short term contract assistance as individual projects demand.

Volunteer Assistance

- Seed collection and plant propagation
- Wetland planting projects
- Spring marsh bird and amphibian monitoring
- Fall migratory bird monitoring

Capital Projects and Items

Anticipated capital projects to support and advance the wetland restoration include;

1. Wetland Plants (~$500,000)
2. New Boathouse ($100,000)
3. Blackbird Marsh berm and structure relocation ($6,000)
4. Sunfish Pond berm relocation and structure replacement ($25,000)
5. Chedoke Bay berm creation ($30,000)
6. Access path improvement to Long Pond ($6,000)
7. Fishway boat gate repairs ($2,500)
8. Cootes Paradise Fishway basket repairs ($2,500)
9. Cootes Paradise Marsh gabion basket/rock removal (TBD)
10. Pond 3 collapsing creek bank restoration ($5,000)
11. RBG Main Centre storm water pond ($100,000)
12. Replacement boats and outboard motor. ($15,000)
13. Replacement fleet vehicles (x2 - $80,000)
14. Replacement electrofisher unit ($10,000)

Potential reset of all carp control barriers and berms would be required if the Lake Ontario water level control plan is updated as high water levels would be anticipated to rise from75.6msl to 75.8msl.

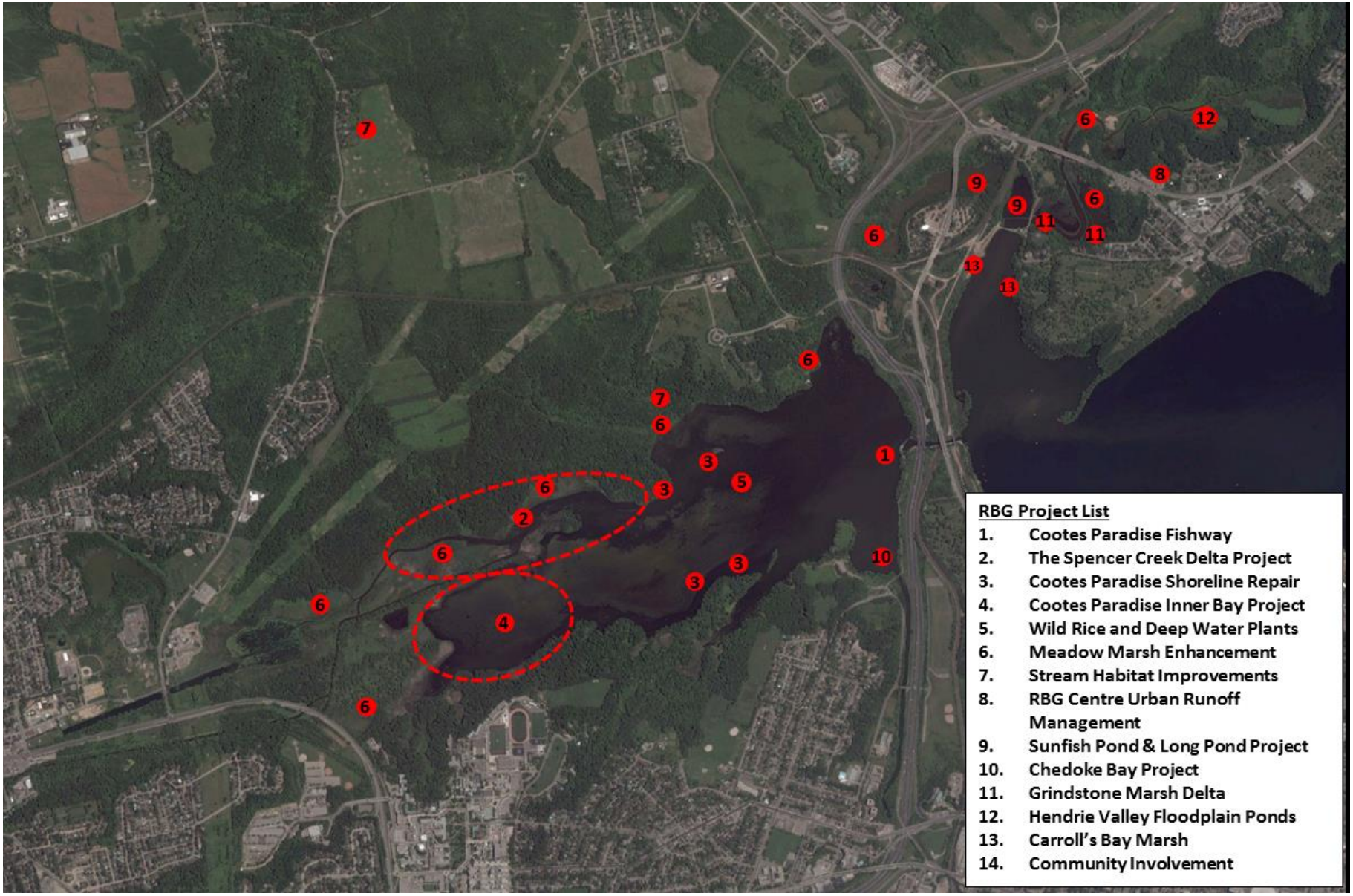


Figure 4. Projects Overview Map depicting 2016-2021 wetland project description locations.

Restoration of Plant Community

Wetland Types

Restoring water quality to the wetland goal of mesoeutrophic in the creek deltas and mesotrophic in the sheltered bays is the most important step in reestablishing a sustainable plant community. After water quality, plant community make up is then structured by water cycles. The wetlands of RBG can be split into two broad water cycle categories, those influenced by the back flooding from Lake Ontario, the coastal marsh portions, and those with water levels that are a function of direct precipitation and inflowing waters, the floodplain portion. Currently Lake Ontario water level regulation places this divide at about the 75.5msl contour. At the intersection of these two cycles there is a transition area between these two wetland water cycles which covers an extensive area due to the annual and inter annual variations in the Lake Ontario water cycle.

The areas associated with the inflowing waters in Cootes Paradise Marsh are increasing with the reestablishment of emergent plants. This currently includes all areas to the west of Rat Island following Spencer Creek, as well as portions of Long Valley, Hickory Valley, and Westdale Inlets. In the Grindstone Marsh system, the inflowing waters control all areas upstream of the Plains Rd Bridge over Grindstone Creek, as well as Long Pond. Within these areas, the wetlands can be further subdivided into mineral and organic marshes, and further subdivided again using the Ecological Lands Classification System (ELC).

Originally almost all of the wetlands were under the influence of river levels rather than back flooding by the lake, with the exception of outer Carroll's Bay. With the loss of the marsh channels to retain the water, and the dredging of the Desjardins Canal through Burlington Heights, the outflow channel became disproportionately large relative to the inflow, allowing the retained wetland waters to drain out. At the same time due to isostatic rebound, over the long term, the lake is continuing to back flood into the wetlands creating "drowned river mouth marshes". This rebound rate is considered to be between 1 and 3 mm per year.

Within the coastal marsh (primary HHRAP focus of restoration), the boundary between the perennial emergent marsh and submergent wetland vegetation is a function of the water cycle. The boundary occurs at the point where in 4 out of 5 years permanent flooding occurs in the summer season. This can be further refined within the longer term water cycle patterns, defining the maximum extent of the emergent zone as bounded by the shoreline interface of the lowest summer water cycle water level. The resulting exposed summer mudflat causes massive emergent marsh regeneration by seedlings on the mudflat. A transition zone remains where low winter water levels expose areas of marsh where summer water levels will prevent emergent marsh establishment. This high disturbance area (which experiences cycles of draining, drying, freezing, and flooding) is dominated by an annual species of wild rice (*Zizania sp.*), ultimately a result of substantial average annual water level fluctuation (70 cm) and further enhance by the Lake Ontario regulation Plan. Through extensive wetland mapping between 2010 and 2015, all the plant community zones within the wetlands are now mapped (Figure 5) and a bathymetry map is contained in the Appendix.

Key plants

- Swamp - TBD
- Meadow marsh - Lakebank Sedge (*Carex lacustris*)
- Emergent Zone - Cattail (*Typha sp.*)
- Transition Zone - Wild Rice (*Zizania aquatic*)
- Submergent zone - White Water Lily (*Nymphaea odorota tuberosa*)
- Littoral Zone/Deep submergent Zone – Wild Celery (*Vallisneria americana*)

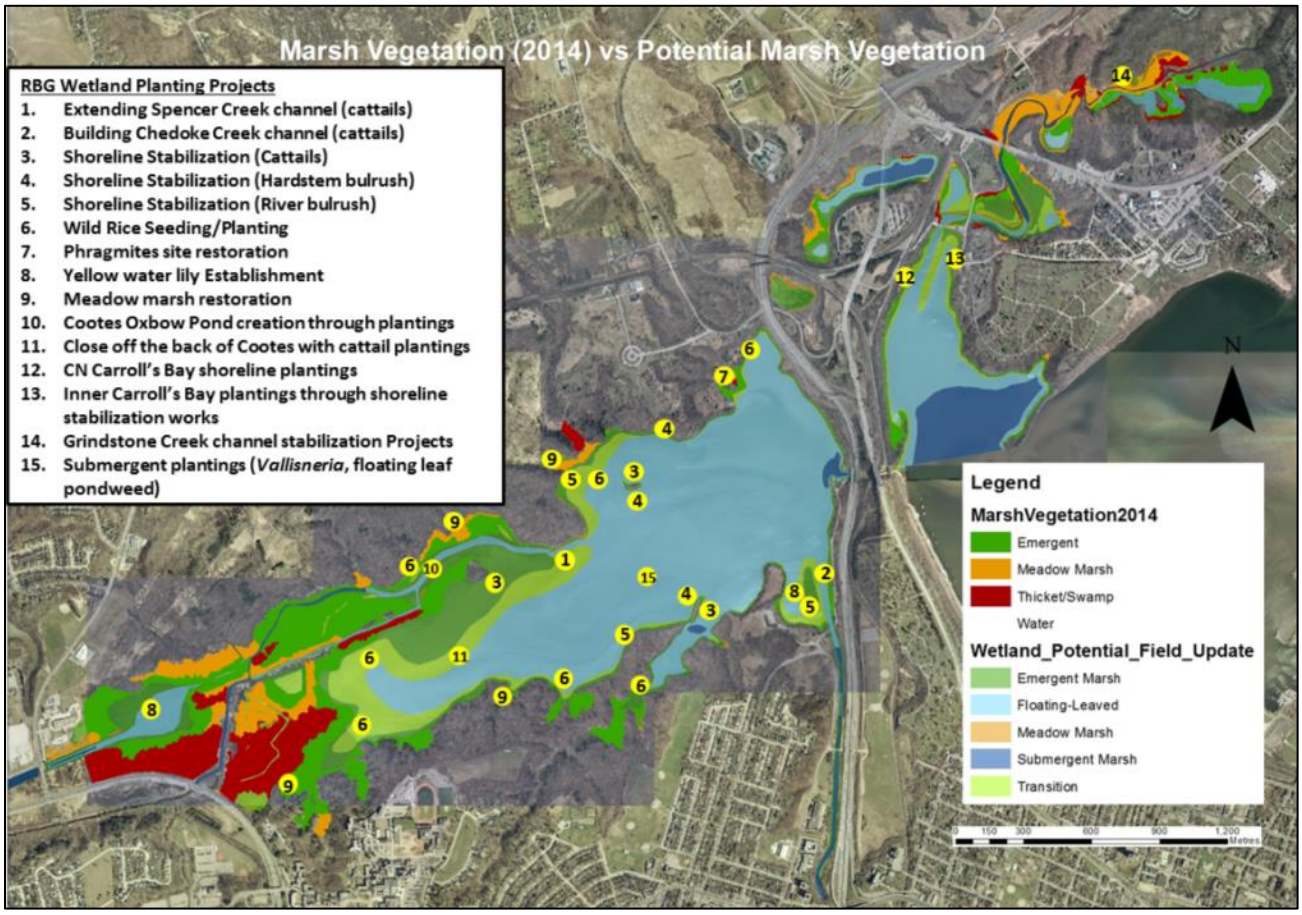


Figure 5. Future planting areas, existing emergent and meadow marsh, and predicted plant community zones based on current Lake Ontario water cycles.

Restoration Activities

Swamp – Keystone plant: TBD

- Assess ELC data and map to determine if data gaps exist and resolve
- Determine future management options
- Follow the Eurasian Manna Grass (*Glyceria maxima*) Management Strategy such that Manna Grass is no longer the dominant herbaceous species
- Develop a management plan for the dominant woody invasive non-native species, Crack willow (*Salix fragilis)*

Meadow Marsh - Keystone plant: Lakebank Sedge (*Carex lacustris*)

- Assess ELC data and GIS map to determine if data gaps exist and if so update the information
- Develop a monitoring protocol using 1x1 m plots randomly selected throughout the habitat
- Follow the *Phragmites* Management Plan with the objective to maintain *Phragmites* at less than 1% of the meadow marsh/shallow marsh (ELC community series) area by the end of 5 years
- Complete the Eurasian Manna Grass (*Glyceria maxima*) Management Strategy with the following objectives:
- Protect the (<1% of total) intact native meadow marsh and lake bank sedge habitat in Borer's Creek floodplain, Marshwalk (Coastal wetland), and South Pasture Swamp (floodplain wetland).
- Eliminate along the steep shorelines in the shallow marsh habitats
- Maintain Manna Grass at less than 1% of the meadow marsh/shallow marsh (ELC community series) at Boathouse area, Kingfisher Bay, Princess Point, Pine Point Inlet, Osprey Marsh, North Grindstone Creek (Plains Rd bridge to Snowberry Island)

- Manage Manna Grass such that it is no longer the dominant species around President's Pond (see site map)
- Manna Grass control options include drowning, herbicide, and smothering.

Emergent Marsh – Keystone plant: Cattail (*Typha sp.*)
- Water Quality – support watershed water quality improvements by partners to restore trophic status
- Common carp control through operation of carp barriers and fishways to protect reeds from being crushed during spawning activities
- Canada goose and mute swan control through egg oiling and habitat modification, and the reestablishment of natural predators
- Fencing of marsh plantings and emergent seedlings in low water years
- Removal of gabion baskets and armour stone along formerly wind-blown shores
- Implementing the *Phragmites* Management Plan with the objective to maintain *Phragmites* at less than 1% of the meadow marsh/shallow marsh (ELC community series) area by the end of 5 years
- Be vigilant to identify new invasive species and keep a close eye on existing non-native species that may require management actions
- Support improvements to the King Street Wastewater Treatment Plant that will minimize algae growth which smothers aquatic vegetation
- Marsh plantings to help establish healthy populations of Hardstem & Softem Bulrush *(Schoenoplectus sp.)***,** Prairie Cordgrass *(Spartina pectinata),* River Bulrush *(Scirpus fluviatilis),* and cattail

Transition marsh - Keystone plant: Wild Rice (*Zizania sp.*)
- Common carp control through operation of carp barriers and Fishway to protect seedlings from uprooting, and to maintain good water clarity
- Marsh river channel restoration using cattail planting and natural sedimentation processes to facilitate restoration of marsh river channels to protect habitat from damaging inflowing waters
- Canada goose and mute swan control through egg oiling and habitat modification, and the reestablishment of natural predators
- Create a seed bank in various locations through seeding and seedling planting of southern wild rice in inlet areas as conditions become appropriate. Inlets in Cootes Paradise Marsh include Mac Landing, Double Marsh, Westdale Inlet, Princess Point Bays, Hickory Bay; Pond 1, Pond 2, South Pasture Swamp, and Blackbird and Osprey Marshes in the Grindstone System.
- Rebuild two tanks in the aquatic nursery to maintain captive population of wild rice
- Water Quality - support improvements to the King Street Wastewater Treatment Plant and urban runoff to l minimize filamentous algal growth and sediment inputs currently smothering aquatic vegetation.

Submergent Marsh - Keystone plant: White Water Lily (*Nymphaea odorota*)
- Common carp control through operation of carp barriers and Fishway to protect seedlings from uprooting and to maintain good water clarity
- Carp removal to maintain a population <20 kg/ha
- Marsh river channel restoration using cattail planting (bioengineering) and natural sedimentation processes to protect interior bay habitat from damaging inflowing waters
- Restoration planting of late season submergent plants including Tape Grass (*Vallisnaria americana)* and floating-leaved pondweeds (*Potamogeton nodosus/natas*), with new propagation tanks to support project.
- White water lilies added to inlet areas as conditions become appropriate, such as the inner bay of Cootes Paradise Marsh, Princess Point Bay, and Hickory Bay
- Water Quality - support water quality improvements by partners throughout the rural watershed
- Water Quality - support improvements to the King Street Wastewater Treatment Plant and urban runoff to l minimize filamentous algal growth and sediment inputs currently smothering aquatic vegetation.
- Support mitigation of the impaired Desjardins Canal sediments to eliminate smothering filamentous algae.

Planting Plan

Plantings will focus largely on the emergent plants, with smaller scale projects pertaining to meadow marsh and submergent marsh (Figure 5). This focus is a result of Lake Ontario water level regulation. Currently, approximately 11 km of shoreline in Cootes Paradise and Grindstone Marshes remain without emergent vegetation. This also contributes to shoreline erosion, with several locations in Cootes Paradise Marsh protected with armour stone in the 1970. Excluding 1999, virtually all emergent plant re-establishment has been through plantings, with these plants expanding naturally once secure. The ongoing missing plants are a consequence of both lake level regulation and the smothering rafts of algae and debris (eutrophication). Summer lake levels have exceeded 75.2msl most years during the HHRAP, with only 1999 providing low enough lake levels to germinate emergent seedlings along some of the marsh shorelines. For emergent seedling germination and subsequent shoreline stabilization to occur, a maximum summer water level of less than 74.75msl is required. Through planting efforts, we hope to establish 4 km of emergent shore habitat by 2021 and remove all shoreline armouring.

Major planting projects will include;

- Shoreline remediation (i.e. removal of armour stone and replanting with emergent marsh)
- Cootes Paradise Spencer Creek delta emergent marsh
- Cootes Paradise Chedoke Creek delta emergent marsh
- Stabilization of Cootes Paradise island shorelines.
- Cootes Paradise Inner Bay Project.
- Shorelines of Grindstone Marsh carp protected areas and inner Carroll's Bay west side.
- Replacement of *Phragmites* and Eurasian Manna Grass stands with native meadow marsh plants with a particular focus at Presidents Pond (Cootes Paradise Marsh).

Sourcing of plants to support the work is a significant project as an estimated 30,000 plants are needed each year. As of 2016, RBG maintains propagation tanks for wild rice and wetland holding tanks for 5,000 plants (as plugs). Future plans for RBG propagation are currently under review, with propagation of the needed wetland plants under consideration as an option. The extent of meadow marsh species required is unknown as the current invasive plant management plans in these areas anticipate significant natural regeneration from the seed bank, and seeding will be the preferred approach. Yellow and White water lily planting objectives will be achieved through direct transplants from in-situ populations and therefore do not require additional sourcing. Emergent marsh plantings will be protected from geese and mute swans with temporary fencing until established, with 1.5 km in use as of the end of 2015. The planting seasons for the various plant groups are influenced by water cycles and fish and wildlife reproduction activity, with planting times as follows;

- emergent marsh plants - late April & July and Early August
- meadow marsh seeding/planting – May & July to September
- water lilies and deep water submergent plants – August

Table 6. Wetland Project Estimated Plant Needs 2016-2021

Project	**Total**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**
The Spencer Creek Delta Project	70,977	11,337	16,140	15,500	11,000	11,000	6,000
Cootes Paradise Shoreline Repair	48,000	5,500	5,000	9,500	9,800	12,000	6,200
Cootes Paradise Inner Bay Project	34,000	6,500	7,500	7,500	7,500	5,000	
Wild Rice and Deep Water Plants	1,725	355	500	510	360		
Meadow Marsh Invasive Species	28,095	3,095	5,000	5,000	5,000	5,000	5,000
Stream Habitat improvement	1,350	450	450	450			
Sunfish Pond & Long Pond Project	TBD		TBD	TBD	TBD	TBD	TBD
Chedoke Bay Project	5,200		3400	1800			
Grindstone Marsh Delta	7,300	1800	1900	1200	1200	600	600
Carroll's Bay Marsh	8,000	2000	x			3000	3000

Shoreline Stabilization

As part of the ongoing restoration of historically damaged habitat, a review and mapping of the state of the RBG shorelines was completed in 2015 (Figure 6). Wave erosion, a result of the historical loss of vegetation has severely undercut several areas of natural sand shorelines within RBG. Further, the terrestrial slope vegetation found upslope on the shores represents much of the undisturbed plant communities left along the shores of Lake Ontario. Cootes Paradise Marsh has a total of 27 km of shoreline, 6.8 km of which remains without regenerated emergent marsh vegetation. Lack of vegetation recovery is a result of historical shoreline wave protection (such as gabion baskets), unmitigated erosion sites, and water level regulation. Grindstone Marsh has and addition 4.3 km of shoreline in similar condition, with most of this found in Long Pond and Carroll's Bay areas were wind fetch has a much lower effect and with no armouring having occurred. The shoreline stabilization goal is, in combination with the regenerating submergent plant wave breaking effect, to restore undercut eroding shorelines planting a 4 m wide band of emergent marsh and shrub thicket to jump start plant re-establishment.

The shoreline repair falls into two broad categories: those historically armoured with gabion stone and baskets (250 m), and those that are natural beach shorelines that have yet to re-generate vegetation. A subset of the latter includes the natural beach shorelines of the three islands in Cootes Paradise Marsh, which totals 520 m. Together these total 770 m are the priority areas for restoration between 2016 and 2021. Armour stone was installed in the 1970s to protect fragile upland plant communities from collapsing into the marsh. In addition to the existing gabion baskets, 205 m of shoreline have loose gabion stone spread along the shoreline. The heavy rock is proving to be a barrier for planting and plant growth. The remaining shorelines in the western half of the marsh are largely low gradient shore and have revegetated, while the eastern shoreline is almost entirely composed of fill, a result Hwy 403. Additional beach locations of focus are the north and south shorelines in the eastern half of Cootes Paradise Marsh with a total of 470 m of shoreline requiring attention.

Erosion in Cootes Paradise Marsh is a consequence of the historical loss of aquatic vegetation, generating long wind fetch and waves. The shorelines themselves represent sensitive habitats, often steep sandy shorelines, with the uplands part of the Cootes Paradise Area of Natural and Scientific Interest (ANSI). Since recovery of the marsh vegetation is occurring through a variety of HHRAP actions, shoreline repair can be initiated. Natural regeneration is not expected in the short term due to Lake Ontario water level regulation water levels that precluded natural emergent vegetation reestablishment. The current regulation plan prevents lower water levels that would otherwise create nursery conditions and subsequent natural regeneration of appropriate vegetation. For much of the remaining unvegetated areas this would require a maximum spring water level of 74.7msl.

During the field assessment along the shores of Cootes Paradise Marsh (Figure 6, Table 7), point specific locations were marked and include small eroded points, old infrastructure, and unsanctioned trails. Four areas within the marsh contained elements of old restoration projects or degraded infrastructure. These items are the old Aquadam, logs and chains, concrete slabs, concrete filled garbage can, a concrete pipe, and two rusty culverts (Table 7). Unsanctioned trails refer to areas where humans have either created new trails to access the open unvegetated shoreline or are historically closed trails for the same purpose. To maintain and restore fragile wildlife and plant populations, these areas along the shoreline will also be priority revegetation sites to discourage access. Exporting soil material to repair undermined slopes remains as the most challenging element of the repair plans.

Table 7: Prioritization of shoreline repair issues at Cootes Paradise Marsh and Grindstone Marsh.

Area	Issue	Length (m)	Details	Priority
Cootes Paradise Inner Bay	Non-emergent Shoreline	380		
	Erosion		Point Specific	
South Shore	Non-emergent Shoreline	975		
	Erosion	100		
	Gabion Baskets	255		
	Loose Gabion Stone	205		
	Unsanctioned Trails		4	
Westdale Inlet	Non-emergent Shoreline	625		
	Erosion	230		
	Old Infrastructure		one concrete filled garbage can	
	Unsanctioned Trails		4	
Princess Point	Non-emergent Shoreline	685		
	Erosion	50		
	Unsanctioned Trails		8	
East Shore	Non-emergent Shoreline	1,325		
	Erosion	115		
	Old Infrastructure		one concrete pipe; two rusty culverts	
North Shore	Non-emergent Shoreline	930		
	Erosion	65	Captain Cootes trail eroding	
	Old Infrastructure		Concrete slabs; logs and chains	
	Gabion Baskets		At Boathouse	
	Unsanctioned Trails		3	
Bull's Point	Non-emergent Shoreline	340		
	Erosion	35		
	Old Infrastructure		Aquadam	
Islands	Non-emergent Shoreline	520		
Grindstone Marsh Carroll's Bay*	Non-emergent Shoreline	2,200	Localized significant toe erosion	
Long Pond*	Non-emergent Shoreline	950	Significant toe erosion in need of assessment	
Sunfish Pond	Non-emergent Shoreline	400		
Osprey Marsh	Non-emergent Shoreline	300		
Lower Grindstone Creek	Non-emergent Shoreline	450	Mostly highly shaded by north facing forest	
Pond 1	Non-emergent Shoreline	250	Shaded by north facing forest	

*unassessed erosion sites

Priority Legend

HIGH
MEDIUM
LOW

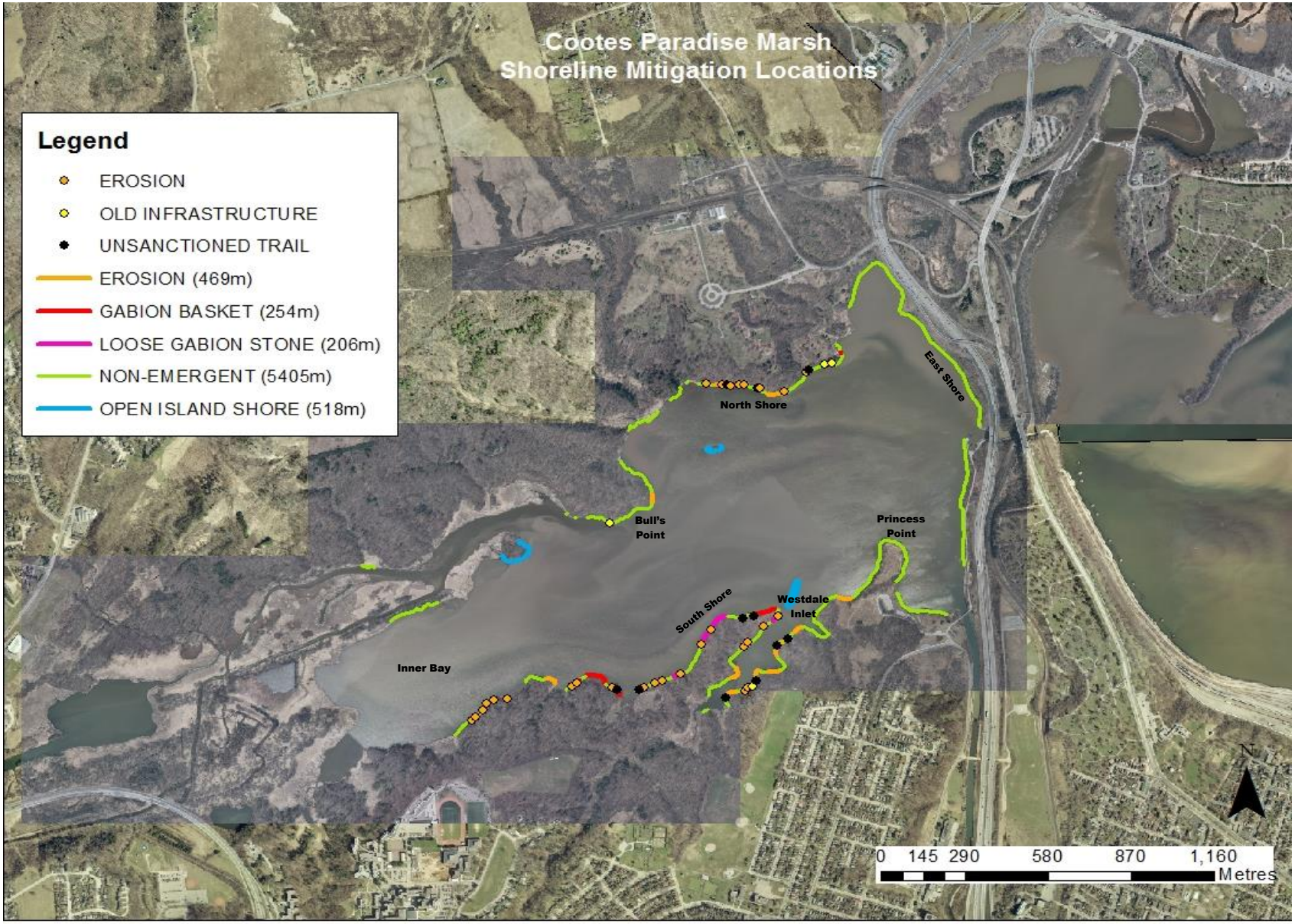


Figure 6. Shoreline condition of Cootes Paradise Marsh. Shoreline restoration planting priorities will focus on gabion basket and stone removal, and island shoreline stabilization between 2016 and 2021.

Water Quality and HHRAP Partners

The work completed by RBG in the marsh is focused on recovering and measuring wetland/marsh plant communities. These plant communities are the bases of the food web, supporting many dimensions of the Hamilton Harbour ecosystem, most significantly fish reproductions. Within the marshes the areas of issues are portrayed in the Figure 7 aerial photo. In this photo, the June 2015 plant coverage is visible, both in areas of recovery and in missing areas associated with specific watersheds of the marshes (Table 8). Virtually all issues limiting plant recovery at this point are related to impaired quality of inflowing water. Overall 80% of Hamilton Harbour watershed surface waters enter the system through these two marshes. Based on our HHRAP committee experience, RBG considers most source locations are known by the partners. In the specific case of urban runoff from the old urban areas of Dundas, Waterdown, and Ancaster, the specific stormwater outfall points in need of remediation have yet to be summarized.

Recovering inflowing water quality limiting the recovery of biota in marsh is the most important step in sustainability delisting the Hamilton Harbour AOC. The summary chart and map (Table 8, Figure 7) highlights current impaired marsh subareas, the watershed based issues, and important actions required to recover the inflowing water quality. The issues fall into three major themes.

1. Sewage and sewage related treatment
2. Urban runoff quality and quantity
3. Localized rural issues particularly in Grindstone Marsh

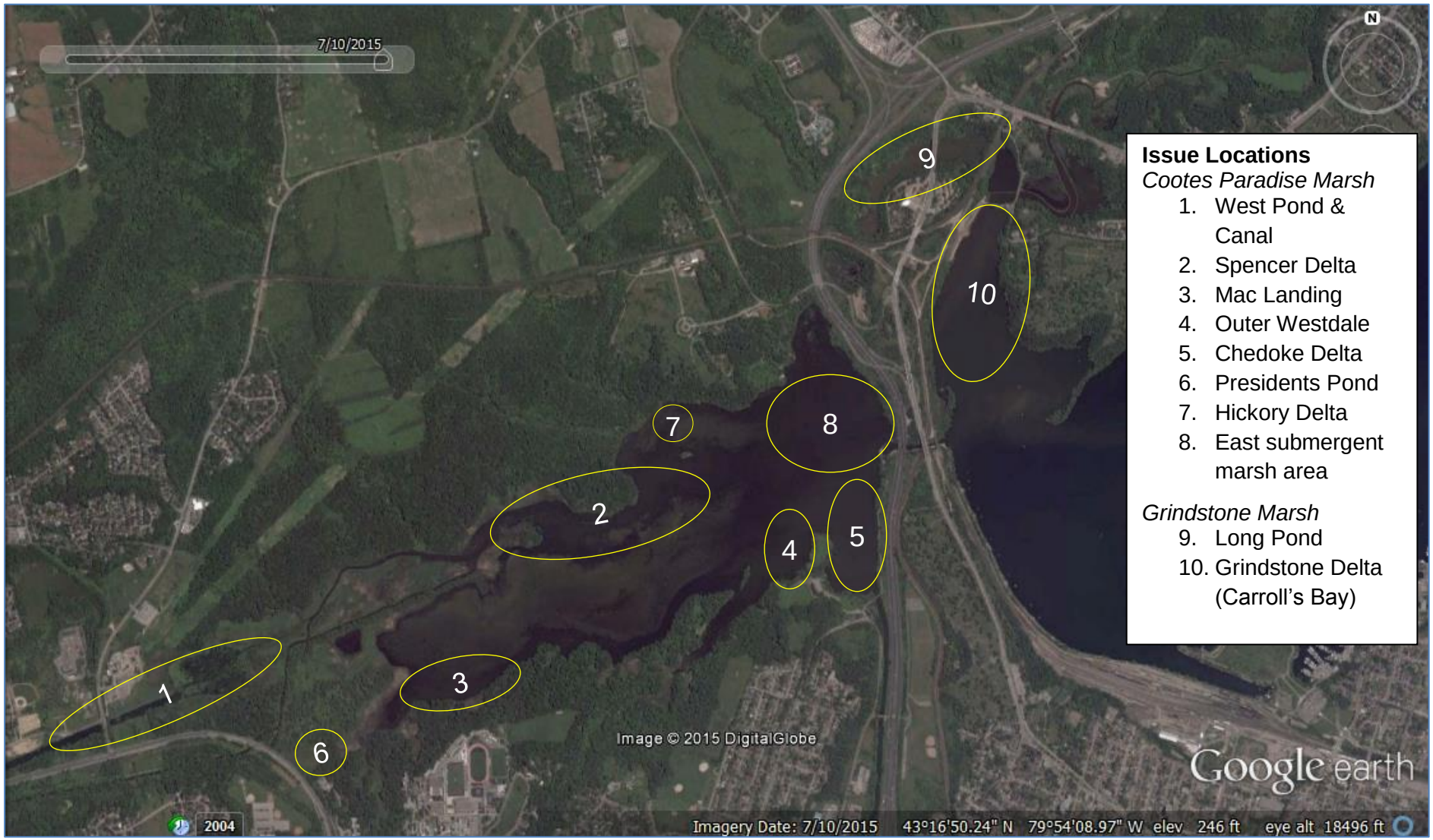
These issues are expected to figure prominently in the 2016-2021 HHRAP Bay Area Implementation Team workplan in order to reach delisting.

RBG also emphasizes that water quality in the harbour is also of great importance to the sustainability of the marsh. It is expected that as long as the harbour continues to be seasonally anoxic in large areas, the fish community will continue to be dominated by low oxygen tolerant species, such as the non-native Common Carp and Goldfish, and native catfish. This results in an ongoing obligation for fish community management that at a minimum consists of management of Common Carp through the use of carp barriers and fishways.

Table 8. Summary chart of issues, associated areas affected, shown in Figure 7, and action themes to delist the wetland portion of the HHRAP.

Location (figure 7)	**Approx. Area**	**Issues limiting success**	**Recommended Remedial Actions**
Cootes Paradise Marsh	***240 ha***	=total HHRAP area	
1. West Pond & Desjardin Canal	9 ha.	• Hypereutrophication from Dundas WWTP • Eutrophication from Canal sediment	• Effluent Improvement to eutrophic • Mitigation of sediment
2. Spencer Delta	20 ha.	• Eutrophication from Dundas WWTP • Urban Runoff (Dundas, Ancaster, Waterdown) • Rural runoff Borers Creek Watershed • Possible herbicides?	• Effluent Improvement to eutrophic • Stormwater management • Buffer rural waterways • Herbicide study
3. Mac Landing	3 ha.	• Urban Runoff (McMaster & Main St)	• Effluent Improvement to Eutrophic
4. Outer Westdale	3 ha.	• Westdale Sterling CSO	• CSO improvement
5. Chedoke Delta	18 ha.	• CSOs & Cross Connections • Urban runoff • Landfill leachate?	• CSO improvement &connection removal • Stormwater management • Complete leachate project
6. Presidents Pond	1 ha.	• Carp? TBD	• Investigate issue
7. Hickory Delta	2 ha.	• Cross Connections • Rural Runoff	• Connection removal • Buffer rural waterways
8. East submergent marsh area	20 ha.	• Combined effects of above stressors	• Implement above items
Grindstone Marsh	***75 ha.***	= total HHRAP area	
9. Long Pond	6 ha.	• Carp • Urban runoff? Clappisons Corner area?	• Remove carp • Investigate and mitigate runoff
10. Grindstone Delta (Carroll's Bay)	20 ha.	• Carp • Urban & rural runoff • Possible herbicides?	• Remove carp • Stormwater management • Buffer waterways
Total area left to recover	**99 ha.**		

Figure 7. Site specific areas of issue (lacking plants) within Cootes Paradise and Grindstone Marshes downstream of independent watersheds.



Monitoring

RBG manages its natural lands with a goal of supporting international ecosystems for migratory birds and fish, protecting rare species, and aligning with Great Lakes monitoring protocols. In connection with this, the monitoring program at RBG targets the subcomponents as summarized in Table 9 & Table 10. Table 9 summarizes the monitoring of RBG's wetlands as they relate to RBG's restoration goals. Table 10 summarizes the monitoring as it relates to the goals of delisting the HHRAP (delisting is anticipated in 2021). The monitoring activities are divided this way because delisting of the harbour incorporated delisting various beneficial use impairments (BUIs) that relate directly to Cootes Paradise and Grindstone Marshes. However, restoration and management of RBG's wetlands are not solely focused on goals of the HHRAP, and restoration and management of these wetlands will continue after the Harbour is delisted as an AOC. As such, RBG has its own monitoring goals and activities for the wetlands.

The Key Performance Indicators RBG will use are:

- Area of submergent marsh
- Area of emergent marsh
- Area of meadow marsh
- % wetland native plants
- Water Clarity or water quality index
- Common Carp abundance
- Winter muskrat lodges present
- Yellow Perch population

Table 9 Anticipated Monitoring Activities of RBG Wetlands related to RBG's wetland restoration goals.

Monitoring Category	Component	2016	2017	2018	2019	2020	2021
1.Plant Community	Submergent	X	X	X	X	X	X
	Transitional (wild rice)	X	X	X	X	X	X
	Emergent	X			X		
	Meadow Marsh		X			X	
2. Endangered Species	Mussels, turtles, birds	X	X	X	X	X	X
3. Birds and Amphibians							
4. Migratory Waterfowl		X	X	X	X	X	X
5. Fisheries Index	Electrofishing	X	X	X	X	X	X
6. Benthic Invertebrates	OBBN					X	
	Emergent traps			X			
7. Aquatic Mammals	Muskrat/beaver surveys	X	X	X	X	X	X

1. Wetland Plant Community monitoring as it pertains to the HHRAP, plus meadow marsh status as it pertains to Great Lakes wetland monitoring
2. Endangered Species monitoring (mussels, turtles, and birds)
3. Marsh monitoring for wetland birds and frogs/toads (Marsh Monitoring Program)
4. Migratory waterfowl – annually in the fall with assistance of volunteers (Long Watch). Index locations in Cootes Paradise will be the west end of Cootes (Mac Landing area), and Grindstone location will be at a view point (future viewing platform) overlooking Blackbird and Osprey marsh.
5. Fisheries Index (39 long term August electrofishing transects)
6. Benthic Invertebrates – (potential student research project with focus on impacts to aerial insectivores and incorporating the use of emergent benthic invertebrate traps)
7. Aquatic Mammals (Winter muskrat den and beaver lodge surveys)

Hamilton Harbour Remedial Action Plan Linkages

Within the HHRAP there are 12 Beneficial Uses Impaired (BUIs), for which 5 are directly measured within RBG properties and several addition that rely on the health of the properties. One of the 12 (BUI v) is currently listed as requiring further assessment to properly summarize its condition.

v -Bird or Animal Deformities or Reproduction Problems (measured by Environment Canada – under review)
vi - Degradation of Benthos (marsh criteria currently not established, no lead assigned)
viii - Eutrophication or Undesirable Algae
xi - Degradation of Aesthetics (no criteria currently established)
xiv - Loss of Fish and Wildlife Habitat

HHRAP BUIs with a direct link to RBG marshes.
iii - Degradation of Fish Population (measured by DFO in the harbour)
iii - Degradation of Wildlife Populations (measured by EC – colonial waterbird populations)
x- Beach closing and water contact sports

Table 10. Anticipated monitoring activities related to HHRAP

Connection	Monitoring Category	2016	2017	2018	2019	2020	2021
Delisting Efficacy measure	Water Quality	X	X	X	X	X	X
Delisting	Plant Community - Submergents	X	X	X	X	X	X
Delisting	Plant Community - Emergents	X			X		
Delisting	Aesthetics Monitoring	X		X		X	
Delisting	Benthos Population						
Efficacy measure	Sediment Recharacterization at sewage inlet points					X	
Efficacy measure	Bathymetry Map/ Sedimentation Rates	X		X			X
Efficacy measure	Fishway + Salmon Redds	X	X	X	X	X	X
Efficacy measure	Fisheries – carp/ overall YOY	X	X	X	X	X	X
Community Involvement	Marsh Monitoring Program	X	X	X	X	X	X
Plant protection*	Goose / Swan Nests & summer residents	X	X	X	X	X	X

**The extent of nest monitoring will be reduced according the recommendations of RBG's Goose Management 2015 Summary Report.*

1. Water
   - annual / biweekly, standard, restoration sites, delisting stations
   - Single season projects
     - Chedoke Bay Pre (2016) and post (single year TBD) berm creation
     - Hickory Bay (single year TBD)
     - CP1 (single year TBD)
       - Pond 4 (single year TBD)
2. Plant community
   - Submergent (annually 32 sites)
   - Emergent coverage (2017, 2020)
   - Emergent plant community (2016, 2019)
   - Meadow marsh plant community (2017, 2020)

3. Aesthetics (Smart phone survey to be developed, Cootes Paradise Fishway interpretation cart, boat launch)
4. Benthos – OBBN monitoring in Cootes Paradise and Grindstone Marshes in 2020
5. Sediment Chemistry – contaminated areas (Chedoke, Westdale Inlet, Desjardins Canal and West Pond) updated in 2020
6. Sediment Deposition Rates – field work completed in Grindstone Marsh in 2016 and Cootes Paradise Marsh in 2017; the updated bathymetry map to be completed in 2018
7. Fishway (annually)
8. Fish – Salmon (annually, Spencer and Grindstone Creeks)
9. Fish -Young of the year monitoring (annually – August 32 sites)
10. Marsh Monitoring Program
11. Nesting geese/swans and summer residents
12. Photo records of key restoration sites updated – Westdale, Spencer Delta, West Pond, Mac Landing, Carroll's Bay, Pond 1, Grindstone Elbow, and Chedoke Bay.

Ongoing Planning

RBG will continue to participate in several HHRAP committees pertaining to water quality and land use in order to prioritize the significance of watershed issues, as well as report on progress towards the delisting of Cootes Paradise Marsh and Grindstone Marsh. These include: the Cootes Paradise Water Quality technical team, the Hamilton Harbour technical team, the BAIT committee, and appropriate Fish and Wildlife related committees. We will also participate in the Hamilton Conservation Authority Subwatershed Stakeholder Advisory Committee, the Hamilton and Halton Watershed Stewardship programs, the Cootes to Escarpment advisory group and the recently formed Lake Ontario Coastal Wetlands Working Group.

Table 11. HHRAP Related Committees

Lead	*Alternate*	**Committee**	**Lead Group**
Head of Natural Lands	Head of Education	BAIT - Bay Area Implementation Team	Environment Canada
Head of Natural Lands	Head of Natural Lands	HHRAP Fish and Wildlife Committee	Conservation Halton
Monitoring Ecologist	Aquatic Ecologist	HHRAP Wildlife Committee	City of Hamilton
Monitoring Ecologist	Head of Natural Lands	HHRAP Access and aesthetics	HHRAP office
Aquatic Ecologist	Head of Natural Lands	HHRAP Technical Team	OMOECC
Aquatic Ecologist	Monitoring Ecologist	HHRAP Cootes Paradise Water Quality	OMOECC
Monitoring Ecologist		Watershed Stewardship task group	HHWSP
Aquatic Ecologist	Head of Natural Lands	Grindstone Creek Erosion Committee	Conservation Halton
Monitoring Ecologist	Aquatic Ecologist	Hamilton Fishing Derby Committee	Waterfront Trust
Aquatic Ecologist	Head of Natural Lands	HHRAP Urban/Rural Runoff Task Group	Hamilton Conservation
Aquatic Ecologist	Head of Natural Lands	HHRAP Hamilton Urban Runoff	Hamilton Conservation
Aquatic Ecologist	Head of Natural Lands	HHRAP Burlington Urban Runoff	HHRAP office

In support of projects to occur in this planning period, as well into the future, several summary reports will be generated. The anticipated list is found in Table 12.

Table 12. List of planned RBG reports and the anticipated year of completion.

Report Topic	**Year of Completion**
15 Years of Common Carp exclusion at RBG	2016
Final HHRAP Water Quality Delisting Targets	2016?
Desjardins Canal Conditions Summary Report	2016
Sediment Accumulation in Cootes and Grindstone	2017
RBG Centre Storm water Management Plan	2017
Long Pond Assessment Report	2017
Finalized HHRAP Plant Community Targets and Monitoring Protocol	2017
Update of Bathymetry Map and “Potential Marsh Map”	2018
Hickory Brook Natural Channel Plan	2018
Treed Swamp Inventory and Strategy	2020
Status of RBG Marshes as it Pertains the HHRAP	2021

A series of practical information management projects will also be undertaken including;

- Realign GIS plant community data to new provincial ELC system (ELC Version 3)
- Update the RBG herbarium database to include a more detailed location field to allow species lists for areas to be generated.
- Assess RBG marsh restoration infrastructure relative to proposed Lake regulation Plan 2014
- Amalgamate/centralize marsh monitoring program (MMP) data within the GIS system
- Past marsh restoration planting’s data digitized to GIS (success failure/report)

Research Projects

Review of ongoing challenges has identified a list of potential research topics as well as research topics in progress (Table 13). Undertaking research at Royal Botanical Gardens requires a research permit administered through RBG's Science Department. Royal Botanical Gardens welcomes partnerships projects to inform management activities. Studies to resolve the status of HHRAP delisting criteria with partner agencies are a part of the research project list.

Table 13. Summary of Research topics of interest for the RBG wetlands, the anticipated lead and partner agencies, and an anticipated year of completion. (EC = Environment Canada, DFO = Fisheries & Oceans)

Theme of Study	Project	RBGs Status	Partner Group	Year to complete
Water Quality	• Pesticides and Pharmaceuticals in Grindstone Creek Marsh system	Partner		
	• Water clarity measurement index (light attenuation vs turbidity vs secchi)	RBG lead		
	• Inventory Pesticide runoff into wetlands and the effects	Partner		
	• Watershed herbicide effect on wetlands plants	RBG lead?		
	• Neonicotinoids testing in invertebrates	Partner		
	• Dissolved Oxygen loggers in the marshes	Partner	DFO lead	2016
	• Updated Marsh Bathymetry Maps	RBG lead		2016-2017
	• Historical Sediment accumulation in Cootes Paradise and Grindstone Marsh	Partner		
	• Pre European bathymetry map – by sediment cores (potential student research project)	Partner		
Plants	• Allopathic effect of Eurasian Manna Grass and *Phragmites* on native plant species	Partner		
	• Seed bank studies in meadow marshes (complete with sediment core study)	RBG lead?		
Fish and Wildlife	• Inventory and tracking of Map Turtles to determine population trends and habitat use aligning with the fish telemetry study.	RBG lead		
	• Fish telemetry with DFO and OMNRF	Partner	DFO lead	
	• Mussels Outer Carroll's Bay – are they there and are they impacted by harbour sediment metal contaminants?	Partner		
	• Sediment ammonia and overwintering turtles and frogs in West Pond	Partner		
	• Groundwater quality entering at herpitile overwintering sites	Partner		
	• Radio tracking of female Blanding's turtles to nest sites to protect the eggs	RBG lead		
	• Micro plastics in Cootes Paradise and Grindstone Marsh	partner		
	• Marsh Amphibian reproductive success	partner	EC lead	2019 / 2020
	• Snapping Turtle reproductive success	partner	EC lead	2019 / 2020
	• Groundwater Springs map – Grindstone Marsh (Cootes Paradise lowlands completed)	RBG lead		2017

Outreach and Education

Community Involvement

Public involvement is essential and the Gardens partners with groups such as the Bay Area Restoration Council (BARC) and RBG Auxiliary. These partnerships are to engage the community to participate and learn how they can be involved in the stakeholder plans that affect inflowing water and are fundamental to the recovery and sustainability of the wetlands. In addition monitoring results of the ongoing wetland recovery are presented each February at an open house at RBG Centre. Other opportunities to involve the public include marsh replanting events, monitoring of amphibians, shoreline and stream cleanups, TurtleWatch, and the Cootes Paradise Fishway. In addition, 2016 and 2021 will be important years within the recovery project with 2016 being the 15th anniversary of the Cootes Paradise Fishway and 2021 the 20th anniversary and delisting target date of the HHRAP.

Education

RBG will continue to work closely with BARC to provide outreach and volunteer opportunities with the local community. The Classroom Mini-Marsh program allows young students to actively participate in the restoration of Cootes Paradise Marsh. Marsh plants are grown at school and later returned to RBG to be planted in Cootes Paradise Marsh. RBG also coordinates multiple volunteer marsh plantings with BARC to accelerate plant regeneration in the marsh.

At the Nature Interpretive Centre (NIC), RBG will deliver three educational programs themed on the restoration of the wetlands at both the primary and secondary school levels. Programs offered each year include Biodiversity/Project Paradise, Fishway Demonstration, and Interactions in the Environment/Conservation and Stewardship, with several thousand school children expected to attend. As well, RBG will host a senior student symposium entitled "Plant Challenge" which allows students learn about the function of plants in the natural environment, both negative and positive.

Additional ways in which RBG plans to disseminate project information include: building modifications and redevelopment of the main display at RBG's Nature Interpretive Centre on the history of the wetland and its restoration, developing a downloadable data package for school project use, a mobile phone trail experience linking with our current GEOTRAILs package, and updating several interpretive signs along RBG trails at the marsh. A short promotional video will also be created and used as a marketing tool for the marsh restoration programs. This will target teachers to spark otherwise unknown interest in the available programs. A new in-class learning unit will be developed with the support of multiple school boards for grade 7 teachers which incorporates cross-curriculum learning of geography, history, and science for their students. In addition, RBG will continue to support post-secondary projects and field trips and will further develop these tours with specific themes pertaining to both Invasive Species and Species at Risk.

Points of Engagement

1. Fishway interpretation and signage
2. Hamilton Harbour fishing derby
3. RBG educational school programs
4. Nature Interpretive Centre and RBG Centre displays
5. Trail interpretive signage
6. Webpage for project information, water quality data, and summary reports
7. Restoration planting enclosure fence signs
8. Turtle nesting signs
9. Annual open house
10. Annual workshop

Available RBG Factsheets that will be updated

Cootes Paradise Fishway, Coastal Marshes Natural Fish Hatcheries, Grindstone Marshes, Amphibians, Waterbirds, Mussels, Breeding Birds, and Reptiles.

Project Descriptions

1. The Cootes Paradise Fishway

The goal of the project is to exclude non-native Common Carp (C*yprinus carpio*), while maintaining free passage for other fish species. The Fishway was built in 1996, beginning operation in 1997. It utilizes 5cm wide grates to allow free passage of water and smaller fish, while screening out larger adult carp. Six fishway cages are seasonally operating to move native fish species in and out of the marsh in association with spawning migrations. Aside from the carp exclusion function, the operation provides valuable monitoring information of water quality and fish populations, a primary visitor contact point, rich public educational experiences, and the elimination of harbour powerboats from the sensitive and shallow habitats of Cootes Paradise Marsh. Over time the excluded carp population is expected to dramatically decline as Cootes Paradise Marsh also represents the primary spawning location for carp at the western end of Lake Ontario. Ongoing maintenance items are expected to increase, as the structure is now over 15 years old.

Common Carp historically reached 90% of the marsh biomass, equivalent to an estimated 800 kg/ha, resulting in loss of most native species across all biological community levels, including plants, invertebrates, fish, birds, mammals, and multiple species at risk. Ongoing carp exclusion experience at RBG indicates that associated issues begin at densities of over 20kg/ha. Common carp arrived in North America the late 1800's and were established as a dominant species at RBG by the 1940's. Most of the wetland loss occurred between 1937 and 1950. The first carp management project at RBG was initiated in 1951. Key drivers of carp population include eutrophication of the marsh, anoxia and ammonia issues of the hypolimnetic zone of the harbour, excessive inputs of watershed sediment, and alteration of the natural marsh water cycle.

2. The Spencer Creek Delta Project

The primary goal of the project is the re-establishment of emergent marsh along the Spencer Creek channel to Bull's Point. This is to create a cattail biofilter for inflowing contaminants and sediment protecting the sensitive marsh habitat to the south east. Secondarily the project helps re-establish a migratory corridor for various fish and wildlife species, as well as people and their canoes. Overall Cootes Paradise Marsh represents the river mouth of Hamilton Harbour's main tributary Spencer Creek, with Spencer Creek connected to slightly more than half of all lands draining to the harbour. This project involves the re-establishment of the missing emergent marsh portion through Cootes Paradise Marsh through emergent marsh replanting. Channel loss was a result of a variety of activities. In the 1800's, the lower reaches were ditched, first behind a now abandoned rail line (1852), and then into the Desjardins Canal (1870's). Subsequently the last 4-5 km of channel just upstream of Hamilton Harbour was completely lost with the loss of the wetland plants in Cootes Paradise Marsh. With the exclusion of carp in 1997, these plants are returning, helping to provide a framework for channel formation. In addition, in 2001 the creek channel was shifted out of the Desjardins Canal, through removal of debris at an old channel crossing point along the canal edge. This allowed the creek to begin channel reformation through natural sediment depositional processes and plant growth.

This project moves at the rate of natural processes, but continues to be enhanced through strategic wetland plantings at the mouth of the ever lengthening channel. As of 2015, about 1.4 km of new channel had reformed and 50,000 plants had been planted (2010-20115). Smaller scale patches of invasive plants including *Phragmites* and Eurasian Manna Grass are also targeted for further management in the upper delta, with management in progress and the species partially removed as of the end of 2015. Subsequent planting of the patches cleared of invasive species will take place in the coming years. Species at Risk associated with this habitat area currently include Least Bittern, turtles, mussels, Spotted Gar, American Eel, and Bald Eagles.

3. Cootes Paradise Shoreline Repair

Cootes Paradise Marsh has a total of 27 km of shoreline, 6.8 km of which remains without vegetation, while Grindstone marsh has 4km without vegetation. The goal is to restore undercut eroding shorelines by naturally stabilizing the shore with a 4 m starting band of emergent marsh and shrub thicket plants. From the 6.8km with vegetation in Cootes Paradise 770m will also require physical repairs prior to planting. The shoreline for

physical repair falls into two broad categories, including shorelines historically armoured with gabion basket and armour stone (250 m) and unregenerated natural beach shorelines. Armour stone shorelines and the islands (520 m) are the priority areas for restoration between 2016 and 2021. Beach locations of focus are the north and south shorelines in the eastern half of Cootes Paradise Marsh. The armour stone was installed in the 1970s to protect fragile upland plant communities from collapsing into the marsh. The remaining shorelines in the western half of the marsh are largely low gradient shore and revegetated, while the eastern shoreline is almost entirely composed of fill, a result Hwy 403.

The erosion is a consequence of the historical loss of aquatic vegetation, generating long wind fetch and waves. The shorelines themselves represent sensitive habitats, often steep sandy shorelines, with the lands part of the Cootes Paradise Area of Natural and Scientific Interest (ANSI). As recovery of the marsh vegetation is occurring through a variety of HHRAP actions, shoreline repair can be initiated. Natural regeneration is not expected in the short term due to Lake Ontario Regulation, which currently prevents low water nursery conditions from along natural reestablishment of appropriated vegetation.

4. Cootes Paradise Inner Bay Project

The Cootes Paradise Inner Bay Project is a new initiative to facilitate the protection of migratory waterfowl and Species at Risk. The project location is west Cootes Paradise Marsh, south of the Old Desjardins Canal, with an area covering 20 hectares. The project goal is to create an interior sheltered marsh area with emergent plants, separating the area from watershed water quality impairments and reducing human disturbance. Planting emergent plants is necessary to overcome the limiting natural seedling regeneration effect of Lake Ontario water regulation. The large planting areas at the bays eastern end incorporates natural bathymetric contours providing a pinch point to define the bay (south side shoreline point, and the north side Spencer Creek Delta – 100m already completed as of 2015). Emergent plantings will also be completed along the shoreline lengths still lacking in emergent marsh vegetation (380 m). Smaller scale patches of invasive plants including *Phragmites* and Eurasian Manna Grass are also targets of management in the bay, to be removed prior to replanting with native species. The project may ultimately include potential signage at the eastern end entrance of the bay to help manage human activity. Species at Risk associated with the area include all aerial insectivores, Bald Eagles, Least Bittern, American White Pelican, and various turtle and mussel species.

5. Wild Rice and Deep Water Plants

The goal of this project is the re-establishment of wild rice, water lily species, floating leaf pondweed, and tape grass as dominant species in the deeper water areas of the marsh. These species exist at very low population levels currently due to poor late summer environmental conditions and small seed bank. Ongoing projects are underway to improve environmental growing conditions to the point where the species can again be abundant. Wild rice, an annual (starting from seed each spring), is considered one of the cornerstone plants of the Gardens' wetlands. To ensure this short lived species is not extirpated again, a captive population is maintained within the Gardens' plant propagation area.

Historically, wild rice (*Zizania sp.*) dominated the local wetlands, with this species ideally suited to the highly variable water level regime of Lake Ontario. The variability places extensive disturbance on the wetland through regular flooding, drying, and freezing, favouring "annual plants" such as wild rice. This species was lost from the areas many decades previous, however only a few years into the current restoration process, a few individual plants spontaneously appeared in the recovering Hendrie Valley Ponds. These plants were Southern Wild Rice (*Zizania aquatic*), a species nearly extirpated from Canada. This inspired a project focused on re-establishing the species in 2001.

6. Meadow Marsh Invasive Plant Management

Meadow marsh is a priority habitat for recovery in Lake Ontario coastal marshes, and is used as an environmental indicator for Lake Ontario water level regulation. The RBG goal for this habitat is to restore a plant community dominated by native plants. The combined total area of this habitat at RBG is mapped at 45 ha. Although much of the potential meadow marsh zone is vegetated, the plant community present is almost entirely non-native and thus not of useful character to most insect and wildlife species. Two highly aggressive non-native plant species dominate RBG's meadow marsh areas, Common Reed (*Phragmites australis)* and

Eurasian Manna Grass *(Glyceria maxima)*. RBG started managing *Phragmites* in 2013 and has had great success. Management of *Glyceria maxima* is still in the initial stages with a management strategy being formulated and only preliminary results available from management trials. Several small scale attempts to eliminate Eurasian Manna Grass have been made over the past 15 years.

Preliminary mapping of the meadow marsh zone has identified 31 areas containing meadow marsh in Cootes Paradise Marsh and 14 in Grindstone Marsh (water boundaries and peninsulas were used to identify separate meadow marsh areas from one another, Appendix A). In Cootes Paradise Marsh, the 31 meadow marsh areas (which either currently contain meadow marsh vegetation or have potential to) make up a total area of 36 ha. In Grindstone Marsh, the 14 sites consist of about 6 ha of meadow marsh area. Future enhancement projects of the meadow marsh zone will include management of these two invasive species as well as native planting efforts. Overall efforts will be prioritized based on the quality of the existing habitat and thus the inclusion of native species (more pristine habitats will be prioritized over impaired areas); area made up of invasive species (both area of the invasive species and proximity to other invasive stands will be considered and small stands which are more isolated will be given greater priority); existing efforts to remove invasive species (areas for example that contain areas cleared of *Phragmites* will be given priority over areas without previous invasive species management); areas supporting species at risk will be given higher priority. A priority area of focus is around President's Pond in Cootes Paradise Marsh, and where Species at Risk including turtles and Prothonotary Warbler occur. Given the diversity of wildflower species that would occupy the meadow marsh and its large area, its restoration would significantly contribute to the provincial pollinator strategy.

7. Stream Habitat Improvement

The goal of the project is to improve water quality and stream habitat within RBG properties. Multiple north shore tributaries of Cootes Paradise Marsh, including Mink Brook, Long Valley Brook, and Hickory Brook are the target. The Hickory Brook project focuses on unditching the lower 150 m of stream and recreating a natural channel. The details of the project will be summarized in a planning document yet to be completed. Extensive meadow marsh area and Eurasian Manna Grass management will be associated with the project. The remaining tributaries represent agricultural stream buffering and riparian habitat re-establishment projects. No Species at Risk are currently associated with these project areas.

In December 2015, Royal Botanical Gardens purchased a 42.5 acre farmed property in the Niagara Escarpment Plan area, targeted for acquisition under multiple strategies. The property is one of a number of fields below the escarpment still farmed, with the headwater tributaries of Mink and Long Valley Brooks farmed through (i.e. no stream buffers and row crops through the stream bed). While the ultimate RBG conservation goals for this property have yet to be fully defined, at a minimum row crop farming will cease within 3 years over the entire property, and in year 1 (2016) existing stream corridors will be buffered. As part of the lease agreement between RBG and the farmer, the farmer will contribute equipment to assist in re-naturalization.

8. RBG Centre Urban Runoff Management

The goal of this project is to provide water quality and quantity improvements to RBG Centre's stormwater runoff before the waters reach the natural environment. RBG Centre and parking lot impervious surface runoff largely through a large storm drain under Plains Road, discharging through a pipe located in the Woodland Garden of Hendrie Park Garden. This water then follows a spring fed ravine to Pond 2 of the Hendrie Valley Ponds. The large volumes of flow are causing significant slope erosion in the Woodland Garden and in the spring fed ravine, with the resulting impaired water quality negatively affecting the Pond 2 wetland system. The larger flows have also resulted in the flooding of the marsh carp exclusion structure found at the connecting point between Pond 2 and Grindstone Creek. A similar issue is emerging associated with a Plains Road a stormwater outfall (City of Burlington), located at the upper end (south east corner) of Pond 4 and will require monitoring and ultimately mitigation. Species at Risk associated with the project are turtles.

9. Sunfish Pond & Long Pond Project

The goal of this project is the recovery of clear clean marsh water habitat. Sunfish Pond and Long Pond are part of the historical outflow channel of Cootes Paradise Marsh. Construction of rail lines in the 1850s reset

the outflow to an alternated location, leaving this area a 7 hectare, distinct marsh area within the Grindstone Marsh complex. The system is impaired by remnant carp populations and watershed suspended sediment. Exclusion of the Harbour's Common Carp is at Sunfish Pond using an early version of an experimental carp barrier, and a deteriorating Christmas tree berm. Long Pond is distinctly named as it is partially separated from Sunfish Pond by a rail line berm. Aside from being coastal marsh habitat, it is the primary location for endangered mussel species at RBG. Actions to recover the water start with an inventory of conditions report and recommendations. Recommendations are expected to include reconstruction of the carp barrier system in Sunfish Pond, removal of all remaining carp from Long Pond, repair of a section of Sunfish Pond and Long Pond shorelines, and partnering with other agencies to improve inflowing water quality. The removal of carp from Long Pond requires improved access to the pond as the pond is surrounded by 25m high steep slopes. Long Pond contains the only meadow marsh area not dominated by Eurasian plant species. Multiple mussel and turtle Species at Risk are associated with the site.

10. Chedoke Bay Project

Chedoke Bay is located in the south east corner of Cootes Paradise Marsh at the mouth of Chedoke Creek. The principle goal of the Chedoke Bay project is to prevent sewage from dispersing through the wetland habitat and wetland public access location (Princess Point). Chedoke Creek continues to provide untreated sewage into Cootes Paradise Marsh, with the City of Hamilton undertaking ongoing projects to find and repair the sources. Hamilton Conservation Authority currently undertakes monitoring illustrating creek conditions with information shared at the HHRAP Cootes Paradise and Grindstone Marsh water quality technical team. Secondarily, the project will also recreate a bank for the creek channel for creek habitat purposes.

The original creek channel was historically filled, ditched, and relocated through the creation of the Kaydrage landfill, Hwy 403, and Macklin Ave, as well as through the loss of wetland vegetation via water pollution and high densities of Common Carp. The creek is currently attempting to reform its channel on the current sediment delta in the bay. The delta area contains no wetland vegetation due to the ongoing water pollution. The project will involve re-contouring the delta to create a natural riverbank level, followed by replanting with cattails. Species at Risk associated with the site currently include aerial insectivores and multiple turtle species.

11. Grindstone Marsh Delta (the elbow)

This project is located at the mouth of Grindstone Creek in Hendrie Valley Sanctuary and adjacent to the RBG's Laking Garden. The goal of this project is to exclude carp and watershed pollution through reconstructed riverbanks and carp barriers and reestablish shoreline emergent vegetation through planting. As with Cootes Paradise Marsh, the loss of wetland plants resulted in the loss of the last several kilometers of wetland river channel in the Grindstone Creek Delta. In January of 2000, following the success of the previous years' smaller-scale pilot projects, the Gardens implemented an innovative experimental wetland restoration project, re-establishing a portion of the channel as well as creating carp barriers to protect a portion of the wetland. Used Christmas trees collected by local municipalities formed the riverbanks, helping to recreate 1 km of natural channel and redefine the wetland areas. These areas are called Osprey Marsh and Blackbird Marsh, an area historically called the "elbow".

Blackbird & Osprey Marshes contain four small carp barrier structures inserted into the rebuilt riverbanks blocking carp access to the wetlands while maintaining the natural flow of water and movement of organisms. The experimental structures were replaced with upgraded metal versions in 2013 & 2014 and significant portions of the riverbanks were relocated, expanding the marsh areas. As with the other carp exclusion projects, the restriction of carp from their reproductive areas is expected to result in the collapse of the overall carp population. Over time, the Christmas trees naturally biodegrade, leaving a build-up of sediment and reeds as a riverbank. As the height of the riverbanks must be maintained above the lakes maximum level to prevent carp access, the riverbanks are regularly augmented with additional trees until sufficient sediment has accumulated. Other invasive species, including *Phragmites* and Eurasian Manna Grass, are also targets of management as is the re-establishment of emergent plants along the newly formed riverbanks and interior open shorelines. In addition, the most downstream 100 m of Blackbird Marsh berm will be relocated and

rebuilt to match the actual edge of Grindstone Creek. Species at Risk associated with the area include multiple turtle and mussel species, with several other species candidates to return with the improving habitat.

12. Hendrie Valley Floodplain Ponds

The goal of this project will be to maintain the integrity of the ponds through invasive species management and repair of Grindstone Creek bank at Pond 3. The ponds are a 15 hectare oxbow pond system located along the floodplain of lower Grindstone Creek, within the Gardens' Hendrie Valley Sanctuary. Restoration of three of the four ponds were the first projects initiated (1994) within the Remedial Action Plan, as the wetlands were the primary remaining spawning location of northern pike. They are also the primary location of the remaining Species at Risk population of Blanding's Turtle. The inflowing waters are of good quality, maintained by several large springs; however, the wetland plants and flooding patterns were significantly degraded and impacted by carp. Once the carp were successfully excluded in 1999, the ponds rapidly recovered clear water and the associated plants community, and are now among the finest examples of oxbow wetland habitat at the western end of Lake Ontario. Also, the ponds no longer provide new carp to the broader system. Restoration of the fourth pond – closest to the lake and not spring feed – was initiated in 2001, with the berm rebuilt and a new structure installed in 2013. This pond has proven more challenging to maintain carp exclusion; however, with ongoing efforts it continues to recovery its vegetation naturally. As with the other harbour connected wetlands, this area requires ongoing management to ensure carp are excluded while maintaining native fish migrations, such as that of the pike.

13. Carroll's Bay Marsh

Carroll's Bay Marsh represents a unique situation within RBG wetlands and the HHRAP. It is associated with several delisting targets including water quality and plants. In relation to the plants, it represents the bulk of the target total area of potential aquatic vegetation area (split into marsh (22 ha) and littoral zone aquatic vegetation targets (17 ha)). The key stressors are inflowing watershed sediment and the carp of the harbour. The marsh is currently near devoid of aquatic vegetation. This marsh remains independent of the carp control initiatives being applied to the remainder of RBG marshes due to large open connection to the harbour. Within the HHRAP the area currently serves as the measure of marsh sustainability (a marsh restoration experimental control), reflecting if underlying stressor are mitigated.

Carroll's Bay Marsh, due to the loss of aquatic vegetation, has become synonymous with the term Carroll's Bay, a term historically applied to the deeper open water at the south end of the inlet. The inlet is located in the North West corner of Hamilton Harbour at the mouth of Grindstone Creek with the entire inlet to the high water mark owned by RBG. Grindstone Creek watershed is 89km^2, with the creek mouth marsh extending 2/3 of the way to the end the harbour inlet of Carroll's Bay. The total area of Grindstone Marsh is 62 hectares with 22 hectares in inlet that is Carroll's Bay. In support of this, actions that will occur include monitoring of water quality, birds, fish, benthos, and aquatic plants as per the monitoring schedule. RBG Species at Risk related activities will involve turtles and freshwater mussels. Shoreline restoration work is intended to occur in the north east and west shorelines in partnership with the land owning agencies (City of Burlington and CN Rail). Floating buoy signage will be seasonally installed at the outer edge of the marsh to inform harbour boaters of the shallow water and the sensitive species still present.

14. Community Involvement

Public involvement is essential and the Gardens partners with groups such as the Bay Area Restoration Council, Stewards of Cootes Watershed, Hamilton Naturalist Club, and RBG Auxiliary to engage the community to participate and learn how they can be involved in the stakeholder plans that affect inflowing water. In addition, monitoring results of the ongoing wetland recovery are presented each February at an open house at RBG Centre. Other opportunities to involve the public include marsh replanting events, monitoring of amphibians and marsh birds through the Marsh Monitoring Program, monitoring of migratory waterfowl, shoreline and stream cleanups, Turtlewatch, and the Cootes Paradise Fishway. The scale and diversity of activities merits the creation of a volunteer coordinator position at RBG, however until this occurs the contacts at RBG will include the staff implementing the projects and the RBG Nature Interpretive Centre.

Key Reference Background Monitoring Documents

1. Biological Inventory of RBG Natural Lands (RBG 1985)
2. Past and Present Limnological Conditions of Cootes Paradise (RBG 1985)
3. HHRAP Stage 1 & 2 (1992), and Stage 2 update (2002)
4. HHRAP loadings Reports (1996, 2002, 2009)
5. Water Quality Study of Cootes Paradise (MOE - 1976)
6. Cootes Paradise Study (MOE – 1986)
7. West Pond Study (1999 RBG)
8. Nutrient Status of Cootes Paradise Marsh (RBG 2001)
9. Sediment Quality Review 1 & 2 (RBG 2006, 2008)
10. Bathymetry / Sedimentation (RBG 1999, 2007)
11. Water levels Implications – (RBG 2004)
12. Water levels Scenarios Review – (RBG 2007)
13. Creek loadings Study 2008 (RBG 2009)
14. Project Paradise Season Summaries – (RBG 1999 – 2015)
15. Target Plant Communities of RBG wetlands (RBG 2004)
16. Fish community use of Cootes Paradise Marsh (Master Thesis - Theysmeyer 1999)
17. Carroll's Bay Recovery Strategy (RBG 2009)
18. Water Quality Characterization of the Main Tributaries of the Garden's Property (RBG 2009)
19. Ecological Lands Classification of Cootes Paradise Marsh (RBG 2010)
20. Various protocols pertaining to measuring biological communities, sediment and water quality.
21. Cootes Paradise Marsh Water Quality Review and Phosphorus Analysis (HHRAP 2012)
22. Emergent and Meadow Marsh Assessment of Cootes Paradise and Carroll's Bay Marsh
23. Ecological Lands Classification of Hendrie Valley Marsh (RBG 2013)
24. 20 Year Trends in Water Quality, Cootes Paradise and Grindstone Marsh (RBG 2012)
25. RBG Turtle Site Specific Plan (RBG 2014)
26. RBG Phragmites Management Plan (RBG 2014)
27. 20 Years of Goose Management Summary at RBG (RBG 2015)
28. RBG Turtle Site Specific Plan (RBG 2014)
29. RBG Eurasian Manna Grass Management Plan (RBG 2016)
30. Summary of Conditions in the upper Desjardin Canal (RBG 2016 - draft)

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Appendix A

Watersheds of RBG Marshes

System	*Creek Name*	*Regulatory Agency*	*Municipality*
Cootes Paradise System	1. Spencer Creek	Hamilton Region CA	City of Hamilton
	2. Ancaster Creek	Hamilton Region CA	City of Hamilton
	3. Borer's Creek	Hamilton Region CA	City of Hamilton
	4. Delsey Creek	Hamilton Region CA	City of Hamilton
	5. Mink Brook	Hamilton Region CA	City of Hamilton
	6. Spencer Oxbow/Presidents Pond	Hamilton Region CA	City of Hamilton
	7. Mac Landing Creek	Hamilton Region CA	City of Hamilton
	8. Double Marsh Springs	Hamilton Region CA	City of Hamilton
	9. Westdale Creek	Hamilton Region CA	City of Hamilton
	10. Chedoke Creek	Hamilton Region CA	City of Hamilton
	11. Corner Brook	Halton Region CA	City of Hamilton
	12. Highland Creek	Halton Region CA	City of Hamilton
	13. Hickory Brook	Halton Region CA	City of Hamilton
	14. Long Valley Brook	Halton Region CA	City of Hamilton
	15. Marsh Boardwalk Brook	Halton Region CA	City of Hamilton
	16. Lilac Dell Brook	Halton Region CA	City of Hamilton
Grindstone Marsh System	17. Grindstone Creek	Halton Region CA	City of Burlington
	18. W1 – Snake Rd 1	Halton Region CA	City of Burlington
	19. W2 – Snake Rd 2	Halton Region CA	City of Burlington
	20. W3 - Cemetery	Halton Region CA	City of Burlington
	21. W4 – Hwy 6	Halton Region CA	City of Burlington
	22. W5 – Upper Long Pond	Halton Region CA	City of Hamilton
	23. W6 – Middle Long Pond	Halton Region CA	City of Burlington
	24. W7 – Lower Long Pond	Halton Region CA	City of Burlington
	25. South Pasture Swamp Spring brook	Halton Region CA	City of Burlington

Coastal Marsh Meadow Marsh Areas of RBG

Figure 8. Meadow Marsh location (bright green) in RBG wetlands as derived from 2011-2013 RBG Ecological Lands Classification projects.

Table 14. RBG meadow marsh priority sites and associated summary information. This information is used to prioritize restoration efforts.

Watershed	Site ID	Location Name	Manna Grass Management Needed	Phragmites Management Needed	SAR Present	Recent Restoration Plantings	Existing Native Meadow marsh	Size (ha)	Priority Ranking (1 to 5 with 1 being highest priority)
Cootes	BC1	Borers Creek	X					1.7	4
Paradise	BH1	Boathouse 1	X	touch up only		X		2.0	2
Marsh	BH2	Boathouse 2 – Highland Cr	x			X		1.2	2
	HB1	Hickory Bay- Lilac Creek	X			X		0.1	3
	HB2	Hickory Bay- Hickory Br	X		X			0.3	4
	HB3	Hickory Bay - Long Valley	X					0.5	3
	HB4	Hickory Bay - Bulls Point	X					0.1	2
	SC1	Marsh Lookout	X					0.6	3
	SC2	North Spencer Oxbow	X	touch up only			X	0.7	1
	SC3	Mink Brook	X	touch up only	X			0.3	3
	SC4	Delta Island	X	touch up only		X		0.5	2
	SC5	Hopkins East	X	X		X		3.3	4
	SC6	Hopkins West	X	X		X		5.7	4
	SC7	Spencer Cr North	X	X		X		1.8	4
	SC8	Rat Island	X	X	X			0.1	3
	SCF1	Presidents Pond	X		X	X		0.9	1
	SCF2	Spencer Creek Floodplain east	X	X	X			9.1	2
	SCF3	Spencer Creek Floodplain west	X	X	X			3.3	5
	Ma1	Mac Landing	X	X	X		X	0.3	1
	WP1	West Pond - North	X	X				2.9	1
	WP2	West Pond - West	X	X				0.5	3
	WP3	West Pond - South1	X	X				0.6	5
	WP4	West Pond - South2	X					1.0	4
	SS1	Kingfisher Marsh	X	touch up only		X	X	<0.1	2
	SS2	Kingfisher Marsh	X	touch up only		X	X	<0.1	2
	WI1	Westdale Inlet 1	X					0.1	2
	WI2	Westdale Inlet 2	X	touch up only	X		X	0.1	1

Watershed	Site ID	Location Name	Manna Grass Management Needed	Phragmites Management Needed	SAR Present	Recent Restoration Plantings	Existing Native Meadow marsh	Size (ha)	Priority Ranking (1 to 5 with 1 being highest priority)
	PP1	Princess Point	X					0.1	3
	PP2	Princess Point	X					0.1	4
Grindstone	LP1	Long Pond		touch up only	X	X	X	0.5	1
Marsh	SF1	Sunfish Pond	X		X			0.1	3
	OS1	Osprey Marsh 1	X		X	X	X	0.1	1
	OS2	Osprey Marsh 2	X	touch up only	X	X	X	0.1	1
	OS3	Osprey Marsh 3	X	touch up only	X	X	X	0.2	1
	GC1	Grindstone Creek North 1	X	touch up only	X	X		0.5	1
	GC2	Grindstone Creek North 2	X	touch up only	X			1.2	2
	GC3	Grindstone Creek North 3	X		X			0.8	4
	GC4	Grindstone Creek South	X					0.8	4
	GC4	Pond 1 Shore	X		X	X		0.1	3
	GC5	Pond 1 Floodplain	X		X			0.3	3
	GC6	Pond 2 & 3	X		X	X		1.2	2
	GC7	Grindstone Oxbow	X		X	X	X	1.5	3
	CB1	Outer Carroll's Bay	X		X			0.1	5

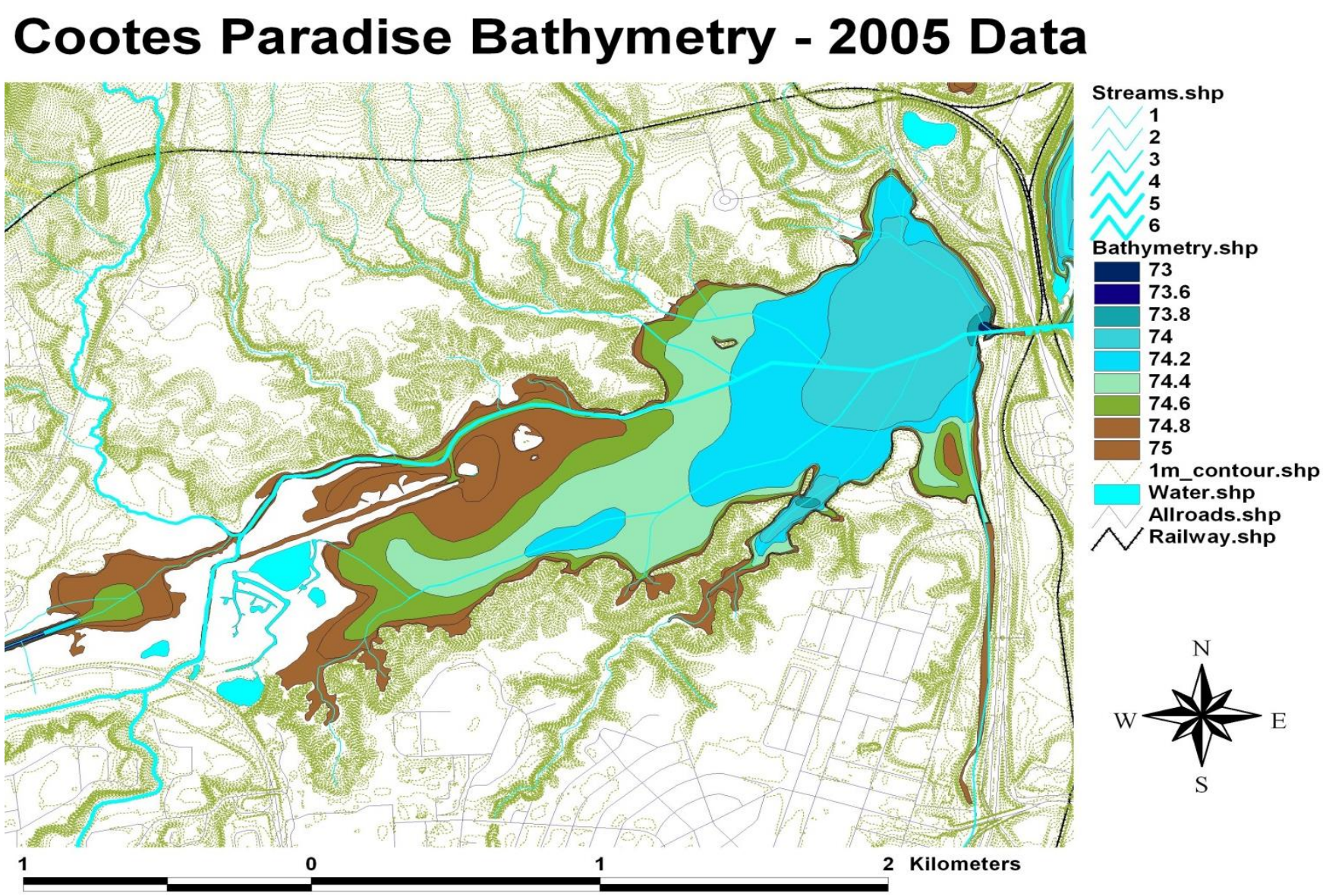

Figure 9. Bathymetry of Cootes Paradise Marsh and associated stream, by stream order size. Average spring high water level in Cootes Paradise is 75.15 msl and average winter low is 74.45 msl (from Water levels Implications RBG 2004). Peak spring water level generally occurs mid May to mid June.

Great Lakes Health Environmental Indicators

Table 15. Comparison chart of the International Joint Commission (IJC) Ecosystem Indicators and the State of the Lakes Ecosystem Conference (SOLEC) indicators. Chart is taken from "Great Lakes Ecosystem Indicators Report – A report of the IJC priority assessment of progress towards restoring the Great Lakes" IJC June 2014. A total of 23 of the 41 measure outlined by the IJC are defined differently from the SOLEC indicators (there are highlighted with an *).

IJC Ecosystem Indicators *and Measures*	**Indicators in 2011 SOLEC Report**
1. Coastal Habitat – Shoreline Alteration Index 1) *Physical shoreline indicator + Biological shoreline indicator**	1. Hardened Shorelines*
2. Extent, Composition, and Quality of Coastal Wetlands 2) *Macroinvertebrates* 3) *Fish* 4) *Plants* 5) *Amphibian (Frogs and Toads)* 6) *Birds* 7) *Wetland Area and Extent**	2. **Wetland Amphibians** 3. **Wetland Birds** 4. Wetland Fish 5. Wetland Invertebrates 6. **Wetland Plants** 7. Wetland Extent and Composition*
3. Land Cover and Fragmentation Status* 8) *Conversion measures** 9) *Fragmentation measures**	8. Land Cover*
4. Seasonal and Long-Term Fluctuations in Great Lakes Water Levels 10) *Long-term water level variability** 11) *Timing of seasonal water level maximum and minimum** 12) *Magnitude of seasonal rise and decline** 13) *Lake-to-lake water level difference**	9. Water Levels (deviation from long term mean)*
5. Tributary Physical Integrity 14) *Hydrologic Alteration (R-B Flashiness Index)* 15) *Tributary Connectivity to Receiving Waters* 16) *Sediment-turbidity measure**	10. **Tributary Flashiness** 11. **Aquatic Habitat Connectivity**
6. Water Temperature 17) *Annual summer (July-September) surface average temperature** 18) *Lake water thermal stratification date* 19) *Fall lake water turnover date** 20) *Maximum and average ice concentrations*	12. Surface Water Temperature (date of the onset summer stratification)* 13. Ice Duration
7. Atmospheric Deposition of Chemicals of Mutual Concern 21) SOLEC indicator Atmospheric Deposition of Toxic Chemicals	14. Atmospheric Deposition
8. Chemicals of Mutual Concern in Water 22) Annex 3 subcommittee recommendation	15. **Toxic Chemicals in Offshore Waters**
9. Contaminants in Groundwater 23) *Urban, agriculture, and industrial contaminants**	
10. Persistent, Bioaccumulating, Toxic (PBT) in Biota 24) *PBT chemicals in whole fishes* 25) *PBT chemicals in Herring Gull eggs and in Bald Eagles*	16. **Contaminants in Whole Fish** 17. **Contaminants in Waterbirds**
11. Phosphorus Loads and In-Lake Concentrations 26) *Phosphorus Loads of TP and DRP** 27) *In-lake concentrations of TP and DRP*	18. Nutrients in Lakes* 19. **TP concentration of offshore***
12. Aquatic Invasive Species: Invasion Rates and Impacts 28) *Rate of Invasion** 29) *Status and impacts**	20. Aquatic Non-Native Species* 21. Sea Lamprey* 22. Dreissenid Mussels*
13. Abundance and Distribution of Fish-Eating and Colonial Nesting Birds 30) *Population Status** 31) *Health Status**	
14. Lower Food Web Productivity and Health 32) *Phytoplankton* 33) *ZooplanktonMysis biomass** 34) *Benthos** 35) *Prey fishes**	23. **Diporeia*** 24. Zooplankton biomass* 25. **Preyfish biomass-9 species***
15. Fish Species of Interest 37) *Adult abundance* 38) *Recruitment**	26. **Lake Sturgeon abundance*** 27. **Lake Trout abundance*** 28. **Walleye abundance***
16. Harmful and Nuisance Algae 39) *Harmful Algal Blooms* 40) *Nuisance Algal Bloom** 41) *Excessive Algal Abundance**	29. Harmful Algal Blooms offshore* 30. Harmful Algal Blooms nearshore*
	31. **Benthos as trophic indicator** 32. **Forest land in tributary buffer** 33. **Forest land in watershed** 34. Air temperature 35. Baseflow due to groundwater discharge 36. Botulism outbreaks 37. Cladophora 38. Contaminants in sediment cores 39. Extreme precipitation events 40. Human population 41. Inland water quality index 42. Phytoplankton 43. Terrestrial non-native species 44. Water chemistry (conductivity. pH, chloride, alkalinity, turbidity, etc.) 45. Water clarity 46. Watershed stressor index

Note: 1. Shaded boxes indicate matches between IJC and SOLEC indicators
2. SOLEC indicators listed in **bold** text are indicators used in SOLEC Highlight Report
3. * indicates that the indicator has a different definition than the corresponding indicator in the other column.

Table 16.Comparison of the effect of the Current Lake Ontario Water Level Regulation Plan (1958DD) versus the unregulated situation and the proposed water level regulation Bv7 (essential Plan 2014) on key Environmental Performance Indicators. Chart is taken from the IJC website.

	Environmental Performance Indicators	1958DD	Unregulated Levels	Bv7
Ontario	**Wetland Meadow Marsh Community**	1.00	**1.56**	**1.44**
	Low Veg 18C - spawning habitat supply	1.00	**0.88**	0.96
	High Veg 24C - spawning habitat supply	1.00	1.08	0.99
	Low Veg 24C - spawning habitat supply	1.00	**1.11**	1.04
	Northern Pike - Young-of-Year (YOY) recruitment	1.00	1.03	0.99
	Largemouth Bass - YOY recruitment	1.00	0.96	0.98
	Least Bittern (IXEX) - reproductive index	1.00	**1.13**	**1.13**
	Virginia Rail (RALI) - reproductive index	1.00	**1.15**	**1.15**
	Black Tern (CHNI) - reproductive index	1.00	**1.16**	1.19
	Yellow Rail (CONO) - preferred breeding habitat	1.00	1.01	1.03
	King Rail (RAEL) - preferred breeding habitat	1.00	**1.27**	**1.19**
Upper River	**Low Veg 18C** - spawning habitat supply	1.00	1.04	1.01
	High Veg 24C - spawning habitat supply	1.00	1.02	1.00
	Low Veg 24C - spawning habitat supply	1.00	1.04	1.02
	Northern Pike - YOY recruitment	1.00	1.06	1.03
	Largemouth Bass - YOY recruitment	1.00	1.00	1.00
	Northern Pike - YOY net productivity	1.00	**2.07**	**1.40**
	Virginia Rail (RALI) - reproductive index	1.00	**1.33**	**1.19**
	Muskrat (ONZI) - house density in drowned river mouth wetlands	1.00	**14.29**	**2.59**
Lower River	**Golden Shiner (NOCR)** - suitable feeding habitat surface area*	1.00	1.01	1.00
	Wetlands fish - abundance index (Lower St. Lawrence River)	1.00	0.97	1.03
	Migratory wildfowl - floodplain habitat surface area*	1.00	0.94	0.98
	Least Bittern (IXEX) - reproductive index*	1.00	1.06	1.01
	Virginia Rail (RALI) - reproductive index*	1.00	1.04	1.03
	Migratory wildfowl - productivity*	1.00	1.02	1.01
	Black Tern (CHNI) - reproductive index*	1.00	1.01	1.00
	Northern Pike (ESLU) - suitable reproductive habitat surface area*	1.00	1.01	0.99
	Frog sp. - reproductive habitat surface area*	**NA**	**NA**	**NA**
	Eastern Sand Darter (AMPE) - reproductive habitat surface area*	1.00	1.00	1.00
	Map Turtle (GRGE) - reproductive habitat surface area*	1.00	1.01	0.99
	Bridle Shiner (NOBI) - reproductive habitat surface area*	1.00	0.97	0.96
	Muskrat (ONZI) - surviving houses*	1.00	1.05	0.94

*(Lake St. Louis to Trois-Rivières)

Related Strategies of Partners

In planning for the future, Royal Botanical Gardens has identified a number of Strategies and Plans that align with the mandate of Gardens, and may help guide stakeholders in relation to their involvement.

1. Great Lakes Water Quality Agreement
2. Canada-Ontario Water Quality agreement
3. Federal Biodiversity Strategy
4. Lake Ontario Binational Biodiversity Conservation Strategy
5. Federal Invasive alien Species Strategy
6. Federal Great Lakes Wetlands Conservation Action Plan.
7. Species at Risk Recovery Strategies – various
8. Provincial Biodiversity Strategy
9. Provincial Great Lakes Protection Act
10. Provincial Invasive Species Act
11. Provincial Lake Ontario Management Plan
12. Provincial Pollinator Strategy
13. City of Hamilton Storm water Master Plan
14. City of Hamilton Wastewater Master Plan
15. Grindstone Creek Watershed Plan
16. Hamilton CA Subwatershed Plans - various
17. MNR Hamilton Area Fisheries Management Plan
18. North American Waterfowl Management Plan
19. North American Shorebird Management Plan
20. Niagara Escarpment Plan
21. The Greenbelt Plan
22. Cootes to Escarpment Ecopark System
23. Canadian Biosphere Network

Appendix B – Preliminary Work Plan

Activities	BUI	2016	2017	2018	2019	2020
Rebuilding of Sunfish Pond structure and associated berm where needed	xiv	Berm maintenance	Sunfish Pond berm relocation and structure placement	Blackbird Marsh berm relocation and structure placement	Berm maintenance	Berm maintenance
Road to Long Pond	xiv					
Chedoke Creek berm creation (Mitigate water quality issues in Chedoke Creek bay (City of Hamilton and HCA))	xi viii					
Boat gate repairs						
Cootes Paradise Fishway basket repairs and maintenance						
Fishway maintenance (dive inspection, bird spikes, repainting)		Bird spikes Repainting				
Inventory shorelines to determine debris removal (e.g. gabion baskets), erosion, etc and other areas of issue	xi xiv	Map creation	Mitigate identified problems	Mitigate identified problems	Mitigate identified problems	Mitigate identified problems
Shoreline work at Pond 3 - allow Grindstone Creek to widen at pinch point, upstream of boardwalk, into manna grass on north side (education partner to be determined)	viii					
RBG main centre storm water pond	viii					
Operation of Cootes Paradise Fishway	xiv					
Operation of Grindstone Marsh carp barriers	iii xiv					
Phragmites management (spraying, smashing, monitoring)	xiv					
Manna grass management (spraying, smothering, monitoring)						
Goose and swan egg oiling	xiv					
Long Pond water draw down and carp removal						
Carp removal from within marsh protected areas	viii xiv					

Activities	BUI	2016	2017	2018	2019	2020
New invasive species inventories						
Extend Spencer Creek Channel	viii xiv					
Build Chedoke Creek channel						
Shoreline Stabilization						
Meadow Marsh restoration						
Cootes Paradise Marsh north shore oxbow creation						
Creation of Cootes inner bay						
Bull's Point Planting						
Island plantings						
Submergent vegetation plantings						
Shoreline Stabilization in Carroll's Bay (CN)	xiv iii					
Inner Carroll's Bay shoreline stabilization						
Grindstone Creek channel stabilization						
Yellow Pond lily establishment	xiv					
Wild rice seeding and seedling planting from aquatic nursery to establish sustainable populations in Cootes Paradise Marsh and Grindstone Marshes	xiv					
Fishway Monitoring						
SAV monitoring	xiv					
Emergent vegetation monitoring	xiv	Field survey	Aerial photographs		Field Survey	Aerial photographs
Meadow Marsh Monitoring			Field Survey			Field Survey
Water Quality monitoring	viii					
Aesthetics						
Sediment characterization						Canal/West Pond, Princess Point, back of Westdale Inlet, Outer Carroll's Bay
YOY fish monitoring	iii					
Salmon survey						
MMP – amphibians and birds	iii					
Migratory Birds						
Benthic invertebrate sampling	vi			Emerging insects		RAP related
Wetland Mammal						

Activities	BUI	2016	2017	2018	2019	2020
Updated bathymetry maps of Cootes Paradise and Grindstone Marshes	viii	Grindstone Marshes	Cootes Paradise Marsh	Map completed		Grindstone Marshes
Long Pond seasonal flow monitoring						
Dundas WWTP upgrade consultation						
Desjardins Canal sediment contamination remediation	viii	Report				
Review plans for a Carroll's Bay recovery plan with the Fish Management Sub-committee	iii xiv					
Amphibian studies in West Pond and Boathouse Bay (EC)						
Water level study with respect to Fishway and berms and associated mitigation	xiv					
Fish telemetry study in Cootes/Hamilton Harbour/Grindstone (DFO)	iii xiv					
DO and temp loggers in marsh (DFO)	iii					
Freshwater mussel work → habitat characterization (RBG)	vi		Report			
Aerial insectivore health/decline (EC)	iii viii					
Marsh aesthetics measurements	xi					
Develop post-secondary wetland programming						
Signage update and new – 4 locations (Fishway, Boathouse, Chegwin Boardwalk, NIC)						
Update interpretive information at the Nature Centre		Dismantle current interpretive display in Nature Interpretive Centre. Create new display/foyer space for Year 2 interpretive display.	Create interpretive signage package and display for Nature Interpretive Centre. Seasonal signs focusing on marsh info and natural history.			
Mobile phone experience – 2 trails (i.e. geotrails or app.)						
Work with local school board to create a Grade 7 based local program to be integrated into local school curriculum		Establish commitments/partnerships from local school board consultants and teachers.	Creation of Grade 7 "place-based" unit on Cootes Paradise Marsh and Bay area. Cross-curricular unit touching on geography, science, history.			

Activities	BUI	2016	2017	2018	2019	2020
Update and deliver the Wetland Restoration and Fishway school programs with new information; programs available at two curriculum levels		Update/refresh marsh-focused school programs with new and/or updated data. Programs to update include: Biodiversity, Interactions in the Environment, Fishway Demonstration, Conservation & Stewardship, Project Paradise.	Deliver all programs	Deliver all programs		
Deliver 10 canoe public programs						
Create a school project package for download from our website, including data and intro video to Cootes Paradise and learning opportunities		School Projects webpage linked to existing Teacher Portal (www.rbg.ca/schools). Direct students and teachers to list of potential projects including real-world data from Cootes Paradise Marsh and RBG Fishway/Project Paradise.				
Create short promotional video featuring Cootes Paradise Marsh, marsh restoration info. Use as marketing tool for school programs and in existing partnership with BARC mini-marsh program.		Create promotional video (contractor)				
Work with BARC for Mini-marsh and volunteer plantings; provide a follow up destination for BARC outreach programs	xiv	TBD				
Establish new working relationship with BARC						