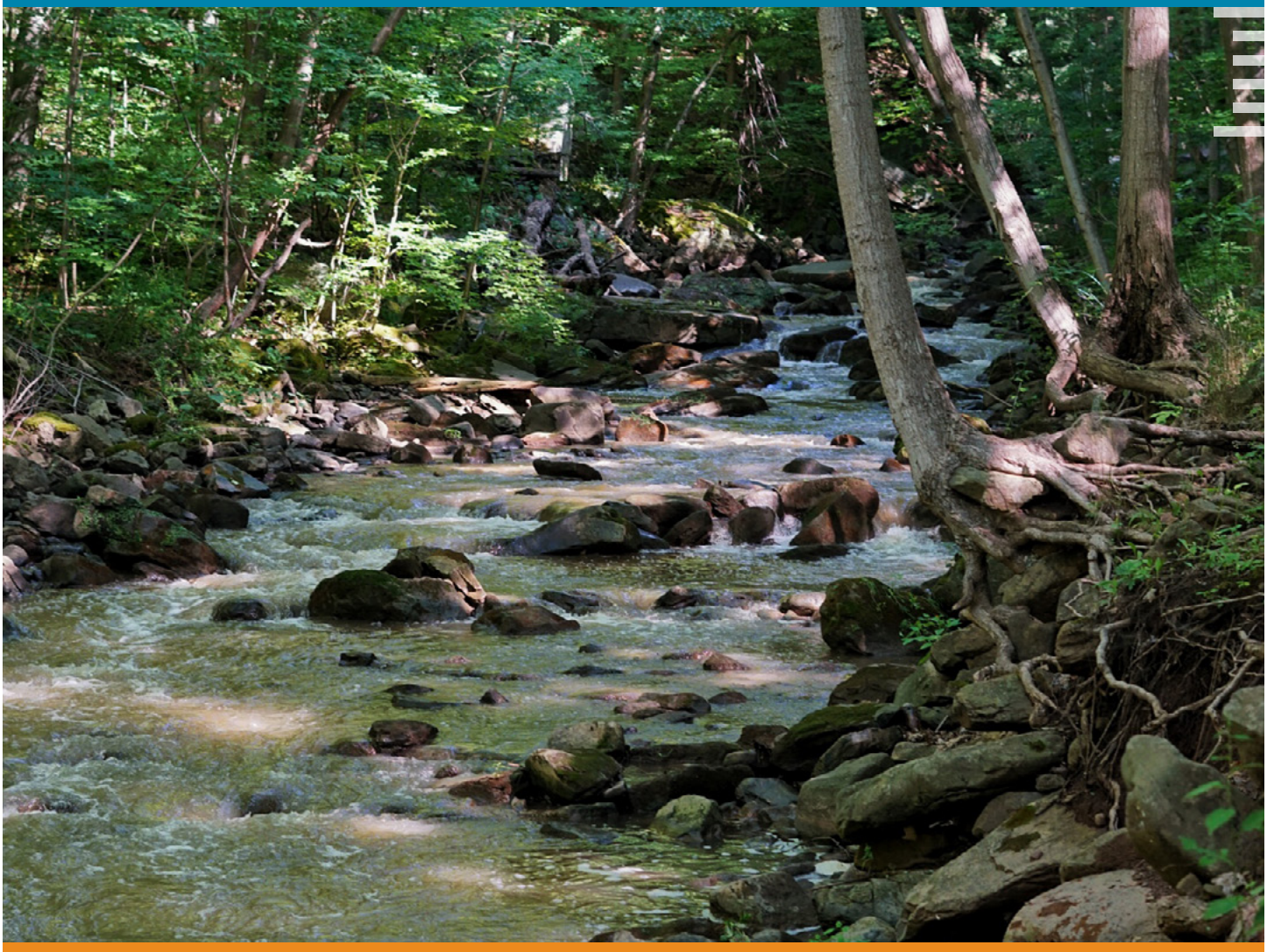
Grindstone Creek Watershed

Natural Assets Management Project

Main Report



August 2022

Municipal Natural Assets Initiative

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The Municipal Natural Assets Initiative (MNAI) is a Canadian not-for-profit that is changing the way municipalities deliver everyday services - increasing the quality and resilience of infrastructure at lower costs and reduced risk. The MNAI team provides scientific, economic and municipal expertise to support and guide local governments and watershed agencies in identifying, valuing and accounting for natural assets in their financial planning and asset management programs, and developing leading-edge, sustainable and climate-resilient infrastructure.

Acknowledgments

This report and the project it describes has been financially supported by the Greenbelt Foundation of Ontario as well as the City of Burlington, the City of Hamilton, and Conservation Halton.

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Please cite as:

Municipal Natural Assets Initiative (MNAI). (2022). *Grindstone Creek Watershed Natural Assets Management Project: Summary Report.* MNAI.ca

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Acronyms

This document summarizes the results of a project to develop a natural asset inventory for the Regional District of Central Okanagan and documents steps the local government can take to proceed to a full natural asset management initiative.

CH	Conservation Halton or The Halton Region Conservation Authority
CCTV	closed circuit television
GLWQA	Canada - United States Great Lakes Water Quality Agreement
ha	hectares
HHRAP	Hamilton Harbour Remedial Action Plan
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
LEMP	CH Long-term Environmental Monitoring Program
km	kilometres
m	metres
MNAI	Municipal Natural Assets Initiative
NEC	Niagara Escarpment Commission
NEP	Niagara Escarpment Plan
NDMNRF	Ontario Ministry of Northern Development, Mines and Natural Resources & Forestry NEPDA: Niagara Escarpment Planning and Development Act
OWES	Ontario Wetlands Evaluation System
RBG	Royal Botanical Gardens
SOLRIS	Southern Ontario Land Resource Inventory System
TEK	Traditional Ecological Knowledge
UNESCO	United Nations Educational, Scientific and Cultural Organization

1 Executive Summary

Canadian local governments and watershed agencies face infrastructure challenges that are increasing in number, frequency and severity as the climate continues to change. Developing and acting on holistic evidence of nature's services and their value can create solutions to these issues, and opportunities to secure many other vital benefits from healthy, connected and biodiverse ecosystems.

Within this context, the City of Burlington, the City of Hamilton, Conservation Halton[1], and Royal Botanical Gardens (the Project Partners) worked with the Municipal Natural Assets Initiative (MNAI), a Canadian non-governmental organization, on the *Grindstone Creek Watershed Natural Assets Management Project* ("the Project").

The Project goals are to:

1/ Support and guide Conservation Halton and the City of Burlington in identifying, valuing and accounting for natural assets in their financial planning and asset management programs and ensure that the City of Hamilton has the required information from the project for the same.

2/ Develop leading-edge, sustainable, cost-effective and climate-resilient flood management and stormwater management infrastructure on a watershed basis

3/ Reduce risk and potential liability due to flooding, erosion and sedimentation.

4/ Provide sustainable municipal service delivery to communities.

The 91 km² Grindstone Creek watershed is well positioned to take advantage of natural asset management approaches:

- It is downstream of predominantly rural areas and substantially within the Niagara Escarpment, a World Biosphere.
- Natural assets in this area are mostly in fair or good condition and serve a high-density, urban population in the lower reaches of a watershed that abuts Lake Ontario.
- Natural assets in this area, such as the Cootes to Escarpment Heritage Lands and the Hendrie Valley Trails, are connected to the wider natural heritage system.
- The use of natural assets as infrastructure, which can lessen the impacts of traditional development patterns (e.g., highly impervious surfaces, loss of natural assets due to sprawl), while promoting a sustainable and value-added range of benefits that grey infrastructure

1 *Conservation Halton was established under the Conservation Authorities Act in 1963 and is set up on a watershed basis to deliver programs and services that further the conservation, restoration, development and management of natural resources in watersheds in Ontario.*

cannot.

- Furthermore, the Project Partners each brought substantial, complementary expertise to the initiative, including:
  - Operational knowledge from the City of Burlington and the City of Hamilton.
  - Watershed-scale expertise, natural asset data and assessment methodologies from Conservation Halton.
  - Scientific knowledge from Royal Botanical Garden, Canada's largest botanical garden.

A rapidly changing climate provides additional Project context. Conservation Halton's strategic plan, Momentum (2021-2024), identifies climate change drivers for watershed science-driven actions for community and environmental resiliency. Local research demonstrates that, in the Grindstone Creek watershed, the duration and volume of large storm events have increased, and will continue to do so. Flooding risks in the region, and in relation to the Grindstone Creek watershed specifically, are expected to grow as development increases (often following traditional patterns) and engineered assets continue to age. The Intergovernmental Panel on Climate Change (IPCC) highlights that flexible, integrated approaches are essential to managing these changes, and notes that nature-based solutions such as natural asset management have both mitigation and adaptation benefits, and need broad uptake.

Over approximately two years, the Project produced data, modeling, and strategies to incorporate natural assets into long-term asset management for all Project Partners. These included:

- Developing an interactive, web-based inventory with information on location, size, and extent of natural assets in the Grindstone Creek watershed, condition of natural assets, and risks to natural assets.
- Modelling to assess role of natural assets in flood reduction (peak flow attenuation and infiltration).
- A valuation of how natural assets contribute to stormwater management.
- An assessment of co-benefits that natural assets provide.
- Scenarios development to consider future states of the watershed.
- Analysis to inform continual improvement.
- Recommended next steps to advance comprehensive natural assets management efforts.

More specifically:

The Project determined that the Grindstone Creek watershed contains 8,769 natural assets covering 7,232 hectares (ha). Of these, almost 70 per cent are rated as being in fair condition, while smaller portions are rated poor (2.45 per

cent) and excellent (7.72 per cent) condition. The inventory, which Conservation Halton now owns, contains these and other details. At the same time, the water flowing to the river delta area remains a priority to restore under the Great Lakes Water Quality agreement as part of the Hamilton Harbour Remedial Action Plan.

Modelling quantified the functions of natural assets in terms of core local government services, in this case, peak flow attenuation and runoff reduction. The Project modelled six scenarios: three to determine baseline natural asset functions, and three to explore climate change scenarios and the impacts of major improvements in the Grindstone Creek watershed.

The Project determined dollar values for natural assets in terms of some of the core services (specifically, stormwater management) they provide in the Grindstone Creek watershed, and some co-benefits (specifically, recreation, soil retention and erosion control, climate mitigation, habitat and biodiversity and atmospheric regulation).

The estimated value of the natural assets for stormwater management (specifically peak flow reduction and infiltration) is approximately $65/m² for forests; swamps is $200/m²; marshes is $203/m²; and open water is $324/m². This means that the total value of natural assets for one service — stormwater management — is approximately $2 billion ($2,071,941,487)[2] in terms of capital costs of equivalent engineered infrastructure assets to provide that same service. Operational costs to maintain natural assets were not estimated, and are an additional cost to be considered. These include annual costs for monitoring and maintenance activities. Emerging research is demonstrating that, on average, natural infrastructure is more cost-effective than engineered infrastructure, due to lower capital investment requirements, lower long-term operating and maintenance costs, and lower requirements for labour, chemicals, and other inputs throughout asset life.[3] In addition, natural assets can provide a wide range of co-benefits.

The estimated annual service value of natural assets in the Grindstone Creek watershed in terms of recreation, soil retention and erosion control, climate mitigation, habitat and biodiversity, and atmospheric regulation is approximately $34 million. Health benefits and Indigenous benefits were considered qualitatively.

These dollar figures by no means represent the full or "true" value of natural assets, and natural assets management is about far more than assigning a value to some services from nature. Nevertheless, valuations can improve decision-making when situated within a broader understanding of the importance of nature as they reflect, in commonly understood terms, the extent to which local governments and communities rely on nature for many vital services.

2 *The methodology used to estimate value is explained in the "VALUE OF ASSETS" section, starting on page 34.*

3 *World Business Council for Sustainable Development, 2017.*

The Project identified several risks related to natural assets, particularly in the Lower Grindstone Creek subwatershed. The Lower Grindstone Creek subwatershed has a small area of assets that are in poor condition and a moderate risk rating. The overall average risk to natural assets in this location is very high when the risk and condition are considered together; this means that natural asset management leading to improved condition could have a high beneficial impact.

Report limitations include the fact that it provides a snapshot at a particular point in time, whereas natural asset management is an ongoing, adaptive management process. There are multiple options for refinements to inventory, condition, valuation, and modelling.

PROJECT IMPACT / OUTCOMES

Notwithstanding clear findings on the importance of natural assets in the Grindstone Creek watershed, there is no single, time-bound intervention that will ensure that they are understood, protected, and managed for the long-term; natural asset management is an ongoing, adaptive management cycle. Rather, the Project has to date provided Project Partners with data, a business case, an interactive dashboard, modelling, and scenarios that provide strong foundations for ongoing efforts. Furthermore, ten recommendations emerged from the Project, covering different types of issues including restoring natural assets in high-risk areas; improving governance, strategy, planning at a watershed scale; and undertaking a number of specific asset management-based activities.

Recommendations are structured to support Project Partners to: maintain existing natural assets, improve their condition upstream to treat and manage water where it lands, improve understanding of natural asset characteristics and functions in mid-watershed[4] to determine causes of and solutions to stormwater management issues, and identify natural and engineered options to manage stormwater in the lower reaches of watershed.

RECOMMENDATIONS (SUMMARY)

1/ Review policies to protect existing natural assets
2/ Develop a collaborative watershed management strategy and plan for Grindstone Creek watershed
3/ Develop a collaborative watershed management approach for the Grindstone Creek watershed
4/ Develop a collaborative monitoring plan
5/ Advance priority restoration projects
6/ Install low impact development projects in priority areas
7/ Strengthen assessment of natural assets in the Grindstone Creek

4 *Watersheds can be defined by their elevation. The mid watershed is lower in elevation than the upper watershed and higher in elevation than the lower watershed.*

watershed

8/ Develop a communications plan and presentation to build awareness of natural asset management needs in the Grindstone Creek watershed

9/ Better integrate natural asset management into overall asset management practices

10/ Identify additional watersheds within Conservation Halton's jurisdiction for natural asset management.

2 Introduction

Canadian local governments and watershed agencies in Ontario face infrastructure and asset management challenges. Many services they provide, including water and wastewater, waste removal, transportation, flood attenuation, erosion control, and environmental services, depend on engineered infrastructure assets that need renewal. Climate change places increasing pressure on the existing infrastructure stock.

There is growing evidence in Canada that if local governments choose to holistically understand nature's values and services, many potential solutions to these challenges are available to them. *Municipal natural assets* are the stocks of natural resources or ecosystems that local governments can or do rely upon for the sustainable provision of one or more local government services[5]; effective stewardship of municipal natural assets helps local governments to be more resilient, deliver affordable services in a changing climate, reduce costs, and provide an alternative to trying to "build their way out" of infrastructure challenges. Municipal natural assets can provide both local government services and many co-benefits that add to community quality of life. Municipal natural asset management is a method that enables local governments to conceptualize, account for, restore, protect and manage nature as a vital asset and ensure its viability for the long-term.

The urgency of accelerating this work is particularly acute in urban and peri-urban areas; approximately 80 per cent of Canadians live in the interface between natural and urban areas where nature is very important but also very vulnerable[6].

Natural asset management is particularly relevant in addressing climate change. A 2021 report from the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and IPCC, for example, notes "only by considering climate and biodiversity as parts of the same complex problem... can solutions be developed that avoid maladaptation ... ignoring the inseparable nature of climate, biodiversity, and human quality of life will result in non-optimal solutions to either crisis."[7] The recently released IPCC Sixth Assessment Report

5 *MNAI 2017*

6 *Brown et al., 2021*

7 *Pörtner et al., 2021*

includes a headline statement that stresses the fundamental importance of safeguarding biodiversity and ecosystems in the development of climate resilience[8]. It goes on to advise that "*maladaptation can be avoided by flexible, multi-sectoral, inclusive and long-term planning and implementation of adaptation actions with benefits to many sectors and systems*"[9]. Nature-based solutions are recognized as both a promising adaptation action that can help reduce some physical and socioeconomic risks from climate change, and a potential mitigation action to store and sequester carbon. Nature-based solutions — of which natural asset management is one — may also play a role in reducing liability risks (*see Recommendation 1*).

A key methodological consideration is that natural assets do not typically align with political boundaries and jurisdictions, and many local governments rely on natural assets that are under the ownership and/or jurisdiction of others. Therefore, collaboration amongst many entities, and action at a watershed scale, is typically required for effective natural asset management.

Within this context, the City of Burlington, the City of Hamilton, Conservation Halton, and Royal Botanical Gardens (the Project Partners) elected to work with the Municipal Natural Assets Initiative (MNAI), a Canadian non-governmental organization, on the *Grindstone Creek Watershed Natural Assets Management Project. This report provides Project* results to-date.

2.1. Project Goals And Objectives

As noted, there are 4 Project goals:

1/ Support and guide Conservation Halton and the City of Burlington in identifying, valuing and accounting for natural assets in their financial planning and asset management programs and ensure that the City of Hamilton has the required information from the project for the same.

2/ Develop leading-edge, sustainable, cost-effective, and climate-resilient flood management and stormwater management infrastructure on a watershed basis

3/ Reduce risk and potential liability due to flooding, erosion, and sedimentation.

4/ Provide sustainable municipal service delivery to communities.

Two objectives support these goals:

1/ Identify, understand, and quantify the current and possible roles of natural assets in the Grindstone Creek watershed as a component of services such as flood mitigation, stormwater management, and water quality control.

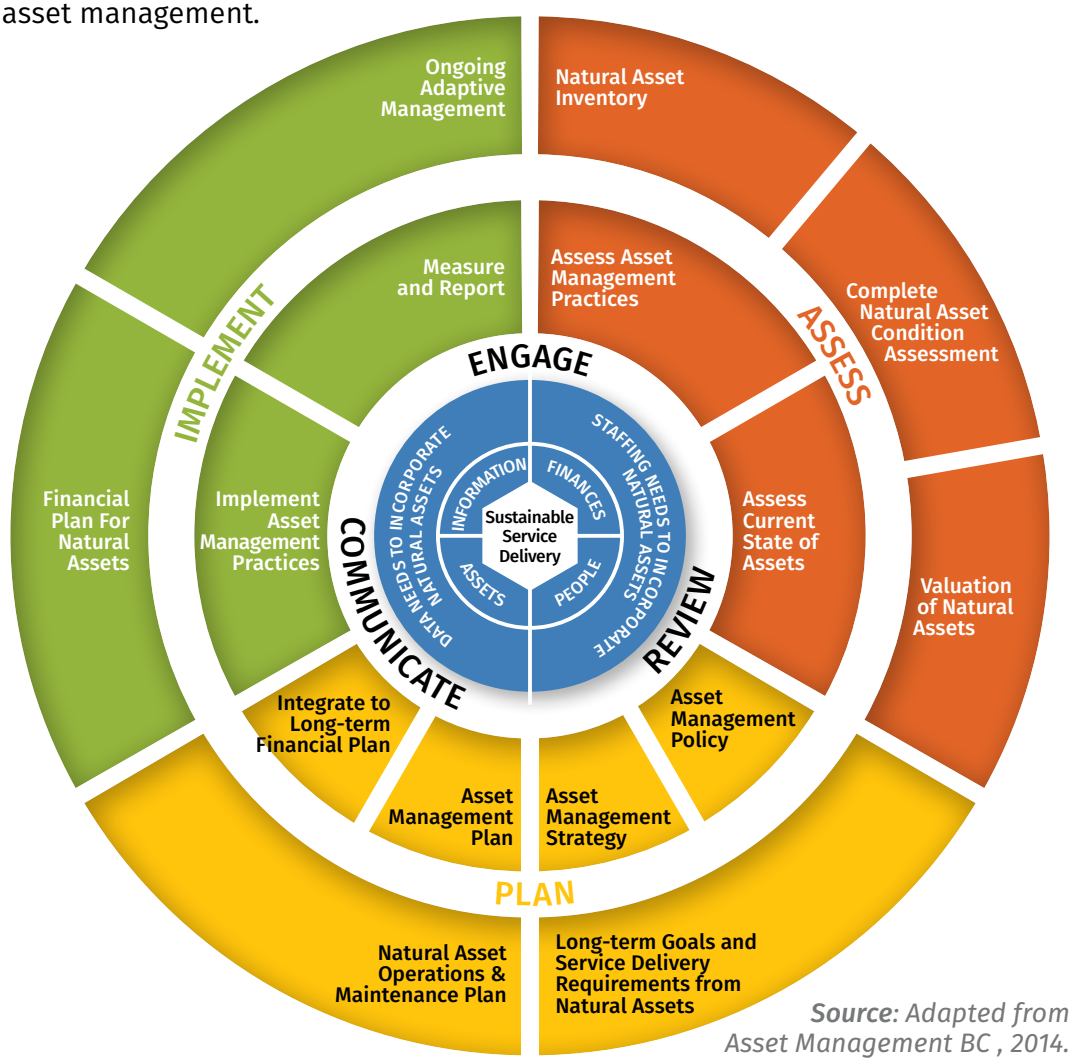
8 *IPCC AR6 WGII 2022*

9 *IPCC AR6 WG II, 2022, p. 35.*

2/ Determine associated costs and benefits of providing these services from natural assets in the Grindstone Creek watershed relative to engineered alternatives and/or long-term operations and maintenance for engineered assets (e.g., diversion channels, stormwater management ponds, stormwater management facilities and systems).

These goals and objectives are laid out in a Memorandum of Understanding between MNAI and the Project Partners.

The methodology for the project is based on standard asset management practices that local governments are increasingly required to adopt in Canada, and which are articulated by organizations such as Asset Management BC, based on global norms. MNAI has adapted these methodologies to ensure that natural assets, which are complex in their role in service delivery, context-specific, and present novel considerations, can be effectively integrated and considered into asset management.



Source: *Adapted from Asset Management BC , 2014.*

Figure 1: *The diagram depicts the natural asset management cycle.*

2.2. Limitations & Assumptions

2.2.1. General

MNAI uses an asset management-based methodology to understand the relationship between local governments and nature, for several reasons:

- Asset management is becoming ubiquitous amongst Canadian local governments (and in Ontario, amongst Conservation Authorities), and thus offers scope to make natural asset management a broadly based, scalable and comparable practice.
- Asset management provides a useful and practical approach for conceptualizing nature not simply in narrow aesthetic terms, but as something upon which communities rely for a multiplicity of important services.
- Asset management is proving to be a mechanism that helps integrate nature-related considerations into core local government decision-making, thus broadening its relevance beyond departments that focus on environmental matters.

Another Project limitation is that, as illustrated in Figure 1, asset management is an adaptive management cycle, not a finite process. Therefore, while this report is current at the time written, many elements will evolve in response to data, feedback loops, actions taken by Project Partners, and continuous improvement.

It is also important to note that MNAI undertakes detailed hydrologic modelling to assess the levels of services that natural assets provide, and the value of those services, to allow for service-based comparisons with engineered assets. However, all modelling uses assumptions, has limitations and is not predictive.

MNAI estimated the value of some of the services from nature relevant to the beneficiaries in this project: local governments, Conservation Halton, and communities more generally. Together, these service values provide a composite figure that can be considered as a minimum service value. This composite figure can support and inform decision-making; however, it is only part of a broader understanding of what is meant by nature's "value". Furthermore, while there are many services provided by the ecosystems of the Grindstone Creek watershed, only a portion of these services are valued in this Project.

2.2.2. Indigenous Peoples

It is acknowledged that Indigenous peoples have a holistic and inherent understanding of nature, the benefits it provides, and of the connections between all living things. As such, any natural assets initiative, including this Project, will achieve better outcomes when it considers and interweaves Indigenous worldviews, knowledge and perspectives.

At a general level, therefore, Project implementation should be aligned with the

United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).[10,11] This, in turn, requires sustained, meaningful collaboration with the Indigenous peoples. The Project provides an opportunity to learn from, Indigenous peoples who have lived in the region for millennia, and determine ways in which their worldviews, knowledge and perspectives can inform and be interwoven into all resultant Project programming.

At a more specific level, there is little published literature specific to the uptake of natural asset management by Indigenous communities, including First Nations (Reed et al., 2022). Therefore, an understanding of how best to engage, and of specific barriers they may face, is similarly limited, due to factors including lack of research and reporting with Indigenous communities, and differences in definition, approaches to managing assets and cultural relationships with nature.

MNAI is aware, for example, that not all asset management terminology and approaches may align with First Nations, Inuit and Métis worldviews and perspectives. These factors must be considered in future Project stages.

2.3. Local Context

2.3.1. First Nations, Metis and Inuit peoples

The Grindstone Creek watershed is situated upon the traditional territories of the Erie, Neutral, Anishinaabeg, Huron-Wendat, Haudenosaunee and the Mississaugas, covered by the Dish With One Spoon Wampum Belt Covenant (1700) and the Between the Lakes Purchase – Treaty 3 (1792)[12]. The Haldiman Proclamation of 1784 also provides important context; its outcome was the Mississauga (Anishinabek subgroup) welcoming the Haudenosaunee into their territory after the American Revolutionary war, to then settle along the Grand River near present-day Hamilton.

2.3.2. Geography

The term watershed refers to the land that water flows across on its way to a common stream, river, or lake. A watershed can be very large, if the receiving body of water of interest is also large, such as a lake or a major river; or small, if the receiving body of water is small, such as a pond or stream. Watersheds may nest within other watersheds; those that nest within larger watersheds are often referred to as subwatersheds. Watersheds are a useful scale at which to

10 *www.un.org/development/desa/indigenouspeoples/wp-content/uploads/sites/19/2018/11/UNDRIP_E_web.pdf*

11 *The City of Hamilton, as one example, is already committed, through its Urban Indigenous Strategy to consult on and develop an appropriate framework and processes for future consultation and relations with Indigenous Peoples & First Nations but has not formally adopted UNDRIP.*

12 *An Ontario Treaties map is available here: files.ontario.ca/treaties_map_english.pdf*

consider natural asset management.

The Grindstone Creek watershed (Figure 2) is located in southwestern Ontario, in the Greater Golden Horseshoe region between Hamilton and Toronto. It is partially within the Cities of Burlington and Hamilton, and the Regional Municipality of Halton.

The Grindstone Creek watershed originates in primarily rural wetland areas[13] above the Niagara Escarpment, within the boundaries of the City of Hamilton. It drains the Waterdown Moraine, Niagara Escarpment and the sands of the Iroquois Plain[14]. It comprises 9,046 ha of land and supplies 14 per cent of natural water into Hamilton Harbour / Burlington Bay[15] at the site of the Royal Botanical Gardens. The Grindstone Creek watershed is the northern limit of the Lake Erie Lowland ecoregion, an ecosystem that houses a greater number of flora and fauna species than any other ecosystem in Canada, including species found nowhere else[16]. Grindstone Creek itself passes through significant residential and recreational areas.

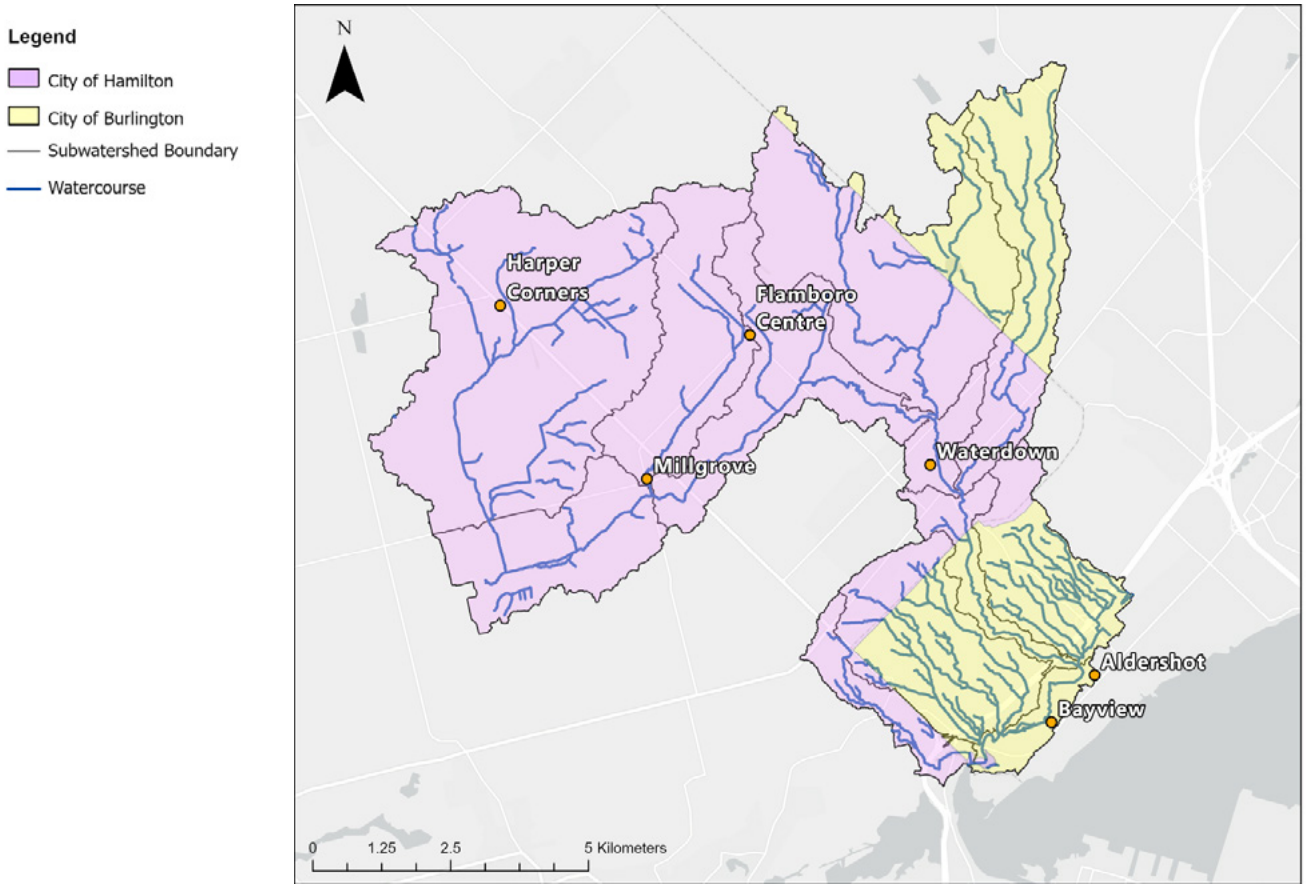


Figure 2: *Grindstone Creek watershed*

13 *Wetlands in the Grindstone Creek watershed are comprised of swamps and marshes.*

14 *An area created by the former glacial Lake Iroquois which was, in effect, a larger version of the current Lake Ontario.*

15 *Fact Sheet in MOU. Conservation Halton Website.*

16 *Carolinian Canada 1994.*

The Grindstone Creek watershed slope and valley configuration is varied. Upstream of the Niagara Escarpment, valley systems tend to be broad and shallow with significant wetland complexes located along the valley. Flows in the tributaries are intermittent over much of their length. In the middle reaches of the Grindstone Creek watershed, groundwater discharge from springs adds flow year-round. Downstream of the Niagara Escarpment, the main Grindstone Creek and its tributaries are generally located within deep ravines. Grindstone Creek is a dendritic system[17] and contains approximately 157 km of watercourse[18].

2.3.3. Land Uses

The Grindstone Creek watershed is predominantly rural, comprising agricultural lands and an almost equal proportion of natural or naturalizing lands such as forests and wetlands. There is minimal impervious coverage within the upper reaches of the watershed, where total wetlands coverage is approximately 15 per cent. Approximately 93 per cent of land use in the upper watershed are rural residential, agricultural, and open space uses. The remaining 7 per cent consists of urbanized and settlement areas above the Escarpment within the City of Hamilton (e.g., Waterdown, Harpers Corners, Millgrove, Flamborough Centre) and in the lower reaches along the shores of Lake Ontario in the City of Burlington, including Aldershot and Bayview.

2.3.4. Priority risks related to the Grindstone Creek watershed

The Grindstone Creek watershed faces several physical risks that climate change continues to increase.

Research demonstrates that the duration and volume of large storm events has increased and will continue to do so[19]. For example, modelling completed for the Project for the years 2050 to 2100 suggests a ~30% increase in total rainfall for 12-hour, 100-year storm events and that peak flow rate increases, in general, will become larger. Figure 3 below from project modeling shows the current 12-hour, 100-year Atmospheric Environmental Service (AES) storm event against the projected 12-hour, 100-year AES storm event. The graph demonstrates considerable increases in intensity of rainfall, but as the duration is pre-defined (i.e. 12-hours) it does not provide an indication of climate related changes to duration or frequency for the area, which are both projected to increase as well. Such storms may increase physical and socioeconomic risks, such as health impacts from long-term exposure to elevated levels of air pollution, more extreme weather events (heat waves, droughts, winter storms, tornadoes, and

17 *A dendritic system in this context means one that branches like a tree.*

18 *Fact Sheet in MOU.*

19 *IPCC 2022*

wind storms), and increased pressure on existing infrastructure[20]. The modelling also suggests that natural assets play an important role in preventing peak flow rate increases from climate change[21].

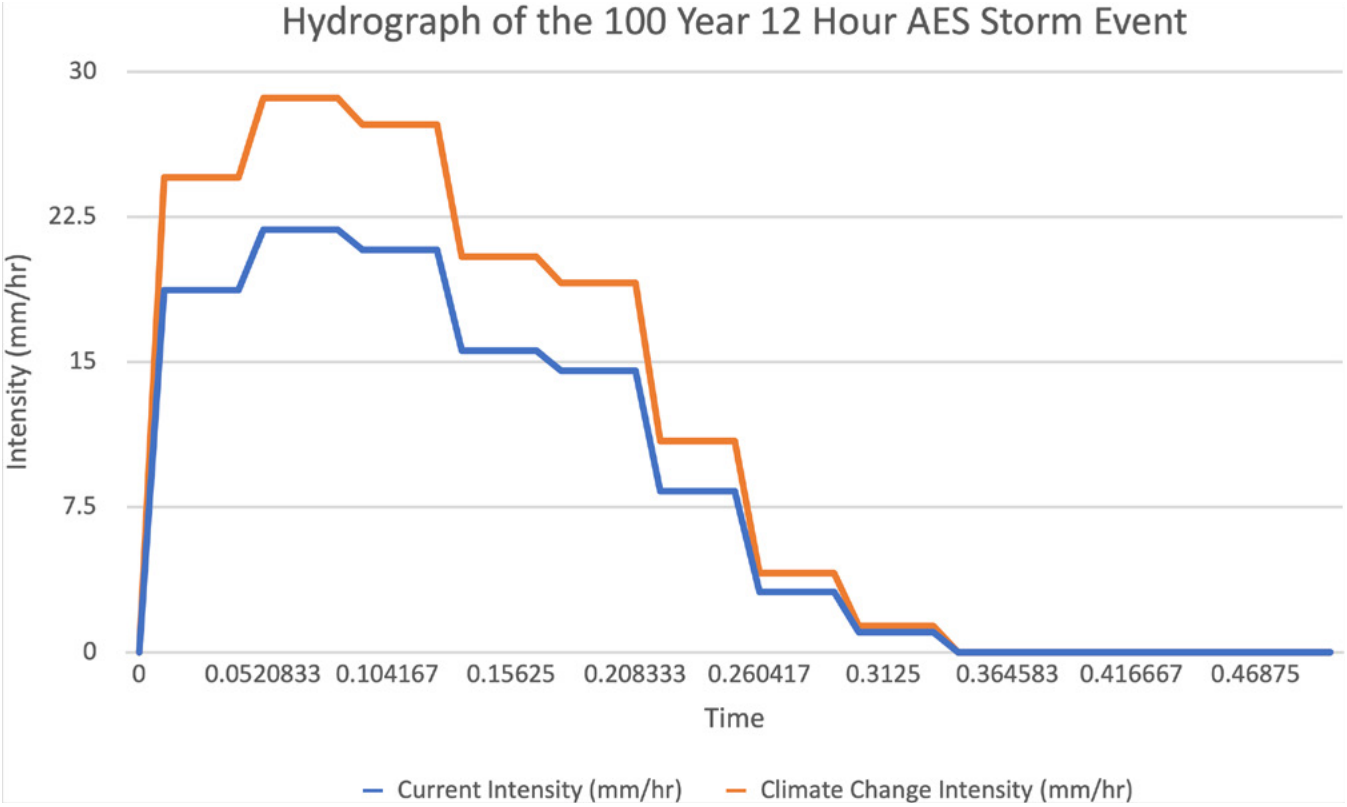


Figure 3: Hydrograph of the 100 Year 12 Hour AES Storm Event

The Project focussed on three interconnected risks that relate to stormwater management: flooding and erosion, aging infrastructure, and degraded water quality. Each risk is briefly described here.

In Canada, flooding accounts for the largest portion of disaster recovery costs on an annual basis. Water damage is a key driver of increases in property and casualty insurance costs[22]. A 2014 storm in a watershed neighboring Grindstone Creek, for example, caused flash flooding and damage to more than 3,000 homes, businesses and infrastructure, resulting in over $90 million of insured damages. Existing creek channels were severely eroded and overtopped, and debris jams exacerbated the flooding.

In 1983, the Grindstone Creek Flood Damage Reduction Study identified significant risk to life and property exists for extreme flood events in the Rural Settlement Area of Millgrove, the City of Hamilton, and Hidden Valley Road in the City of Burlington. Conservation Halton updated this modelling in 2020[23]

20 *Council of Canadian Academies, 2019.*

21 *Associated Engineering 2022.*

22 *assets.ibc.ca/Documents/Resources/IBC-Natural-Infrastructure-Report-2018.pdf.*

23 *Flood Hazard Mapping Report, Grindstone Creek Watershed. Prepared by Matrix for Conservation Halton.*

and confirmed that during a Regional Storm event[24], Grindstone Creek would receive significant spill flows from Bronte Creek. The Highway 6 crossing north of Carlisle Road, will, according to the analysis, impact how and where spills occur.

Flooding risks in the region, and in relation to the Grindstone Creek watershed specifically, are expected to grow as the population increases in high-growth areas and more people are exposed to hazards; and, as engineered assets continue to age[25]. Existing engineered stormwater infrastructure that was not designed to cope with increased water volume and flow rate associated with storm events requires upgrades to meet the current standards and/or measures that limit demands on it. The latter could involve natural asset interventions to extend the life of aging infrastructure stock and may become an attractive approach given that neither climate risks nor population levels are likely to decline.

In terms of water quality, the Hamilton Harbour/Burlington Bay is designated as one of 17 Canadian Areas of Concern under Annex 2 of the Canada - United States Great Lakes Water Quality Agreement (GLWQA). Stormwater quantity and quality are identified as important factors influencing the health of the water and as noted, the Grindstone Creek watershed drains a significant amount of freshwater into Hamilton Harbour/Burlington Bay. A 2016 geomorphological assessment found that upstream reaches in the main valley of the watershed are sensitive to bank erosion, where slopes are greatest[26]. These areas are suspected to contribute sediment loads to the lower reaches of the watershed, including Hamilton Harbour/Burlington Bay. Through the Hamilton Harbour Remedial Action Plan (HHRAP)[27], the Project Partners, together with other HHRAP partners, have committed to actions to address urban runoff, sedimentation, and water quality problems.

2.3.5. Risk management efforts

Numerous risk management efforts have been taken to mitigate risks from flooding, erosion and address water quality and quantity challenges. Examples are below; the list is by no means exhaustive.

The City of Burlington, in response to 1960s-era flooding linked to floodplain development, upstream urban development, and insufficient stormwater control, partnered with Conservation Halton and the Province of Ontario to undertake watercourse improvements, diversions, channelization and upstream water storage facilities. After 1977, stormwater management was incorporated

24 *The Regional Storm event is defined as a storm of the magnitude, duration, and intensity of Hurricane Hazel (1954).*

25 *Greenbelt Foundation, 2021.*

26 *GeoMorphix 2016.*

27 *Conservation Halton provides administrative and technical support to the Hamilton Harbour Remedial Action Plan (HHRAP). Staff of the HHRAP program are employees of Conservation Halton, and the program is support by Federal, Provincial and municipal partners, including the cities of Burlington and Hamilton.*

into the City of Burlington's design standards. Stormwater management facilities were typically located on sites redeveloped starting in the 1980s.[28]

In 2020, the City of Burlington updated its Stormwater Management Design Guidelines in line with anticipated climatic changes and the need for adaptation. This update includes a review of global climate change models, low impact development (LID) concepts, controls on post-development peak flows, and stormwater quality.

Efforts such as wastewater treatment upgrades will contribute to the future potential delisting of Hamilton Harbour/Burlington Bay as an Area of Concern. Additional action is still needed to improve the quality, and reduce the quantity, of stormwater being discharged into Hamilton Harbour/Burlington Bay. Specifically, there is a need to reduce sediment and phosphorus loadings and increase infiltration of stormwater. This has led the Cities of Hamilton and Burlington to recognize the need to maintain and enhance stormwater management services. In 2021, Conservation Halton expanded water quality sampling in Grindstone Creek to quantify loadings and begin identifying source hotspots for sediment and phosphorus. Conservation Halton worked with the City of Burlington to implement two bioswale features to intercept and infiltrate stormwater runoff in the Brighton Beach community.

2.3.6. Ecosystem services from natural assets in the Grindstone Creek watershed

The Grindstone Creek watershed provides valuable services to multiple beneficiaries. These can benefit local governments, the Conservation Halton, and the community more generally. For example:

- Its natural assets buffer flooding and erosion effects of storms and snowmelt, and moderate summer flows by allowing surface water to infiltrate into groundwater, filter contaminants and sediment, and reduce the rate and total volume of runoff into the Grindstone Creek and its tributaries.
- It provides recreational opportunities on publicly-held lands within the Grindstone Creek watershed that comprise part of the Cootes to Escarpment EcoPark System, including the City of Burlington-owned Hidden Valley Park, the Conservation Halton-owned Clappison and Waterdown Woods, and various landholdings of Royal Botanical Gardens.

The Project is, therefore, an opportunity for Project Partners to take a holistic, evidence-based, watershed-scale approach to:

28 *Conservation Halton has undertaken other risk management efforts for flooding and erosion as well, including restoration work and implementing regulations to keep development away from flood hazards.*

- Maintain and enhance multiple services, including those noted above.
- Enhance and complement long-standing efforts to reduce flooding risks and address water quality.
- Prepare for and adapt to changing precipitation patterns in a changing climate described above, which will amplify existing risks.
- Address specific sediment and phosphorous issues in the Hamilton Harbour/Burlington Bay using innovative municipal natural asset management methods and tools.

Based on evidence from other natural asset management efforts, the Project will contribute to lower lifecycle costs than relying solely on engineered solutions. It will also provide co-benefits that correlate with health, protected and well-managed ecosystems, and take advantage of the opportunities presented by engaging a Conservation Authority with a mandate and means to undertake programming at a watershed scale.

The Project is also an opportunity to learn from Indigenous peoples about how a "holistic" effort can be best conceptualised; and, to recognise and assert UNDRIP rights.

2.3.7. Area of focus

The entire watershed jurisdiction of Conservation Halton covers 1,059 km² and includes numerous watersheds and streams entering Lake Ontario (see Figure 4 below). The Grindstone Creek watershed itself is just one of three main watersheds that Conservation Halton manages and is the focus of this study;[29] the other two are the Bronte Creek Watershed and Sixteen Mile Creek Watershed.

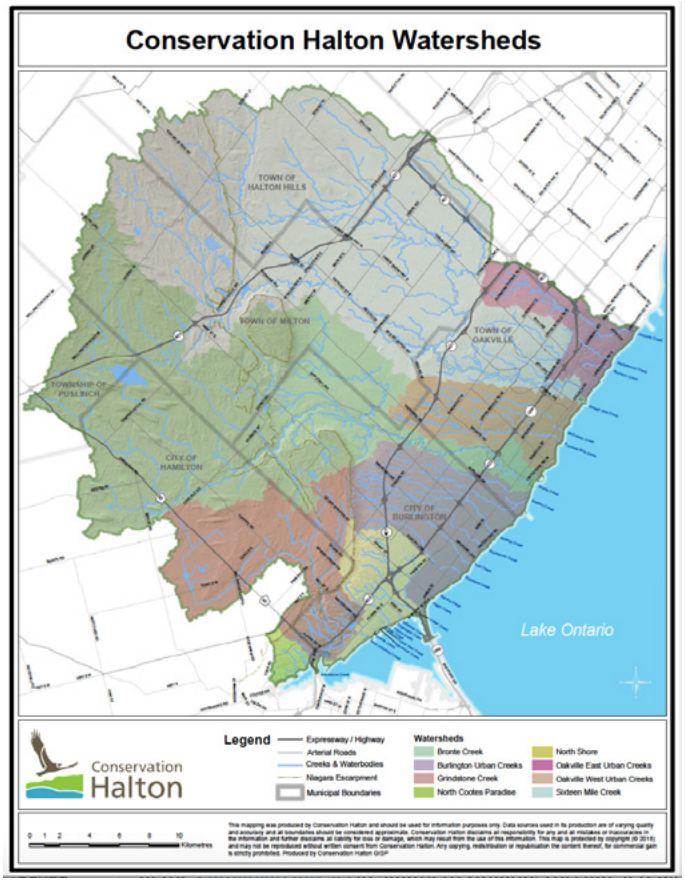


***Figure 4**: Conservation Halton Watersheds*

***Source**: Conservation Halton 2022 https://gis.conservationhalton.net/doc/OpenDataHub/MapGallery/MapGall_Watershed_Map_1.pdf*

29 *Conservation Halton 2022.*

2.4. Regulatory And Policy Context

2.4.1. Governance of the Grindstone Creek watershed

The Grindstone Creek watershed is a multi-owner, multi-jurisdiction, and multi-use area. Many entities including local governments and Conservation Halton share governance responsibilities.

The City of Burlington (population ~183,000) is within the Regional Municipality of Halton and forms the western end of the Greater Toronto area. The City of Hamilton (population ~587,000) is southeast of the City of Burlington and outside the jurisdiction of the Regional Municipality of Halton. Water, in part, flows from the City of Hamilton towards the City of Burlington.

Royal Botanical Gardens is Canada's largest botanical garden. It owns approximately 90 hectares of land at the mouth of the Grindstone Creek and approximately 1,100 ha overall. It has a statutory mandate focussed on human interaction with the natural world and protection of environmentally significant lands. Thus, it is an important element of governance in the Grindstone Creek watershed[30].

CONSERVATION AUTHORITIES ACT

In Ontario, the Conservation Authorities Act established 36 Conservation Authorities as watershed management agencies that are responsible for the delivery of programs and services that further the conservation, restoration, development, and management of natural resources.

Conservation Halton was established in 1963 under the Conservation Authorities Act.[31] It plays an important role in natural asset management and is a key partner to local governments within its jurisdiction. To fulfill its mandate, Conservation Halton delivers programs and services including: watershed planning and monitoring, land acquisition and management, operation and maintenance of water control infrastructure, flood forecasting and flood warning, administration of regulations to keep development away from hazard areas, planning advisory services, environmental restoration and stream rehabilitation, provision of outdoor recreation, and conservation education and awareness. The ability to collaborate and undertake programming at a watershed scale is essential to effective natural asset management efforts, given that many local governments receive services from natural assets that they do not own and/or are outside their jurisdiction.

ONTARIO ASSET MANAGEMENT REQUIREMENTS

The *Regulation Asset Management Planning for Municipal Infrastructure* (O. Reg. 588/17) requires Ontario municipalities to have had a strategic asset

30 *tools.bgci.org/garden.php?id=98*

31 *www.ontario.ca/laws/statute/90c27*

management policy in place by July 1, 2019, an asset management plan for core infrastructure assets by July 1, 2022, and for all other municipal infrastructure assets by July 1, 2024. O. Reg. 588/17 also requires municipalities to inventory, value, and integrate green infrastructure – including natural infrastructure and, by extension, natural assets – into their asset management planning[32].

The Grindstone Creek watershed provides multiple services to the Cities of Hamilton and Burlington. The City of Hamilton is generally upstream from the City of Burlington, so protection and management of natural assets in Hamilton may support both cities to manage stormwater and mitigate flood risk, and Royal Botanical Gardens to manage risks to water quality and biodiversity at the mouth of Grindstone Creek.

The Cities of Burlington and Hamilton, Royal Botanical Gardens and Conservation Halton shared data individually with MNAI to support the development of the Grindstone Creek natural asset inventory. Conservation Halton and MNAI signed a Data Licensing Agreement for this project. The data and information in the inventory will assist both cities in meeting O. Reg. 588/17 as they must incorporate natural assets into asset management plans by 2024. Conservation Halton will own and manage the inventory resulting from the Project.

Therefore, collaboration will be required to ensure that natural asset data is strengthened and updated to inform the development of asset management plans for natural assets in the Grindstone Creek watershed. Project Partners may wish to develop a collaborative watershed management plan to achieve shared objectives (see Recommendation 2), consistent with policy directives in the Provincial Policy Statement 2020 (described below) and the requirement for Conservation Authorities to develop watershed-based resource management strategies (O. Reg. 626.21, s.7)

NIAGARA ESCARPMENT COMMISSION REQUIREMENTS

Some land in the Grindstone Creek watershed is in the Niagara Escarpment Plan (NEP).[33] In 1990, the United Nations Educational, Scientific and Cultural Organization (UNESCO) named the Niagara Escarpment a World Biosphere. It is now known as the Niagara Escarpment Biosphere. This recognizes the Escarpment and nearby land as internationally significant and endorses the Niagara Escarpment Plan, Canada's first, large-scale environmental land use plan. Implementing the Niagara Escarpment Plan upholds Biosphere principles by balancing protection, conservation, and sustainable development to ensure the Escarpment remains a substantially natural environment for future generations.

32 *See mnai.ca/resource-to-help-navigate-and-implement-o-reg-588-17/ for additional details.*

33 *Niagara Escarpment Plan - Niagara Escarpment Commission*

The Niagara Escarpment Commission (NEC)[34] together with the Ontario Ministry of Natural Resources and Forestry (NDMNRF) share responsibility for ensuring development activities within the Niagara Escarpment Plan Area comply with the Niagara Escarpment Planning and Development Act (NEPDA), NEP and associated regulations. The NEP includes land use designations such as escarpment natural areas, escarpment protection areas, escarpment rural areas, escarpment recreation areas, escarpment urban areas, minor urban centre, and mineral extraction areas. To ensure the Niagara Escarpment is protected, landowners within its boundaries must obtain a permit for certain types of development.

Natural asset management strategies or plans developed for the Grindstone Creek watershed must be consistent with the requirements of the NEC for the natural assets located within the Niagara Escarpment Plan area (*see Recommendation 2*).

ONTARIO PROVINCIAL POLICY STATEMENT 2020

The Provincial Policy Statement 2020 is part of the More Homes, More choice: Ontario's Housing Supply Action Plan. It links to land use planning systems found in the *Planning Act* through *More Homes, More Choice Act, 2019* and *A Place to Grow: Growth Plan for the Greater Golden Horseshoe*.

Some policies in the Statement are particularly relevant to natural assets management because they focus on supporting land use patterns that protect environmental health, biodiversity, water, and prime agricultural lands.

Appendix A lists generally relevant policies in the Statement and three policy directives that provide a rationale for Conservation Halton and the Cities of Burlington and Hamilton to collaborate and develop a collaborative natural asset management strategy or plan for the Grindstone Creek watershed. Considered alongside the results of this Project, they offer a rationale for developing a collaborative watershed management plan for the Grindstone Creek watershed (*see Recommendation 2*).

2.5. Asset Management Readiness Of Project Partners

At Project outset, Conservation Halton and the City of Burlington conducted *an asset management readiness assessment*, based on the Federation of Canadian Municipalities (FCM)'s approach and with support from MNAI, to estimate their organization's maturity in asset management in four competency areas: 1) Policy and Governance, 2) People and Leadership, 3) Data and Information, and 4) Planning and Decision-Making (see Appendix B for the Readiness Template). Conservation Halton and the City of Burlington shared their results during the project launch workshop. Staff from the City of Hamilton and Halton Region added insights about their asset management readiness but did not conduct a readiness assessment in advance. The results provide insights into

34 *See NEC - Niagara Escarpment Commission.*

opportunities to support the integration of natural asset management into asset management practices.

COMPETENCY ONE: POLICY AND GOVERNANCE

The City of Burlington has an asset management policy that does not exclude natural assets, but does not mention them either. Staff report on progress towards asset management objectives annually to Council. Conservation Halton did not have an asset management policy when it conducted its readiness assessment but has an asset management plan. MNAI recommends updating or developing asset management policies to make explicit the role of natural assets in service delivery. An example[35] that could be used is illustrated in the box to the right.

***Scope:* Template of text to use**

The City/Town of _____ owns a wide range of asset types that deliver services to the people _____. Each year the city/town may receive or construct new assets. In addition, the City/Town of _____ may rely on natural assets or other assets that it does not own, in order to deliver services. This asset management policy applies to the assets owned by the city/town. Where service provision is supported by other assets not owned by the city/town, we will work collaboratively with those asset owners and promote the principles outlined in this policy.

The City/Town of _____ recognizes the importance of natural assets and will include these in its inventories and asset management practices. Examples include water bodies, wetlands and wildlife corridors.

Table 1 summarizes the services that the City/Town of _____ provides, and gives examples of the asset groups and asset types owned by the city/town that support the delivery of those services.

Based on the asset management readiness assessment, Conservation Halton is at an intermediate-to-advanced stage in implementing the first two of a three-phased approach to asset management. This includes dams and channels, buildings, and capital assets associated with recreational parks. The third phase had not yet been implemented. Work has yet to be done to incorporate natural asset management considerations into its asset management planning, but senior management recognizes the important role of natural assets in service delivery. In addition to its asset management plan, Conservation Halton has a Strategic Forest Management Plan that guides Master Plans for their lands and contains elements of an asset management plan including inventorying and management recommendations. Conservation Halton noted the need to incorporate natural assets in a formal asset management framework.

35 *Federation of Canadian Municipalities 2018*

PEOPLE AND LEADERSHIP

The City of Burlington has a cross-functional asset management team that does not yet include anyone responsible for integrating natural asset management into asset management planning. Staff noted that adding natural asset management expertise to the team would help support that integration but that staff capacity and resourcing of natural asset management was limited.

Conservation Halton has cross-functional staff efforts that support asset management for engineered assets. It has staff from disciplines that can support natural asset management, such as ecologists, foresters, and restoration specialists. Forestry staff plan, implement and monitor the management of Conservation Halton's forests and to deliver sustainable forest and hazard tree management.

Resourcing of lifecycle management activities was noted as a challenge. Funding is typically only available for staff to assess the condition of natural assets, while funding for lifecycle management activities usually comes from external sources such as grant programs.

The capacity and resource limitations that both organizations identified point to the importance of building awareness of the results of this Project so needs related to natural assets management factor into senior administrators', Councils' and Conservation Halton Board decision making.

DATA AND INFORMATION

The City of Burlington conducts ongoing storm sewer inspections, creek inventory inspections, and stormwater pond inspections. It uses the information to prioritize condition assessments and generate a list of rehabilitation projects to be implemented over a five-year period; it also does interim three-year inspections for erosion control.

In 2008, the City of Burlington began a creek monitoring program for erosion within the urban boundary. This now includes all tributaries and smaller creeks, and had a total length surveyed of 130 km. A visual inspection of urban creeks is completed every five years to monitor erosion, debris and infrastructure conditions. It aims to identify measures that support erosion control including armour stone, gabion baskets, stone blocks, or natural channel design. Part of the survey re-confirms the height and length of those erosion control assets. Staff noted that a potential improvement is to survey beyond the City of Burlington's urban boundary to include all rural areas of the city.

The City of Burlington has not yet developed levels of service or assessed risks to engineered or natural assets other than a high-level risk assessment for the Hidden Valley area due to flood risk. Staff noted risks to operations and maintenance due to limited staff capacity and funding. The creeks that come down the Niagara Escarpment are typically identified as high risks for erosion. Stormwater runoff from the City of Hamilton has a major impact on water

quality coming down the Niagara Escarpment and any future development there could also impact water quality; by contrast, appropriate data could help build a case for restoration. The City of Burlington would also like to monitor water quality for suspended solids and phosphorous. Water quality is also an issue of concern for Royal Botanical Gardens.

Conservation Halton has a comprehensive inventory of natural assets for the entire Grindstone Creek watershed with mapping of vegetation cover, size, location, and types of wetlands (swamps and marshes) and forests. These assets have not been linked to municipal service delivery but are linked to management programs carried out by Conservation Halton that support communities across member municipalities. This Project strengthened the information in Conservation Halton's inventory and through a data sharing agreement with the Cities of Burlington and Hamilton, Project Partners can collaborate to strengthen and update it. Conservation Halton has begun to modernize and integrate databases to improve data management and report generation.[36]

Conservation Halton is mandated to undertake provincial surface and groundwater quality monitoring, including at a long-term station near the mouth of Grindstone Creek at Unsworth Avenue. Conservation Halton also established automated samplers at this location and on Indian Creek in 2021 to track loading in Hamilton Harbour/Burlington Bay. Water quality data has been gathered for other projects, and all Conservation Halton water quality data is available through the Great Lakes DataStream Portal. Monitoring data helps prioritize lifecycle management activities such as restoration. Conservation Halton also monitors wetland hydrology, including at a swamp in Flamborough and a marsh at North of 5th Concession Road and west of Highway 6 in Hamilton. There are two Water Survey Canada flow gauges installed near Aldershot and Highway 6 at Millgrove.

All Project Partners are also partners of the Cootes to Escarpment EcoPark System, which includes a portion of the Grindstone Creek watershed. The EcoPark System commissioned a study to estimate the value of ecosystem services that is scheduled for completion in 2022.

This Project provided insight into the extent and value of stormwater services that natural assets provide and has estimated the value of co-benefits they bring to communities.

PLANNING AND DECISION-MAKING

The City of Burlington is updating its asset management plan to include 60-year projections. The COVID-19 pandemic delayed the completion of this update. By 2024, the update will need to include stormwater creek assets. Lifecycle costing has been done for most City of Burlington built assets; staff noted a

36 *The RBG did not complete a readiness assessment, but noted that it has data on the natural assets at the mouth of the creek including wetland habitat, water quality, and health of the forests and surrounding terrestrial habitat.*

need to assess natural assets and develop lifecycle management plans for them too. This area of continuous improvement will support the City of Burlington in developing long-term investment forecasts. The City of Burlington noted other required continuous improvement measures including incorporating risk management into asset management, setting corporate priorities, developing a more structured approach to asset investment planning, and incorporating natural asset considerations for all services.

Conservation Halton's asset management plan incorporates channels and dams. It noted a need to further integrate natural assets into its overall asset management framework and needs for funding for the physical management of natural assets to increase ecosystem health and corresponding goods and services. The Conservation Halton Strategic Forest Management Plan 2020 guides the implementation of healthy forests across their land holdings. It sets metrics to determine the health of the forests with the initial step being an inventory of the forest natural assets and includes management measures. Thus, the Plan contains core elements of natural asset management. It supports the delivery of a series of Master Plans that guide Conservation Halton's functions and services in their Conservation Areas.

Conservation Halton has a restoration opportunities database and has undertaken actions across the Grindstone Creek watershed that support natural assets. To do so it used a combination of insights from their monitoring data and ecological goals. This helped identify areas where restoration projects will have a high impact, although these have been individual projects limited by available funding and are yet to be implemented through an asset management approach based on long-term investment plans. Efforts have included mitigating risks to natural assets such as by controlling invasive species like European Buckthorn, removing trees affected by the Emerald Ash Borer and removing weirs that are a barrier to fish passage. Other projects in the Grindstone Creek watershed include improving water quality and channel morphology with installation of livestock fencing to restrict creek access, and enhancing wetlands at Flamborough Centre Park (*conservationhalton.ca/flamborough*).

Conservation Halton is a member of a regional groundwater management partnership program led by the Toronto and Region Conservation Authority; groundwater and wetland monitoring data are shared within the program database. The program supports the regional hydrogeological context for ongoing groundwater studies and management, including groundwater resource utilization and predicting potential impacts of infrastructure and urban development.

3 Current State of Natural Assets

The natural asset management assessment phase (the red part of the circle depicted in Figure 1) provides a baseline understanding of the current services that natural assets provide, and some corresponding values. This section describes the results of the assessment phase, including:

- The approach and results of efforts to identify and inventory natural assets in the Grindstone Creek watershed. (An accompanying document – Grindstone Creek Natural Asset Inventory Technical Report – provides further details on the approaches used to create the Grindstone Creek inventory and conduct the condition and risk assessments. Appendix A provides a data checklist that was provided to Project Partners at the start of the project).
- The current condition of natural assets in the Grindstone Creek watershed.
- The value of a range of different services provided by the natural assets.

3.1. Identification Of Natural Assets

As depicted in Figure 1, a natural asset inventory is a first component of the natural asset management assessment phase. Natural asset inventories provide details on the types of natural assets a local government relies upon[37], their condition, and the risks they face. The assessment phase, in turn, is the first of three phases of a full natural asset management project.

The Grindstone Creek watershed natural asset inventory is composed of three interconnected sub-inventories organized as spatial data layers. This approach provides a foundation to integrate watershed reporting with natural asset management. The sub-inventories are:

1/ **Core natural asset inventory**. This terrestrial inventory of natural assets across the Grindstone Creek watershed captures the location and extent of forest, wetlands (specifically swamps and marshes), ponds, successional, and agricultural land covers within the watershed. The core natural asset inventory is based on the landcover data for the watershed boundary.

2/ **Watercourse-based inventory**. This is conceptually the same as the core inventory but applies to watercourse features and is an inventory of the hydrologic network with each stream reach defined as a unique asset. The watercourse inventory is based on the water-related spatial layers for the watershed.

3/ **Subwatershed level inventory**. This is a high-level inventory where each subwatershed within the Grindstone Creek watershed is defined as an

37 *Note that many local governments rely on services from natural assets they do not own.*

asset. The subwatershed inventory provides a way to roll up detailed core asset and watercourse inventories to a subwatershed scale. It also facilitates the inclusion of pre-existing Watershed Report Card data[38] and variables in the inventory.

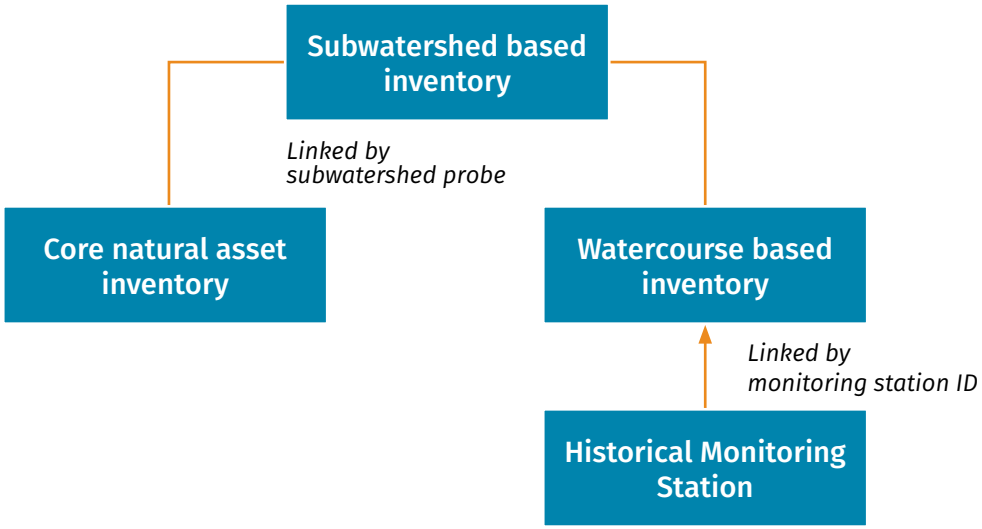


***Figure 5**: Structure of the Grindstone Natural Asset Inventory.*

Details on each sub-inventory follow.

3.1.1. Core Natural Asset Inventory

The foundation of natural asset inventories is mapping natural features within a given area. For the Grindstone Creek watershed, this involved MNAI acquiring data layers from the Project Partners and reviewing and filtering the data, based on the MNAI team's expertise with natural asset inventories and the local expertise of Project Partners. Developing the core natural asset inventory involved the following:

1/ **Defining the natural assets**. This required combining information from existing data sets based on a hierarchy that prioritised best available data. The highest priority layer was the wetland layer that Conservation Halton provided. The pond and waterbody layer, also provided by Conservation Halton, was the second priority layer. The third priority layer was Conservation Halton's Ecological Land Classification layer. These were used to define spatial boundaries for areas other than wetlands, ponds and waterbodies. The final priority layer was the Southern Ontario Land Resource Inventory System (SOLRIS) data from the Government of Ontario. This was used to fill gaps in the land cover data. Once the base natural inventory was completed, a riparian zone

38 *Conservation Authorities produce report cards to provide details on local watershed conditions using a standardized set of indicators and evaluation focusing on surface water quality, forest cover and groundwater quality. The one referenced in this document can be accessed here: camaps.maps.arcgis.com/apps/MapJournal/index.html?appid=0d98b4a22c5947e4a0f696f5c50a7810*

was developed from watercourse data. This zone was defined as a 30m buffer from watercourse line features.

2/ **Splitting assets by subwatershed boundaries**. Some natural asset areas cross subwatershed boundaries within the Grindstone Creek watershed. To link the assets to their respective subwatersheds, individual assets were split according to these boundaries.

3/ **Adding attributes to describe natural assets**. Once the base asset inventory was established, additional attributes beyond boundaries were added to define whether the assets are associated with:

- city and regional parks
- street trees
- development permit applications
- tile drainage areas

Individual assets were defined in GIS as any continuous natural or semi-natural area that is contained within the same subwatershed.

3.1.2. Watercourse Inventory

Watercourse network data that Conservation Halton provided formed the foundation of the watercourse inventory. Additional attributes were added, including:

- Stream type
- Stream order
- Length of reach
- The relevant subwatershed (received separately from CH)
- Monitoring station ID (if present, received separately from CH)
- Hazard flood plain (if relevant, received separately from CH)

3.1.3. Subwatershed Inventory

Using the subwatershed spatial data that Conservation Halton provided, attributes were assigned to each subwatershed area, specifically:

- Subwatershed name
- Subwatershed area
- Percent natural assets
- Percent forest assets
- Percent wetland assets
- Percent agriculture

3.2. Overall Inventory Results

Table 1 summarizes the overall natural asset inventory (e.g., core + watercourse + subwatershed), which comprised 8,769 assets covering 7,231 ha in the Grindstone Creek watershed.

TABLE 1: SUMMARY OF NATURAL ASSET INVENTORY FOR GRINDSTONE CREEK

ASSET TYPE	NUMBER OF ASSETS	AREA OF ASSETS (HA)
Agriculture	2,728	3,892
Forest	977	1,017
Marsh	2,110	475
Meadow Successional	400	374
Swamp	2,554	1,474
Total	**8,769**	**7,231**

Figure 6 demonstrates the contribution of agriculture assets to the Grindstone Creek inventory.

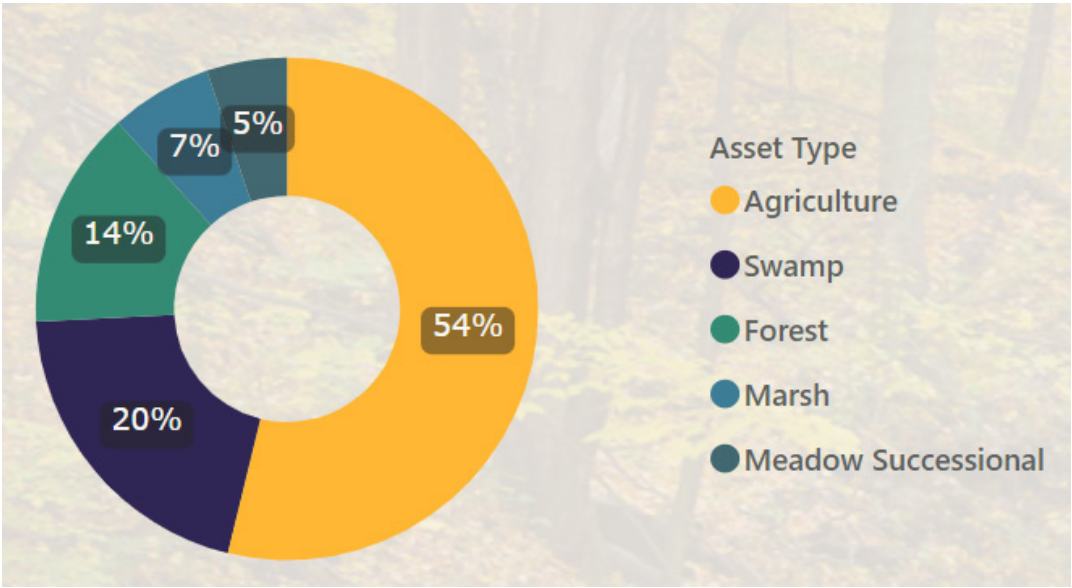


***Figure 6**: Percent of total asset area by asset type*

Figure 7 demonstrates the location and extent of the natural assets within Grindstone Creek.

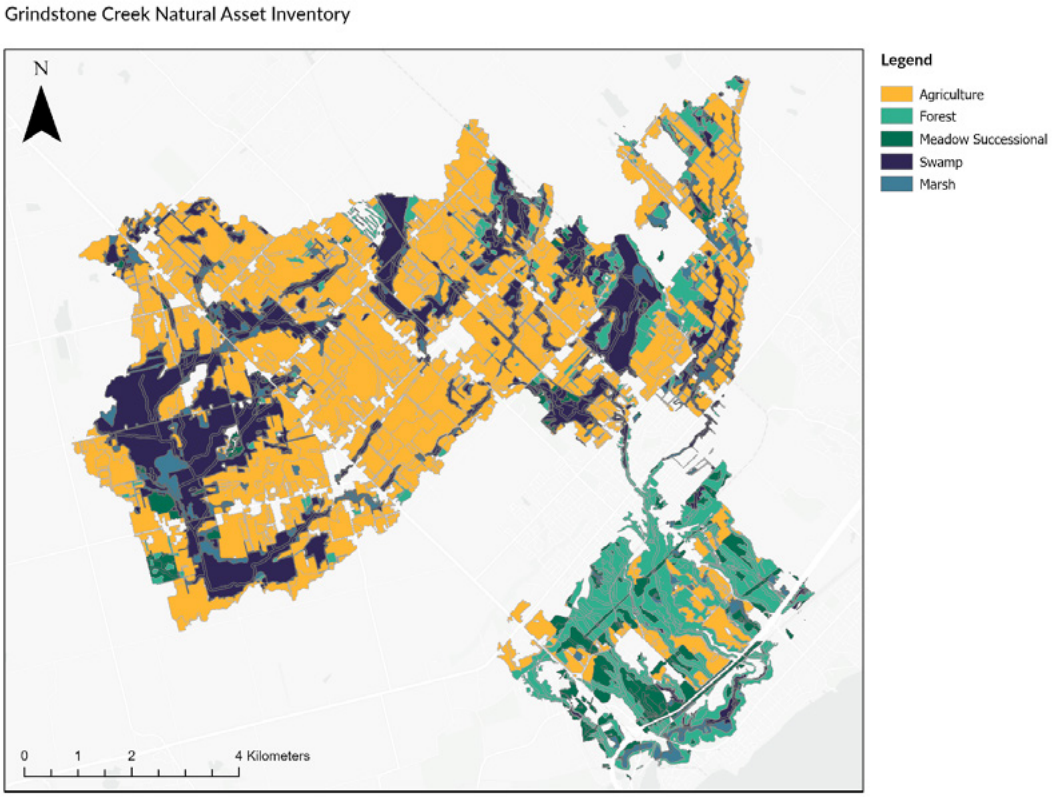


***Figure 7**: Location and spatial distribution of natural assets within the Grindstone Creek watershed*

The Grindstone Creek inventory is available for viewing in a web-based dashboard at *go.greenanalytics.ca/grindstonecreek*; a screen shot from this site is presented in Figure 8.

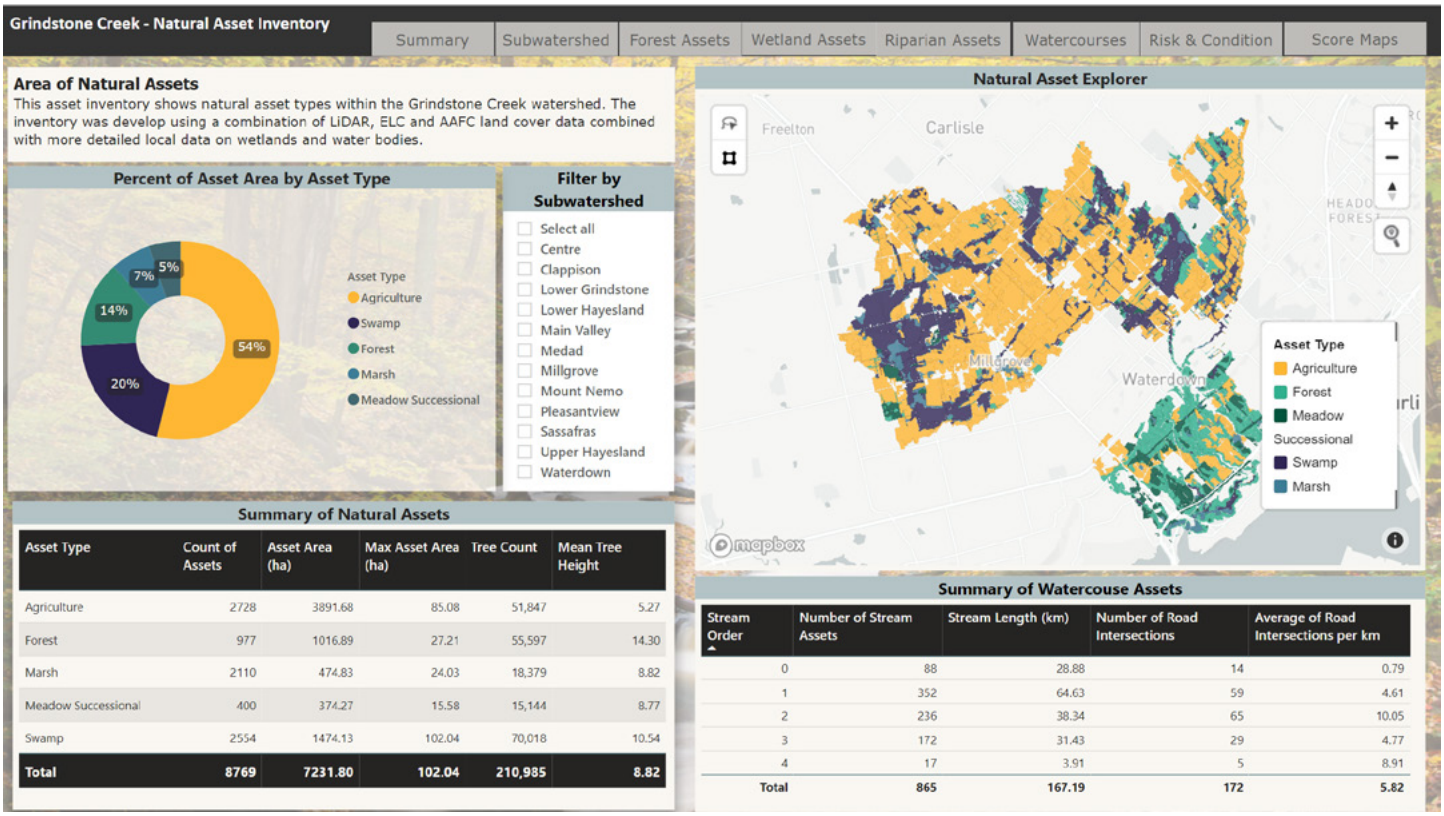


***Figure 8**: Grindstone Creek natural asset inventory online dashboard*

3.3. Natural Asset Condition

Assessing the condition of natural assets is essential to natural asset management. Natural asset condition influences their ability to provide services and resiliency to threats, amongst other things. A condition assessment thus provides valuable information on how well natural assets function relative to their ability to provide specific services. Baseline condition assessment data, expressed in an inventory, is a starting point and can also be used to assess changes in the level of service provision that result from impacts or interventions that may either improve or degrade asset conditions.

Condition assessments can be done using desktop reviews, reviews of past studies, field observations, and combinations thereof. In the case of the Project, the condition assessment is based on a combination of a GIS desktop assessment and incorporating existing condition metrics for the natural features within the watershed. This approach was taken to ensure that existing data were leveraged, and to expand upon it by defining and incorporating additional condition metrics of interest to Project Partners. The additional metrics were identified in consultation with Conservation Halton and the City of Burlington.

Nine condition metrics were incorporated into the Grindstone Creek watershed project condition assessment:

1/ **Hydrologic Score**. This was obtained from the Ontario Wetlands Evaluation System (OWES)[39], which provides a score based on flood attenuation, water quality improvement, carbon sink, shoreline erosion control and groundwater recharge. For the Grindstone Creek watershed, the hydrologic scores range from 0 to 213 with higher scores indicating better hydrologic condition.

2/ **Linear Road Density**. Higher road density implies more fragmentation and higher hydrologic impairment of water flows. It was measured as km of road per km² of area with the following condition ratings assigned according to the density of roads:

- **Low** - asset with road density greater than 2km per km²
- **Medium** – assets with road density between 1km and 2km per km²
- **High** – assets with road density less than 1km per km²

3/ **Adjacent Land Use**. This metric measures and distinguishes natural assets that are next to other natural assets from those that are next to built infrastructure. Natural asset condition tends to be negatively impacted when more of the surrounding land uses are impervious (e.g., paved, concrete or buildings) because this can alter drainage and infiltration pathways and cause an area to receive more or less drainage than prior to being in an urban context. Each asset in the inventory was

39 *www.ontario.ca/page/wetlands-evaluation*

assigned an adjacent land use score out of 100 in accordance with the land use surrounding the asset. Table 2 provides the land use intensity rating.

TABLE 2: SUMMARY OF LAND USE INTENSITY RATINGS

LAND USE	INTENSITY RATING
Industrial / Airports	100
Extraction-Aggregate	100
Commercial	80
Built-up impervious land use	72.5
Under Construction / Bare ground	60
Transportation	60
Residential	50
Agriculture / Golf course	40
Sports fields and urban parks	30
Country residential	25
Built-up pervious land use	25
Restricted development district	20
Natural areas	0

4/ **Development Area**. Natural assets associated with development applications were rated according to the number of applications.

5/ **Percent Interior Natural Area**. This measures the degree to which individual natural assets are contributing to a greater network of continuous natural area. It measures the size of area inside a 100m buffer of continuous natural assets in relation to the total area of the natural assets.

6/ **Percent Interior Forest Area**. This measures the degree to which individual forest assets contribute to a greater network of continuous forest area. This is done by measuring the size of forested area inside a 100m buffer of continuous forest assets in relation to the total area of the forest assets.

7/ **Canopy Cover Rating**. This is a measure of forest area health based on the assumption that larger forest assets with larger canopy cover mean better forest condition. Forested assets with canopy closure greater

than 70 per cent were rated as high (H), assets with closure of 50-70 per cent were rated medium (M) and assets with closure of less than 50 per cent were rated as low (L).

8/ **Tree Height Rating**. This measures how healthy a forest area is, based on the assumption that a larger average tree height represents a more well-established forest area. Forest assets were rated as high (H) if they had an average tree height greater than 9m, medium (M) if they had an average tree height between 7 and 9m, and low (L) if they had an average tree height less than 7m.

9/ **Tile Drainage**. Agricultural areas that are tile drained were considered to have a low (L) condition for stormwater management services. Areas with no tile drainage were considered to have a high (H) condition rating.

WATERCOURSE INVENTORY CONDITION

For the watercourse inventory, a similar approach to condition was applied. Three condition variables were added:

1/ **Road Crossings**. The number of road crossings for each stream reach asset was calculated and converted to a ratio of road crossings / km of stream.

2/ **Association with Hazard Flood Plain**. Any stream asset within the hazard flood plain was rated as (Y), otherwise it was registered as not within the hazard flood plain (N).

3/ **Surface Water Quality (SWQ) Grade**. The surface water quality grade from Conservation Halton's Watershed Report Card was applied to each relevant stream asset and subwatershed. Grade ratings are: A=Excellent, B=Good, C=Fair, D=Poor, F=Very Poor, and "Insufficient Data".

SUBWATERSHED INVENTORY CONDITION

The subwatershed inventory links natural assets to their hydrologic areas and incorporates data from Conservation Halton's Watershed Report Card. Eight condition variables were added to the inventory:

1/ **Surface Water Quality (SWQ) Grade**. The surface water quality grade from Conservation Halton's Watershed Report C was applied to each relevant subwatershed. Ratings are: **A** = Excellent, **B** = Good, **C** = Fair, **D** = Poor, **F** = very poor, and "Insufficient Data".

2/ **Forest Grade**. The forest grade from Conservation Halton's Watershed Report Card was applied to each subwatershed. Ratings are: A=Excellent, B=Good, C=Fair, D=Poor, and F=Very Poor.

3/ **Impervious Grade**. The surface water quality grade from Conservation Halton's Watershed Report Card was applied to each relevant stream asset and subwatershed. Based on the area of impervious surfaces within each subwatershed. Ratings are: **A** = Excellent, **B** = Good, **C** = Fair, **D** = Poor, **F** = Very Poor, and **E** = Somewhat Poor.

4/ **Per cent Wetland Cover**. The percentage of the subwatershed that is wetland cover. Wetlands include swamps (treed and thicket) and marshes.

5/ **Per cent Forest**. The per cent of subwatershed that is forest cover.

6/ **Per cent Natural**. The per cent of the subwatershed that is natural cover, including forest, wetland, grassland, shrubland, cliff and talus.

7/ **Per cent Agriculture**. The per cent of the subwatershed that is agricultural cover.

8/ **Drainage Density**. Stream length (km) as a measure of the total area of the subwatershed (km²) to get (km/km²).

3.4. CONDITION RESULTS

Figure 9 demonstrates the relative condition ratings for the natural assets within Grindstone Creek.

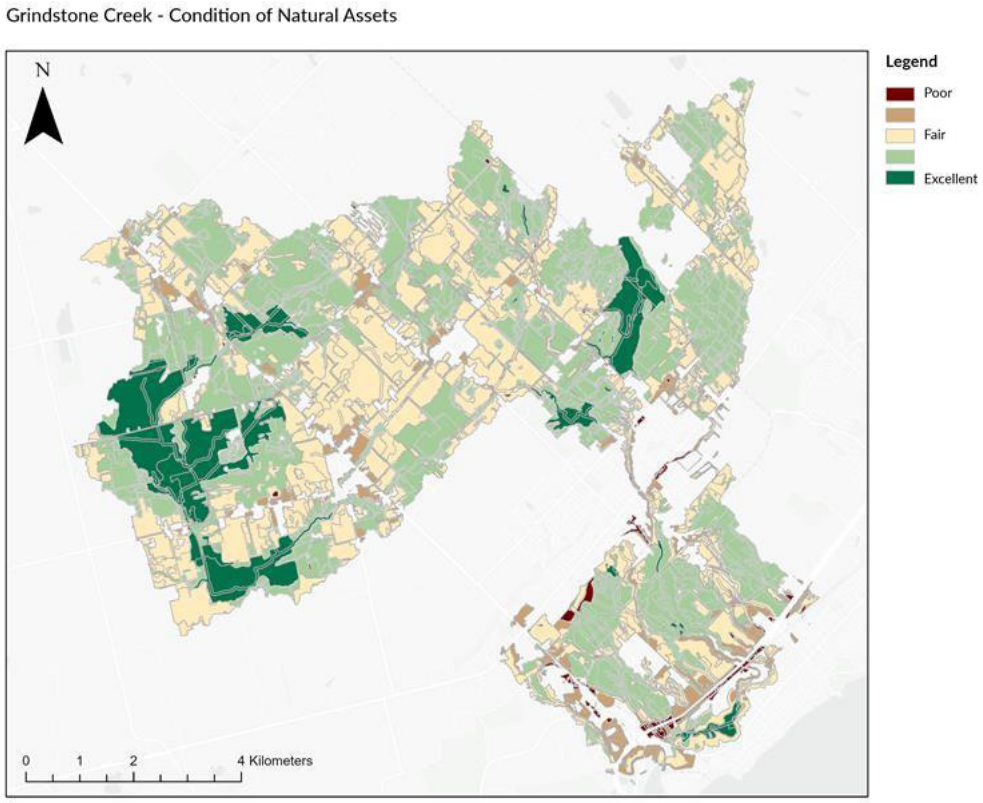


Figure 9: Grindstone Creek condition assessment results

Figure 10 shows the percentage area of natural assets within the Grindstone Creek watershed by condition rating. The majority (almost 70 per cent) of assets are rated fair. A small portion are rated either poor (2.45 per cent) or excellent (7.72 per cent).

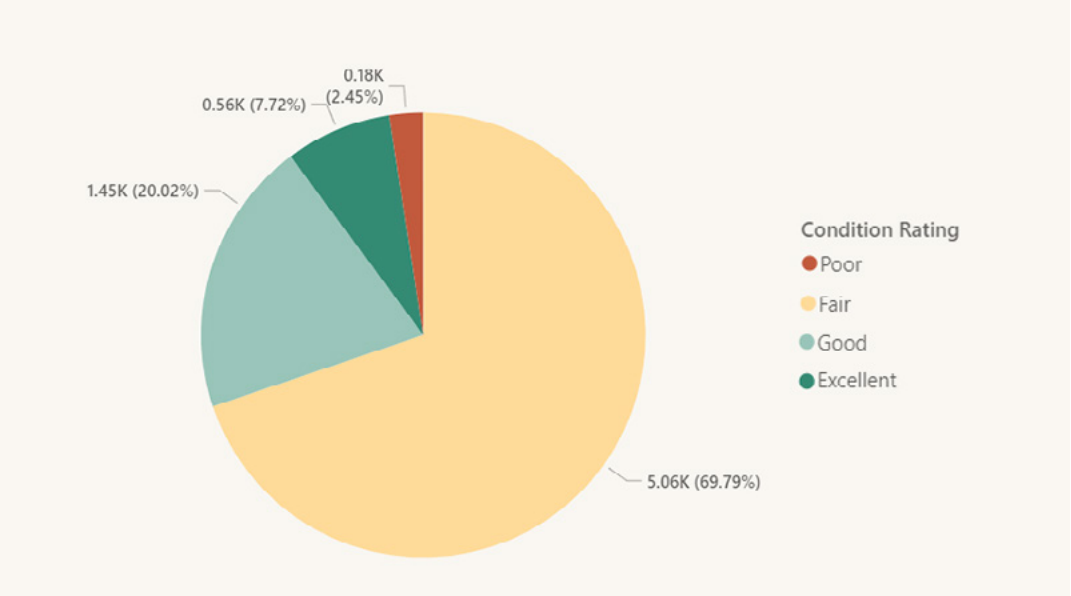


Figure 10: Per cent asset class by condition

Table 3 contains area (ha) values for the assets in poor condition by asset type and subwatershed name. The majority of the assets in poor condition are located south of Waterdown on the outer edges of the Clappison, Pleasantview, and Sassafras subwatersheds. Forest assets hold the highest area of assets in poor condition. This rating is due to a combination of the condition variables applicable to forest assets including linear road density, adjacent land use, development permits, interior natural areas, interior forest area, canopy cover and tree height. Forest assets located close to Highway 403 and the southern portion of Highway 6, where the majority of the poor rated forest assets are located, would be more impacted by road density and adjacent land use condition metrics.

TABLE 3: AREA (HA) OF NATURAL ASSETS IN POOR CONDITION SORTED BY SUBWATERSHED

SUBWATERSHED	ASSET CLASS						
	AGRICULTURE	FOREST	MEADOW SUCCESSIONAL	SWAMP	MARSH	Asset Area (ha)	% of assets in poor condition
Centre				0.03	0.03	**0.06**	<1%
Clappison	0.17	20.91	32.27		2.03	**56.38**	10%
Lower Grindstone		0.10	0.87		0.49	**1.46**	1%
Lower Hayesland				0.02	0.01	**0.03**	<1%

TABLE 3: AREA (HA) OF NATURAL ASSETS IN POOR CONDITION SORTED BY SUBWATERSHED

SUBWATERSHED	ASSET CLASS						
	AGRICULTURE	FOREST	MEADOW SUCCESSIONAL	SWAMP	MARSH	Asset Area (ha)	% of assets in poor condition
Main Valley		10.24	2.65		0.08	**12.97**	9%
Medad		0.59		0.58		**1.16**	<1%
Millgrove	0.53			0.36	0.77	**1.66**	<1%
Mount Nemo	0.76	1.57	1.34	1.76	2.43	**7.86**	1%
Pleasantview	0.19	12.26	17.02	0.08	1.34	**30.88**	25%
Sassafras	0.12	9.36	8.04	1.85	2.97	**22.34**	6%
Upper Hayesland	0.01		0.60	0.25	2.38	**3.24**	<1%
Waterdown	0.62	5.99	0.40	0.94	1.95	**9.90**	27%
Asset Area (ha)	**2.40**	**61.02**	**24.17**	**5.87**	**14.48**	**147.94**	2%

3.5. Value Of Assets

THE VALUE OF STORMWATER REGULATION SERVICES

Natural asset management is about far more than assigning a financial value to their services. Nevertheless, valuations can be helpful tools to build awareness and inform decision-making when they are situated within a broader understanding of the importance of nature.

In MNAI's process, the primary objective of the economic evaluation is to measure how natural assets contribute to the core services that a local government and other agencies provide. These are 'operational' figures that support asset management decision-making directly. This is typically determined using detailed hydrologic modelling to ensure comparability with engineered asset performance.

The secondary objective of the economic evaluation is to measure additional service values, or co-benefits, from the same natural assets to users other than the local government — for example, recreational users and citizens who may receive quantifiable health benefits. These additional service values may be of

less relevance for asset management but of great relevance to, for example, community awareness and engagement, and a more holistic understanding of nature's importance. Together, these two evaluations provide a composite valuation, which, while far from exhaustive, provides a basis for both asset management and community awareness and other processes.

This Project used a modelling and valuation exercise to understand the benefits that natural assets provide within the Grindstone Creek watershed related to stormwater management (SWM). Specifically, the value of the natural assets' hydrologic functions in terms of peak flow attenuation and runoff reduction (e.g., infiltration) within the Grindstone Creek watershed were estimated. Existing hydrologic and hydraulic models for Grindstone Creek were used to facilitate development of a new hydrologic model (PCSWMM), which was used for the Project. Natural assets including forests, marshes, water bodies, and swamps were delineated in the model to better understand their hydrologic function from a SWM perspective. The full modelling report (Associated Engineering 2022) has been provided to the Project Partners.

Three *primary scenarios* were modelled for this project:

- **Scenario 1** reflects baseline conditions (i.e., the location and extent of existing natural assets) of the watershed to manage a 100-year, 12-hour rainfall event.
- **Scenario 2** assumed natural assets are removed and replaced with a "bare earth" land-use type. The same rainfall event as Scenario 1 is modelled to demonstrate the peak flow and infiltration changes without the natural assets.
- **Scenario 3** assumed stormwater strategies such as stormwater ponds and low impact development (LID) measures were added to the model to replicate the water quantity benefits provided by the natural assets. The stormwater ponds were designed to replicate the peak flow metrics resulting from scenario one (i.e., the peak flow realized in the presence of natural assets). A bio-retention cell was used to replicate the infiltration volume provided by the existing natural assets (i.e., the infiltration achieved in scenario one). The model was run with the same rainfall event (100-year, 12-hour) to demonstrate water quantity benefits of the natural assets.

Once modelling was completed, a valuation of the role of natural assets in SWM was undertaken to quantify stormwater benefits. This was done by analyzing the capital replacement cost of natural assets with built stormwater infrastructure (i.e., stormwater ponds and LID). This data can inform the development of sustainable financial asset management strategies, stormwater management plans, and maintenance plans for the watershed. To underscore, the figures do not include operating, maintenance and renewal costs; good asset management planning requires an understanding of infrastructure lifecycle costs, and these could be added in the future.

Based on the modelling and valuation, the conceptual cost of replicating natural assets' hydrologic functions using conventional SWM and LIDs was estimated at a rate of $65.11/m2 for forest, $200.02/m2 for swamp, $203.17/m² for marsh, and $324.38/m² for bodies of water.

The total value of natural assets for stormwater services is estimated at more than $2 billion ($2,071,941,487).

Results of a review of the average per unit cost based on recent tenders by Project Partners was used to estimate construction costs. Using the results of the tender review, a relationship was created between cost and stormwater infrastructure size. The stormwater infrastructure sizes from Scenario 3 were then applied to the relationship to obtain the total cost of stormwater infrastructure for the natural asset catchments within the watershed.

The total value of natural assets for stormwater services alone is estimated at more than $2 billion ($2,071,941,487). A detailed break-down of the costs for each sub-catchment and natural asset type is available in Appendix E of the modelling report, which has been provided separately to Project Partners. Table 4 provides total cost by natural asset type.

TABLE 4: VALUE OF NATURAL ASSETS BY ASSET CLASS

NATURAL ASSET TYPE	AREA (HA)	POND COST	LID COST	TOTAL SWM COST
Forest	452.39	$ 129,260,470	$ 49,480,361	$ 178,740,831
Marsh	53.65	$ 155,204,143	$ 961,390	$ 156,165,533
Swamp	789.15	$ 1,607,866,305	$ 10,616,012	$ 1,618,482,317
Open water	36.06	$ 117,768,428	$ 784,378	$ 118,552,806
Total	**1331.25**	**$ 2,010,099,346**	**$ 61,842,141**	**$ 2,071,941,487**

The total cost of the stormwater infrastructure was divided by the natural asset catchment area to obtain cost/m². The cost/m² was averaged between natural assets with the same land-use type. Based on this approach, the cost of replicating natural assets' hydrologic functions using conventional SWM and LIDs was estimated at a rate of $65.11/m² for forest, $200.02/m² for swamp, $203.17/m² for marsh, and $324.38/m² for bodies of water.

3.6. THE VALUE OF OTHER SERVICES (CO-BENEFITS)

As noted, watersheds with a healthy and naturally functioning ecosystem provide both operational services (such as stormwater management) to local governments, and numerous co-benefits. These co-benefits may include services such as recreation, soil retention and erosion control, climate mitigation, habitat and biodiversity, and atmospheric regulation. Many

these benefits are interconnected and/or interdependent. Engagement with Indigenous peoples of the region and interweaving their knowledge, worldviews and perspectives would help to further elaborate these connections and the ways in which natural asset management can be undertaken in a holistic manner. This section provides information on these other services from the Grindstone Creek watershed.

3.6.1. Approach

Table 5 summarizes the services that Project Partners considered for valuation (see *Appendix D* for further discussion of the approach and its limitations). These were selected based on local relevance and the ability to measure them with existing information for Southern Ontario. The valuation does not provide definitive values for the services, but highlights their importance, which would be maintained or improved from investments in natural asset management. The values estimated assume that the existing natural assets of the Grindstone Creek watershed are currently in sufficient condition to provide the services noted. These values can be enhanced (or lost) if the condition of the natural assets is improved (or degraded) over time.

TABLE 5: SUMMARY OF SERVICES EXPLORED, THEIR DESCRIPTIONS, AND THE OUTCOME MEASURED

Service	Descriptions	Outcome Measured
Recreation and tourism	Non-market value derived from engaging in recreation/tourism activities within Grindstone Creek (e.g., canoeing, kayaking, swimming, hiking, hunting, bird watching, biking, cross-country skiing, snowshoeing, ATV, snowmobiling, etc.)	Value people place on recreation opportunities
Soil retention and erosion control	Non-market value associated with the formation, protection and decontamination of soils and sediments. This includes sediment retention and erosion control, soil formation and maintenance of soil structure, decomposition, and nutrient cycling.	Value of avoided erosion control costs
Climate mitigation (e.g., carbon storage and sequestration)	Addresses the non-market values associated with the regulation of climate, including regulating albedo, some aspects of greenhouse gas emissions, and carbon sequestration.	Value of carbon sequestered by natural areas
Habitat and biodiversity preservation values	Addresses the non-market values associated with the refuge and reproductive habitat that ecosystems provide to wild plants and animals.	Value people place on preservation of biodiversity and habitat
Atmospheric regulation	Addresses the non-market value of regulation of CO2/O2 balance, ozone for ultraviolet-B absorption, polluting gases.	Avoided health care costs from air pollution

TABLE 5: SUMMARY OF SERVICES EXPLORED, THEIR DESCRIPTIONS, AND THE OUTCOME MEASURED

Service	Descriptions	Outcome Measured
Health	Addresses the role of nature in improving physical and mental health.	Addressed qualitatively
Indigenous values	Addresses the role of natural resources in Indigenous well-being. This can include maintenance of culture, food, ceremony, sites of importance, etc.	Addressed qualitatively

For the services identified in Table 5 (except carbon sequestration), average values per unit area (per ha) of different land cover types were extracted from Troy and Bagstad (2013). Troy and Bagstad (2013) incorporates existing estimates from literature, provides a consistent approach that can be compared to other areas of Southern Ontario, and can be applied once a land cover classification has been established. The most appropriate average value per ha reported by Troy and Bagstad (2013) was selected, converted to current 2022 Can$[40], and applied to the land cover classification from the inventory. For carbon sequestration, average rates of carbon sequestration by land cover type were extracted from relevant literature (see Table 8) and applied to the area defined by the natural asset inventory. The value was then calculated using the price of carbon.

RECREATION AND TOURISM

Recreation in nature is a tangible way in which people derive benefit from natural assets, and the Grindstone Creek watershed provides many such opportunities. There are several parks and hiking trails along the Niagara Escarpment that draw users from the City of Hamilton, the City of Burlington, and beyond, and natural assets within Grindstone Creek watershed provide opportunities for picnicking, cycling and mountain biking, hiking, birdwatching, snowshoeing, and cross-country skiing. Data from the trail tracking app Trailforks demonstrates that certain areas of Grindstone Creek watershed are heavily used for recreational purposes, particularly in the Waterdown area (Figure 11).

40 *All values were converted to 2022 dollars by the Bank of Canada Inflation Calculator (www.bankofcanada.ca/rates/related/inflation-calculator/). Calculations were completed June 12, 2022.*

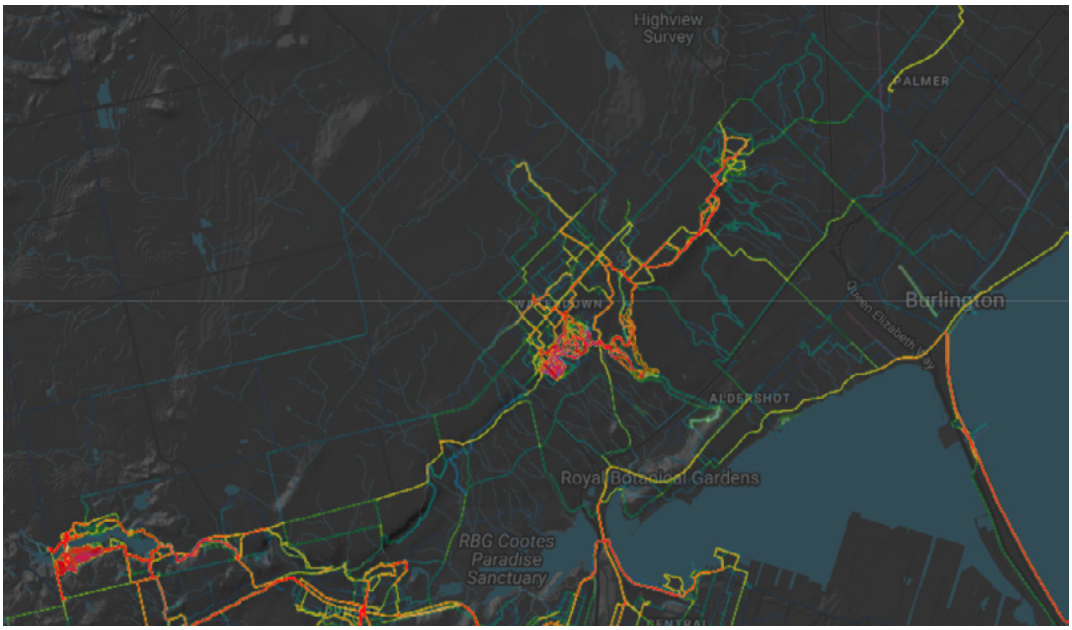


***Figure 11**: Screen Capture of the Trailforks Heatmap Showing Heavy Recreation Use in Grindstone Creek*

Quantifying recreation service values requires knowing how many people use the natural assets, and how often. This data is difficult to acquire without detailed surveys, which were beyond the scope of the Project. Instead, existing research was employed to first estimate the number of recreational users. Drawing on research for the Ontario Government by Troy and Bagstad (2013), average recreational values were then estimated on a per hectare per year basis. Applying these average values to the area of natural assets in the Grindstone Creek watershed provides an indication of the recreational services generated; Table 6 summarizes these values in 2022 Can$.

TABLE 6: SUMMARY OF RECREATION VALUES BY ASSET CLASS

ASSET CLASS	SERVICE VALUE ($/HA/YR)	AREA OF NATURAL ASSETS (HA)	ANNUAL SERVICE VALUE ($/YR)
Agriculture	$ 231	3,892	$ 899,000
Forest	$ 21,153	1,022	$ 21,986,000
Meadow / Successional	$ 89	375	$ 33,000
Swamp	$ 4,652	1,493	$ 6,945,000
Marsh	$ 4,652	475	$ 2,210,000
Total Recreation Service Value			**$ 32,073,000**

** **Note**: Annual service values have been rounded to the nearest 1,000 to highlight that these values should be considered order of magnitude estimates only.*

SOIL RETENTION AND EROSION CONTROL

Natural assets play an important role in the formation, protection and decontamination of soils and sediments. This includes sediment retention and erosion control, soil formation and maintenance of soil structure, decomposition, and nutrient cycling. The value of these services can be measured through avoided costs associated with constructing erosion control structures and replacing lost soil volume and nutrient management. In other words, losing natural assets could increase the cost required to offset the impacts of soil loss and erosion.

Quantifying these services requires detailed hydrologic modelling that can correlate changes in erosion and soil loss with the loss of natural assets. While this is technically feasible, it requires significant time, information, and financial resources to accomplish. As an alternative, an order-of-magnitude estimate of erosion control value that natural assets provide can be established using Troy and Bagstad (2013) estimated ecosystem service values.

Average erosion control values were estimated on a per hectare, per year basis. Applying these average values to the Grindstone Creek watershed provides an indication of the erosion control services generated; Table 7 summarizes these values. Troy and Bagstad (2013) only provides values for forest and successional areas. It was assumed that swamps would provide values similar to forest assets. Note that all figures are reported in 2022 Can$.

TABLE 7: SUMMARY OF EROSION CONTROL VALUES BY ASSET CLASS

ASSET CLASS	SERVICE VALUE ($/HA/YR)	AREA OF NATURAL ASSETS (HA)	ANNUAL SERVICE VALUE ($/YR)
Agriculture		3,892	Data not available
Forest	$ 1,272	1,022	$ 1,300,000
Meadow / Successional	$ 7	375	$ 3,000
Swamp	$ 1,272	1,493	$ 1,900,000
Marsh		475	Data not available
Total Soil Retention & Erosion Control Service Value			**$ 3,203,000**

** **Note:** Annual service values have been rounded to the nearest 1000 to highlight that these values should be considered order of magnitude estimates only.*

CLIMATE MITIGATION

Forests, wetlands, and meadows within the Grindstone Creek watershed mitigate climate change impacts through sequestering and storing greenhouse gases. The mitigation of climate change is likely to have a wide range of benefits to humans in the form of avoided severe weather events. Here, only sequestration is valued, as it represents an annual service flow and is thus comparable with the other service value estimates.

The first step in estimating the value of carbon sequestration was to establish the rate of sequestration. Average rates of sequestration for each asset class were drawn from relevant literature (see Table 8 for sources). Table 8 summarizes the carbon sequestration rates assumed for each natural asset class. Once this was determined, a price per tonne of carbon was applied to the sequestration estimates. The 2022 Canadian price of carbon of $50 per tonne of CO_2e (i.e., CO_2 equivalents) was used. Since the cost of carbon is measured in tonnes of CO_2e, and sequestration is measured in tonnes of carbon, values were converted to comparable units based on relative atomic weights. Thus, 1 tonne of carbon sequestered translates into 3.667 tonnes of CO_2 removed from the atmosphere.

TABLE 8: ASSUMED CARBON SEQUESTRATION RATES

ASSET CLASS	ASSUMED SEQUESTRATION RATE		SOURCE
	tC/ha/yr	tCO_2e/ha/yr	
Agriculture	0.50	1.84	Tomalty (2012)
Forest	1.23	4.51	Green Analytics (2020)
Swamps	2.06	7.56	Assumed to be the same as forest
March	2.06	7.56	Green Analytics (2020)
Meadow / Successional	0.70	2.57	Green Analytics (2020)

Applying the price of carbon to the rates of sequestration by asset class results in average sequestration values per hectare per year. Applying these average values to the area of natural assets in Grindstone Creek provides an indication of the carbon sequestration services generated, as summarized in Table 9 by asset class. All figures are in 2022 Can$.

TABLE 9: SUMMARY OF CARBON SEQUESTRATION VALUES BY ASSET CLASS

ASSET CLASS	SERVICE VALUE ($/HA/YR)	AREA (HA) OF NATURAL ASSETS	ANNUAL SERVICE VALUE ($/YR)
Agriculture	$ 102	3,892	$ 397,000
Forest	$ 249	1,022	$ 254,000
Meadow / Successional	$ 142	375	$ 53,000
Swamp	$ 417	1,493	$ 623,000
Marsh	$ 417	475	$ 198,000
Total Climate Sequestration Service Value (annual)			**$ 1,525,000**

** **Note**: Annual service values have been rounded to the nearest 1000 to highlight that these values should be considered order of magnitude estimates only.*

HABITAT REFUGIUM[41] AND BIODIVERSITY

Natural assets within Grindstone Creek provide habitat for plants, animals, birds and reptiles. The diversity of land cover enhances the biodiversity of the Project area. Narrowly speaking, biodiversity is not generally considered an ecosystem service. However, without biodiversity there are no ecosystem services at all. Furthermore, biodiversity is also inseparable from concepts such as healthy, diverse and connected land cover. This can be seen as an asset value to the extent that individuals place value on the preservation of species and habitat. Estimating these values requires complex surveys to measure willingness to pay for habitat preservation. Since such values have not been measured for the Grindstone Creek watershed, research from other areas was used as a proxy, in this case Troy and Bagstad (2013). Average habitat preservation values were estimated on a per hectare per year basis. Applying these average values to the area of natural assets in the Grindstone Creek provides an indication of the value of services they generate. Table 10 summarizes these values by asset class in 2022 Can$.

41 *Refugia are habitats that components of biodiversity retreat to, persist in and can potentially expand from under changing environmental conditions (Keppel et al., 2011)*

TABLE 10: SUMMARY OF HABITAT PRESERVATION VALUES BY ASSET CLASS

ASSET CLASS	SERVICE VALUE ($/HA/YR)	AREA (HA) OF NATURAL ASSETS	ANNUAL SERVICE VALUE ($/YR)
Agriculture		3,892	data not available
Forest	$ 215	1,022	$ 220,000
Meadow / Successional	$ 147	375	$ 55,000
Swamp	$ 215	1,493	$ 321,000
Marsh	$ 102	475	$ 48,000
Total Habitat Service Values			**$ 644,000**

** **Note**: Annual service values have been rounded to the nearest 1,000 to highlight that these values should be considered order of magnitude estimates only.*

ATMOSPHERIC REGULATION

The Grindstone Creek watershed's natural assets play a role in regulating atmospheric gases and providing clean air. Specifically, trees regulate gases and improve air quality by collecting particulate matter on the surface area of leaves and absorbing gaseous pollutants into leaves. Improved air quality benefits the surrounding population, for example through fewer visits to the hospital for respiratory and other illnesses[42].

In the absence of detailed modelling, an order of magnitude estimate of the value of atmospheric regulation provided by natural assets was established, drawing from Troy and Bagstad (2013). Applying per hectare per year values from Troy and Bagstad (2013) to the area of natural assets in Grindstone Creek provides an indication of the value of this service. Table 11 summarizes these values by Asset Class. All figures are reported in 2022 Can$.

42 *Nowak et al., 2018*

TABLE 11: SUMMARY OF HABITAT PRESERVATION VALUES BY ASSET CLASS			
ASSET CLASS	**SERVICE VALUE ($/HA/YR)**	**AREA (HA) OF NATURAL ASSETS**	**ANNUAL SERVICE VALUE ($/YR)**
Agriculture		3,892	n/a
Forest	$ 213	1,022	$ 218,000
Meadow / Successional	$ 27	375	$ 10,000
Swamp	$ 213	1,493	$ 318,000
Marsh	$ 20	475	$ 10,000
Total Annual atmospheric Regulation Benefits			**$ 556,000**

** **Note**: Annual service values have been rounded to the nearest 1000 to highlight that these values should be considered order of magnitude estimates only.*

3.6.2. Non-quantified values

In consultation with the Project Partners, MNAI identified and qualitatively addressed two additional benefits: health-related benefits of nature, and Indigenous values. The importance of both benefits is widely acknowledged but few studies quantify these services, and no appropriate studies were identified for transferring to the study area.

INDIGENOUS VALUES

Indigenous Peoples have a reciprocal relationship with nature, where it is recognized that nature provides for us, and we have a responsibility for the care of nature. In this project, Indigenous values represent the role of natural assets in supporting Indigenous well-being. This can include food provision, ceremonies, sites of importance and the development of capabilities (knowledge and skills) as well as an understanding of the connections to place in which, all-encompassing is the maintaining of culture. However, it would be misleading to imply that a list of Indigenous values could capture the richness and diversity of Indigenous Peoples' knowledge of and connections to the lands and waters. Project Partners recommended that Indigenous communities be engaged to help inform the project. A synopsis of Traditional Ecological Knowledge and recommendations for engaging Indigenous Peoples in natural asset management are provided below. The recommendations were informed by a discussion with Kerry-Ann Charles of CAMBIUM Indigenous Professional Services in April 2021 (Charles, 2021).[43]

43 *Kerry-Ann Charles is a member of the Chippewas of Georgina Island First Nation and is the Environment Partnership Co-ordinator for Cambium Indigenous Professional Services (CIPS).*

As noted, the Grindstone Creek watershed is situated upon the traditional territories of the Erie, Neutral, Anishinaabeg, Huron-Wendat, Haudenosaunee and the Mississaugas. Today, the watershed is home to many Indigenous Peoples, including Métis and Inuit. These Communities have been leading the protection, management, and conservation of their traditional territories for millennia. As stewards of the land and natural resources, Indigenous Peoples have shaped the landscape and developed knowledge of local ecosystems and management based on adaptive learning.

TEK has been described as a process that explores how constituent parts of a system interrelate, and how the systems they are a part of change over time and relate to larger systems (Berkes, 1998). TEK is a framework for understanding complexity, developed through in-depth knowledge of place accumulated over long timeframes. TEK should not be separated from the social, cultural, and spiritual contexts of which it is a part[44].

The most important questions pertaining to research and natural resource management with Indigenous Peoples are not necessarily about particular techniques or methods, but the degree to which an organization understands the cultural, social, political, and institutional contexts in which research is conducted and in which it is put to use. This message came through clearly in discussions with Charles (2021), who indicated that such an understanding requires reflection on the part of Project Partners about mission and goals, the use to which work will be put, and thorough knowledge of the Indigenous Community or Communities with which it is working. Only with such understanding can TEK be effectively used and in a manner that is of lasting benefit to the Indigenous Communities to which it belongs. Next steps for the Grindstone Creek watershed Project Partners could include:

- Gather knowledge upfront about Indigenous Peoples and the land prior to engagement. An appropriate Indigenous organization can assist with training, facilitating introductions and scoping future work.
- Articulate the intent of engagement, who should be engaged, what partners have to offer, and expectations and wishes of the Community.
- Adhere to OCAPTM (ownership, control, access and possession) principles to ensure ethical research practices and to ground community engagement.
- Become familiar with guidance on applying Indigenous knowledge through a code of ethical conduct, which includes principles related to:
  - Free, prior and informed consent.
  - Confidentiality and protection of Indigenous knowledge.
  - Equitable sharing of the benefits that arise from using such knowledge.
  - Recognition that the inclusion of Indigenous Peoples in natural asset management is reconciliation at the local level.

44 *Nadasdy 1999*

HEALTH - PHYSICAL AND MENTAL WELLNESS

The natural environment provides health benefits including opportunities for regular physical activity that lead to a reduced risk of obesity, coronary heart disease, diabetes, some cancers, mental illness[45] and mortality[46]. Exposure to the natural environment can lower the pulse rates, reduce cortisol levels, and improve immune functioning[47]. It also improves the air quality which decreases the chances of respiratory illnesses[48]. This connection between people and nature is also important for everyday enjoyment and work productivity[49].

Capaldi et al. (2015) demonstrate that from a psychological perspective, the connection with nature enhances both the hedonic and *eudaimonic* well-being.

Hedonic well-being is the "feel-good component" and includes getting outdoors and connecting directly with nature, which boosts mood and happiness. There is evidence that access to nature near home promotes life satisfaction. *Eudaimonia* is the "functioning well" component of well-being and relates to psychological well-being, personal growth, self-esteem, self-regulation, and social competency. The social connection amongst neighbours is found to be correlated to the amount of neighbourhood green space which further makes people more connected to others, more caring, and more spiritual.

Contact with nature offers benefits at a different scale. Per the attention restoration theory, contact with nature brings about improvements in concentration, directed attention[50], and emotional functioning. The stress-reduction theory states that nature decreases arousal and perceived stress levels[51], thereby promoting psychophysiological stress recovery[52]. This can lead to a decrease in the blood pressure[53]. Nature connectedness is also associated with humanitarianism, social wellbeing, kindness, empathic concern, altruistic concern, and perspective-taking. This results in decreased anxiety due to significantly higher levels of happiness and energy[54].

EcoHealth Ontario developed an approach to measure and quantify some physical and mental health benefits from nature. Green Analytics (2020) established a framework to help communities consider human health benefits provided by natural assets. The framework is being tested in communities in Southern Ontario and it could help Project Partners quantify benefits.

45 *Capaldi et al., 2015; Haq 2011*
46 *White et al., 2016; Capaldi et al., 2015*
47 *Capaldi et al., 2015*
48 *Haq 2011*
49 *Ibid.*
50 *Capaldi et al., 2015*
51 *ibid*
52 *Capaldi et al., 2015; Haq 2011*
53 *Capaldi et al., 2015*
54 *Ibid.*

NATURAL ASSET CO-BENEFIT SERVICE VALUES SUMMARY

Table 12 provides an overall summary of the value of co-benefits (noting health and Indigenous values were not valued in monetary terms) that natural assets provide in the Grindstone Creek watershed. It shows that natural assets provide approximately $38 million in public benefits annually from the listed services. The list is by no means exhaustive and could be expanded in the future. These values are estimated using a value transfer method, not detailed modelling, and should be understood as *indicative estimates*. Notwithstanding the lack of precision, they provide valuable insight into the magnitude of co-benefit values and can help guide natural asset management decisions.

TABLE 12: SUMMARY: PARTIAL LIST OF CO-BENEFIT SERVICE VALUES FROM GRINDSTONE CREEK NATURAL ASSETS ($/year – indicative estimates)

SERVICE	AGRICULTURE	FOREST	MEADOW SUCCESSIONAL	SWAMP	MARSH	Asset Area (ha)
Recreation and tourism	$ 899,000	$ 21,986,000	$ 33,000	$ 6,945,000	$ 2,210,000	**$ 32,073,000**
Erosion control	Not assessed	$ 1,300,000	$ 3,000	$ 1,900,000	N/A	**$ 3,203,000**
Carbon sequestration	$ 397,000	$ 254,000	$ 53,000	$ 623,000	$ 198,000	**$ 1,525,000**
Habitat Preservation values	Not assessed	$ 220,000	$ 55,000	$ 321,000	$ 48,000	**$ 644,000**
Atmospheric regulation	Not assessed	$ 218,000	$ 10,000	$ 318,000	$ 10,000	**$ 556,000**
Asset Area (ha)	**$ 1,296,000**	**$ 23,978,000**	**$ 154,000**	**$ 10,107,000**	**$ 2,466,000**	**$ 38,001,000**

For example, while this information is not designed to assess benefits of specific on-the-ground actions, it informs decisions about resource allocation. For instance, when combined with information on asset condition, resource managers can examine this asset of interest, and assess the likelihood or significance of each of the key “additional” services likely to be provided by the asset of interest. These values provide a rough indication of the potential loss in value if action is not taken, or the potential improvement in value if restoration actions are taken.

3.7. Monitoring Programs

Conservation Halton and Royal Botanical Gardens have extensive monitoring programs to track the condition of lands and waters in which they operate or have jurisdiction for. Each program is briefly outlined below.

Conservation Halton's Long-term Environmental Monitoring Program (LEMP) began in 2005. Conservation Halton brings together partners using a watershed-based approach to discuss resourcing and monitoring needs. Science-based protocols to monitor water flows, surface and groundwater quality, groundwater water levels, aquatic and terrestrial species and their habitats (e.g., streams, forests, marshes) contribute to a comprehensive understanding of ecosystem structure and function and assess changes in the watershed. This information supports planning and resource management decisions, community outreach initiatives[55], and informs restoration activities. Water quality monitoring began in Conservation Halton's jurisdiction in 1964. Water sampling occurs at one surface water site within the Project area. Samples are taken from March to November and submitted to the Ministry of Environment, Conservation, and Parks for analysis, and contribute to the Provincial Water Quality Monitoring Network program[56].

Conservation Halton also monitors groundwater wells beyond the Provincial Groundwater Quality Network, although there are no sites in the Grindstone creek watershed. Conservation Halton monitors wetland hydrology, including two wetlands in the Grindstone Creek watershed: a swamp in Flamborough and a marsh at North of 5th Concession Road and west of Highway 6 in Hamilton. This monitoring helps better understand surface and groundwater interactions and supports planning and actions (such as restoration) to ensure healthy wetland functions, in turn ensuring provision of core services. In 2021 an expanded program was launched including sampling at subwatershed confluences and the installation of an automated ISCO sampler to track loadings to Hamilton Harbour/Burlington Bay. Once hotspots and parameters of interest have been identified, monitoring will be adapted accordingly.

Conservation Halton's Flood Forecasting & Operations team collects stream flow and other key information as shown in Table 13. Since 2015, Conservation Halton has expanded its data collection network to monitor runoff and stream flows from 8 to 20 stream gauges, 9 of which are operated by Water Survey Canada and 11 by Conservation Halton. They include 2 stream flow gauges in the Grindstone Creek watershed near Aldershot and Highway 6 at Millgrove. The number of rain gauges monitoring within Conservation Halton's jurisdiction has grown from 6 to 41 telemetered rain gauges. Conservation Halton purchased LiDAR data in 2018 to support riverine flood hazard mapping, including hydrologic and hydraulic models. Stream flow gauges, precipitation gauges, and records from past flood events are used where available to calibrate or 'ground

55 *Conservation Halton 2020*

56 *Conservation Halton 2021*

truth' the models.

The data collected from these sensors support the floodplain mapping program and flood management operations such as flood forecasting and warning, water control operations and emergency response and administration of regulations under the Conservation Authorities Act. These are mandated programs delivered by Conservation Halton. Future expansions to the water quantity monitoring network may include an increase in the number of stream flow gauge stations in flood sensitive urban areas.

Royal Botanical Gardens also conducts monitoring that aligns with the Great Lakes monitoring protocols,[57] including long-term forest monitoring, breeding bird surveys, marsh monitoring, and species at risk monitoring[58]. Water quality in the Hamilton Harbour/Burlington Bay is also a key concern and Royal Botanical Gardens has contributed to HHRAP projects and initiatives (see above).

Table 13 provides an overview of monitoring programs and ecological studies in the Grindstone Creek watershed of relevance to the Project.

TABLE 13: MONITORING PROGRAMS AND ECOLOGICAL STUDIES IN THE GRINDSTONE CREEK WATERSHED

ORG	LONG-TERM ENVIRONMENTAL MONITORING	# OF SITES	YEARS SAMPLED	NOTES
CH	Fish Community	13	2006 – 2019	Odd years sampled (rotation)
CH	Benthic Invertebrate Community	14	2006 – 2019	Odd years sampled (rotation)
CH	Water Temperature	13	2004 - 2019	# of sites sampled per year varies
CH	Channel Morphology	12	2006 – 2017	Odd years sampled (rotation), on as needed basis 2017-2019.
CH	Water Quality	1	1967-present	Annual, station change and gap in mid 2000s. Data pre-2000s not regular
CH	Marsh Monitoring	1	2000 – present	Annual ecological monitoring of frogs & birds
CH	Forest Bird Monitoring	1	2007 – present	Annually

57 *Royal Botanical Gardens 2018*

58 *Royal Botanical Gardens 2018*

TABLE 13: MONITORING PROGRAMS AND ECOLOGICAL STUDIES IN THE GRINDSTONE CREEK WATERSHED

ORG	LONG-TERM ENVIRONMENTAL MONITORING	# OF SITES	YEARS SAMPLED	NOTES
CH	Forest Health (Vegetation)	1	2007 – present	Survey dates vary by parameter
CH	Forest Health (Salamanders)	1	2007 – present	Annually
CH	Wetland Monitoring	10	2012 – present	Continuous monitoring of water level depth
CH	Groundwater monitoring	13	2000 - present	13 sites, 18 wells monitored 2-4 times a year
CH	Flood Forecasting and Operations – stream gauges	5		Cloud-based real-time data acquisition system called DataCurrent. Note: data from Water Survey Canada stream gauges also used
CH, partners	Flood Forecasting and Operations – rain gauges	38		Cloud-based real-time data acquisition system called DataCurrent. Partners include CH, Halton Region, Town of Oakville, City of Burlington & City of Hamilton
CH	Flood Forecasting and Operations – climate stations	3		Cloud-based real-time data acquisition system called DataCurrent
CH	Flood Forecasting and Operations – snowpack	8		6 manually measured stations, 2 ultrasonic measurements
CH	Flood Forecasting and Operations – water levels related to flood control structures	4		Continuous dam water levels monitored at all 4 dam locations. Embankment groundwater levels monitored at all 4 dam locations
RBG	Forest Monitoring	18	2008 - present	Surveys follow the Ecological Monitoring & Assessment Network (EMAN) protocols
RBG	Breeding bird surveys	22	2008 - present	Annual (June). In 2008, Breeding Bird monitoring was paired with Forest Ecosystem Monitoring

TABLE 13: MONITORING PROGRAMS AND ECOLOGICAL STUDIES IN THE GRINDSTONE CREEK WATERSHED

ORG	LONG-TERM ENVIRONMENTAL MONITORING	# OF SITES	YEARS SAMPLED	NOTES
RBG	Marsh Monitoring Program	6	1995 - present	Number of sites surveyed and type of surveys have varied; Amphibian surveys consistently completed
RBG	Water quality monitoring	2	2008 - 2016	Cootes Paradise & Hendrie Valley System
CH	Halton Natural Areas Inventory	Historical ESAs	2003 and 2004	Includes inventory and historical information for flora & fauna
CH	Hamilton Natural Areas Inventory	Historical ESAs	2011-2013	# of sites approximate. Includes inventory of current and historical flora & fauna
CH	Water Quality	19	2013	Source detection sampling
CH	Water Quality	28	2014	Source detection sampling
CH	Ecological Land Classification	Entire Conservation Halton watershed	Annually since 2003	
RBG	Ecological Land Classification		2001 - present	Ecological features & plant community assemblages mapped

3.8. ASSESSMENT PHASE LIMITATIONS AND KNOWLEDGE GAPS

MNAI's assessment of the current state of natural assets contains limitations and knowledge gaps related to inventory, condition data, valuation data, water quality modelling and co-benefit valuation, as follows.

The natural asset inventory and condition assessment does not include information on soils or groundwater as data limitations did not allow for their inclusion in this project. Specifically:

- there are no provincial groundwater monitoring wells in the Grindstone Creek watershed, (although condition assessment discussions revealed an interest in adding water quality indicators).

- E.coli is monitored by some Conservation Authorities, but not tracked across the Grindstone Creek watershed. Royal Botanical Gardens do complete monitoring at the mouth of the Grindstone Creek.
- Royal Botanical Gardens has data on water clarity, but this is not available across the Grindstone Creek watershed.

Modelling limitations are addressed in a report completed for the Project by the firm, Associated Engineering (2021). Limitations that may impact the representation of the state of natural assets include:

- Evapotranspiration data was not used in the model.
- Elevation of the groundwater table and of bedrock were not considered and a high groundwater table may reduce the infiltration.
- LIDs were modelled through an approach in which the Grindstone Creek watershed is captured by LIDs of uniform size and efficiency. In practice, the size, shape and function of LIDs to service a large catchment area may vary due to factors such as topography, drainage conditions, soil conditions, and groundwater.
- Conduits used in the model are simplified and may require refinement to accurately define sinuosity, slope, and length of the creek.

The valuation of primary services contains the following limitation:

- The valuation of primary services approximates cost per square metre to install engineered stormwater strategies if the natural assets were removed. This is not an exact representation of what would actually occur.

For the co-benefits valuation, effort was made to transfer primary studies from sites with similar ecological and socio-demographic characteristics. However:

- Every ecosystem is unique and per-hectare values derived from another location may not be relevant to the ecosystems they are applied to.
- Valuations are static analyses that provide values at a point in time and need to be updated regularly.
- Values can only be regarded as a minimum, as primary studies may not be available to monetize all services, and/or the valuation of some services may not be possible or desirable.

3.9. NEXT STEPS FOR CONTINUOUS IMPROVEMENT IN THE ASSESSMENT PHASE

Asset management is an iterative process of refinement and improvement over time. Next steps for the project could include:

- additions to the inventory and monitoring data.
- field verification of natural asset conditions.
- assessing gaps in water quality monitoring through the model developed for this project.

More specifically, the inventory can be enhanced with the addition of soils, groundwater recharge zones, and age data. The first two items are relatively straight-forward; age data for natural assets, by contrast, can be more difficult to assess. While some natural asset ages can be determined (e.g., trees), others are difficult or impossible (e.g., streams). As such, it is recommended to start with tree age or ages of recently restored assets and factor in other assets as guidance becomes available.

Over a longer term, the inventory should allow monitoring data to be fully integrated into the inventory outputs. The inventory could be structured to provide real time integration with the monitoring stations, resulting in real time updates to the inventory and condition assessment.

Project Partners can also consider building on current collaborations with Indigenous communities in the watershed. Training, facilitating introductions, and scoping future work from a qualified Indigenous professional services organization could be a starting point to assist in understanding the context of local Indigenous groups, who to engage, what each partner brings, and what they expect from one another.

With respect to monitoring, there are opportunities for staff to install flow loggers in accessible locations where automated, continuous information is required. Where installation is not possible, Conservation Halton could rely on modelling. In the short-term, monitoring data should be constructed for priority points where flooding is likely to lead to erosion. Over the long-term, improvements in modelling will provide additional information on the effectiveness of natural assets for erosion reduction.

The condition assessment provides an indication of overall ecological health through desktop-based criteria; it can be refined and confirmed through field verification.

Water quality was not modelled in the project since it required continuous simulation techniques rather than event-based modelling that was used to assess peak flow and infiltration. However, the existing model can be calibrated with pollutant data to compare the water quality benefits that the existing natural assets and stormwater controls provide, or calibrated for sediment load to explore erosion impacts at a watershed level.

4 Looking Ahead: Possible Future States

The natural asset management planning phase (the yellow part of the circle depicted in Figure 1) allows scenarios to be explored through modelling once baseline conditions are established in the assessment phase. These scenarios can inform decisions based on changes in services and values from different simulated climatic conditions or land use decisions. This section describes planning phase results.

4.1. Scenario Modelling

In addition to the three primary modelling scenarios described earlier (baseline conditions, bare earth conditions, and stormwater pond / LID conditions), the Project modelled three additional scenarios. The scenarios speak to possible futures the project partners can influence and achieve, should they choose to do so. In some scenarios, low-impact development is pursued to address increased development in a way that mimics natural processes (scenario 4), whereas others seek to improve understanding of the impacts of climate change under existing conditions (scenario 5) and climate change impacts under a future where there are significant losses of natural assets (scenarios 6).

The scenarios provide an understanding of (i) impacts of large-scale improvements; (ii) impacts of climate change on peak flow and infiltration under existing conditions; and (iii) impacts of climate change on peak flow and infiltration under Scenario 3 conditions (natural assets replaced with artificial stormwater management controls).

- **Scenario 4** simulated the addition of LID units to heavily urbanized catchments with a high percent impervious surface near Waterdown. This was done by adding LID units to Scenario 1. The units, modelled to capture 25 mm of rainfall, resulted in a 6 per cent reduction in peak flows at a watershed scale. The models demonstrated an increase in infiltration by 2.3 – 12.6 mm on natural asset catchments as a result of the LID units. This means the LID units were more effective at increasing infiltration on urban catchments near Waterdown compared to the LID units in non-urban catchments in Scenario 3.
- **Scenario 5** applied climate change considerations to Scenario 1 by incorporating a climate change-impacted future rainfall event (specifically a 2050 climate change rainfall event). The purpose was to analyze climate change impacts on the peak flow and infiltration of the Grindstone Creek watershed under existing conditions. The modelling revealed a peak flow increase of 18.0 m3/s or 41.8% on average. This means forest assets provide additional infiltration as the climate changes while other natural assets were found to have already reached infiltration capacity.

- **Scenario 6** applied climate change conditions (i.e., a 2050 climate change rainfall event) to Scenario 3 (the stormwater ponds and LID scenario) to determine impacts of climate change on peak flow and infiltration in the Grindstone Creek watershed with stormwater management controls replacing natural assets. The modelling revealed a peak flow increase of 16.7 m3/s (or 63% increase in peak flow on average), meaning that LID reduced the impact of climate change on catchments with a water, marsh, or wetland land-use but LIDs replacing forests did not perform as well, in terms of infiltration, as existing forest natural asset under climate change.

Overall, modelling demonstrated the effectiveness of natural assets to manage peak flows and infiltration. As such, existing natural assets should be maintained wherever possible and restored where needed. The removal of natural assets and replacement with bare earth (Scenario 2) resulted in significant increases of peak flow (between 9 and 434 per cent). When natural assets were conceptually replicated using LIDs and SWMFs, (Scenario 3), engineered alternatives were able to reduce peak flows except in areas north of Concession 6 E, south of Concession 6 W, and at the midpoint between Concession 6 W and Concession 5 W.

Incorporating climate change projections into the model demonstrated that natural assets and engineered stormwater controls provide roughly equal prevention of climate change impacts. It is important to note that new facilities are limited in terms of their capacity to manage peak flows as they only manage flows to the level they are designed to handle. In terms of infiltration, forests provide additional infiltration under modelled climate change scenarios, while other natural asset classes such as wetlands and swamps will have reached capacity.

Scenarios 4-6 reveal the importance of upstream natural assets, as peak flows become larger as they travel downstream. These scenarios also highlighted the need for LIDs in Waterdown, where the percentage of impervious surfaces is high.

4.2. Risk Management

Local governments and watershed agencies can determine how to prioritize efforts by identifying risks facing natural assets. This section provides an overview of the risk identification completed for the project using the Core Natural Asset Inventory. It is a starting point for understanding risks to natural assets and their associated services. A full risk assessment, by contrast, is a detailed process that includes risk identification, analysis of probability and consequence, development of risk mitigation strategies, and control and documentation. MNAI's risk identification tool informs the first and second stages of risk management by identifying the top risks to natural assets and their associated services, plus a high-level analysis of impacts and consequences. Risks relevant to natural asset management typically include:

- **Service risk:** the risk of an asset failure that directly affects service delivery.
- **Strategic risk:** the risk of an event occurring that impacts the ability to achieve organizational goals.
- **Operations and maintenance risk:** risks related to poor asset controls and oversight, which can lead to poor record-keeping, poor management, and poor monitoring of assets.
- **Financial risk:** risks related to financial capacity to maintain local government services.
- **Political risk:** risks related to the nature of municipal politics; specifically, the values and priorities of decision-makers or the community may not align with natural asset management.

Liability risk may also be an impetus for local governments to undertake natural asset management. Many local governments do not know what core services they derive from natural assets, the value of those services, or whether their tax base could replace assets and/or services should the natural ones degrade. This understanding becomes more important as a changing climate puts more pressure on existing engineered stock, which, in many instances, is already aging and in need of repair in many communities.

A November 2020 workshop with Project Partners identified nine risks to natural assets in the watershed (see Appendix 4 for additional information on the approach) and ranked them based on the likelihood of occurrence and the severity of impacts:

1/ Flood
2/ Drought
3/ Illegal dumping
4/ Development pressure
5/ Beaver dams
6/ Ice jams
7/ Pollutant loading
8/ Erosion
9/ Changes to sediment deposition

As shown in Figure 12, the risk ranking is the result of multiplying the likelihood of occurrence (a rating scale from 0 to 5, where 0 is no likelihood and 5 is extremely likely) and the impact severity (a rating scale from 0 to 5, where 0 is no impact severity and 5 is extreme impact severity). The resulting ranking is a scale from 0 to 25. The rank is then converted to an overall rating such as minor, moderate, major, or severe.

4.2.1. Risk Results

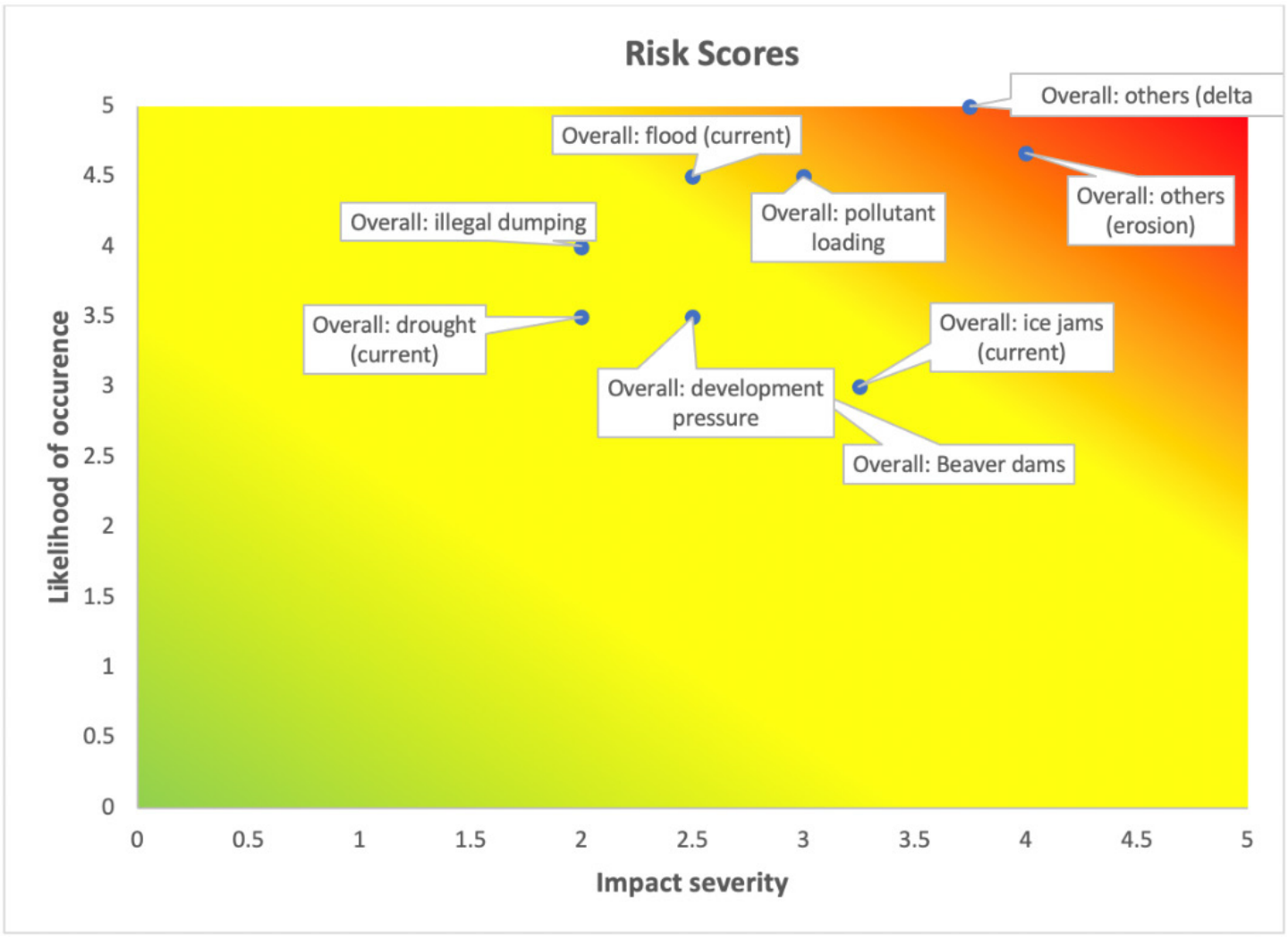


Figure 12: Summary of Risk Rankings for the Grindstone Creek

The spatial extent of each risk is summarized and depicted in the figures below.

1/ **Flooding -** Conservation Halton provided a flood hazard mapping boundary. Natural assets that lie entirely or partly within it were assumed to be at flood risk. For vulnerable areas around Hidden Valley Road, natural assets were classified as having flood risk using the Stable Top Of Bank boundary that Conservation Halton provided.

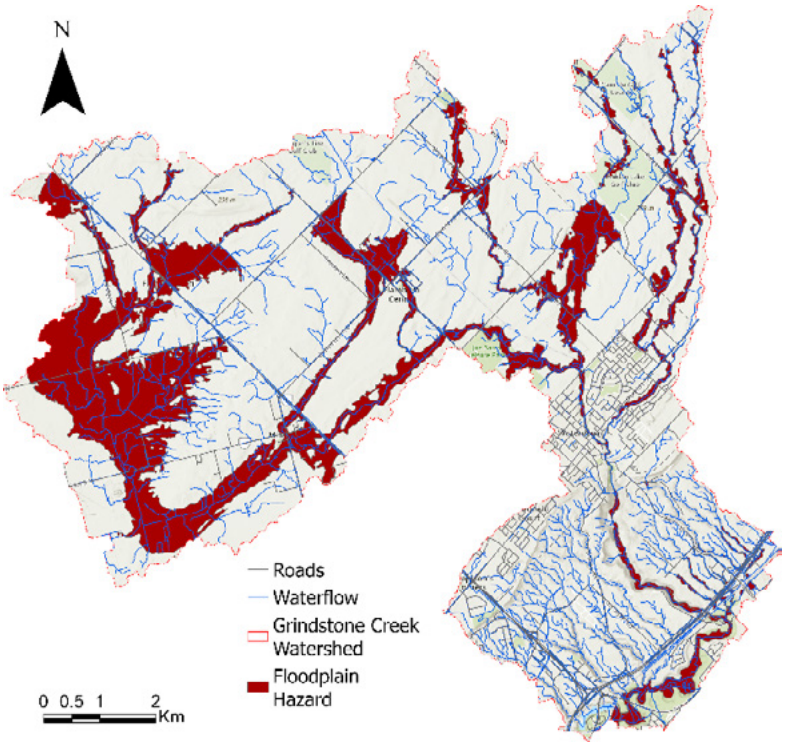


Figure 13: Map of Flood Risk Areas

2/ **Development -** Development applications identified development points. The project assumed natural assets within 50 metres of those points to be at risk from development.

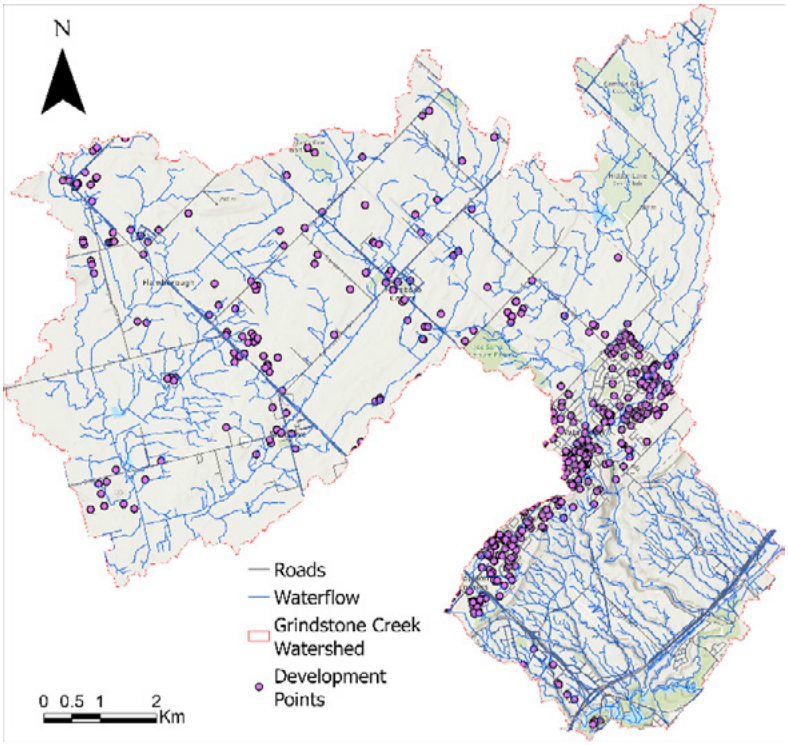


Figure 14: Map of Development Risk Locations

3/ **Erosion –** An approximate area of erosion risk was delineated based on discussions with Project Partners familiar with areas of key erosion concern in the Grindstone Creek watershed. Conservation Halton developed and provided the spatial boundary.

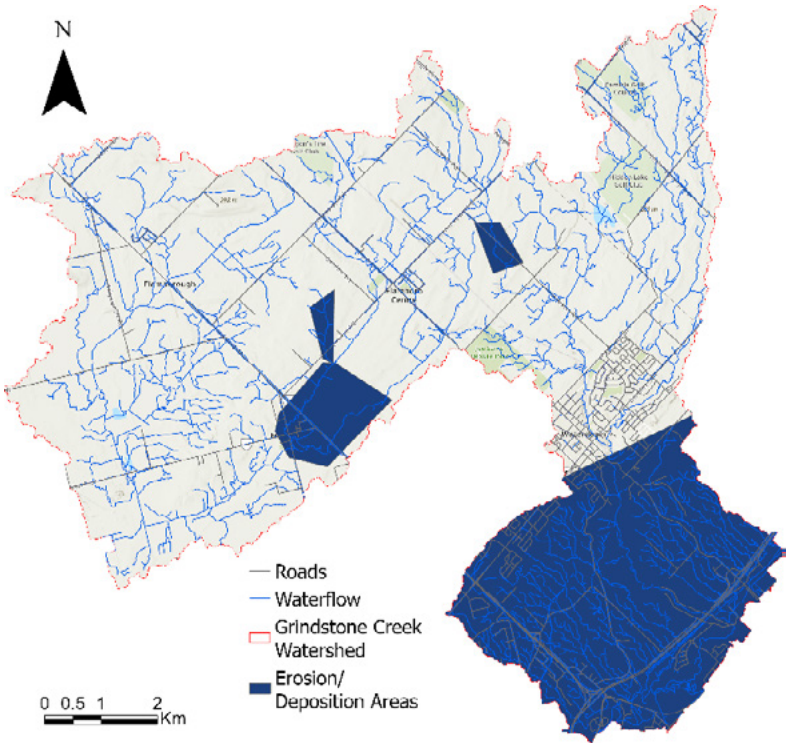


Figure 15: Map of Erosion Risk Areas

4/ **Ice jams -** Based on discussions with Project Partners who have knowledge and experience with ice jams in Grindstone Creek, it was assumed that meandering watercourse segments and areas with bridges would be at risk from ice jams. Project Partners also provided locations of historical ice jams. Using this information, areas around historical ice jam areas were examined for watercourse meandering and bridges to develop the area of ice jam risk. Other areas in the Grindstone Creek watershed were manually inspected for conditions similar to those of historical ice jams that project stakeholders identified. These areas were also classified as having potential for ice jam risks.

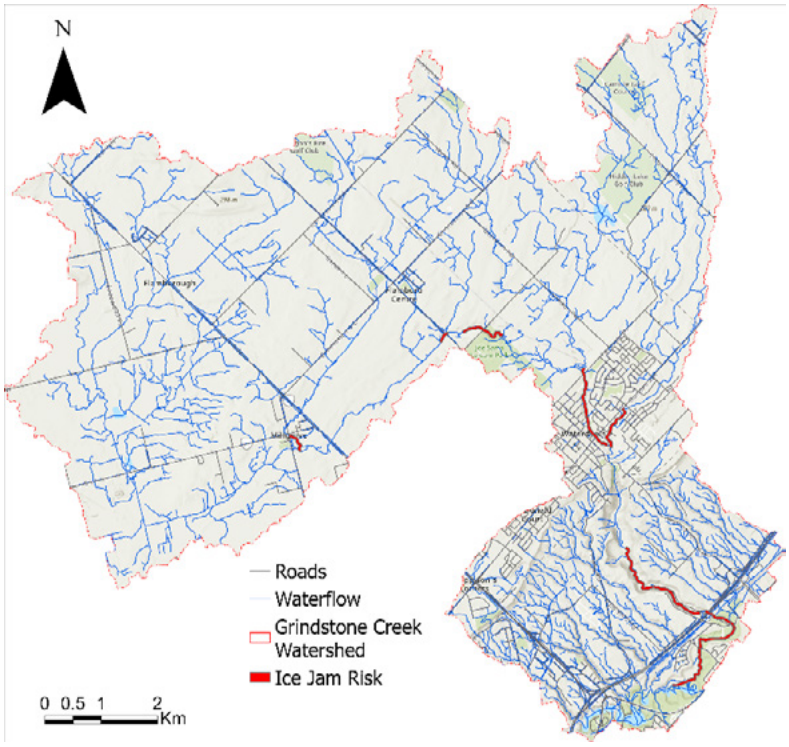


Figure 16: Map of Ice Jam Risk Locations

5/ **Pollutant loading -** Potential salt damage was the variable captured in the inventory for pollutant loading. Areas of risk were identified based on proximity to salted roads. Generally, areas located within 12.2 to 18.3 m of heavily traveled, salt-treated highways are primary candidates for salt-related damage[59]. Research by the Transportation Research Board provides parameters for road salt effects on natural assets:

- 10m - The distance from paved surfaces that contain the greatest concentration of road salts.
- 35m – The distance from paved surfaces within which salt-sensitive trees (i.e., broad-leaved species including maples and black walnut) showed growth reductions because of salt damage.

59 *Transportation Research Board. 1991.*

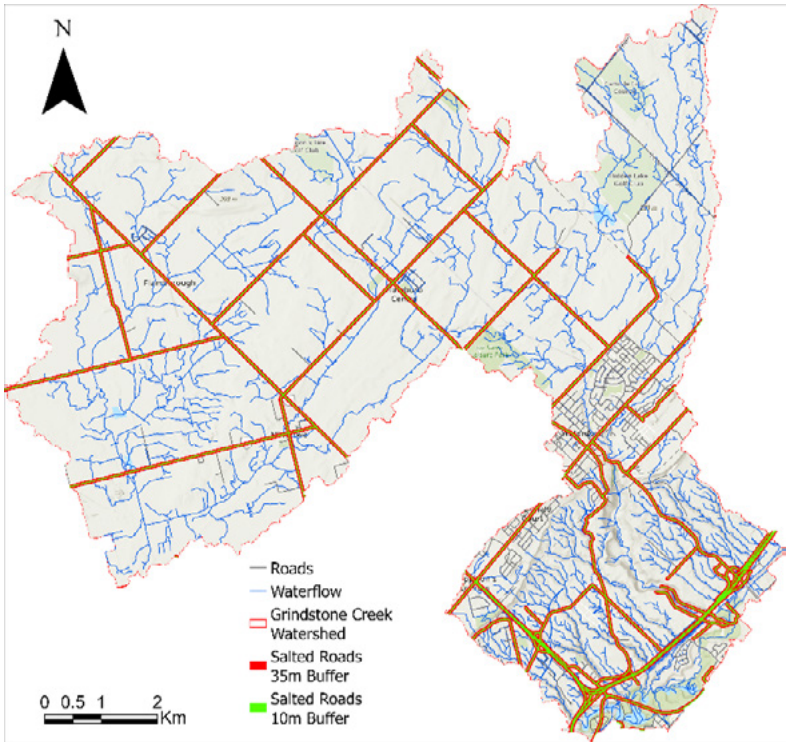


Figure 17: Map of Road Salt Risk

6/ **Beaver dams –** Project Partners indicated beaver dam locations by examining maps and flagging general areas where historical beaver dams have occurred, or are occurring. From these areas, the extent of potential beaver habitat was established by capturing forest and swamp assets in direct proximity to a watercourse.[60]

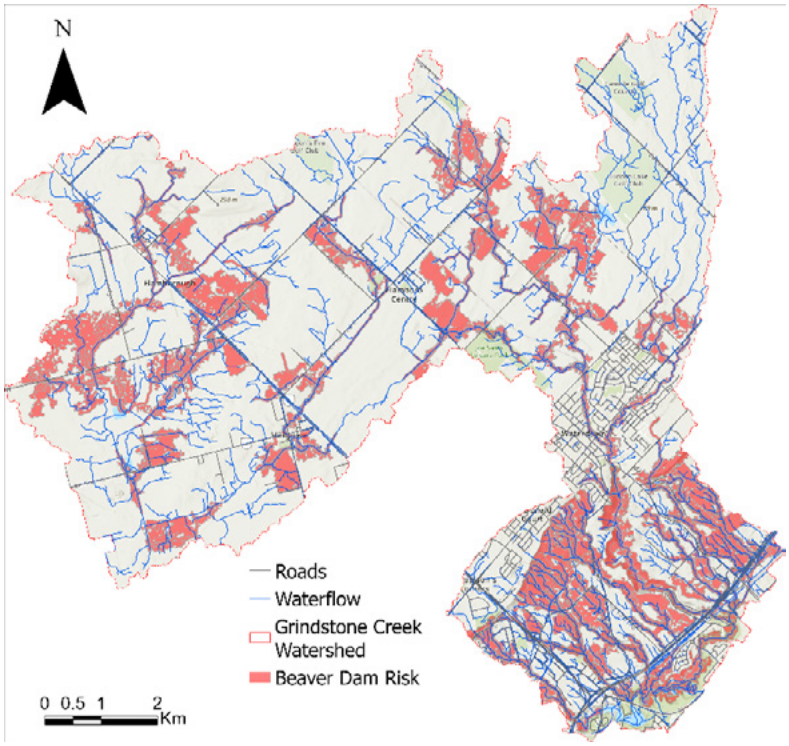


Figure 18: Map of Beaver Dam Risk Areas

60 *The presence of beaver dams is unlikely where creek slopes are high. If a threshold height can be established, the map of Beaver Dam risk areas should be revised.*

7/ **Illegal dumping -** Illegal dumping is a frequent issue in the Grindstone Creek watershed and can damage natural assets. Project Partners identified the areas flagged in Figure 20 as regular locations for illegal dumping.

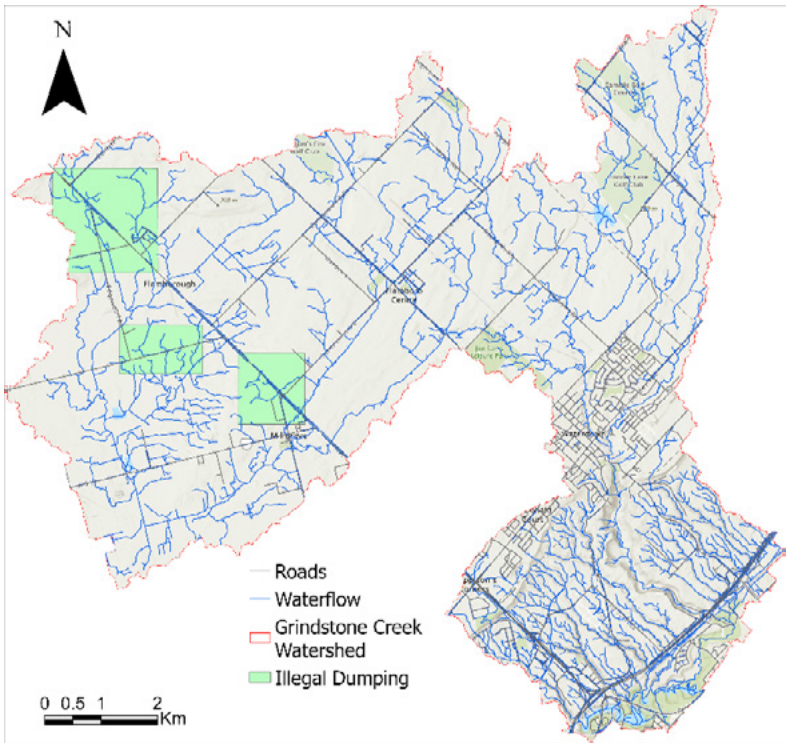


Figure 19: Map of Frequent Illegal Dumping Risk Zones

8/ **Drought -** the extent of drought risk was assumed to cover the entire Grindstone Creek. Therefore, all assets within the watershed have the same exposure to drought risk.

4.2.2. Summary of risk assessment

Figure 20 summarizes the scale of risk to assets within the Grindstone Creek watershed across all risks. Details on how risk and condition results were incorporated into the natural asset inventory are contained in the Grindstone Creek Natural Asset Inventory Technical Report.

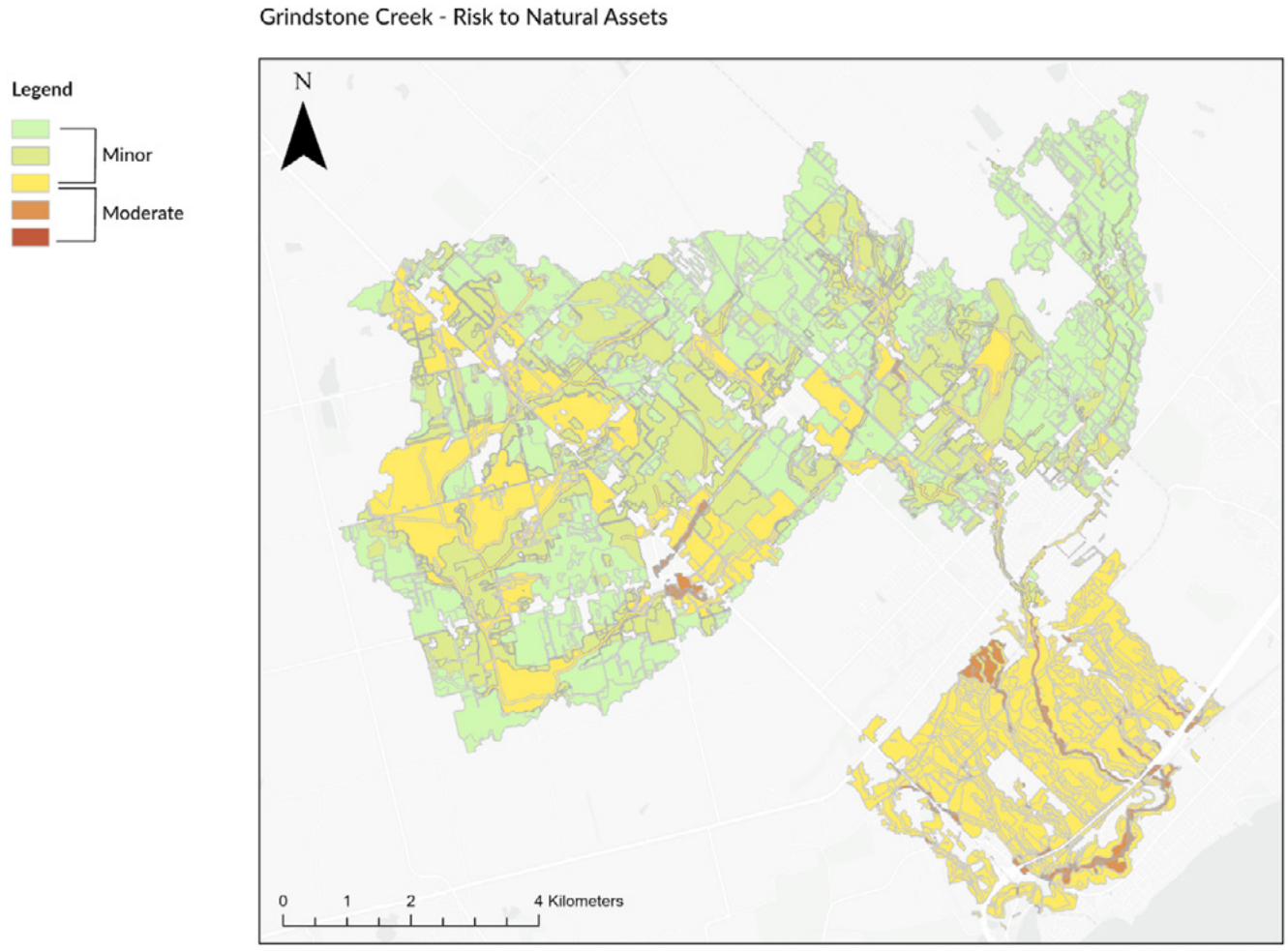


***Figure 20**: Summary of Risk Assessment for Grindstone Creek*

Table 14 shows risk scores by asset class type and subwatershed. The total average risk score is a weighted average of the risk score by asset class, weighted by the area of each asset class within the subwatershed. The highest concentration of assets most vulnerable to risks are forest assets south of Waterdown (Main Valley, Sassafras, Clappison, Pleasantview, Lower Grindstone) and swamp/marsh assets in the boundaries of Royal Botanical Gardens. Natural assets alongside Grindstone Creek at the south side of Mill Street South are highest amount of risk, bearing moderate risk scores as Grindstone Creek progresses towards Royal Botanical Gardens.

TABLE 14: AVERAGE NATURAL ASSET RISK SCORES BY SUBWATERSHED. HIGHER SCORES REPRESENT HIGHER RISK TO THE NATURAL ASSET

SUBWATERSHED	ASSET CLASS					
	Agriculture	Forest	Meadow Successional	Swamp	Marsh	Total Average Risk Score
Centre	16	16	20	20	26	**20**
Clappison	38	36	35	41	41	**37**
Lower Grindstone	49	44	34	47	45	**44**
Lower Hayesland	11	8	10	16	23	**16**
Main Valley	31	40	36		29	**37**
Medad	14	12	12	16	17	**15**
Millgrove	19	7	7	28	31	**24**
Mount Nemo	9	11	13	15	14	**12**
Pleasantview	29	34	32	35	33	**33**
Sassafras	27	34	34	36	37	**33**
Upper Hayesland	14	10	21	19	20	**18**
Waterdown	15	25	28	20	22	**18**
Total	**15**	**25**	**28**	**20**	**22**	**20**

4.2.3. Results of risk and condition combined

The Lower Grindstone subwatershed has a small area of assets in poor condition with a moderate risk rating (i.e. < 1%) but the overall average risk to natural assets within this subwatershed is very high. This indicates that natural asset management within the Lower Grindstone subwatershed may have a high impact.

TABLE 15: AREA (HA) OF NATURAL ASSETS IN POOR CONDITION WITH A MODERATE RISK RATING BY SUBWATERSHED

SUBWATERSHED	ASSET CLASS						
	Agriculture	Forest	Meadow Successional	Swamp	Marsh	Asset Area (ha)	% of subwatershed at high risk
Centre				0.03	0.03	**0.06**	**0.06**
Clappison	0.06	11.51	19.67		0.50	**31.75**	**31.75**
Lower Grindstone		0.10	0.81			**0.92**	**0.92**
Lower Hayesland				0.02	0.01	**0.03**	**0.03**
Main Valley		9.16	2.65			**11.80**	**11.80**
Medad						**0**	**0**
Millgrove				0.05	0.77	**0.82**	**0.82**
Mount Nemo				0.18		**0.18**	**0.18**
Pleasantview		0.82	11.38	0.08	0.29	**12.56**	**12.56**
Sassafras	0.09	6.28	6.93	1.80	2.01	**17.11**	**17.11**
Upper Hayesland			0.60	0.24	0.34	**1.17**	**1.17**
Waterdown		1.71				**1.71**	**1.71**
Total	**0.15**	**29.58**	**42.04**	**2.40**	**3.94**		

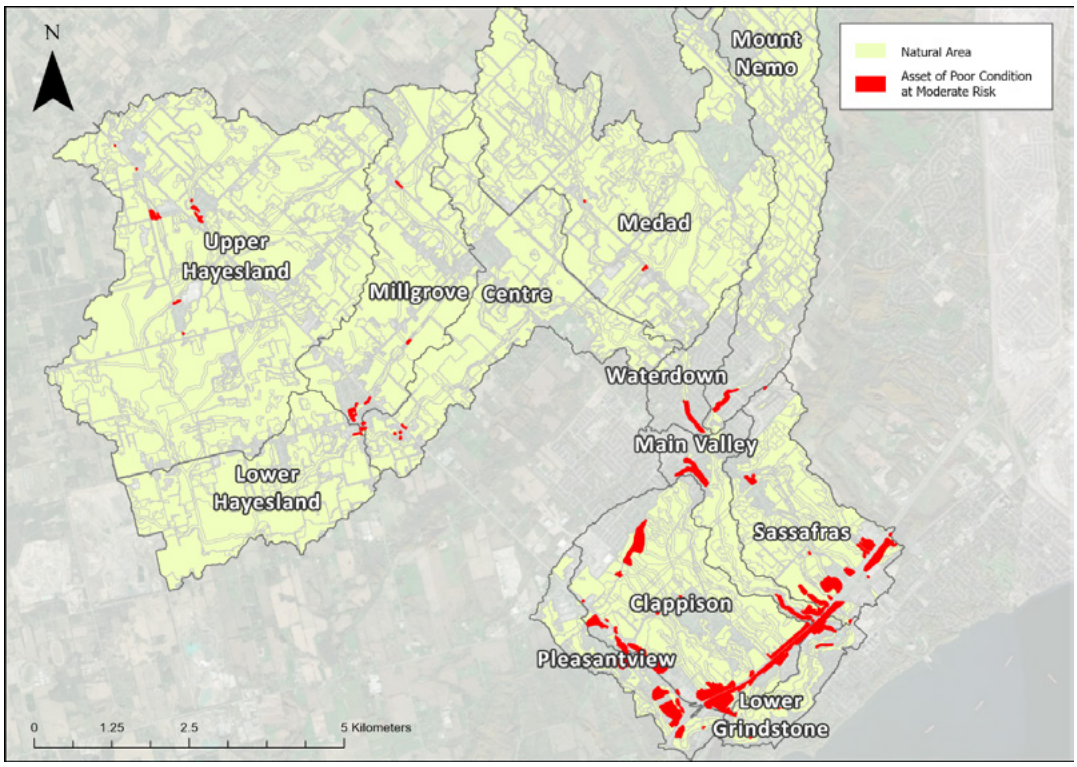


Figure 21: Map depicting natural assets in poor condition with a moderate risk rating

4.2.4. Planning phase limitations

Limitations include completing the scenarios at a coarse scale, which did not allow for testing at a fine resolution, and that modelling did not include a valuation component as these components were outside Project scope of the project. Nevertheless, they can be incorporated in future.

5 Next steps for continuous improvement in the planning phase

The hydrology model for this Project can be modified to explore impacts of additional changes to the Grindstone Creek watershed. Scenarios that could be considered include:

- Replacing natural assets with residential or commercial land and assessing the impact of costs to develop new stormwater controls.
- Plans for future restoration projects to understand the impact to flood mitigation at a watershed scale.
- Calibrating the model for sediment load to study the erosion impacts at a watershed level.

The risk identification should be extended to identify mitigation responses and the costing of responses, as well as to develop a roadmap to manage risks including targets, timelines, and roles and responsibilities.

5.1. Recommendations to Advance Natural Asset Management in the Grindstone Creek watershed

The recommendations identified in this section connect the results of the project with the regulatory/jurisdictional/policy context, and are based on natural asset management priorities that Project Partners identified: improving watershed governance and strategy; restoring natural assets in high-risk areas; and specific asset management activities. Recommendations are structured according to whether they could be undertaken over the short-term (1-2 years), the medium-term (3-5 years), or as part of continuous improvement efforts. Uptake of these recommendations should be done consist with UNDRIP; in a manner that engages Indigenous peoples of the region; and, such that it interweaves Indigenous knowledge, worldviews and perspectives wherever possible.

RECOMMENDATION #1:
REVIEW POLICIES TO PROTECT EXISTING NATURAL ASSETS

Objective: Ensure that future land use change considers the value of existing natural assets and their role in service delivery.

Rationale: This Project demonstrates that natural assets in the Grindstone Creek watershed provide both operational services (such as stormwater management) to local governments and Conservation Halton, and many co-benefits to the local population. Nature-based solutions are also both a promising adaptation action that can reduce some physical and socio-economic risks from climate change, and a mitigation action that can store and sequester carbon. Nature-

based solutions may also play a role in reducing liability risks.

Efforts should therefore be made to maintain existing natural assets where possible. As a rule of thumb, it is more cost-effective to protect what already exists, than to attempt rehabilitation efforts later (Moudrak et al. 2018). Therefore, it is recommended to review municipal land use policies and by-laws as well as Conservation Halton's regulatory policies and programs and services in light of this report; assess the effectiveness of environmental restoration projects; and, track the use of natural assets to support their protection and enhancement in the Grindstone Creek watershed, particularly where they provide significant stormwater benefits.

Who: Conservation Halton, Halton Region, and the Cities of Burlington and Hamilton.

RECOMMENDATION #2:
DEVELOP A COLLABORATIVE WATERSHED MANAGEMENT STRATEGY AND PLAN FOR GRINDSTONE CREEK WATERSHED

Timeline: Short- to medium-term

Objective: Project Partners can develop a *watershed natural asset management strategy* for the Grindstone Creek watershed, based in part on the work and collaboration in this Project. This would describe practices, processes, tools and a decision-making framework that partner organizations can use to prioritize actions and guide management of natural assets in the Grindstone Creek watershed. Details on typical contents of a strategy are included in Appendix F. A *watershed natural asset management plan* would be a more detailed, long-term asset investment plan for natural assets in the watershed. Project Partners could develop both a strategy and a plan. These could inform their respective asset management plans for the natural assets in their jurisdiction.

Rationale: The Provincial Policy Statement 2020 and the *Conservation Authorities Act* provides the rationale for the development of a collaborative watershed management strategy or plan for the Grindstone Creek watershed, which provides multiple services to multiple jurisdictions. Natural asset management is an important part of cost-effective service delivery over the long-term and of mitigating flood and erosion risks, particularly in the City of Burlington. Changes to the Conservation Authorities Act also require Conservation Authorities to undertake watershed-based resource management strategies as a mandatory program.

Collaboration is required to strengthen natural asset data and update it to inform asset management plans in the Grindstone Creek watershed. In some cases, actions will need to be included in asset management plans of the Cities of Hamilton and Burlington and in Conservation Halton's own plans. In other cases, Conservation Halton may be the appropriate organization to lead activities and will require funding to undertake them. Lifecycle management plans are needed for creeks in upstream areas and natural assets in the Lower Grindstone subwatershed.

Project Partners noted a window for collaboration as local governments need to have asset management plans that include green infrastructure by 2024. Collaboration on a watershed management plan could ensure a consistent approach across the watershed and ensure that investments are prioritized based on shared objectives. This would be consistent with policy directives in the Provincial Policy Statement 2020. Note that natural asset management strategies or plans developed for the Grindstone Creek watershed must also be consistent with the requirements of the NEC for natural assets in the Niagara Escarpment Plan area and must not contravene the Conservation Authorities Act for natural assets located within regulated areas.

Who: Conservation Halton, the City of Burlington, the City of Hamilton, Royal Botanical Gardens, Halton Region, in consultation with Indigenous communities, other stakeholders and landowners.

RECOMMENDATION #3:
DEVELOP A COLLABORATIVE WATERSHED GOVERNANCE APPROACH FOR THE GRINDSTONE CREEK WATERSHED

Timeline: Short-term (Immediate)

Objective: Collaboration is required to set priorities and optimize investments in natural asset management in the Grindstone Creek watershed. A group representing Project Partners could be formed to have accountability for making progress on natural asset management, providing input and development of a renewed collaborative watershed management strategy and planning for the Grindstone Creek watershed. Terms of reference that clearly define roles and responsibilities of the partners should be developed.

Rationale: To collaborate effectively on natural asset management in the Grindstone Creek watershed, Project Partners will need support from their respective governance bodies. A collaborative group could be established to support effective watershed-scale management of natural assets through the renewal of the Grindstone Creek Watershed Study (1998).

Who: Conservation Halton to lead with representation from the Cities of Burlington and Hamilton, and possibly broader stakeholder representation (to be determined).

RECOMMENDATION #4:
DEVELOP A COLLABORATIVE MONITORING PLAN

Timeline: Short-term

Objective: Project Partners expressed interest in a collaborative monitoring plan for priority natural assets in the watershed. Conservation Halton can build on its existing approach to convene Project Partners in a watershed-based approach, which is an efficient means of undertaking natural asset monitoring and management. Project Partners can discuss resourcing and monitoring needs beyond what they are already doing. They should consider areas where natural

assets are in poor condition and exposed to moderate risks in their monitoring plan. This includes areas south of Waterdown, the southeast portion of outer edges of Clappison, Pleasantview and Sassafras subwatersheds.

Rationale: The project reiterated that the area north and south of Concession 5 W is prone to flood risk. There are 2 Water Survey Canada stream flow gauges in the Grindstone Creek watershed near Aldershot and Highway 6 at Millgrove, which represent areas of flood risk. Other locations can be identified by overlaying the GIS locations of current monitoring locations (monitoring for TSS) against areas of concern related to both erosion and flooding. These should be in easy-to-access spots where automated, continuous information is required.

Project Partners identified the need to expand water quality monitoring locations in priority areas. Conservation Halton expanded water quality sampling in the Grindstone Creek watershed in 2021, to complement the water quality station sampled annually and funded through the Ministry of Environment, Conservation and Parks. As well, since 2015 Conservation Halton has expanded a data collection network for stream flows, rainfall and other information supporting its flood forecasting and operations program.

Finally, the plan should include additional ecological monitoring, and monitoring and enforcement of illegal dumping, particularly in the northwest section of the watershed where illegal dumping was identified as a risk. Conservation Halton has authority to address illegal dumping within regulated areas, whereas municipalities have authority to address under a site-alteration by-law.

Conservation Halton started ecological monitoring (frogs and birds) at Fuciarelli Resource Management Area in 2000[61]. It has also been monitoring forest health, salamanders and breeding birds at Waterdown Woods since 2006 (*camaps.maps.arcgis.com/apps/MapJournal/index.html?appid=5c5b47db21fb4d6dbd2e348fc14d93e3*).

Conservation Halton will release its next Watershed Report Card in 2023, which could provide additional insight into monitoring needs. Most Conservation Halton environmental monitoring is reported through story maps (*conservationhalton-camaps.opendata.arcgis.com/pages/story-maps*). Conservation Halton also provides flood forecasting and floodplain mapping (*conservationhalton.ca/natural-hazards*) and identifies erosion hazards in its regulatory mapping. While it does not conduct formal erosion monitoring of active erosion sites, CH maintains a restoration opportunities database which identifies key areas for restoration. The City of Burlington also monitors active erosion sites within its jurisdiction.

Who: Conservation Halton collects flow information through its Flood Forecasting and Operations team, and carries out water quality monitoring in the Grindstone Creek watershed. The information collected is limited by funding

61 See the related story map: Marsh Monitoring (arcgis.com).

and staff availability. Monitoring and maintenance, including condition and risk assessments of natural assets, is a shared responsibility between Conservation Halton and the municipality and generally falls under operational budgets while restoration projects fall under capital budgets. The City of Burlington has been monitoring erosion in its jurisdiction. Should a collaborative monitoring plan be developed, the Cities of Burlington and Hamilton and Conservation Halton would need to coordinate each monitoring program to be compatible with the other and endorse and resource it.

RECOMMENDATION #5:
ADVANCE PRIORITY RESTORATION PROJECTS

Timeline: Short-term

Objective: Seek funding to undertake restoration projects in areas identified as high priority. Project Partners identified restoration as a priority in Clappison, Pleasantview, Dundas and Dunsworth to address erosion concerns. To address flood risk, the area north and south of Concession 5 W was identified as a priority for natural heritage system work in upland forests and in wetlands. In addition, the lower Grindstone subwatershed has a very small area of assets in poor condition with a moderate risk rating but the overall average risk to natural assets within this subwatershed is very high. This indicates that natural asset management within the Lower Grindstone subwatershed may have a high beneficial impact. The comprehensive analysis in this report could underpin a sub-watershed scale application for funding, as opposed to project-by-project applications.

Rationale: Overall, modelling demonstrated the effectiveness of natural assets to manage peak flows and infiltration. Natural assets are also more flexible and adaptable to change than grey infrastructure assets. As such, existing natural assets should be maintained and rehabilitated where needed. It may take time to develop natural asset management plans for the Grindstone Creek watershed and Project Partners are advised to take advantage of grants, municipal capital budget resource allocations, or other funding opportunities to begin priority restoration projects. Conservation Halton has a robust ecological restoration program to improve the condition of natural assets and reduce risk. Existing tools include a restoration opportunities database for which they recently developed a mobile app for staff to use in the field. Conservation Halton is currently compiling information about existing data (ecology, land cover, water quality) and identifying external data sets of interest. Immediate next steps will be to use the database to set restoration priorities with partners.

Who: Conservation Halton (external funding needed).

RECOMMENDATION #6:
INSTALL LOW IMPACT DEVELOPMENT PROJECTS IN PRIORITY AREAS

Timeline: Continuous improvement

Objective: Seek opportunities to install LID projects in priority areas and to build them into asset management plans.

Rationale: The modelling report shows that in the future climate scenario, natural assets in the Grindstone Creek watershed combined with the installation of LID in Waterdown would provide additional stormwater management benefits that could mitigate downstream flooding and reduce the stormwater infrastructure needed in the City of Burlington. LID would also reduce the need for stormwater management ponds, which can cause thermal pollution in receiving waters and poor habitat quality for wildlife and fish. The Project can inform updates to relevant asset management plans in the City of Hamilton, particularly related to transportation and stormwater services.

Conservation Halton has expertise in LID and restoration of natural areas, which presents opportunities for collaboration. Should Project Partners develop a collaborative natural asset management strategy or more detailed asset investment plan, there is an opportunity to develop LID opportunities in collaboration with the Cities of Hamilton and Burlington. Agreements would be needed as to how initiatives are funded given that LID investments in Hamilton will benefit both Hamilton and Burlington. With funding from the Ministry of Environment, Conservation and Parks, Conservation Halton is administering the Rainwater Conservation Fund to support private landowners in implementing LID projects on their properties. The development community is also an important partner to include to increase uptake of LID.

Who: The City of Hamilton, City of Burlington and Conservation Halton, developers.

RECOMMENDATION #7:
STRENGTHEN ASSESSMENT OF NATURAL ASSETS IN THE GRINDSTONE CREEK WATERSHED

Timeline: Continuous improvement

Objective: Enhance the understanding of the condition of natural assets in Grindstone Creek, the risks to them, and the services they provide.

Rationale: The project added to an understanding of the condition of natural assets in the Grindstone Creek watershed, the risks to them, and the level of service they provide now and in future climate scenarios. Conditions assessment methods carried out by Conservation Halton (e.g. analysis that support the Watershed Report Cards) as well as provincial methods (e.g. OWES) were used in the Project. The following data gaps and limitations can be addressed and should be built into future asset management plans or strategies:

- **Inventory and monitoring data:** The inventory can be deepened with the addition of soils and groundwater recharge zones. The inventory could also be consolidated and shared with others in adjacent areas as they are developed and options explored to share these. For example, one option might be a public registry which could draw inspiration from the Rick Hansen Foundation Accessibility Foundation Certification Registry.
- **Condition assessment:** Refine through field verification of natural asset condition.
- **Develop a fully integrated system:** Over the long term, integrate monitoring data into inventory outputs, ideally with real time updates to the inventory and condition assessment.
- **Incorporate traditional ecological knowledge:** Project Partners can consider collaborating with Indigenous communities in the watershed. Training, facilitating introductions, and scoping future work from a qualified Indigenous professional services organization could assist in understanding the context of local Indigenous groups, whom to engage, and how.
- **Modelling (stormwater):** The hydrology model developed for the Project could be modified to explore impacts of additional changes to the Grindstone Creek watershed. Scenarios that could be considered include: 1) replacing natural assets with residential or commercial land and assessing the impact of costs to develop new stormwater controls 2) future restoration projects to understand the impact to flood mitigation at a watershed scale, and 3) different sediment loads to study erosion impacts.
- **Modelling (water quality):** The Project did not model water quality since this requires continuous simulation, not event-based modelling used to assess peak flow and infiltration. In future, a model could be calibrated with pollutant data to compare the water quality benefits provided by the existing natural assets and the stormwater controls, or calibrated for sediment load to explore erosion impacts.
- **Risk Assessment:** The highest concentration of assets most at risks are forest assets south of Waterdown (Main Valley, Sassafras, Clappison, Pleasantview, Lower Grindstone) and swamp/marsh assets residing in the boundaries of Royal Botanical Gardens. Natural assets alongside Grindstone Creek at the south side of Mill Street South have the highest amount of risk, and moderate risk scores as Grindstone Creek progresses towards Royal Botanical Gardens. The risk identification should be extended to identify mitigation responses, cost of responses, and a roadmap to manage risks including targets, timelines, and roles and responsibilities.

Who: All Project Partners share responsibility for management of natural assets in the Grindstone Creek watershed. Conservation Halton, as the owner of the natural asset inventory, is in a good position to coordinate inventory updates. They can apply current, and adopt new, assessment methods to determine conditions and risks. The development of a collaborative natural

asset management strategy or plan for the Grindstone Creek watershed (Recommendation 1) can help build political support to fund continuous improvement efforts.

RECOMMENDATION #8:
DEVELOP A COMMUNICATIONS PLAN AND PRESENTATION TO BUILD AWARENESS OF NATURAL ASSET MANAGEMENT NEEDS IN THE GRINDSTONE CREEK WATERSHED

Timeline: Short-term

Objective: Communicate the value of services provided by the Grindstone Creek watershed among decision-makers and the broader community.

Rationale: Project results demonstrate the high value of services that the Grindstone Creek watershed provides, highlight the risks to these services, and opportunities to protect them. To progress on natural asset management, additional resources and commitment are required. A first step is to build awareness of Project results and their implications among local elected officials, decision-makers and the broader community. Another target group for communications are the planning staff at the City of Burlington given that part of the Grindstone Creek watershed in North Aldershot (shown below, Schedule D of the City's Official Plan) has a special planning designation due to planned development. Planning staff should be aware of Project implications in that area, including for stormwater management.

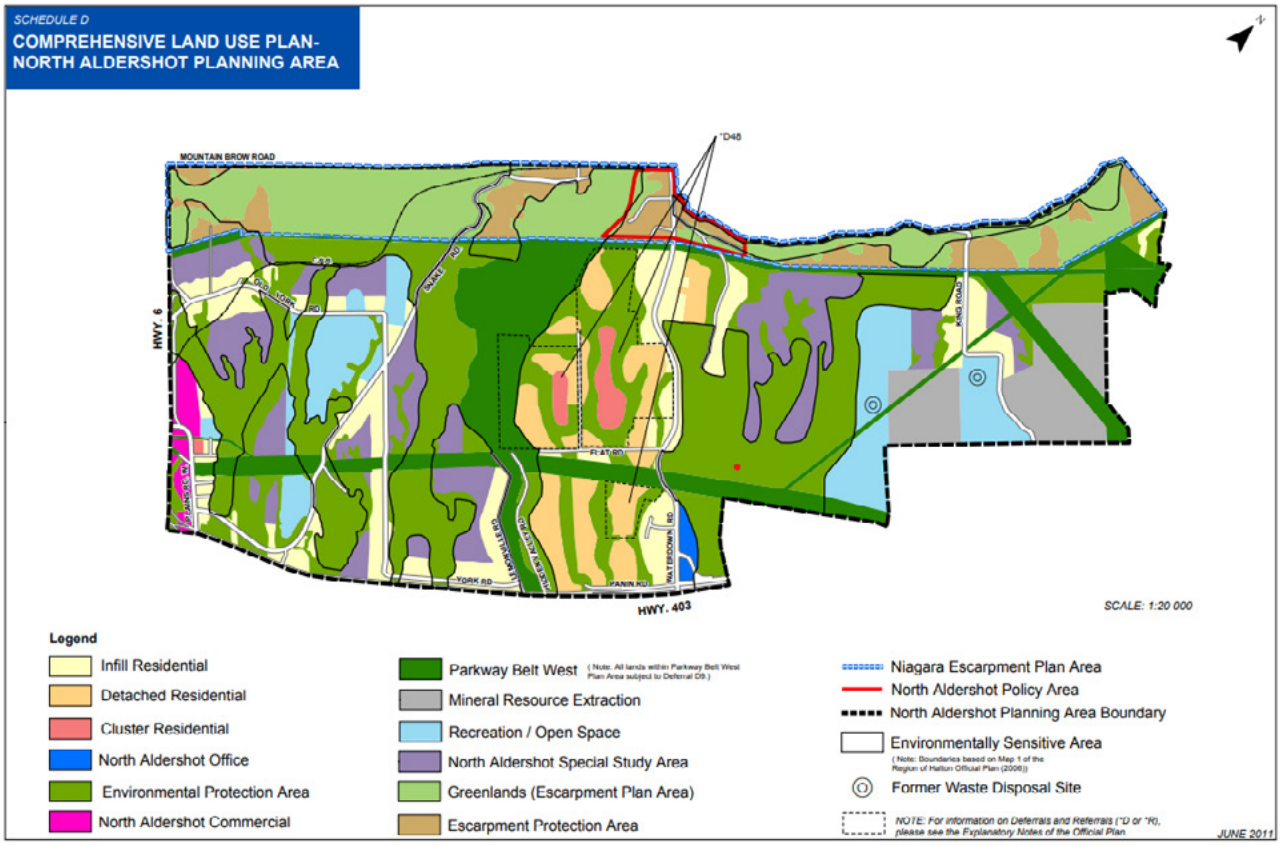


Figure 22: Schedule D of City of Burlington's Official Plan

Who: All Project Partners. Conservation Halton is well-positioned to communicate Project results through programs such as its Healthy Neighbourhoods workshop series[62]. Project Partners may wish to develop a presentation for the Cities of Hamilton and Burlington Councils, and the governing boards of Conservation Halton and Royal Botanical Gardens.

RECOMMENDATION #9: BETTER INTEGRATE NATURAL ASSET MANAGEMENT INTO OVERALL ASSET MANAGEMENT PRACTICES

Timeline: Short-term and continuous improvement

Objective: All Project Partners were at an early stage of integrating natural asset management into their asset management practices, which focussed primarily on built infrastructure. Opportunities to better integrate natural asset management include:

- Include natural assets in asset management policies and frameworks.
- Complete a lifecycle economic assessment for the stormwater services of natural assets[63]. For those assets under Project Partner jurisdiction, this includes considering:
  - Acquisition costs of SWM natural assets (e.g. land purchase, conservation covenant fees)
  - Maintenance and monitoring costs
  - Disposal costs
- Connect natural asset data and information from this Project to asset management planning.
- Ensure asset management teams or committees include someone with specific responsibility for natural asset management.
- Build awareness amongst staff of the role of natural assets in service delivery, and awareness amongst Councils of the value of natural assets in the Grindstone Creek watershed and the resources required to maintain and restore them.

Rationale: Until natural assets are explicitly incorporated into asset management policies and practices, the services they provide risk being undervalued and ignored in decision-making.

62 *The Healthy Neighbourhoods workshop series teaches participants how stormwater is managed and how they can implement sustainable alternatives. See: https://conservationhalton.ca/landowner-environmental-assistance/. Other educational programs can be found here: conservationhalton.ca/education/. Conservation Halton is also developing a watershed climate action plan with a core building block of education and awareness.*

63 *At this time PSAB does not have accounting principles for natural assets, but the considerations provided here are common to any lifecycle assessment.*

Who: All Project Partners

RECOMMENDATION #10:
IDENTIFY ADDITIONAL WATERSHEDS WITHIN CONSERVATION HALTON'S JURISDICTION FOR NATURAL ASSET MANAGEMENT

Timeline: Continuous improvement

Objective: Advance natural asset management in other watersheds.

Rationale: The Project demonstrated the service value of natural assets in the Grindstone Creek watershed. The approach could be suitable for replication in other watersheds in Conservation Halton's jurisdiction as part of continuous improvement of natural asset management. Conservation Halton may wish to prioritize watersheds where there are risks to be addressed in the short to medium-term.

Who: Conservation Halton

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7 Appendices

Appendix A: Relevant aspects of the Provincial Policy Statement 2020 & Ontario Regulation 686/21: Mandatory Programs and Services

GENERALLY RELEVANT POLICIES IN THE PROVINCIAL POLICY STATEMENT 2020

1. Healthy, liveable and safe communities are sustained by:

c) *avoiding development and land use patterns which may cause environmental or public health and safety concerns.*

e) healthy, liveable and safe communities are sustained by transit-supportive development, intensification and infrastructure planning to achieve cost-effective development patterns, optimization of transit investments, and *standards to minimize land consumption and servicing costs.*

h) promoting development and land use patterns *that conserve biodiversity*.

i) preparing for the regional and local impacts of a *changing climate*.

1.1.3.2 Land use patterns within settlement areas shall be based on densities and a mix of land uses which:

c) minimize negative impacts to air quality and climate change and promote energy efficiency.

d) prepare for the impacts of a changing climate.

1.1.3.8 A planning authority may identify a settlement area or allow the expansion of a settlement area boundary only at the time of a comprehensive review and only where it has been demonstrated that:

c) in prime agricultural areas: 1. the lands do not comprise specialty crop areas, 2. alternative locations have been evaluated, and i) there are no reasonable alternatives which avoid prime agricultural areas and ii) there are no reasonable alternatives on lower-priority agricultural lands in prime agricultural areas.

1.1.4.1 Healthy, integrated and viable rural areas should be supported by:

h) conserving biodiversity and considering the ecological benefits that nature provides.

1.2.1 A coordinated, integrated and comprehensive approach should be used when dealing with planning matters within municipalities, across lower, single and/or upper-tier municipal boundaries, and with other orders of government, agencies and boards including:

c) managing natural heritage, water, agricultural, mineral, and cultural heritage and archaeological resources.

e) ecosystem, shoreline, watershed, and Great Lakes-related issues.

f) natural and human-made hazards.

1.2.1 Planning authorities shall engage with Indigenous communities and coordinate on land use planning matters.

1.5.1 Healthy, active communities should be promoted by:

b) planning and providing for a full range and equitable distribution of publicly accessible built and natural settings for recreation, including facilities, parklands, public spaces, open space areas, trails and linkages and where practical, water-based resources.

c) providing opportunities for public access to shorelines.

d) recognizing provincial parks, conservation reserves and other protected areas, and minimizing negative impacts on these areas.

1.6.2 Planning authorities should promote green infrastructure to complement grey infrastructure.

1.6.3 Before consideration is given to developing new infrastructure and public service facilities:

a) the use of existing infrastructure and public service facilities should be optimized.

b) opportunities for adaptive re-use should be considered, wherever feasible.

1.6.6.7 Planning for stormwater management shall:

a) be integrated with planning for sewage and water services and ensure that systems are optimized, feasible and financially viable over the long term.

b) minimize or, where possible, prevent increases in contaminant loads.

c) minimize erosion and changes in water balance and prepare for the impacts of a changing climate through the effective management of stormwater, including the use of green infrastructure.

d) mitigate risks to human health, safety, property and the environment.

e) maximize the extent and function of vegetative and pervious surfaces.

f) promote stormwater management best practices, including stormwater attenuation and re-use, water conservation and efficiency, and low impact development.

1.7.1 Long-term economic prosperity should be supported by:

k) minimizing negative impacts from a changing climate and considering the ecological benefits that nature provides.

1.8.1 Planning authorities shall support energy conservation and efficiency, improved air quality, reduced greenhouse gas emissions, and preparing for the impacts of a changing climate through land use and development patterns which:

g) maximize vegetation within settlement areas, where feasible.

2.0 Wise Use and Management of Resources Ontario's long-term prosperity, environmental health, and social well-being depend on conserving biodiversity, protecting the health of the Great Lakes, and protecting natural heritage, water, agricultural, mineral and cultural heritage and archaeological resources for their economic, environmental and social benefits. This section sets out policy directives promoting long-term protection of natural heritage, water, prime agricultural areas, minerals and petroleum and mineral aggregate resources.

2.2.1 Planning authorities shall protect, improve or restore the quality and quantity of water by:

a) using the watershed as the ecologically meaningful scale for integrated and long-term planning, which can be a foundation for considering cumulative impacts of development.

b) minimizing potential negative impacts, including cross-jurisdictional and cross-watershed impacts.

c) evaluating and preparing for the impacts of a changing climate to water resource systems at the watershed level.

d) identifying water resource systems consisting of ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas, which are necessary for the ecological and hydrological integrity of the watershed.

e) maintaining linkages and related functions among ground water features, hydrologic functions, natural heritage features and areas, and surface water features including shoreline areas.

f) implementing necessary restrictions on development and site alteration to protect all municipal drinking water supplies and designated vulnerable areas, and to protect, improve or restore vulnerable surface and ground water, sensitive surface water features, and sensitive ground water features and their hydrologic functions.

g) planning for efficient and sustainable use of water resources through practices for water conservation and sustaining water quality.

h) ensuring consideration of environmental lake capacity, where applicable, and ensuring stormwater management practices minimize stormwater volumes and contaminant loads, and maintain or increase the extent of vegetative and pervious surfaces.

Policy directives that provide a rationale for Conservation Halton and the Cities of Burlington and Hamilton to collaborate and develop a collaborative natural asset management strategy or plan for the Grindstone Creek watershed.

- **Policy 1.2.1** calls for a coordinated, integrated, and comprehensive approach to planning matters within municipalities, across lower, single and/or upper-tier municipal boundaries, and with other orders of government, agencies and boards managing natural heritage, water, agricultural, mineral, and cultural heritage and archaeological resources; ecosystem, shoreline, watershed, and Great Lakes-related issues; and natural and human-made hazards. Policy 1.2.1 also requires planning authorities to engage with Indigenous communities and coordinate on land use planning matters.
- **Policy 2.2.1** requires planning authorities to protect, improve or restore the quality and quantity of water through a variety of watershed management obligations (see Annex E for details).
- **Policy 1.6.6.7** requires integrated planning for stormwater management with a range of measures supportive of natural asset management (see Annex E for details).
- **Section 2** provides direction around how natural heritage should be treated:
    - **Policy 2.1.1** requires that natural features and areas be protected for the long term.
    - **Policy 2.1.2** requires that the diversity and connectivity of natural features in an area, and the long-term ecological function and biodiversity of natural heritage systems, should be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features and ground water features.
    - **Policy 2.1.3** requires that natural heritage systems shall be identified in Ecoregions 6E & 7E1, recognizing that natural heritage systems will vary in size and form in settlement areas, rural areas, and prime agricultural areas.
    - **Policy 2.1.4** requires that development and site alteration shall not be permitted in: a) significant wetlands in Ecoregions 5E, 6E and 7E1; and b) significant coastal wetlands.
    - **Policy 2.1.5** requires that development and site alteration shall not be permitted in: a) significant wetlands in the Canadian Shield north of Ecoregions 5E, 6E and 7E1; b) significant woodlands in Ecoregions 6E and 7E (excluding islands in Lake Huron and the St. Marys River)1; c) significant valleylands in Ecoregions 6E and 7E (excluding islands in Lake Huron and the St. Marys River); d) significant wildlife habitat; e) significant areas of natural and scientific interest; and f) coastal wetlands in Ecoregions 5E, 6E and 7E1 that

are not subject to policy 2.1.4(b) unless it has been demonstrated that there will be no negative impacts on the natural features or their ecological functions.

- **Policy 2.1.6** requires that development and site alteration shall not be permitted in fish habitat except in accordance with provincial and federal requirements.
- **Policy 2.1.7** requires that development and site alteration shall not be permitted in habitat of endangered species and threatened species, except in accordance with provincial and federal requirements.
- **Policy 2.1.8** requires that development and site alteration shall not be permitted on adjacent lands to the natural heritage features and areas identified in policies 2.1.4, 2.1.5, and 2.1.6 unless the ecological function of the adjacent lands has been evaluated and it has been demonstrated that there will be no negative impacts on the natural features or on their ecological functions.
- **Policy 2.1.9** requires that nothing in policy 2.1 is intended to limit the ability of agricultural uses to continue.

- **Section 3** focuses on natural hazards with implications for how natural assets shall be managed.
  - **Policy 3.1.1** requires that development shall generally be directed, in accordance with guidance developed by the Province (as amended from time to time), to areas outside of: a) hazardous lands adjacent to the shorelines of the Great Lakes - St. Lawrence River System and large inland lakes which are impacted by flooding hazards, erosion hazards and/or dynamic beach hazards; b) hazardous lands adjacent to river, stream and small inland lake systems which are impacted by flooding hazards and/or erosion hazards; and c) hazardous sites.
  - **3.1.2** requires that development and site alteration shall not be permitted within: a) the dynamic beach hazard; b) defined portions of the flooding hazard along connecting channels (the St. Marys, St. Clair, Detroit, Niagara and St. Lawrence Rivers); c) areas that would be rendered inaccessible to people and vehicles during times of flooding hazards, erosion hazards and/or dynamic beach hazards, unless it has been demonstrated that the site has safe access appropriate for the nature of the development and the natural hazard; and d) a floodway regardless of whether the area of inundation contains high points of land not subject to flooding.
  - **Policy 3.1.3** requires that planning authorities shall prepare for the impacts of a changing climate that may increase the risk associated with natural hazards.
  - **Policy 3.1.4** requires that despite policy 3.1.2, development and site alteration may be permitted in certain areas associated with the flooding hazard along river, stream and small inland lake systems: a) in those exceptional situations where a Special Policy Area has been approved. The designation of a Special Policy Area, and any change or modification to the official plan policies, land use designations or boundaries applying to Special Policy Area lands, must be approved by the Ministers of Municipal Affairs and Housing and Natural Resources and Forestry prior to the approval authority approving such changes or modifications; or b) where the development is limited to uses which by their nature must locate within the floodway, including flood and/or erosion control works or minor additions or passive non-structural uses which do not affect flood flows.
  - **Policy 3.1.5** requires that development shall not be permitted to locate in hazardous lands and hazardous sites where the use is: a) an institutional use including hospitals, long-

term care homes, retirement homes, pre-schools, school nurseries, day cares and schools; b) an essential emergency service such as that provided by fire, police and ambulance stations and electrical substations; or c) uses associated with the disposal, manufacture, treatment or storage of hazardous substances.

- **Policy 3.1.6** requires that where the two zone concept for flood plains is applied, development and site alteration may be permitted in the flood fringe, subject to appropriate floodproofing to the flooding hazard elevation or another flooding hazard standard approved by the Minister of Natural Resources and Forestry.
- **Policy 3.1.7** requires that further to policy 3.1.6, and except as prohibited in policies 3.1.2 and 3.1.5, development and site alteration may be permitted in those portions of hazardous lands and hazardous sites where the effects and risk to public safety are minor, could be mitigated in accordance with provincial standards, and where all of the following are demonstrated and achieved: a) development and site alteration is carried out in accordance with floodproofing standards, protection works standards, and access standards; b) vehicles and people have a way of safely entering and exiting the area during times of flooding, erosion and other emergencies; c) new hazards are not created and existing hazards are not aggravated; and d) no adverse environmental impacts will result.

GENERALLY RELEVANT POLICIES IN ONTARIO REGULATION 686/21: MANDATORY PROGRAMS AND SERVICES

Risks of certain natural hazards

- **Section 1.1** provides direction around how to design programs and services related to natural hazards. It states an authority shall provide programs and services related to the following types of natural hazards:
  - Dynamic beach hazard.
  - Erosion hazard.
  - Flooding hazard.
  - Hazardous lands,
  - Hazardous sites.
  - Low water or drought conditions.
- **Section 1.2** provides the objectives for the design of programs and services, which include:
  - Developing an awareness of the areas that are important for the management of natural hazards within the authority's area of jurisdiction.
  - Understanding how risks to natural hazards may be affected by climate change.
  - Managing, preventing, or mitigating risks.
  - Promoting public awareness of risks related to natural hazards.
- **Section 1.3** provides the required components of programs and services, which includes:
  - The collection, provision and management of information enabling the authority to:
    - delineate and map areas of natural hazards within its area of jurisdiction,
    - study surface water hydrology and hydraulics, including surface water flows and

levels, and the related interactions between surface and ground water,
        - study stream morphology,
        - study the potential effects of climate change on natural hazards, and
        - study the management of natural hazards.
    - The development of plans and policies that will support the delivery of those programs and services.
    - Public awareness, education and outreach components related to the risk of natural hazards within the authority's area of jurisdiction.
    - Consultation on the development and provision of those programs and services.

Sections 1.2 through 1.5 provides further information flood forecasting and warning, drought or low water response, ice management, and infrastructure.

Conservation and Management of Lands

- **Section 9** provides required components of programs and services provided by an authority regarding the conservation and management of lands, which includes:
    - A conservation area strategy, prepared on or before December 31, 2024 for all lands owned or controlled by the authority.
    - Where the authority considers it advisable to achieve the objectives referred to in the Conservation area strategy (see below) shall include the following components:
        - programs and services to secure the authority's interests in its lands that include measures for fencing, signage, patrolling and any other measures to prevent unlawful entry on the authority's land and to protect the authority from exposure to liability under the Occupiers' Liability Act,
        - programs and services to maintain any facilities, trails or other amenities that support public access and recreational activities in conservation areas and that can be provided without the direct support or supervision of staff employed by the authority or by another person or body,
        - programs and services to enable the authority, in its capacity as an owner of land, to make applications or comment on matters under the Planning Act,
        - programs and services to conserve, protect, rehabilitate, establish, and manage natural heritage located within the lands owned or controlled by the authority,
        - programs and services to plant trees on lands owned or controlled by the authority, excluding commercial logging, and
        - the development of one or more policies governing land acquisitions and land dispositions.
    - A land inventory, prepared on or before December 31, 2024, that meets the requirements set out in section 11.
    - Programs and services to ensure that the authority carries out its duties, functions and responsibilities to administer regulations made under section 29 of the Act.

Conservation area strategy

- **Section 10.1** states the required components of a conservation area strategy and includes:
  - Objectives established by the authority that will inform the authority's decision-making related to the lands it owns and controls, including decisions related to policies governing the acquisition and disposition of such lands.
  - Identification of the mandatory and non-mandatory programs and services that are provided on land owned and controlled by the authority, including the sources of financing for these programs and services.
  - Where the authority considers it advisable to achieve the objectives referred to in paragraph 1, an assessment of how the lands owned and controlled by the authority may,
    - augment any natural heritage located within the authority's area of jurisdiction, and
    - integrate with other provincially or municipally owned lands or other publicly accessible lands and trails within the authority's area of jurisdiction.
  - The establishment of land use categories for the purpose of classifying lands in the land inventory described in section 11 based on the types of activities that are engaged in on each parcel of land or other matters of significance related to the parcel.
  - A process for the periodic review and updating of the conservation area strategy by the authority, including procedures to ensure stakeholders and the public are consulted during the review and update process.
- **Section 10.2** states the authority shall ensure stakeholders and the public are consulted during the preparation of the conservation area strategy in a manner that the authority considers advisable.
- **Section 10.3** states the authority shall ensure that the conservation area strategy is made public on the authority's website, or by such other means as the authority considers advisable.

Land inventory

- **Section 11** states a land inventory shall include the following information for every parcel of land the authority owns or controls:
  - The location of the parcel.
  - The identification of any information the authority has in its possession in respect of the parcel, including any surveys, site plans or other maps.
  - When the authority acquired the parcel.
  - Whether the parcel was acquired using a grant made under section 39 of the Act.
  - Whether the parcel was acquired through an expropriation.
  - Whether the authority owns the parcel or has a registered legal interest in the parcel, including an easement.
  - Identification of the land use categories mentioned in paragraph 4 of subsection 10 (1) that apply to the parcel.
  - For the purpose of ensuring a program or service is not included as a mandatory program or service under subparagraph 2 ii or v of subsection 9 (1), identification of whether,

- a recreational activity is provided on the parcel that requires the direct support or supervision of staff employed by the authority or by another person or body, or
- commercial logging is carried out on the parcel.

- **Section 11.2** states that the land inventory shall include a process for the periodic review and updating of the inventory by the authority.

Other programs services

- **Section 12.1** address requirements for other programs and services, including:
  - Programs and services to support the authority's functions and responsibilities related to the implementation and enhancement of the provincial groundwater monitoring program.
  - Programs and services to support the authority's functions and responsibilities related to the implementation and enhancement of the provincial stream monitoring program.
  - Programs and services to support the authority's functions and responsibilities related to the development and implementation of a watershed-based resource management strategy on or before December 31, 2024.
- **Section 12.4** provides the required components of the watershed-based resource management strategy, which include:
  - Guiding principles and objectives that inform the design and delivery of the programs and services that the authority is required to provide under section 21.1 of the Act
  - A summary of existing technical studies, monitoring programs and other information on the natural resources the authority relies on within its area of jurisdiction or in specific watersheds that directly informs and supports the delivery of programs and services under section 21.1 of the Act.
  - A review of the authority's programs and services provided under section 21.1 of the Act for the purposes of,
    - determining if the programs and services comply with the regulations made under clause 40 (1) (b) of the Act,
    - identifying and analyzing issues and risks that limit the effectiveness of the delivery of these programs and services, and
    - identifying actions to address the issues and mitigate the risks identified by the review, and providing a cost estimate for the implementation of those actions.
  - The broadening of the scope of the strategy under sections 21.1.1 (1) and 21.1.1 (2) of the Act where a memorandum of understanding or other agreement includes provisions that those programs and services be included in the strategy.
  - A process for the periodic review and updating of the watershed-based resource management strategy by the authority that includes procedures to ensure stakeholders and the public are consulted during the review and update process.

Appendix B:
Readiness Assessment Template

This Maturity Scale (based on FCM's Readiness Scale) measures progress of local governments in asset management practices. MNAI has adapted it for natural assets. The scale shows that creating and implementing an asset management system is an iterative process that takes time and resources and does not happen overnight. It is meant to structure the asset management journey and provide an objective means of evaluating progress.

Why complete the assessment as a first step?

This assessment will help municipalities understand their stage of asset management in the four competency areas for both engineered and natural assets, which will enable them to understand how their work on natural asset management fits into the asset management process. It can also help them develop a roadmap for progress and ensure that natural asset management considerations are incorporated into municipal planning, operations and service delivery.

How does it work?

FCM has developed a readiness scale with five main competencies that local governments need to develop a well-functioning asset management system:

1/ **Policy and governance:** creating policies and objectives related to asset management, bringing those policies to life through a strategy and roadmap, and measuring progress and monitoring implementation over time.

2/ **People and leadership:** creating cross-functional teams with accountability and ensuring adequate resourcing and commitment from senior management and elected officials to advance asset management.

3/ **Data and Information:** collecting and using asset data, performance data and financial information to support effective asset management planning and decision-making.

4/ **Planning and decision-making:** documenting and standardizing how the organization sets asset management priorities, conducts capital and O&M planning, and decides on budgets.

5/ **Contribution to asset management:** supporting staff in asset management training, sharing knowledge internally to communicate benefits of asset management and participating in external knowledge-sharing.

Communities can use the scale (*fcm.ca/en/resources/mamp/tool-asset-management-readiness-scale*) to assess maturity in asset management and progress in the competencies. The Canadian Network of Asset Managers has produced an "Introduction to AM for Communities" that explains the five AM competencies aligned with FCM's Readiness Scale[64].

Local governments may be performing well in one competency while working actively to improve performance in others. Every local government will have unique strengths and weaknesses and will need to create its own roadmap based on current status and priorities.

Tool: Competencies for building natural asset management into FCM's Asset Management Readiness Scale

MNAI has adapted the FCM Asset Management Readiness Scale to include indicators that demonstrate how local governments can build natural asset management considerations into standard asset management practices. MNAI has done this for four of the five competencies identified in the scale. The competency "Contribution to Asset Management" is less relevant and has been omitted for the purpose of this tool.

Instructions

1/ Bring a group of cross-functional staff together to conduct the self-assessment; this should not be done by one person in isolation.

2/ For each asset management competency, read through the descriptions and outcomes for each level.

3/ Discuss and evaluate your organization's current state. You may be at different levels for standard, engineered assets than for natural assets in each category or sub-category. Select a score based on your organization's level as a whole. You may be further advanced in some asset classes than others; the score should reflect the organization's overall maturity in asset management.

4/ Assign the level for which your organization has completed the corresponding outcomes.

5/ In the "Maturity Assessment Completion Form" below, describe briefly why you chose this level. You may note where you are further ahead (or behind) in certain areas.
Note: Natural asset management outcomes are shown in *blue, italics*.

64 *FCM. Asset Management Readiness Scale; https://cnam.ca/wp-content/uploads/2018/03/CNAM_AM101_BOOKLET_EN_HIRES.pdf*

Tips

- When self-assessing, choose the level that describes your achieved outcome. The exception would be Level 1, at which point you may be in the process of getting started. If you are still working on a level, assign yourself the previous level.
- Do not worry if you are at an early stage/level. This is not a test!
- You can progress through the five competencies in any order. The focus your efforts is up to you and will depend on local needs and priorities.
- Although the exercise is intended to be applicable to all infrastructure assets, please focus on water infrastructure assets (both engineered and natural) for the competencies: Data and information and planning and decision-making.

Competency: Policy and Governance

This competency involves putting in place policies and objectives related to asset management, bringing those policies to life through a strategy and framework, then measuring and monitoring implementation over time.

Working on Level 1	Completed Level 1	Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
We have set expectations for our AM program. We have the support we need to begin work on an AM policy.		We have drafted an AM policy and strategy and have developed a framework for our AM system.	We are using our AM policy to guide our actions. We have created a road map and have established performance measures.	We have a fully functional AM system. We are using performance measures to track progress and outcomes.	We are continually improving the AM system. Our AM objectives and road map are refined based on the evolving needs of our community.
POLICY AND OBJECTIVES OUTCOME					
Senior management is committed to formalizing an AM program. *Senior management has recognized the role of natural assets in service delivery as part of its commitment to a formal AM program.*		We have drafted an AM policy. Senior management and council have endorsed the AM policy. *Our AM policy explicitly includes natural assets and ecological services they provide to support municipal service delivery.*	We are starting to use AM policy to guide our actions. *Our policy objective(s) around natural assets are starting to guide our actions.*	We are managing assets and services in accordance with AM policy and organizational objectives. *We are managing natural assets in accordance with AM policy and objectives.*	We are validating and refining corporate, service and AM objectives based on the evolving needs of our community.

STRATEGY AND ROAD MAP					
Working on Level 1	Completed Level 1	Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
We have identified the benefits that we want AM to deliver and the benefits support organizational objectives. *We have identified the benefits that we want natural assets to deliver and the benefits support organizational objectives.*		We have completed the strategy and road map for our AM system that outlines our approach for the next 1 to 3 years. *Our strategy and road map include objectives related to natural asset management and show how it will be integrated into core infrastructure management processes over the next 1 to 3 years.*	We have established a road map to guide the detailed actions surrounding our AM strategy deployment over the next 3 to 5 years. *Our road map includes ecosystem-based management activities over the next 3 to 5 years, such as identifying plans and procedures to assess the health of natural assets.*	We are achieving our AM policy objectives through a fully functional AM system. Necessary workflows, documents and reporting tools are in place. We are updating our road map to address evolving needs. *We are achieving our natural asset-management objectives through our AM system.* *Necessary documents and reporting tools for the health of, and services provided by natural assets are in place.* *We are updating our natural assets-management plan to address evolving needs.*	We are following our road map in continually improving the AM system and in documenting the improvements. *We are continually improving our natural asset management plan.*

MEASUREMENT AND MONITORING OUTCOME					
Working on Level 1	Completed Level 1	Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
We have identified short-term actions that will demonstrate early progress on AM. *We have identified short-terms actions that incorporate natural assets.*		We are collecting baseline data on our current AM practices. *We have identified relevant baseline data for our natural assets.*	We have established performance measures to monitor AM system progress and its outcomes and benefits to our community. *We have included common monitoring measures of the health of natural assets, such as the total number of ecologically important species and pollution levels.*	We are using performance measures to monitor AM progress, outcomes and benefits. *We are using monitoring and performance measures of the health of natural assets that support municipal service delivery.*	We are monitoring performance and using the feedback to prioritize and make ongoing refinement and improvements. *We are refining our monitoring and performance measures of the health of natural assets that support municipal service delivery.*

Competency: People and Leadership

This competency involves setting up cross-functional groups with clear accountability, and ensuring adequate resourcing and commitment from senior management and elected officials to advance asset management.

CROSS-FUNCTIONAL REPRESENTATION OUTCOME					
Working on Level 1	Completed Level 1	Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
We have council support to establish a cross-functional AM team to explore AM needs and develop a plan for improving our AM system.		We have a clear mandate for our AM team, and council has approved funding for priority Improvements to our AM system.	Our AM team has clear responsibility for improving our AM system. Council champions AM as a core business function.	Our AM team is responsible for guiding and supporting AM on an ongoing basis. AM system roles and responsibilities are operationalized.	Our council's commitment drives continuous improvement of the AM system. Roles and responsibilities evolve to meet ongoing needs.
We have identified the representation we need on our cross-functional AM team. *The resources we have identified include staff from the key departments, such as engineering, public works, parks, engineering, planning, and finance to ensure a holistic and effective approach that can integrate natural asset management into the AM requirements.*		We have formed a cross-functional AM team to guide and oversee AM system planning and deployment. *Our cross-functional team includes a staff person responsible for incorporating natural asset management-related needs into our AM system.*	The AM team works within our organization to lead, communicate and support AM improvement and organizational changes. *A member of the AM team leads, communicates and supports improvements to natural asset management and champions its incorporation into core AM practices.*	Our AM team has been made permanent and tasked with guiding and supporting the AM function across the organization on an ongoing basis. *Our AM team has been tasked with guiding and supporting the integration of natural asset management in our AM system.*	The AM team guides and supports the ongoing improvement of the AM system within the organization. *The AM team is guiding and supporting the integration of natural asset management in our AM system.*

ACCOUNTABILITY OUTCOME					
Working on Level 1	Completed Level 1	Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
We have a champion who has been tasked with planning for our AM program. *The resources appointed to investigate our AM needs will include natural asset management-related needs in the terms of reference.*		Our AM team has been made accountable for guiding AM development, with a documented mandate, terms of reference, and a 1- to 3-year road map. Our AM team is accountable to senior management and council. *Our mandate and the terms of reference include a requirement to assess AM needs related to natural asset management.*	Our AM team has been made accountable for AM implementation and we have added AM system roles and responsibilities to staff job descriptions. *We have included natural asset management roles and responsibilities in staff job descriptions.*	We have operationalized AM roles and responsibilities across our organization. *We have operationalized natural asset management roles and responsibilities across our organization.*	We are documenting changes to AM roles and responsibilities as needed to support our evolving requirements. *The changes we are documenting include AM system roles and responsibilities needed to support evolving requirements related to natural asset management.*

RESOURCING AND COMMITMENT OUTCOME					
Working on Level 1 / Completed Level 1		Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
Council is aware of the resourcing and funding dedicated to exploring AM system requirements and to proposing an AM road map. *Council is aware of the resourcing and funding needed to incorporate natural asset management into the AM system requirements and road map.*		Council demonstrates buy-in and support for AM and has approved funding for priority improvements. *Council has demonstrated buy-in for priority initiatives that will improve natural asset management and incorporate it into core asset management business practices.*	Council champions AM as a core business function and has approved funding to continue AM road map activities. *Council has approved funding to improve natural asset management and incorporate it into core AM business practices.*	Council has approved funding for ongoing AM system monitoring and enhancement. *Our ongoing AM system monitoring and enhancement includes monitoring and enhancement of natural assets.*	The AM team measures and monitors this progress. Council is committed to ongoing improvement of the AM system. *The AM team measures and monitors this progress related to natural asset management. Council is committed to improving this aspect of our AM system.*

Competency: Data and Information

This competency involves using asset data, performance data and financial data to support effective asset management planning and decision-making.

ASSET DATA					
Working on Level 1 / Completed Level 1		Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
We have pooled inventory data, including approximate quantities of assets, within most asset groups. We have some anecdotal information on asset condition and age. *We have started to take an inventory of the natural assets in our jurisdiction that supports municipal service delivery.*		We have basic inventory data for most major assets, including information on general asset properties such as size, material, location and installation date. We are moving our data to a centralized location for use by the AM team. We have defined critical assets and have some condition information for them. *We have basic inventory data for some key natural assets, which includes the type, location and size of the asset.*	We have basic inventory data for all our assets, with some level of service information and standardized condition ratings. We have defined life-cycle investment requirements for critical assets. We have linked AM and financial information for our critical assets. *We have basic inventory data for all critical natural assets assumed to support municipal service delivery, which includes the type, location and size of the asset.*	We have expanded inventory data on some assets, including condition and performance information. We have evaluated the relative risks and life-cycle investment requirements associated with critical assets. We update data according to AM plans or strategy cycles. *We have expanded inventory data for some critical natural assets and have assessed the risks to them and evaluated operations and maintenance requirements to ensure they support the desired level of service.*	We have expanded inventory data and have evaluated the relative risks and life-cycle investment requirements associated with most assets. *We have expanded inventory data for most natural assets and have assessed the risks to them and evaluated operations and maintenance requirements to ensure they support the desired level of service.*

PERFORMANCE DATA OUTCOME					
Working on Level 1	Completed Level 1	Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
We have informal or anecdotal approaches for measuring asset condition or performance. *We are aware of common or emerging approaches for measuring the condition of our natural assets and their performance in supporting municipal service delivery.*		We have some information on asset condition and performance of critical assets collected from a variety of sources. *We have some information on the condition and performance of at least one critical natural asset, based on a combination of online data collection, field data collection and modelling (e.g., SWIMM for stormwater management performance).*	Some level-of-service measures have been defined and data have been captured. We have reviewed service levels and asset performance with council. *We have information on the condition and performance of the most critical natural assets and have defined the desired level of service for them and have reviewed this information with council.*	We have defined and measured levels of service for critical service areas. We communicate the results from our level-of-service measurement program to staff and council regularly. *We have defined the desired level of service for some critical natural assets and include results from our level-of-service management program to staff and council.*	We have defined and measured levels of service for most or all critical service areas. We continually improve how we collect data on level-of-service performance. *We have defined the desired level of service for most critical natural assets and we continually improve how we collect data on level-of-service performance and connect it to standard AM data.*

FINANCIAL DATA OUTCOME					
Working on Level 1	Completed Level 1	Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
We have financial data on our assets, supporting minimum PS-3150 reporting requirements. *We do not yet have financial data that puts a value on the national assets that support municipal service delivery.*		We have captured capital and operating expenditure data for some assets. We have developed a strategy to link AM and financial information. *We have captured capital and operating expenditure data for at least one critical natural asset, which will support the desired level of service required by the asset.* *We have completed an economic valuation of at least one critical natural asset, based on the replacement cost of grey infrastructure alternatives that could provide equivalent services.*	We have captured capital and operating expenditure data for most assets. We have linked AM and financial information for all critical assets. We can demonstrate the gaps between forecasted infrastructure needs and current spending levels. *We have captured capital and operating expenditure data for most critical natural assets that will support the desired level of service required by the asset.* *We have completed an economic valuation of most critical natural assets and have integrated this information into our AM system to support long-term financial planning.*	We have calculated the cost of service delivery for all critical assets. *We have incorporated the cost of managing some natural assets into financial planning and budgeting.*	We understand the trade-offs between investment and quality of the front line service we deliver, and we use this to refine our financial plans. *We have incorporated the cost of managing most critical natural assets into our long-term financial plans.* *We understand the trade-offs between investments in natural asset management and the quality of service they can deliver, and we use this to refine our financial plans.*

Competency: Planning and Decision-making

This competency involves documenting and standardizing how the organization sets asset management priorities, conducts capital and operations and maintenance planning, and decides on budgets.

Working on Level 1	Completed Level 1	Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
Our asset investment plans address basic needs and respond to known problems. We evaluate priorities based on experience, council and management input and available information.		Our asset investment plans address observed short-term issues. We evaluate each need individually, and teams set priorities independently of each other, based on objectives and criteria representing the needs of their departments.	Our asset investment plans manage short-term risks and service impacts. We set priorities based on common organizational goals and objectives. We have drafted preliminary AM plans.	Our asset investment plans balance short-term service objectives (our desired level of service) with longer-term goals and risks. Planning is carried out using our AM system and kept up to date via normal business.	Our asset investment plans are integrated to address risks to service and business goals. We have detailed AM plans for all services. We are continually improving our approach.
DOCUMENTATION AND STANDARDIZATION OUTCOME					
Our approach to asset investment planning varies across the organization. *Our approach to asset investment planning does not yet include a documented approach to managing or protecting the natural assets that support municipal service delivery.*		Our departments follow a similar but informal asset investment planning approach. We evaluate investment needs and priorities based on a mix of structured and ad-hoc practises and criteria. *One department is responsible for conservation and protection of natural assets, which have not typically been included in asset investment planning or evaluated in relation to the municipal services they provide.*	We have deployed a structured asset investment planning approach, but application is inconsistent. We set priorities using similar criteria based on organizational goals and objectives. *We have begun to incorporate investment plans for natural assets into our asset investment planning, in coordination with related service areas and departments.*	We employ a consistent structured asset investment planning approach across each of our critical services. We set priorities using criteria which are fully aligned with our organizational goals and objectives. *We are incorporating investment plans for natural assets in our asset investment planning and setting priorities that ensure conservation and protection of natural assets.*	We employ our structured asset investment planning approach across all services. We adapt our planning approach and criteria to align with evolving organizational goals and objectives. *Natural assets have been formally incorporated into structured asset investment planning, and their conservation, protection and management is a key organizational goal.*

ASSET MANAGEMENT PLANS OUTCOME					
Working on Level 1 / Completed Level 1		Completed Level 2	Completed Level 3	Completed Level 4	Completed Level 5
Our asset investment plans are typically reactive and focus on addressing basic needs (e.g., growth, regulations and known problems). Priorities are evaluated with available information, staff experience and input from council and management. *Asset investment plans focus on addressing needs related to grey infrastructure assets.* *Some commitments have been made to conserve and protect critical natural assets/areas, but these commitments have not yet translated into developing formal natural asset management plans.*		We have draft AM plans for some asset classes, with forecasted financial needs based on estimated data. *Natural assets are not yet incorporated into our asset investment plans in any formal way. Our approach to managing natural assets is short-term and reactive.*	Our asset management plans are based on short-term issues and priorities. We have drafted preliminary AM plans for critical services based on available information about service levels and risk management. *We have developed AM plans for some critical natural assets, which are based on available information about service levels and risk management. Plans are reviewed annually.*	Our asset management plans are based on short- and long-term issues and priorities. We have developed detailed AM plans for most services. They include basic-needs forecasting and risk management strategies for critical assets. *Our asset investment plans incorporate analysis from our risk-assessment and adaptive-management plans for key natural assets.*	We have integrated and optimized asset management plans. We have developed detailed AM plans for all services based on actual data. Our AM plans include needs forecasts and risk management strategies for most assets. Plans address risk to service and business goals. *Our asset investment plans are optimized and fully integrate management of natural assets to support sustainable service delivery.*

Appendix C:
MNAI Data Gathering Checklist

Introduction

Supporting communities in their natural asset management efforts requires data regarding the nature and extent of natural assets within the project area(s). This data underpins inventories, assessments and analyses. It includes GIS data, planning and management documents, and recent studies and assessments.

Many variables can be taken into consideration when identifying data inputs for an asset inventory; however, almost all inventories start with two data sets:

- Watershed, subwatershed, or other catchment area boundary
- Detailed land cover (e.g., forest, wetlands, grasslands, etc.) mapping of the area within the catchment boundary

The data collection process is iterative. As communities progress from determining asset boundaries to codifying asset attributes, for example, additional data will likely be needed. These additional inputs can be identified and incorporated into the inventory over time.

Data Availability

Not all communities will have all the required data sources readily available. Table A1 provides an overview of commonly used data and their source.

Inventory Component	Comments
Base map	Municipal boundaries, topography, regional watershed boundaries, landmarks and heritage sites, land ownership
Geology and Soils	
Bedrock and surface geology	Provincial data sets
Soils	Provincial data sets
Slopes and elevation	LiDAR
Water Resources	
Groundwater and Aquifers	Local data, where available
Watersheds	Local or provincial data sets
Streams and water bodies	Provincial data sets
Floodplains	Local or provincial data sets
Wetlands	Local or provincial data sets
Water quality	
Habitat & Wildlife	

Inventory Component	Comments
Significant biodiversity areas	Availability of this information is likely to vary across communities and will depend on how much your community has invested in research, mapping, and analyzing these features. These are more aspiration items to include in an asset inventory and not required to get started. If they already exist, then they can be included in the asset inventory to improve the associated attributes of the asset.
Stream and riparian habitat	
Wetland habitat	
Forests	
Grasslands and shrublands	
Unfragmented habitat blocks	
Cultural Resources	
Historic resources	As with habitat and wildlife supporting data, these are aspiration items to include in an inventory. If they already exist, then they can be included to improve the associated attributes of the asset.
Scenic resources	
Recreational resources	
Land use	
Zoning maps	Local data sets
Land use and land cover	Local, provincial, or national data sets Best to use the data set your community typically uses to define land use and land cover.
Farmland	Local data, or AAFC Annual Crop Inventory
Conservation and public lands	Provincial data sets Local data on land ownership

***Table C1**: Overview of Useful Data and Information to Support MNAI Asset Inventory Process*

Data Request/Checklist

As a starting point, MNAI seeks data and information pertaining to the items listed in Table 2. The data can be shared with MNAI via email or, for larger files that are not suitable for email, MNAI can provide a Sharepoint file dropbox link and password. This folder will allow secure transfer of up to 1TB of data.

DATA	STATUS, SOURCE AND AVAILABILITY
Land cover	
Forest composition (age, species)	
Forest canopy	
Forest management plans and forest harvest data	
Wetlands (type) and waterbodies	

DATA	STATUS, SOURCE AND AVAILABILITY
Watershed and sub-watershed boundaries	
Road networks	
Municipal planning documents	
Parks and protected areas	
Trails and recreation site	
Natural heritage strategy and action plans	
Land ownership and management	
Elevation	
Soil classification	
Crops and agriculture	
Stormwater management plans	

Table C2: *MNAI Data Request for Natural Asset Inventories*

Appendix D:
Co-benefit assessment methodology and limitations

Methodology

Within the past decade, considerable progress has been made to document links between functioning ecosystems and human well-being. de Groot et al. (2002), the Millennium Ecosystem Assessment (MA, 2005), and The Economics of Ecosystems and Biodiversity (TEEB, 2010) all marked key advancements in this task. Although all recognize the linkages are a simplification of reality and consequently the need for further research and refinement, these studies provide a framework for valuing natural capital and its related (ecosystem) goods and services.

Economists have numerous techniques for assigning dollar values to non-market goods and services of ecosystems, in three categories:

- Direct market valuation methods that derive estimates of ecosystem goods and services from related market data.
- Revealed preference methods that estimate economic values for ecosystem goods and services that directly affect the market prices of some related goods.
- Stated preference methods that obtain economic values by asking people to make trade-offs among sets of ecosystems, or environmental services or characteristics.

Valuation	Description	Welfare Measure
DIRECT MARKET VALUATION APPROACHES		
Market prices	Assigns value equal to the total market revenue of goods/ services.	Total revenue
Replacement cost	Services can be replaced with human-made systems; for example, waste treatment provided by wetlands can be replaced with costly built treatment systems.	Value larger than the current cost of supply
Avoided cost	Services allow society to avoid costs that would have been incurred in the absence of those services; for example, storm protection provided by barrier islands avoids property damages along the coast.	Value larger than the current cost of supply
Production approaches	Services provide for the enhancement of incomes; for example, water quality improvements increase commercial fisheries' catch and therefore fishing incomes.	Consumer surplus, producer surplus

Valuation	Description	Welfare Measure
REVEALED PREFERENCE APPROACHES		
Opportunity cost	Value of the next best alternative use of resources; for example, travel time is an opportunity cost of travel because this time cannot be spent on other pursuits. The travel cost method is a well-accepted application of the opportunity cost approach.	Consumer surplus,
Travel cost	Service demand may require travel, which have costs that can reflect the implied value of the service; recreation areas can be valued at least by what visitors are willing to pay to travel to it, including the imputed value of their time.	producer surplus,
Hedonic pricing	Service demand may be reflected in the prices people will pay for associated goods; for example, housing prices along the coastline tend to exceed the prices of inland homes.	or total revenue for
STATED PREFERENCE APPROACHES		
Contingent valuation	Service demand may be elicited by posing hypothetical scenarios that involve some valuation of alternatives; for instance, people generally state they are willing to pay for increased preservation of beaches and shoreline.	Compensating or equivalent surplus

Table D1: *Accepted valuation methods used to value ecosystem services*

Benefit transfer

Ideally, a valuation of ecosystem services should involve detailed ecological and economic studies of each ecosystem of interest for each land cover type, using one or more of the above valuation techniques. However, such studies are expensive and time-consuming. The benefit transfer approach can indicate order-of-magnitude values for services to help prioritize natural assets for a natural asset inventory.

The Troy & Bagstad study is a benefit transfer study. It employed criteria to identify appropriate primary studies including:

- Similar ecological and socio-economic context: studies from temperate areas in North America, Europe, and New Zealand were included.
- Acceptable methodology: Primary studies that used standard Environmental Economics non-market valuation methodologies were considered for inclusion.
- Peer reviewed studies: Although Troy & Bagstad included some grey literature, the vast majority of primary studies were peer reviewed.

Next, asset classes were assigned to the primary studies, per Table D2.

Source Data	Combined Landcover Types (i.e. the Continuous Asset Area)	Aggregated Asset Class (referred to as "Asset Type" in the Inventory)
SOLRIS	Agriculture	Agriculture
ELC	Cultural Meadow	Meadow / Successional
ELC	Cultural Plantation	Forest
ELC	Cultural Savanah	Meadow / Successional
ELC	Cultural Thicket	Meadow / Successional
ELC	Cultural Wetland	Marsh
ELC	Cultural Woodland	Forest
ELC	Forest	Forest
Wetlands	Marsh	Marsh
ELC	Open water	Water
ELC	Shallow water	Water
Wetlands	Swamp	Marsh
ELC	Tallgrass Prairie / Savanah / Woodland	Meadow / Successional

Assessment of uncertainty and limitations

Valuation exercises have limitations, although these should not detract from the core finding that ecosystems produce a significant economic (and other) value to society. These can be grouped into general limitations of non-market valuation, and limitations of benefit transfer.

General limitations might include:

- Static analysis: the majority of analyses are static, partial equilibrium frameworks that ignore interdependencies and dynamics.
- Increases in scarcity: valuations often underestimate shifts in the relevant demand curves as the sources of ecosystem services become more limited.
- Existence value: people value the existence of certain ecosystems, even if they never plan to use or benefit from them in any direct way.

Benefit transfer limitations might include:

- Unique ecosystems: every ecosystem is unique, so per-hectare values from another location may be irrelevant to the ecosystems being studied.
- Under-estimating the true value of ecosystems: gathering all information needed to estimate the specific value for every ecosystem within the study area is not feasible. Therefore, the true value of all the wetlands, forests, pastureland, etc. in a large geographic area cannot be ascertained and will be therefore be underestimated.
- GIS data: GIS quality assurance is a function of the reliability of land cover maps used in the benefits transfer, both in terms of accuracy and categorical precision.
- Spatial effects: ecosystem service valuation assumes spatial homogeneity of services within ecosystems (i.e. that every hectare of forest produces the same ecosystem services) which is clearly not the case.

Appendix E:
Risk identification template: MNAI Replicable Approach to Risk Identification for Natural Asset Inventories

Context

Once local governments have a completed natural asset inventory and condition assessment, a risk identification follows.

In the context of asset management, risk is often defined as a combination of the probability of an impact occurring and the relative magnitude of its negative consequences. MNAI's Natural Asset Inventory projects incorporate a *Risk Identification* as a first step in the risk assessment process to identify top risks to natural assets in terms of their ability to provide target services.

Risk identification is less resource-intensive and comprehensive than a full risk assessment. The latter consider a wider range of risks and can involve: specifying priorities, acceptable levels of risk, procedures to be followed within the organization, allocation of resources, identification of necessary policies and setting up systems to ensure required actions are in place.

The goal of the Risk Identification is to identify top risks to natural assets and their associated services. This is a starting point for setting priorities. Outputs should be assessed against a local government's risk tolerance. Risks that are of high priority, and towards which the local government has low tolerance, can then be formally assessed to identify and evaluate actions to reduce vulnerability.

Type of Risk	Explanation	Examples
Natural asset service risk	The risk of an asset failure that directly affects service delivery.	■ Aquifer contamination that results in a lack of safe drinking water ■ An inaccessible trail network restricts recreational activities
Strategic risk	The risk of an event occurring that impacts the ability to achieve your organizational goals.	■ Hot, dry conditions related to climate change that puts pressure on ability to meet water service demands ■ Change in provincial or federal grant programs that reduces available grant funding
Operations and maintenance risk	Risks related to poor asset controls and oversight, which can lead to poor record-keeping and poor monitoring of asset performance.	■ Flooding due to improperly maintained culverts ■ Crowding out of native species due to unmonitored expansion of invasive species

***Table E1**: Types of risk relevant to natural asset management*

Approach

STEP 1: IDENTIFICATION OF RISKS

- For the natural assets identified in this Project (e.g., wetlands, forests, urban greenspace and agriculture), review the list of common risks in the box below. As you review each risk, think about cascading effects that the loss of functions of this natural asset would have on built infrastructure, personal health and safety, and private property.
- Remove risks that are not relevant and add any that are missing. A 10-year time horizon is recommended for this exercise.
- Key staff to involve could include:
  - Environmental management staff (e.g., biologists, ecologists, hydrologists), municipal planners, parks staff, asset managers, public works/engineering, and finance.

Common Risks to Natural Assets:

- Overuse of trails/dumping
- Flooding (current and future)
- Forest fire
- Invasive species
- Development pressure
- Pollutant loading from urban, agricultural, or industrial sources (e.g., overuse of salt on roads)
- Drought (current and future)
- Erosion
- Ice jams
- Storm surge

STEP 2: COMPLETE SURVEY

MNAI recommends a 1-2-hour internal workshop to complete this exercise.

1/ Amend Table 2 to reflect the relevant risks identified in Step 1.
2/ In Amended Table 2, rate each risk as low, medium or high.
3/ For each risk, identify the location of the risk (where possible) on a map using the risk number corresponding with Table 2.
4/ In the notes section, include considerations of importance (e.g., imminent risk vs. future risk, manageable vs unmanageable, tolerable vs intolerable).

Sources of information for identifying risks include:

- Risk registers and risk reports
- Issues log
- Business Impact Analysis
- Environmental assessments
- Watershed studies
- Flood hazard mapping
- Land management plans
- Monitoring reports

Risk	Ranking	Assets Affected	Location	Notes
1/ **Overuse of trails/ dumping**				
2/ **Flooding**				
3/ **Forest fire**				
4/ **Invasive species**				
5/ **Development pressure**				
6/ **Pollutant loading from urban, agricultural, or industrial sources**				
7/ **Drought**				
8/ **Erosion**				
9/ **Ice jams**				
10/ **Storm surge**				
11/ **Others?**				

Table E2: *Simplified Risk Identification Survey*

Appendix F:
Natural Asset Management Strategy Guidance

Through Ontario's Provincial Policy Statement 2020, the regulatory context in Ontario requires watershed-scale land use planning. It also recognizes the role of green infrastructure in supporting cost-effective service delivery and building resilience to climate impacts. Furthermore, natural assets have to be included in local government asset management plans by 2024. The Conservation Authorities Act does not yet require green infrastructure to be included in asset management plans, but Conservation Halton has expressed interest in incorporating natural assets into its asset management framework. MNAI advises that Project Partners consider developing a *natural asset management strategy* to guide next steps on management of natural assets in the Grindstone Creek, using Project results and recommendations as a basis.

The natural asset management strategy would describe the key practices, processes, tools and decision-making framework that partner organizations will use to prioritize actions and guide management of natural assets in the Grindstone Creek watershed. A strategy is a higher-level document than a watershed asset management plan, which would represent a detailed, long-term asset investment plan for natural assets in the watershed. Project Partners could develop such a collaborative plan or the strategy could guide each organization's asset management plans for the natural assets in their jurisdiction. Content could include:

1. PURPOSE AND SCOPE OF THE STRATEGY

Identify the services and assets within the scope of the strategy.

2. BACKGROUND

Describe general characteristics of the Grindstone Creek watershed and current roles and responsibilities related to protecting and managing natural assets and related services and co-benefits they provide to the community.

3. STRATEGIC ALIGNMENT

This section would describe the regulatory and policy context ford land use and asset management planning that the strategy aligns with, including O. Reg 588/17 asset management requirements, the Provincial Policy Statement 2020, and the requirements of the NEC. It could also describe how this strategy supports any Project Partner strategic documents including asset management policies, strategies or plans, climate change strategies or plans, resilience strategies, urban forest strategies or plans, stormwater management plans, and Official Community Plans.

4. BUSINESS CONTEXT

This section would explain the business context for the natural asset management strategy and outline the challenges and opportunities the strategy will help Project Partners address, including:

- The impacts to the City of Burlington on stormwater management and water quality resulting from factors arising in the City of Hamilton (e.g., development, degradation of natural assets, erosion).
- The need for collaboration and partnerships to prioritize and fund natural asset management.
- The need to better incorporate natural asset management considerations into asset management planning in all partner organizations.
- The need to strengthen information about ecological performance, condition of and risks to natural assets in the Grindstone Creek watershed.
- The need to share natural asset data and information, coordinate monitoring and updates related to condition, risks and levels of service.
- The need to develop clear roles, responsibilities and accountability mechanisms that ensure protection and proactive management of natural assets in the Grindstone Creek watershed.

Understanding the business context helps determine resources and effort required to implement the strategy.

5. NEEDS AND EXPECTATIONS OF STAKEHOLDERS

This section would identify stakeholders and rights holders (e.g., Indigenous communities) receiving or possibly helping to deliver natural asset-related services, and their needs and expectations. This helps inform setting-appropriate natural asset management objectives. The section could articulate how stakeholders and rights holders will convene and collaborate; and, describe the governance structure, meeting routines, and decision-making approach. Project Partners may wish to articulate how they will engage with relevant stakeholders outside of a core governance group.

Considerations that Project Partners will need to address include:

- How they will coordinate tracking, reporting and managing condition, risks and service performance of natural assets in the Grindstone Creek watershed.
- Whether and how partners will evaluate and prioritize infrastructure investment projects within and across service areas where multiple jurisdictions are implicated (e.g., stormwater management).
- What governance and accountability mechanisms will ensure the strategy receives support from Councils and governing bodies.

- How the broad group of stakeholders with interests in the Grindstone Creek watershed will be engaged in the development or implementation of the strategy.

6. GOVERNANCE AND DECISION-MAKING FRAMEWORK

This section would: describe the governance structure and decision-making framework guiding strategy implementation; include the roles of stakeholders (including partner organizations) in managing and protecting natural assets in the watershed; and, note agreements in place or to be negotiated to support protection and management of natural assets in the Grindstone Creek watershed.

To successfully implement a collaborative natural asset management strategy, partner organizations will need support and visible endorsement from senior management and a governance structure that ensures the right people are assigned to the right roles, and understand their roles, responsibilities and accountabilities.

This section should define criteria around which objectives are set and decisions made, who is responsible for the strategy, who is implementing it, and who reports on it.

7. ASSET MANAGEMENT OBJECTIVES

Asset management objectives guide decision-making and define what Project Partners are trying to achieve with natural assets in the Grindstone Creek watershed. Each party to the strategy would need to support them. Some objectives may be achieved through a partner organization's own asset management plans, others, through a collaborative watershed natural asset management plan, should Project Partners develop one. There may be opportunities to jointly seek funding for restoration projects that support natural asset management.

Some objectives can be defined to address the priorities identified through this Project, for example, to address gaps in capacity, resources, and asset management planning that Project Partners identified.

8. RISKS AND OPPORTUNITIES OF THE STRATEGY

Project Partners may wish to document the risks and opportunities arising from the strategy and articulate how it could mitigate risks and take advantage of opportunities.

An example of a risk could be a lack of buy-in from senior administrators or Councils that results in insufficient resources to implement the strategy, or governance challenges that stifle agreement on shared objectives.

Examples of opportunities could be the willingness of stakeholders to collaborate and share the cost of restoration activities, or technology that improves monitoring of the performance, functioning or condition of natural assets.

9. MONITORING AND CONTINUAL IMPROVEMENT

This section would articulate how partners will monitor implementation of the strategy and measure performance. Good practice suggests to:

- Seek opportunities to use existing data and monitoring activities to monitor progress.
- Create metrics that are SMART (Specific, Measurable, Achievable, Realistic and Timebound) to ensure monitoring is relevant.
- Solicit ideas from people on the front lines of service delivery.

Appendix G:
Implementation options chart

COMPONENTS & EXAMPLES	SHORT-TERM Actions that can be prioritized in next 12 mos, OR already underway and into which Project results can be integrated	MEDIUM-TERM Actions that can be considered over 12-36 mos, OR are within current planning horizon of local governments already and into which project results can be integrated	LONGER-TERM Actions for 36 mos+ and/or to research further	KEY QUESTIONS	SKILL SETS / WHO TO ENGAGE Consider both local government and/or others with title/ jurisdiction	LEAD
LOCAL GOVERNMENT EDUCATION, CAPACITY						
Increased staff understanding of role of NAM in delivering service				Does your organization have a cross departmental asset management team? Is there interest in merging natural asset management with traditional asset management?	Asset management	
Human resources practices are adapted	Services can be replaced with human-made systems; for example, waste treatment provided by wetlands can be replaced with costly built treatment systems.	Value larger than the current cost of supply			Human resources	
Staff receive training where needed	Services allow society to avoid costs that would have been incurred in the absence of those services; for example, storm protection provided by barrier islands avoids property damages along the coast.	Value larger than the current cost of supply			Human resources	
LOCAL GOVERNMENT STRATEGY, POLICY, BYLAW						
Natural asset management policy	Is Halton Region currently revising its policy?	CoB - Forestry dept could be interested in NA policy; COH - no policy, but could be brought forward			Asset management; policy specialists	
Natural asset management plan	Region of Halton completing AM plan updates	Applicability in other CH watersheds to incorporate natural asset planning into asset management for infrastructure as CH owns and operates 4 large dams and reservoirs and owns and maintains 3 concrete-lined channels in urban setting		Where is AM planning at and how are you going to bring in NA considerations and when?	Asset management; policy specialists; planners	
Natural asset management strategy					Asset management; policy specialists; planners	
Official Community Plans, Subdivision Bylaws, Development Charge Bylaws, Zoning	Process is underway for CH to participate in the review of municipal Official Plans. CH is delegated responsibility to comment on Official Plan policies on behalf of natural hazard aspects and provides advice regarding natural heritage and water management.			What existing practices, tools, plans, and resources are related to the management of natural assets(e.g. bylaws, conservation plans, ISMPs, etc.) Can each partner provide a list of relevant toola, policies, plans, etc.? What abilities do you have to change or provide input to recommended regulations, bylaws, policies?		

COMPONENTS & EXAMPLES	SHORT-TERM Actions that can be prioritized in next 12 mos, OR already underway and into which Project results can be integrated	MEDIUM-TERM Actions that can be considered over 12-36 mos, OR are within current planning horizon of local governments already and into which project results can be integrated	LONGER-TERM Actions for 36 mos+ and/or to research further	KEY QUESTIONS	SKILL SETS / WHO TO ENGAGE Consider both local government and/or others with title/ jurisdiction	LEAD
PROGRAMS, FINANCING, INVESTMENT & OPERATIONS (LOCAL GOVERNMENT AND/OR COMMUNITY PARTNERS OR OTHERS WITH TITLE/RIGHTS)						
Rehabilitation project				Partners should identify and rank by priority a few scenarios of interest and share them with the MNA|team to discuss whether they can realistically be modelled for this project, and what type of resources may be required to model them in the future		
Acquisition Project						
Integration of NAM into stormwater management plan				When is next update of stormwater management plan (CoH, CH, RBG)?		
Monitoring project				Where are monitoring & weather stations currently located and what is being monitored.		
Activities to scale up from subwatershed		There would be applicability in other CH watersheds to incorporate natural asset planning into asset management for infrastructure as CH owns and operates 4 large dams and reservoirs and owns and maintains 3 concrete-lined channels in urban settings				
Long term financial planning				What information is required for financial planning in CH, COB, COH,and RBG? How different are your financial planning needs? What knowledge from this project could feed into the capital project planning and procurement process over the short- term and over the longer term as natural asset management planning becomes more integrated into your asset management planning?		
Costed 0&M plans						

COMPONENTS & EXAMPLES	SHORT-TERM Actions that can be prioritized in next 12 mos, OR already underway and into which Project results can be integrated	MEDIUM-TERM Actions that can be considered over 12-36 mos, OR are within current planning horizon of local governments already and into which project results can be integrated	LONGER-TERM Actions for 36 mos+ and/or to research further	KEY QUESTIONS	SKILL SETS / WHO TO ENGAGE Consider both local government and/or others with title/ jurisdiction	LEAD
EXTERNAL ENGAGEMENT, AWARENESS & PARTNERSHIPS						
Mechanisms in place to engage others win title/ jurisdiction				List your current partnerships that support natural asset management (assessment, management, restoration, etc.) Who is missing? Who needs to be at the table to help advance these goals?	What organization is leading? Discussion needed on what level of support each partner will contribute What resources are available and what is missing?	
Incorporation of traditional Indigenous knowledge				Need early / ongoing scoping and dialogue with relevant First Nations		
School/community engagement						
University partnerships						
Communication through financial reports and tote community				Is there interest in assessing priority co-benefits of the watershed? If so, identify which co-benefits are of interest to assess for this project (up to 6 co-benefits)?		
THIRD PARTY SUPPORT FOR NAM						
Funding from ICP. DMAr	Hamilton water dept is looking into ICIP. DMAF, FCM; CH tapping into some of those organizations; RBG apply for funding annually for restoration work			What sources of funding for asset management do you normally apply for? Do you see new opportunities on the horizon (e.g. Economic Stimulus Funding?		
Insurance Sector						
Capital markets						
ADDITIONAL ENGAGEMENT OF OTHERS WITH TITLE/JURISDICTION						
Covenants. Easments or similar tools						

Municipal Natural Assets Initiative