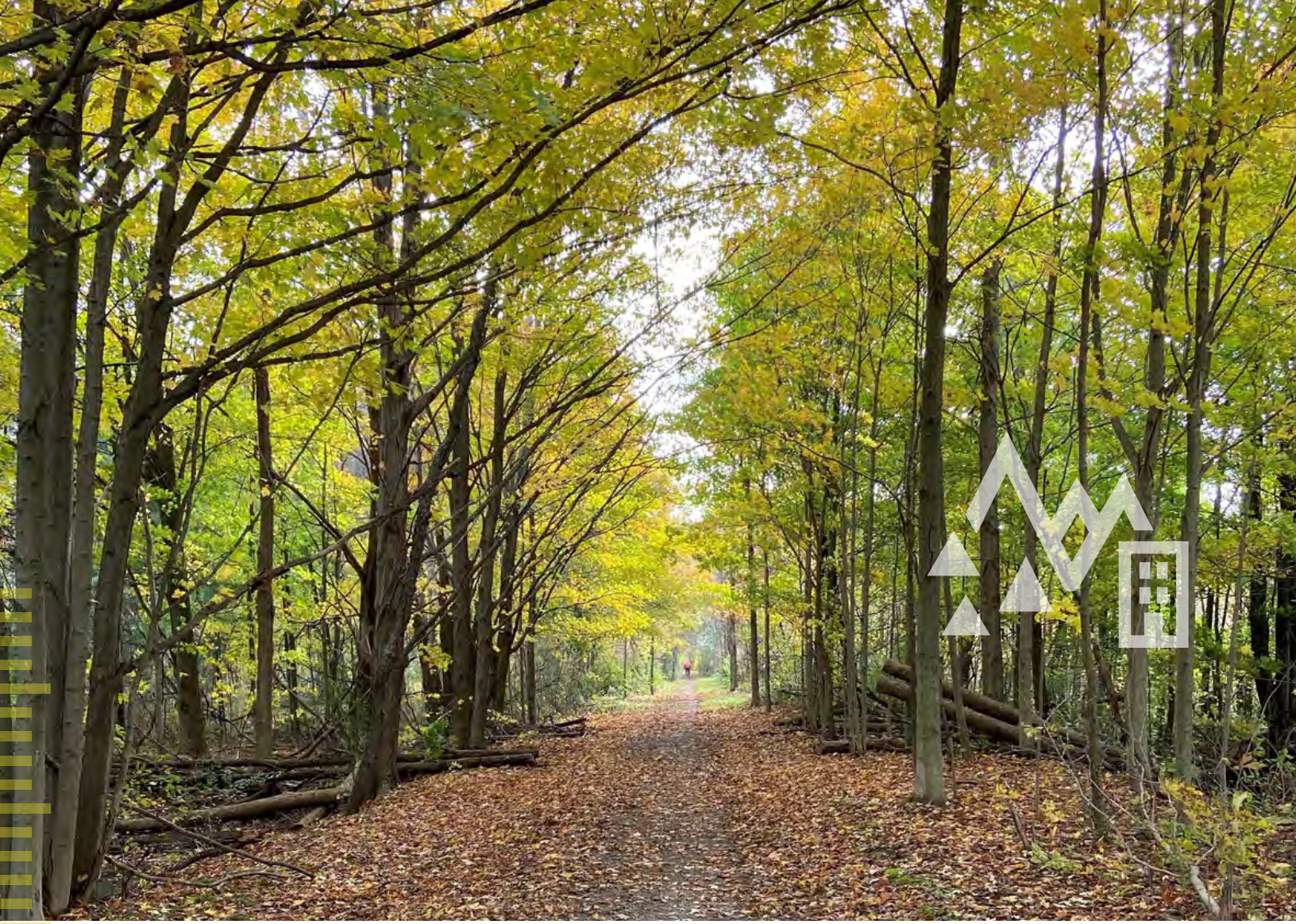

The Pelham Greenbelt

Natural Asset Management Project

Pelham NIAGARA

Natural Assets Initiative
MAKING NATURE COUNT

Technical Report

June 2024

Invest in Nature

The Natural Assets Initiative (NAI) is a Canadian not-for-profit that is changing the way local governments, watershed agencies, and others deliver everyday services — increasing the quality and resilience of infrastructure at lower costs and reduced risk. The NAI team provides scientific, economic, and municipal expertise to support and guide local governments 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.

Town of Pelham Land Acknowledgement

The Town of Pelham acknowledges the land on which we gather is the traditional territory of the Haudenosaunee and Anishinaabe peoples, many of whom continue to live and work here today. This territory is covered by the Upper Canada Treaties and is within the land protected by the Dish With One Spoon Wampum agreement. Today this gathering place is home to many First Nations, Métis, and Inuit peoples and acknowledging reminds us that our great standard of living is directly related to the resources and friendship of Indigenous people.

Acknowledgement

This project was generously supported by the Greenbelt Foundation.

Disclaimer

While reasonable efforts have been made to ensure the accuracy of the report's content, any statements made are made only as of the date of the report and such information and data are subject to uncertainties, inaccuracies, limitations and to changes based on future events. Natural Assets Initiative makes no representations, warranties or guarantees (express, implied, statutory or otherwise) regarding the data on which the information is based or the information itself, including quality, accuracy, usefulness, fitness for any particular purpose, reliability, completeness or otherwise, and assumes no liability or responsibility for any inaccuracy, error or omission, or for any loss or damage arising in connection with or attributable to any action or decision taken as a result of using or relying on the information in the report.

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photos courtesy of the Town of Pelham

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Acronyms

AES	Atmospheric Environment Service
CVC	Credit Valley Conservation Authority
EC	Environment Canada
EPA	Environmental Protection Agency
ESRI	Environmental Systems Research Institute
GIS	Geographic information system
ha	Hectares
ICI	Commercial and Institution
IPBES	Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services
IPCC	Intergovernmental Panel on Climate Change
LOS	Levels of Service
LID	Low impact development.
m	metre
NAI	Natural assets initiative
NAM	Natural asset management
NbS	Nature-based solutions
NDMNRF	Ontario Ministry of Natural Resources and Forestry
NEC	Niagara Escarpment Commission
NPCA	Niagara Peninsula Conservation Authority
O&M	Operations and Maintenance Plans
OP	Official Plan
PCSWMM	Personal computer storm water management model
SWM	Stormwater management
TMC	Twelve Mile Creek
TRCA	Toronto Region Conservation Authority
UTMC	Upper Twelve Mile Creek
WTP	Willingness to Pay

1.0 Executive Summary

Canadian local governments, conservation authorities, Indigenous and Métis Nations, and other entities face infrastructure and asset management challenges. 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 Town of Pelham, Ontario, with support from the Greenbelt Foundation, partnered with the Natural Assets Initiative (NAI), a Canadian non-governmental organization on the *Pelham Greenbelt Natural Asset Management Project*. The goal of this project is to ensure that natural assets in the Town of Pelham, and particularly those that overlap with Ontario's Greenbelt, are identified, measured, valued, and ultimately managed to protect their integrity, thereby ensuring a reliable flow of core services and diverse co-benefits across the municipality and the Greenbelt.

Three project objectives support this goal:

1/ Understand the current roles of natural assets in the project area in providing stormwater management and flood mitigation services to the residents of Pelham

2/ Quantify the value of natural assets in the project area in terms of service provision, including determining costs and benefits relative to engineered alternatives

3/ Develop strategies for long-term management of natural assets based on this understanding

The Project is unique to previous NAM projects in that it had specific considerations for the local government and the Ontario Greenbelt, which covers 2 million acres (> 80,000 ha) of protected farmlands, forests, rivers, wetlands, and lakes. Two study areas were required; the first analysis was completed in the Upper Twelve Mile Creek subwatershed, which intersects the Town and the Greenbelt, to assess stormwater management benefits. The second was the Town of Pelham's jurisdictional boundaries, which is a common scale for natural asset management assessments.

Over the course of the study, the Project produced data, modelling, and strategies for the Town of Pelham to protect and manage natural assets in order to enhance sustainable core services, and the sustainable delivery of co-benefits. These included:

- Developing an interactive, web-based inventory with information on location, size, and extent of natural assets in the Town of Pelham, and condition of natural assets.
- Scenario modelling to assess role of natural assets in stormwater management (peak flow attenuation and runoff) and consider future development alternatives.

- A valuation of natural asset service contributions to stormwater management, and well as an assessment and valuation of co-benefits (e.g., climate regulation, fresh water, and recreation services).
- An analysis of planning and management strategies, including operations and maintenance, to inform continual improvement.
- Outlining recommended next steps to advance comprehensive natural assets management efforts.

PROJECT OUTCOMES

The Project demonstrates that the natural assets in the Town of Pelham provide core ecosystem services that contribute to the community's well-being, ecosystem health, and mitigating infrastructure challenges.

Specifically, the stormwater modelling and analysis highlighted the significant stormwater management services provided by natural assets in Upper Twelve Mile Creek. While LID units and SWM ponds can partially replicate these functions, their implementation is significantly more expensive and less effective at reducing peak flow compared to maintaining natural assets.

The natural assets do face several risks including climate change, urbanization, and pollution, which can affect their ability to provide essential services in the Town. The Project provides a foundation of initial data and priorities on which the Town can expand efforts to further effective natural asset management, as well as policy strategies to support NAM implementation. Specific recommendations are provided for long-term management.

RECOMMENDATIONS

Detailed recommendations are listed in *Section 6*.

1/ Review policies and governance to protect and manage natural assets
2/ Proactively manage and monitor erosion sites
3/ Formalize invasive species management
4/ Identify priority areas for naturalization
5/ Continue to secure or protect priority forests and wetlands
6/ Review opportunities to proactively manage riparian areas along watercourses
7/ Support collaboration and develop partnerships to advance natural asset management in the Town of Pelham
8/ Strengthen assessment of natural assets and related services in the Town of Pelham
9/ Include a costed lifecycle management strategy for natural assets in updates to the Town's asset management plan
10/ Develop a communications plan and presentation to build awareness of the value of natural asset management needs in the watershed
11/ Build staff and Council awareness of and support for natural asset management

2.0 Introduction

This section introduces the context for natural asset management (NAM) including: the rationale for NAM, the Pelham Greenbelt Natural Asset Management Project goals and objectives and the project limitations.

Canadian local governments, conservation authorities, Indigenous and Métis Nations, and other entities face infrastructure and asset management challenges. Many services these organizations provide, including water and wastewater, waste removal, transportation, flood attenuation, erosion control, and environmental services, depend on ageing engineered infrastructure assets that need renewal. Meanwhile, climate change places increasing pressure on the existing infrastructure stock.

The term 'natural assets' refer to the stock of natural resources or ecosystems that a municipality, regional district, or other watershed rightsholders or stakeholders could rely on or manage for the sustainable provision of one or more services.[1] Effective stewardship of natural assets helps these entities deliver more resilient services in a changing climate, reduce associated costs, and provides an alternative to "building their way out" of infrastructure challenges. Natural assets can provide both critical infrastructure services and numerous co-benefits that add to community quality of life. This practice has become known as a natural asset management (NAM), a subset of the broader field of nature-based solutions (NbS). NAM enables nature to be conceptualized, accounted for, restored, protected, and managed as a vital asset to ensure its long-term viability. NAM is based on standard asset management methods that Canadian public sector entities are increasingly required to adopt, methods which the Natural Assets Initiative (NAI) has adapted for the unique considerations of nature. NAM has evolved from a single isolated initiative in 2017 to action being taken by over 140 local governments across multiple provinces in 2024.

Natural asset management is highly relevant in addressing climate change. A 2021 report from the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) and the Intergovernmental Panel on Climate Change (IPCC), for example, notes that "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."[2] The recently released IPCC Sixth Assessment Report includes a headline statement that stresses the fundamental importance of safeguarding biodiversity and ecosystems in the development of climate resilience.[3] It goes on to advise that "maladaptation can be avoided by flexible, multi-sectoral, inclusive, and long-term planning

1 MNAI (2017).

2 *Pörtner et al. (2021).*

3 *IPCC AR6 WGII (2022).*

and implementation of adaptation actions with benefits to many sectors and systems"[4]. 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.

The urgency to accelerate NAM is particularly acute in urban and peri urban areas; approximately 80% of Canadians live in the interface between natural and urban areas where nature is extremely important, but also highly vulnerable.[5] This project addresses this need. The Town of Pelham is located within the Ontario Greenbelt — the world's largest greenbelt at over 2 million acres. The Pelham Greenbelt Natural Asset Management Project (hereafter, "the Project") is designed to integrate nature and its services into the Town's financial planning and asset management programs. This report provides Project results to date.

2.1 Project Goal & Objectives

The Project's goal is to ensure that the natural assets within the Town of Pelham, and particularly those that overlap the Town and the Greenbelt, are understood, measured, valued, and ultimately managed to protect their integrity, and thus ensure their reliable flow of core infrastructure services and diverse co-benefits.

Three objectives support this goal:

1/ Understand the current roles of natural assets in the project area in providing stormwater management and flood mitigation services to the residents of Pelham
2/ Quantify the value of natural assets in the project area in terms of service provision, including determining costs and benefits relative to engineered alternatives
3/ Develop strategies for long-term management of natural assets based on this understanding

These objectives required two study areas:

1/ Stormwater benefits were assessed for a subwatershed that intersects the Town and the Ontario Greenbelt using hydrological modelling. This analysis was completed at an appropriate ecological scale for assessing water-based services in the Upper Twelve Mile Creek subwatershed.
2/ Local government scale (i.e., the Town of Pelham's jurisdictional boundaries), which is a common scale for natural asset management assessments.

4 *IPCC AR6 WGII (2022,* p. 35).
5 *Brown et al. (2021).*

These goals and objectives are laid out in a Service Agreement between NAI and the Pelham.

NATURAL ASSET MANAGEMENT METHODOLOGY

The methodology for the Pelham Greenbelt Natural Asset Management Project is based on standard asset management practices that Canadian local governments are increasingly required to adopt, and which are articulated by organizations such as Asset Management BC, based on global norms (see Figure 1). NAI has adapted methodologies to ensure that natural assets — which are complex in their role in service delivery, are context-specific, and present novel considerations — can be effectively integrated and considered in asset management.

***Figure 1**: Natural Asset Management Wheel*

Source: NAI, 2017; Adapted from Asset BC, 2014

Why use an asset management-based methodology to understand the relationship between local governments and nature?

- Asset management is becoming ubiquitous among Canadian local governments, offering scope to make NAM a broadly based, scalable and comparable practice.
- Ontario is the first province in Canada to regulate asset management planning at the municipal level and to require consideration of both human-made and natural assets as part of this process.
- 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.

2.2 Limitations & Assumptions

The Project contains several limitations and assumptions. For this project, the following modelling limitations are noted.[6]

INCOMPLETE INFORMATION

Asset management is an *adaptive* management cycle, not a finite process. While this report is current at the time of its writing, many elements will evolve in response to data, feedback loops, actions taken by Pelham, and continuous improvement.

VALUATION

NAI estimated the value of some of the services from nature relevant to the beneficiaries in this project, including local governments and communities more generally. Together, these service values provide a composite figure that can be considered as a *minimum service value*.[7] 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, only a portion of the many services provided by the ecosystems are valued in the Project.

6 Assessment limitations are explained in further detail in sections 4.4 and 5.3 of this report.

7 It is also important to recognize these findings in terms of minimum service value because, unlike engineered assets that depreciate and decay, natural assets are often adaptable, providing services that become more valuable over time within a changing climate.

MODELLING

NAI undertakes detailed hydrologic modelling to assess the Levels of Service (LOS) that natural assets provide, and the value of those services, to allow for service-based comparisons with engineered assets. However, all environmental modelling simplifies systems and is limited by the assumptions required for generalization.

INDIGENOUS PEOPLES

The project has several limitations with respect to Indigenous peoples. Indigenous Traditional Knowledge and practices are based in a holistic and inherent understanding of nature, the benefits it provides, and the connections between all living things. All NAM initiatives, including the Pelham Greenbelt Natural Asset Management Project, will achieve better outcomes when they include Indigenous worldviews, knowledge, and perspectives.

This requires sustained, meaningful collaboration with Indigenous Nations. The Project provides an opportunity to learn from those who have lived in the region for millennia and determine ways in which their knowledge and perspectives can inform and be included in all resultant project programming.

There is little published literature specific to the uptake of NAM by Indigenous Nations, including First Nations.[8] 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 Nations, and differences in definition, approaches to managing assets, and cultural relationships with nature.[9] Long-term, culturally-appropriate engagement may be required to overcome this in the context of the Town of Pelham.

8 *Reed et al. (2022).*

9 NAI recognizes 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.

3.0 Local context

This section introduces the local context for the Pelham project including: the geography, people of the area and the land uses.

3.1 Indigenous Peoples

The project area is located on the traditional territory of the Haudenosaunee and Anishinaabe peoples. The territory is covered by the Upper Canada Treaties and protected by the Dish With One Spoon Wampum agreement. Today, the project area is home to several First Nations, Metis, and Inuit people. The Project and related work respects their Rights and Title.

3.2 Geography

The modelling focus for the Pelham Greenbelt Natural Asset Management Project are the lands that intersect with Ontario's Greenbelt — a protected area of greenspace, farmland, forests, and wetlands — that surrounds much of the Golden Horseshoe region in the province. Wherever possible, results were provided for the entire Town of Pelham to accommodate the Town's desire to complete natural assets management for the Town.

The ecological modelling boundary of the project is the Upper Twelve Mile Creek (UTMC) subwatershed.

The Upper Twelve Mile Creek is a natural ecosystem largely untouched by human activity and provides a diverse landscape and unique ecosystem. The stewardship of this watershed is crucial for maintaining high-quality groundwater for the Town of Pelham while preventing erosion and providing flood control for the lower and middle Twelve Mile Creek.

The UTMC subwatershed spans approximately 51 km² and is part of the larger Twelve Mile Creek (TMC) watershed that spans 178 km² and drains into Lake Ontario. The natural assets of focus include forests, watercourses, and wetlands. It originates as a spring-fed tributary and spans 22 km. It flows through the municipalities of Pelham, Thorold, St. Catharines and Lincoln. The UTMC spans approximately ⅔ of the Town (80 km²). Of this, 24 km² is within the Niagara Escarpment Plan area, which includes Fenwick, the Hamlet of North Pelham, and the Hamlet of Ridgeville. *Figure 2* shows the approximate location of the UTMC subwatershed in relation to the Town of Pelham and the TMC watershed.

The UTMC subwatershed has unique characteristics, including[10]:

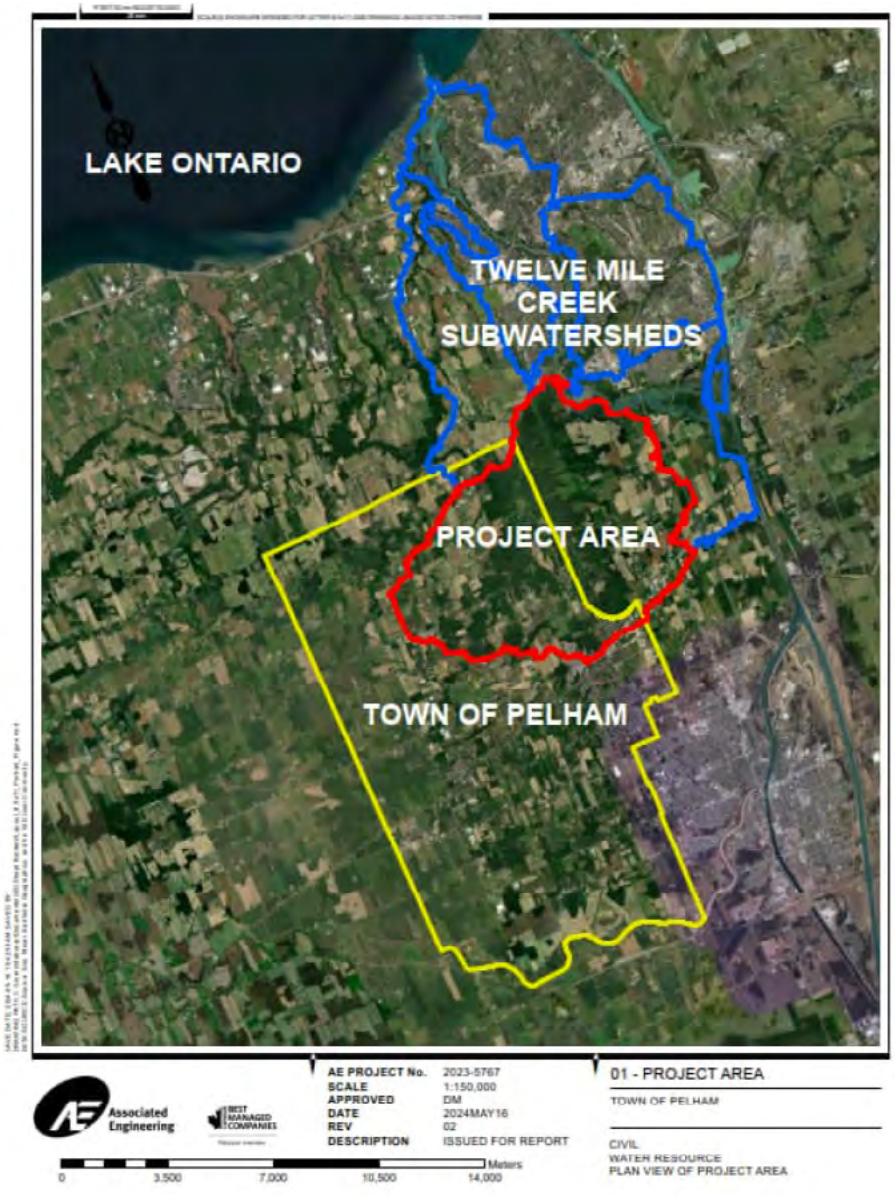
- The geology of the Fonthill Kame-Delta Complex. The porous Kame soils allow for rapid infiltration of precipitation and snowmelt and the pressure differential created by the underlying Haldimand clays allows for the release of constant, cold-water (18 degrees Celsius or less).

10 *Baker, J.L. (2021).*

- A self-sustaining population of Brook Trout. Brook Trout are the last remaining salmonid fish species in the Niagara region and their reproductive health is sensitive to change in creek conditions such as temperature increase, pollution, or increased turbidity.
- Diverse flora and fauna. Due to the moderated climate by the Great Lakes and unique land-formations, the UTMC contains the highest percentage of protected natural areas in Canada. Several at-risk bird species, such as the Hooded Warbler and the Acadian Flycatcher reside in the protected areas of the UTMC.
- Many natural features are intact, owing to sloping terrain, Fonthill Kame, numerous conservation areas, and Niagara Escarpment protections.

The Town of Pelham is the second, larger scope for the project. It is one of twelve municipalities of the Niagara Region, occupying a central location. This broader scope was identified for natural asset management, which is completed at a jurisdictional scale.

Figure 2: Project Area



3.3 Land Use

The land use in UTMC subwatershed is a mix of rural and urban communities with natural areas, including mixed forests. Rural is the dominant land class and are primarily agricultural lands (hosting greenhouses, nurseries, orchards, cash crops, and some livestock), but include estates and rural residents, a LaFarge quarry operation, and a few golf courses. The UTMC includes geological features such as the Niagara Escarpment and Fonthill Kame. Natural features include the last spring-fed cold-water stream in Niagara Region and several conservation areas.

The total built or impervious area is estimated at over 20%[11] of the total subwatershed area. If the total impervious area continues to increase, services provided by the subwatershed (water quality, erosion control) will degrade and the unique characteristics of the subwatershed will be at risk.

3.4 Governance, Policy and Structures

As in many communities, natural assets in the Town of Pelham are within a multi-owner, multi-jurisdiction, and multiuse area. Many entities including local governments, the Niagara Peninsula Conservation Authority (NPCA), the Niagara Escarpment Commission (NEC), and the Province of Ontario share governance responsibilities. Most of the land is in private ownership. A small percentage is in public ownership or stewardship (e.g., Nature Conservancy of Canada lands, Niagara Region public lands, Town public lands, NPCA lands and Short Hills Provincial Park.).

The **Town of Pelham** is in the heart of the Niagara Region in southwestern Ontario. It is 127 km² in size and houses a population of ~18,000. The Town has two urban areas — Fonthill and Fenwick — and two Hamlets — North Pelham and Ridgeville. The Town's southern boundary is the Welland River. Pelham lies to the north of the Welland River, east of the Township of West Lincoln, west of the City of Welland and the City of Thorold, and south of the City of St. Catharines and the Town of Lincoln. The northeast section of Pelham contains the Short Hills Provincial Park. The Town is responsible for a range of public services provided by natural assets including stormwater and drinking water. Management of natural assets in the Town of Pelham may support downstream cities in their management of stormwater and mitigation of flood risk.

The **Niagara Region** (population ~448,000) is a regional government that comprises 12 lower-tier municipalities. It is the southern end of the "Golden Horseshoe"[12] and occupies most of the Niagara Peninsula. Lake Ontario lies to the north and Lake Erie to the south. They are responsible for the natural heritage system, source water protection and a water resource system.

11 Ibid.

12 A region in Ontario centered on Toronto and extending around western Lake Ontario

The **Niagara Peninsula Conservation Authority (NPCA)** is the relevant Conservation Authority providing watershed management services. NPCA is responsible for the delivery of programs and services that further the conservation, restoration, development, and management of natural resources within the watershed and matters related to flood risk.

The **Niagara Escarpment Commission (NEC)** is responsible for implementing the Niagara Escarpment Plan (NEP), Canada's first large-scale environmental land use plan. Together with the Ontario Ministry of Natural Resources and Forestry (NDMNRF), NEC shares 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. The escarpment natural area, escarpment protection and escarpment rural area designations apply in Pelham.

ONTARIO ASSET MANAGEMENT REQUIREMENTS

The Regulation Asset Management Planning for Municipal Infrastructure (O. Reg. 588/17) requires Ontario municipalities to have had a comprehensive strategic asset management policy in place 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.[13]

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

4.0 Current State of Natural Assets

This section describes the results of the NAM assessment phase for natural assets in the Town of Pelham, their condition, their service value, and options to continue enhancing understanding.

The NAM assessment phase[14] provides a baseline understanding of the current services that natural assets provide, and some corresponding values. Below are the results, including:

- The approach to identify and inventory natural assets in the subwatershed
- The current condition of natural assets in the Watershed
- The value of a range of different services provided by the natural assets

4.1 Identification of Natural Assets

INVENTORY OVERVIEW

NAI's natural asset inventories have two main components to express natural asset information: an asset registry (which is a tabular representation of the data) and an online dashboard. NAI provided the registry to the Town of Pelham in an Excel file and the dashboard as a website address. Information on the condition of the assets is a subset of the inventory and is depicted in both the registry and dashboard. This inventory is consistent with the Canada Standards Association (CSA) Group recently released W218:23 standard 'Specifications for Natural Asset Inventories.[15]

INVENTORY DATA

To establish the inventory and complete the condition assessment, NAI obtained data from several sources as shown in Table 1. NAI combined the spatial data layers to establish a comprehensive depiction of natural assets.

Table 1: *Datasets Used to Create the Natural Asset Inventory*

File Name	Descriptive Name	Source	Purpose
NPCA_ ELC_20221121	Niagara Region Updated ELC (2021)	Niagara Peninsula Conservation Authority	The series description was used as the main landcover source for identifying natural areas.
2K_Hydropoly_ NPCA.shp	2K Water	Niagara Peninsula Conservation Authority	Used to capture open water and wetlands not represented in the ELC or other datasets, given priority over ELC for water features.
Built_up_Area	Built-up Area	Ontario GeoHub	Used to fill in landcover where ELC not present (impervious and pervious areas).

14 See *Figure 1*

15 *CSA Group (2023).*

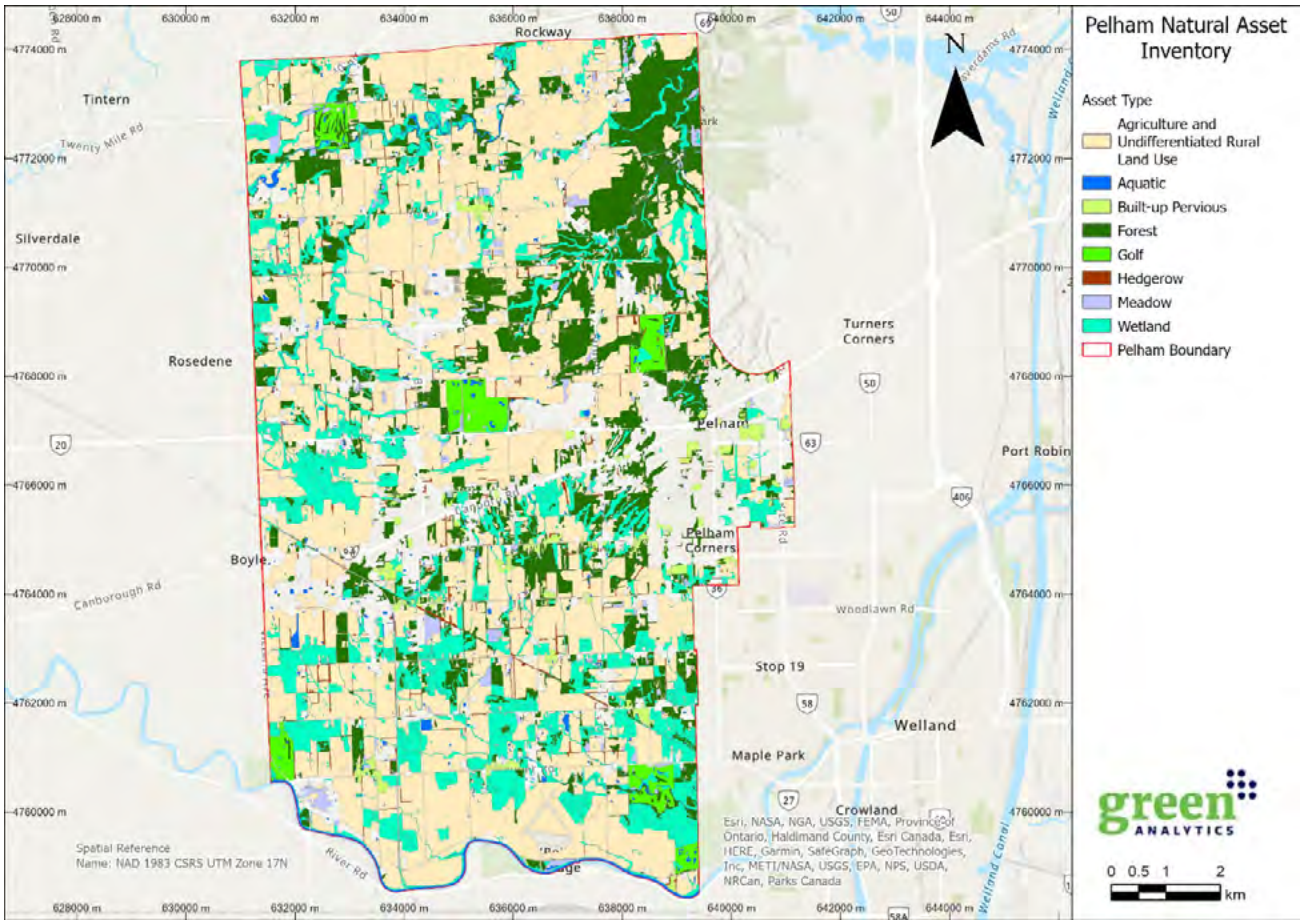
File Name	Descriptive Name	Source	Purpose
gis_osm_ landuse_a_ free_1.shp	OSM Land Use Data	Open Street Map (© OpenStreetMap, Available with Open Database license) (*download.geofabrik.de/ north-america/canada.html*)	Used to help classify areas as Built-up Pervious in the study area.
gis_osm_ pois_a_free_1. shp	OSM POIS Data	Open Street Map (© OpenStreetMap, Available with Open Database license) (*download.geofabrik.de/ north-america/canada.html*)	Used to help classify golf courses in the study area.
gis_osm_ traffic_a_free_1. shp	OSM Traffic Data	Open Street Map (© OpenStreetMap, Available with Open Database license) (*download.geofabrik.de/ north-america/canada.html*)	Used to help classify parking lots in the study area.
SOLRIS_ Version_3_0_ LAMBERT	SOLRIS V3	Ontario GeoHub	Used to help identify the location of excavation sites to remove from the natural asset inventory.
UAB.shp	Urban Area Boundaries	Niagara Peninsula Conservation Authority	Used to help reclassify areas as Built-up Pervious in the urban centres.
17T_20220101-20230101.tif	ESRI Land Cover Data	ESRI	Used as base file for land cover classification.
NRN_ON_15_0_ ROADSEG.shp	National Road Network	*National Road Network - NRN - GeoBase Series - Open Government Portal* (*canada.ca*)	Used to delineate roads from natural areas in the study area.
NRWN_ON_2_0_ TRACK.shp	National Railway Network	*National Railway Network - NRWN - GeoBase Series - Open Government Portal* (*canada.ca*)	Used to delineate railways from natural areas in the study area.
OLCC_V2	Ontario Landcover Compilation	Ontario GeoHub	Used to fill in landcover where ELC not present (as an input for Built-up Pervious areas).
Municipal_ Boundaries	Municipal Boundaries	Niagara Peninsula Conservation Authority	Used to split assets by municipality boundaries. Extent of Pelham polygon in this file was used for the study area boundary.
Sub watershed_ Areas_2K_NPCA. shp	Subwatershed Areas	Niagara Peninsula Conservation Authority	Used to divide asset by subwatershed boundaries.
Watershed_ Planning_ Areas_NPCA.shp	Watershed Planning Area	Niagara Peninsula Conservation Authority	Used to split natural assets by watersheds and map/summarize natural assets by watershed in inventory dashboard
Conservation_ Areas	Conservation Areas	Niagara Peninsula Conservation Authority	Used to subdivide assets by conservation area boundaries.

The inventory assessment defined a total of 4,428 individual assets, covering 10,458 hectares (ha), as noted in Table 2. An **asset** is defined as a continuous area of the same land cover type. For example, an intact forested area would be defined as one asset, but a forested area that is bisected by a road would constitute two assets. The majority of natural assets in Pelham are agriculture, followed by swamp and forest.

Table 2: Natural assets in the Town of Pelham

Natural Asset Type	Asset Count	Area (ha)
Agriculture	1,570	5,790
Built-up Pervious	192	173
Forest	816	1,930
Golf	31	258
Hedgerow	271	106
Meadow	167	153
Open Aquatic	663	135
Wetland	718	1,913
Total	**4,428**	**10,458**

Figure 3: Spatial Distribution of Natural Assets from the Online Registry



ASSET REGISTRY

Each asset within the inventory has a unique identification number that allows users to select and analyze individual assets and manipulate the corresponding data as required. For example, changes in condition can be noted for individual assets. Information on each asset is housed in an asset registry. Table 3 is an excerpt from Pelham's online registry showing natural asset characteristics and details. Additional detail is provided in the online dashboard.

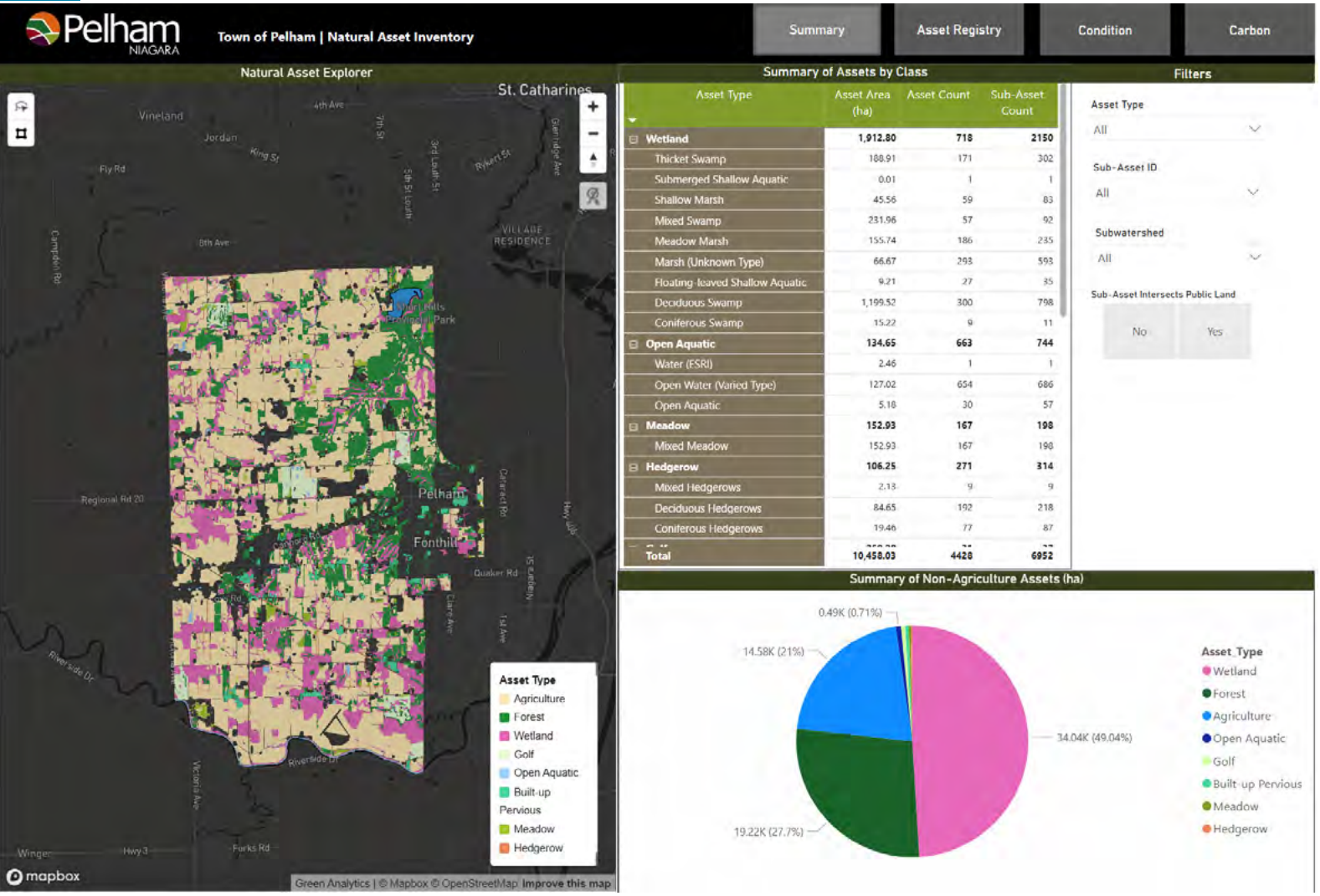
Table 3: Excerpt from the Town of Pelham's Online Registry

Natural Asset Registry						
Asset ID	Sub_Asset_ID	Asset Area (ha)	Asset Type	ELC Class	Subwatershed	Greenbelt Status
AGR(UNDF)1000	AGR(UNDF)1000-2	6.35	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1001	AGR(UNDF)1001-1	0.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1002	AGR(UNDF)1002-1	6.55	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1003	AGR(UNDF)1003-2	0.37	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1004	AGR(UNDF)1004-1	0.63	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1005	AGR(UNDF)1005-1	0.73	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1006	AGR(UNDF)1006-1	0.01	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1007	AGR(UNDF)1007-1	0.03	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1008	AGR(UNDF)1008-2	0.37	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1008	AGR(UNDF)1008-3	0.37	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1009	AGR(UNDF)1009-1	0.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1010	AGR(UNDF)1010-1	0.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1011	AGR(UNDF)1011-1	0.19	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1012	AGR(UNDF)1012-1	0.50	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1013	AGR(UNDF)1013-1	0.39	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1013	AGR(UNDF)1013-2	0.39	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1014	AGR(UNDF)1014-1	0.06	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1015	AGR(UNDF)1015-1	0.01	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1016	AGR(UNDF)1016-1	1.53	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1017	AGR(UNDF)1017-1	0.02	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1018	AGR(UNDF)1018-1	0.72	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1019	AGR(UNDF)1019-1	0.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1020	AGR(UNDF)1020-1	0.34	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1021	AGR(UNDF)1021-1	0.01	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1022	AGR(UNDF)1022-1	0.02	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1023	AGR(UNDF)1023-1	0.03	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1024	AGR(UNDF)1024-1	6.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1025	AGR(UNDF)1025-1	0.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1026	AGR(UNDF)1026-1	0.01	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1027	AGR(UNDF)1027-1	0.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1028	AGR(UNDF)1028-1	0.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1029	AGR(UNDF)1029-1	12.28	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1030	AGR(UNDF)1030-1	0.04	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
AGR(UNDF)1031	AGR(UNDF)1031-1	0.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	TWEL Upper Twelve Mile Creek	Within Greenbelt
AGR(UNDF)1032	AGR(UNDF)1032-1	0.00	Agriculture	Agriculture and Undifferentiated Rural Land Use	FSEM Fifteen Mile Creek	Within Greenbelt
Total		41935.31				

ONLINE DASHBOARD

Inventories may provide more insights when characterized visually in a dashboard, which enables users to explore different aspects of the data. For instance, natural asset information can be quickly summarized by watershed area, or, if users want to dive into the specifics of forest assets, they can quickly filter the data to focus on that particular asset type. Figure 4 is a screenshot from the dashboard that NAI provided to Pelham. The full version can be accessed at: *go.greenanalytics.ca/pelham*

***Figure 4**: Screenshot of Dashboard Inventory Summary*



4.2 Natural Asset Condition Assessment

Documenting the condition of natural assets is a key aspect of natural asset inventories. A natural asset condition assessment provides an understanding of both the ecological integrity of natural assets, and their ability to provide services. This information, in turn, can support the effective management of natural assets, be reflected in the registry and the dashboard, and updated over time.

NAI completed a desktop-based condition assessment and built it into the inventory to provide an initial understanding of the status of the natural assets for Pelham. As part of a full natural asset management project, NAI would expand this assessment to include additional metrics related to condition (e.g., relative biodiversity, riparian and wetland health, soil condition, connectivity, and others) and employ site visits to confirm and verify the condition ratings. The desktop exercise completed as part of this inventory is a reasonable first step in assessing condition and can be used as a foundation for future work in this area.

The condition indicators described in this report can be applied at different levels (as in wider groupings) of the natural asset inventory. The three levels of Pelham's inventory are presented in Tables 4 and 5 for natural assets and other land assets, respectively. Descriptions of the various levels are as follows:

Level 1 – all adjacent level 2 natural assets are merged based on common boundaries. In this case, the condition indicator is applied to a contiguous "asset" that is comprised of all adjoining level 2 assets.

Level 2 – all adjacent level 3 natural assets merged based on common boundaries. In this case, the condition indicator is applied to an uninterrupted area of level 2 asset types.

Level 3 – In this case, the condition indicator is applied directly to the individual areas of each level 3 asset type.

Table 4: Natural Assets Hierarchy

Level 1	Level 2	Level 3
Natural Areas	Forest	Coniferous Forest
		Coniferous Savanna
		Coniferous Thicket
		Coniferous Woodland
		Deciduous Forest
		Deciduous Savanna
		Deciduous Thicket
		Deciduous Woodland
		Mixed Forest
		Mixed Savanna

Level 1	Level 2	Level 3
Natural Areas *cont'ed*	Forest *cont'ed*	Mixed Thicket
		Mixed Woodland
		Treed Agriculture
	Hedgerow	Coniferous Hedgerow
		Deciduous Hedgerow
		Mixed Hedgerow
	Meadow	Mixed Meadow
	Aquatic	Open Aquatic
		Open Water (Varied Type)
		Water (ESRI)
	Wetland	Coniferous Swamp
		Deciduous Swamp
		Floating-leaved Shallow Aquatic
		Marsh (Unknown Type)
		Meadow Marsh
		Mixed Swamp
		Shallow Marsh
		Submerged Shallow Aquatic
		Thicket Swamp

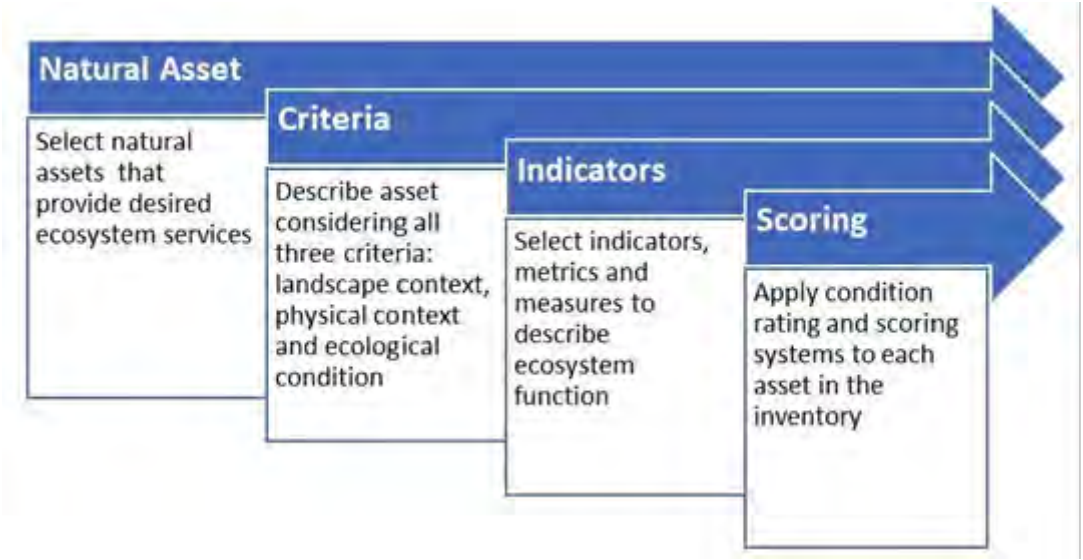
***Table 5**: Other Land Assets Hierarchy*

Level 1	Level 2	Level 3
Agriculture	Agriculture and Undifferentiated Rural Land Use	N/A
Built-up Pervious	Built-up Pervious	Cemetery
		Mixed Grasses (grass f-code from OSM land use data)
		Mixed Pervious
		Mixed Pervious Surface (UAB)
		Parks
	Golf	Golf

Note that the condition indicators (described below) employed in this condition assessment were applied to the natural assets defined in Table 4 only. The other land assets (built-up pervious and agricultural land) are included in the inventory to provide a complete picture of the land-based assets within Pelham and to recognize their important contribution to community services such as stormwater management, tourism, and recreation. For this class of assets (i.e., other land assets) condition ratings can be useful from a management perspective, however, such ratings require input from field staff on each individual property and is beyond the scope of the Project.

The framework and process used for the condition assessment in this project aligns with the framework and process outlined in the recently released Canada-wide standards and specifications for natural asset inventories (Figure 5).[16]

***Figure 5**: The Natural Asset Condition Assessment Process (Source: CSA 2023)*



The condition indicators are noted below and categorized into two criteria (i.e., landscape context and physical context) to align with the CSA standard for natural asset inventories. Note there are currently no condition indicators for ecological condition due to limited data available. This should be noted as a gap for future research.

CRITERIA FOR PHYSICAL CONTEXT

1/ Natural area patch size and shape
2/ Natural asset proximity to watercourses
3/ Forest proximity to other natural assets
4/ Wetland proximity to other natural assets

CRITERIA FOR LANDSCAPE CONTEXT

5/ Extent of adjacent complementary land uses

The indicators employed in the desktop assessment are proxy metrics for broader ecological condition considerations. The underlying assumption for natural asset condition assessments is that an asset that is assessed as being in a "good" condition from an ecological perspective is anticipated to be able to provide a "good" level of ecological services. For example, larger asset size implies more connectivity of natural areas, higher road density implies more fragmentation and higher hydrologic impairment of water flows, and more permeability implies greater ability to store water which means more effective stormwater management. The indicators are described in detail in *Appendix B*.

16 *CSA 2023*

CONDITION RESULTS

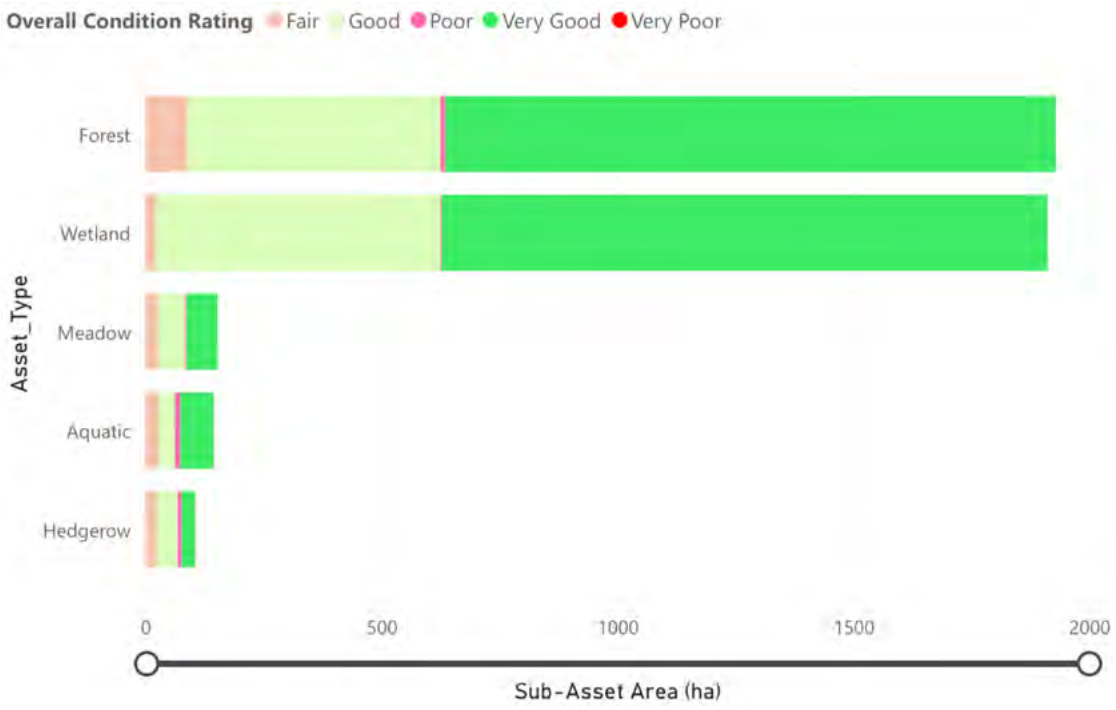
Overall, about 2,744 ha (or 26%) of natural assets were assessed in very good condition and 1,275 ha (or 12%) were assessed in good condition. Forest and wetland assets largely ranked good and very good, while meadow, aquatic, and hedgerow assets ranked across the full range of condition scores from poor to very good. Table 6 summarizes the condition results by condition rating.

Table 6: Breakdown Of Condition Ratings by Area and Number of Assets

Condition Rating	Number of Assets	Area (ha)
Very Good	1,765	2,743.97
Good	2,206	1,274.79
Fair	767	190.38
Poor	240	35.16
Very poor	8	1.07
Total	**4,986**	**4,245.37**

Figure 6 shows the results of the condition assessment by asset type. These results signal the strong role natural assets have to provide or supplement long term services, as well as their role in addressing risks such as climate change and development pressure as a result of population growth.

Figure 6: Summary Of Condition Rating by Natural Asset Type



4.3 Value of Natural Asset Stormwater Services

STORMWATER REGULATION SERVICES

Associated Engineering Ltd. (Associated) was retained by the Town of Pelham as part of a multidisciplinary team lead by NAI to prepare a stormwater management (SWM) hydrologic modelling and costing analysis of the Upper Twelve Mile Creek subwatershed. The analysis evaluates the SWM services provided by the natural areas in the subwatershed and allow for a comparison of the estimated costs of replacing these ecosystem services with engineered stormwater management facilities. The full analysis was provided to the Town of Pelham. A summary is provided here.

RATIONALE FOR VALUATION STORMWATER REGULATION

The purpose of this valuation is to gain a better understanding of the current and future value of the natural assets in the Twelve Mile Creek subwatershed from a stormwater management perspective. This study uses stormwater management modelling to:

(a) Apply a partial value to the natural assets by estimating the level of stormwater services they provide
(b) Replicate those services with engineered solutions for which current costs are readily available

This valuation will be the first of its kind for Pelham and lay the foundation for further asset valuation studies which are expected to enhance its asset management program and allow for more informed decision-making regarding protection and management of the town's natural assets. There have been very few studies of this kind done, particularly in Ontario and of this scale. This study can serve as an example for other municipalities as they work to integrate natural assets into their asset management programs.

STORMWATER MODELLING

Background Information

The following sources provided background information including open GIS data and reports used to complete the models and this report:

- Town of Pelham – DEM, watershed boundaries, rainfall data and relevant costing information
- Niagara Peninsula Conservation Authority (NPCA) – ELCs, watercourse, soil classification, hydrology model (SWMHYMO, 2005)
- Niagara Region (NR) – municipality boundaries

Model Selection & Construction

PCSWMM (Personal Computer Storm Water Management Model) was selected as the hydrologic model because it can accurately simulate rainfall/runoff processes using the SWM Model (SWMM) engine. EPA SWMM is capable of accurately simulating rainfall runoff processes including runoff volume, peak

runoff and water quality in complex environments. The software has a flexible set of infiltration and hydraulic equations used for calculating runoff and routing drainage networks. The rainfall input can range from single design storms to long term continuous simulations. Recently, SWMM version 5.0, (SWMM 5.0) added a low impact development (LID) module capable of simulating the rainfall runoff process on single or grouped LID measures.

The base model is built as an approximation of site conditions rather than a calibrated model. Calibration was not completed because the focus of the results is the change in values, rather than the modelled value of the results at each scenario. Therefore, the peak flow, infiltration or any published result from the model should be carefully used and investigated before being used in future models or reports.

The model is run with a synthetic rainfall distribution to determine worst-case scenario results in the models. The 100-year return period for the 12-hour AES (Atmospheric Environment Service) distribution was used as the synthetic rainfall distribution.[17]

The 100-year return period storm is ideal because:

- The storm generates significant rainfall to maximize the infiltration capacity of the soil;
- the runoff generated can maximize the storage of the existing wetlands, and;
- it is typically recommended by municipalities to size stormwater infrastructure.

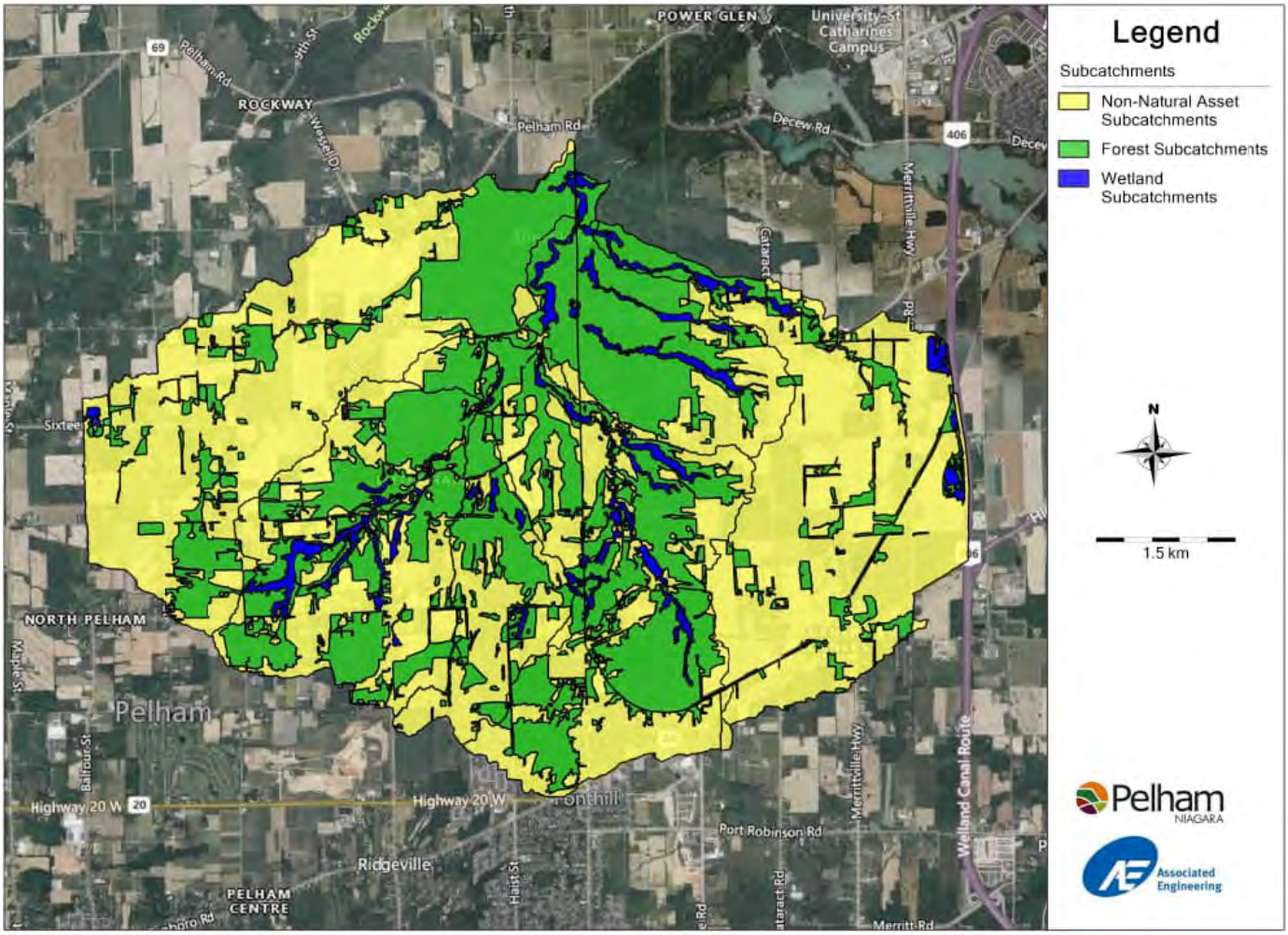
Subcatchment Delineation

The subcatchments were automatically delineated at a 200 ha level using a 2020 DEM from the Town of Pelham. The delineation produced 12 subcatchments and was compared to the municipal boundary of Pelham (provided by Niagara Region). It was determined 11 of the 12 subcatchments would be relevant in completing a natural asset inventory assessment for the Town.

The natural asset subcatchments were defined by overlaying the ELC layer (provided by NPCA) on the 11 delineated subcatchments. If the polygons from the ELC had an attribute of FO (forest) or SW (swamp) representing a forest or swamp (a type of wetland) and were inside the boundary of the subcatchments, they were created into new natural asset subcatchments. A total of 11 forest subcatchments and 11 wetland subcatchments were created (and these areas were deleted from the original subcatchment to prevent area overlap). Due to the size and spatial variability of some of the forest subcatchments, they were broken up further into two additional subcatchments, creating 13 forest subcatchments for a total of 35 subcatchments. Figure 7 below shows the delineated subcatchments.

17 The parameters to represent the 100-year return period were defined by the MTO IDF curve tool and can be found with the rainfall distribution in the modelling report.

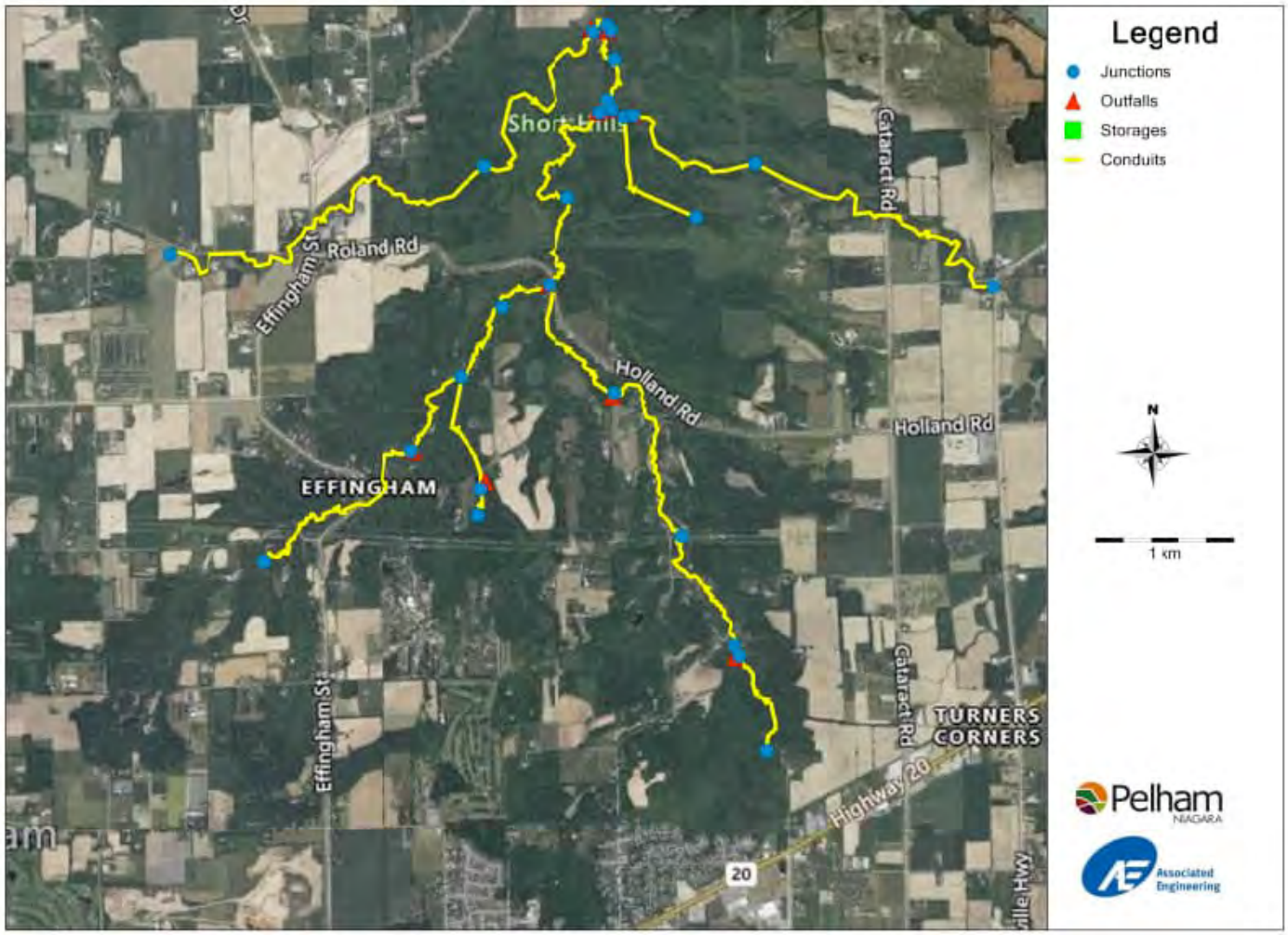
Figure 7: Subcatchment Delineation for the Upper Twelve Mile Creek Subwatershed



The overland flow path for the runoff generated by each subcatchment varied by catchment type. It was assumed the non-natural asset subcatchments (which have a primarily agricultural land use) would disperse runoff to forest natural asset subcatchments. Based on the spatial variability of the natural asset subcatchments, it was assumed both forest and wetland subcatchment would outlet directly to the watercourse.

The TMC tributaries were represented as a channel (nodes and conduits) in PCSWMM, as seen in *Figure 8*.

Figure 8: Twelve Mile Creek Represented by Conduits and Nodes in PCSWMM



STORMWATER INFRASTRUCTURE MODELLING

The model was assumed to use typical stormwater management infrastructure to achieve the basic stormwater management functions and services that are currently provided by the natural assets. They were designed as:

- A simple SWM pond design to mimic the peak flow reduction of the wetland storage units.
- A low impact development (LID) unit designed as a bio-retention cell that can provide infiltration and storage of precipitation to match the runoff depth from the forest subcatchments of Scenario 1.

SCENARIO DEVELOPMENT

The model was constructed with scenarios to analyze changes in results, such as peak flow in the TMC and the volume of runoff leaving the subcatchments. The scenario analysis allows for results comparison between:

- The existing condition
- Removal of the natural assets
- Replacement of natural assets with stormwater strategies
- Other site-specific scenarios requested by the client

The PCSWMM model was divided into three scenarios listed below.

Scenario 1 - the existing conditions of the UTMC subwatershed with the natural assets distinguished separately into forest and wetland subcatchments.

Scenario 2 - the natural assets subcatchments from Scenario 1 are replaced with subcatchments that represents a 'natural area catastrophic loss' land-use.

Scenario 3 - stormwater infrastructure is added to Scenario 2 to match the infiltration and peak flow reduction achieved by the natural assets subcatchments in Scenario 1.

MODELLING RESULTS

The results are a summary of valuable comparisons compiled from the PCSWMM model result. These results compare the peak flow and runoff depth of each scenario. The peak flow is compared downstream of the storage units and the runoff depth is compared within the forest natural assets subcatchments.

Peak Flow

The peak flow is the maximum rate of discharge during the 12-hour 100-year AES storm event, often resulting in erosive forces and water level increases, such as flooding, scouring, and erosion of riverine and/or local drainage systems. Stormwater quantity controls are typically designed to limit a development's peak runoff rate to prevent downstream impacts (i.e., flooding, erosion, etc.) due to the increased runoff rate and volumes resulting from development.

The peak flow in the Twelve Mile Creek is compared across Scenario 1 (baseline conditions), Scenario 2 (removal of natural assets) and Scenario 3 (addition of stormwater management ponds and LID units) in Figure 9, Figure 10, and Figure 11 respectively. The peak flows are shown on a gradient from light blue (low) to dark red (high).

Figure 9: Peak Flow in the Twelve Mile Creek in Scenario 1

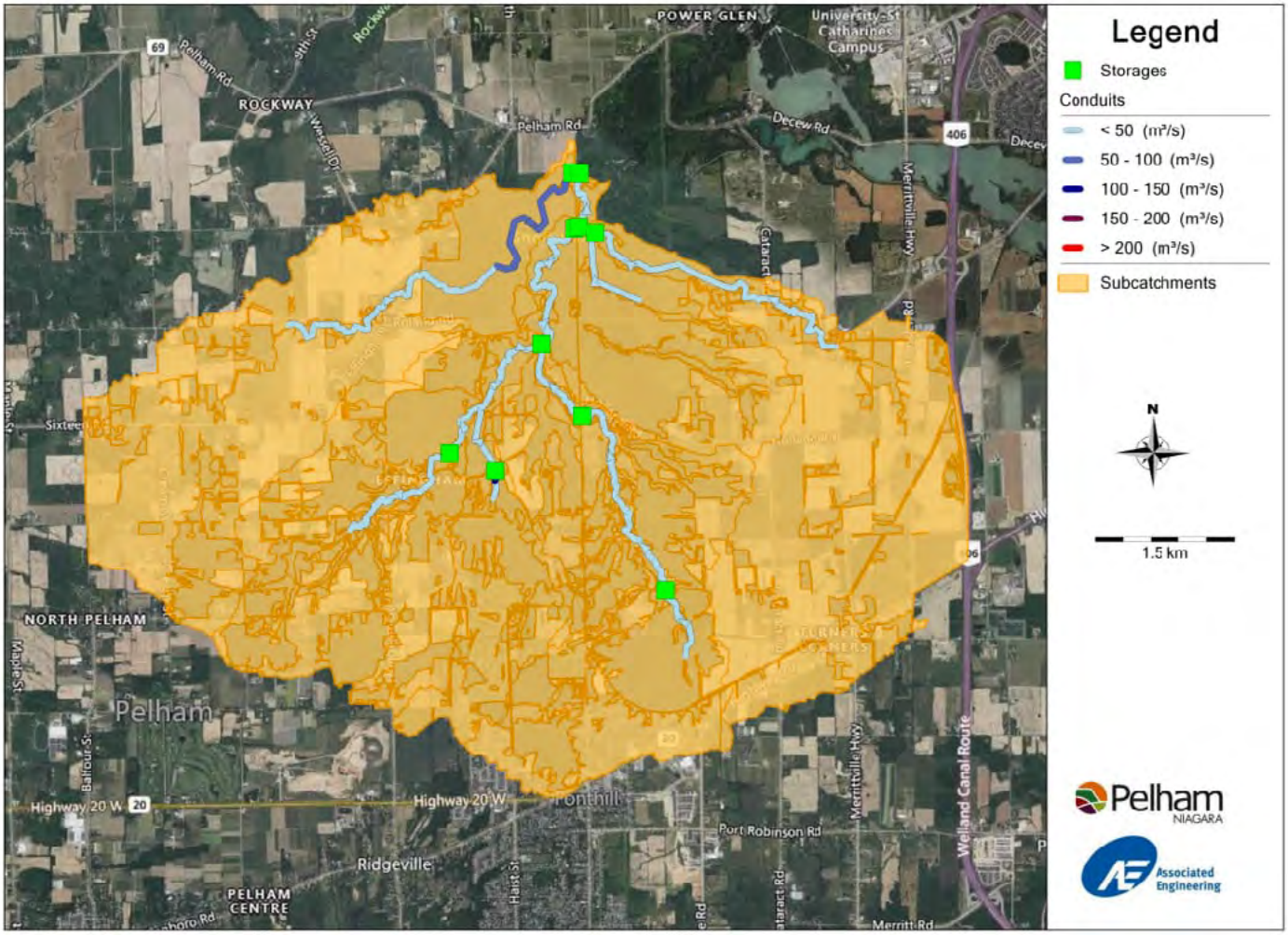


Figure 10: Peak Flow in the Twelve Mile Creek in Scenario 2

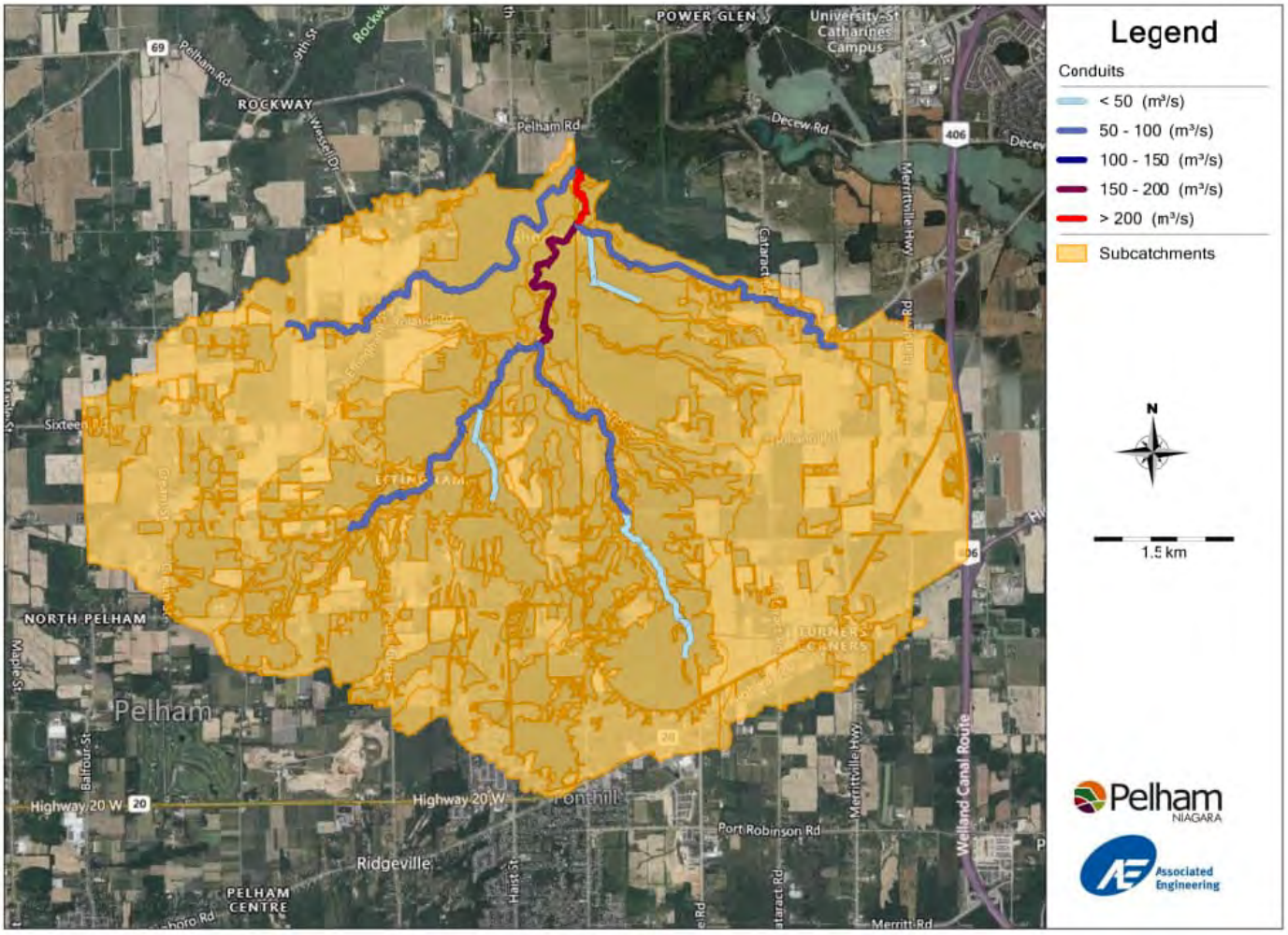
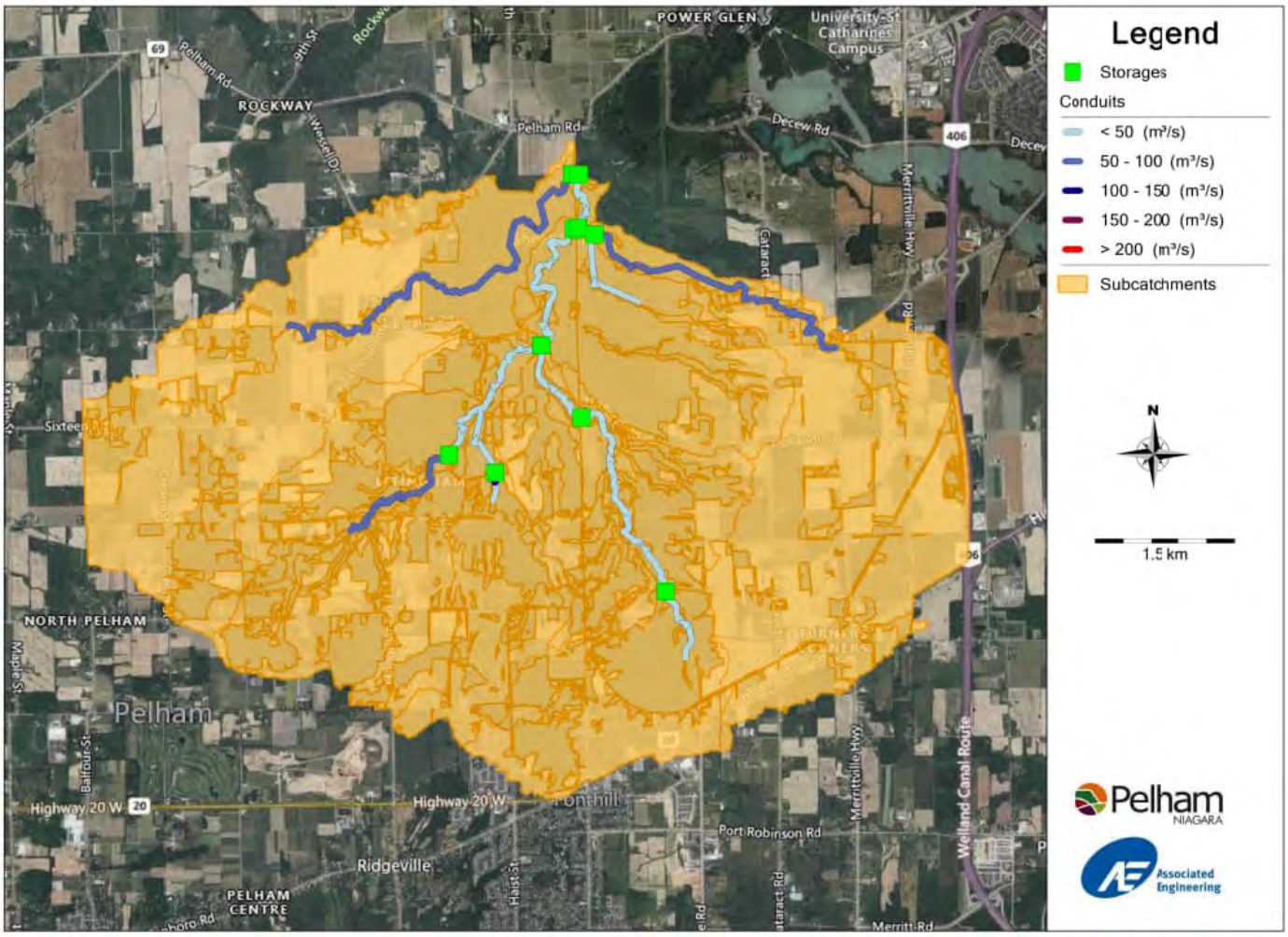


Figure 11: Peak Flow in the Twelve Mile Creek in Scenario 3



The Scenario 1 model demonstrates most peak flows in the Twelve Mile Creek are under 50 m^3/s with a maximum peak flow near the outlet of 52.0 m^3/s.

The removal of natural assets in the Scenario 2 model significantly increased the peak flow, with the majority of flows greater than 50 m^3/s. The maximum flow in Scenario 2 near the outlet is 304.8 m^3/s, an increase of 486% (six times the flow rate) over the maximum peak flow in Scenario 1.

The Scenario 3 model added LID units to the natural asset subcatchments and stormwater ponds to the TMC. The LID units did not have a significant impact on reducing peak flow, as the headwater streams of the TMC continued to experience an elevated peak flow greater than 50 m^3/s caused by the removal of natural assets. The SWM ponds had a significant impact, reducing the peak by approximately 50-75% of the original peak flow as seen in Table 7. Most of the TMC experiences a peak flow under 50 m^3/s with a maximum flow of 57.8 m^3/s, located in the headwaters of the TMC.

Table 7: The Flow Results from Sizing Stormwater Ponds for Wetland Natural Assets

Subcatchment	Storage Unit	Scenario 1 Peak Outflow (m^3/s)	Scenario 3 Peak Outflow (m^3/s)	Flow Reduction Attained (%)	Flow Depth	SWM Pond (ha)
WET-01	S-01	35.081	16.979	51.6	1.96	2.39
WET-02	S-02	15.926	6.221	60.9	1.19	17.86
WET-03	S-03	5.59	2.058	63.2	1.16	2.97
WET-05	S-05	24.409	8.062	67.0	1.34	3.60
WET-06	S-06	22.196	10.026	64.1	1.82	6.34
WET-07	S-07	11.129	5.774	56.6	1.33	3.18
WET-08	S-08	11.627	2.836	75.6	0.99	9.66

Scenario 3 revealed that low impact development units had little impact on reducing peak flow if natural assets were removed, as Twelve Mile Creek's headwater streams continued to experience peak flow greater than 50 m3/s.

The stormwater ponds employed in Scenario 3 did have a significant impact in reducing peak flow.

Runoff Depth

Runoff depth (mm) is part of the water balance process and represents the excess water leaving a subcatchment after a rainfall event occurs. The water balance process includes the inputs such as:

- Precipitation
- Run-on from other subcatchments
- The hydrologic processes that occur on the subcatchment, including storage, infiltration, and evaporation

The hydrologic processes allow for groundwater recharge, infiltration for plants, and other natural process to occur. A high runoff depth may indicate a degraded ecosystem due to a lack of hydrologic processes and may cause erosion, flooding, and stress on the groundwater system.

The runoff depth was compared across Scenario 1 (baseline conditions), Scenario 2 (removal of natural assets) and Scenario 3 (addition of stormwater management ponds and LID units). The results for the subcatchments selected for infiltration comparison can be found in Figure 12, Figure 13, and Figure 14 respectively.

Figure 12: Runoff Depth of the Forest Natural Asset Subcatchments in Scenario 1

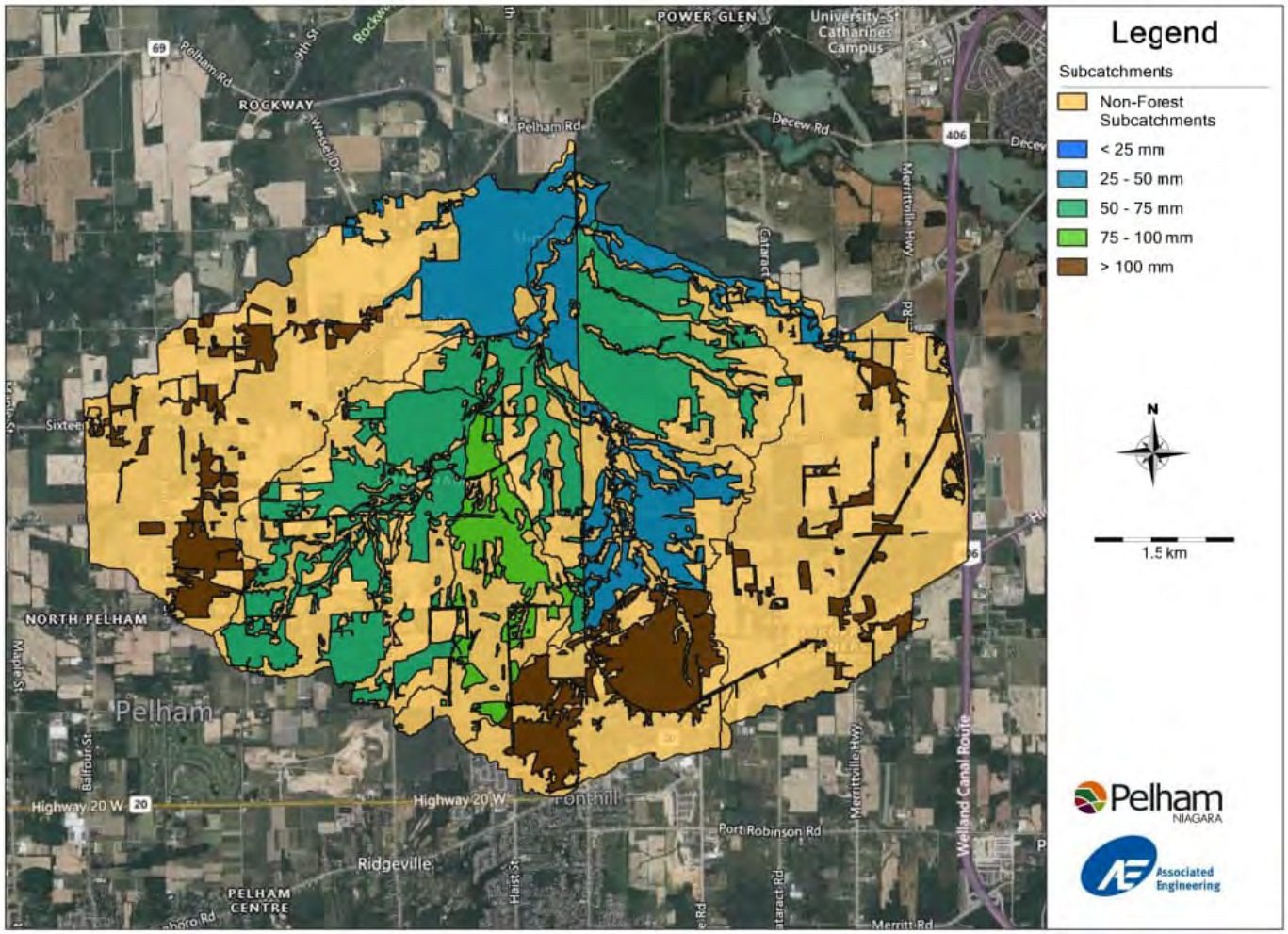


Figure 13: Runoff Depth of the Forest Natural Asset Subcatchments in Scenario 2

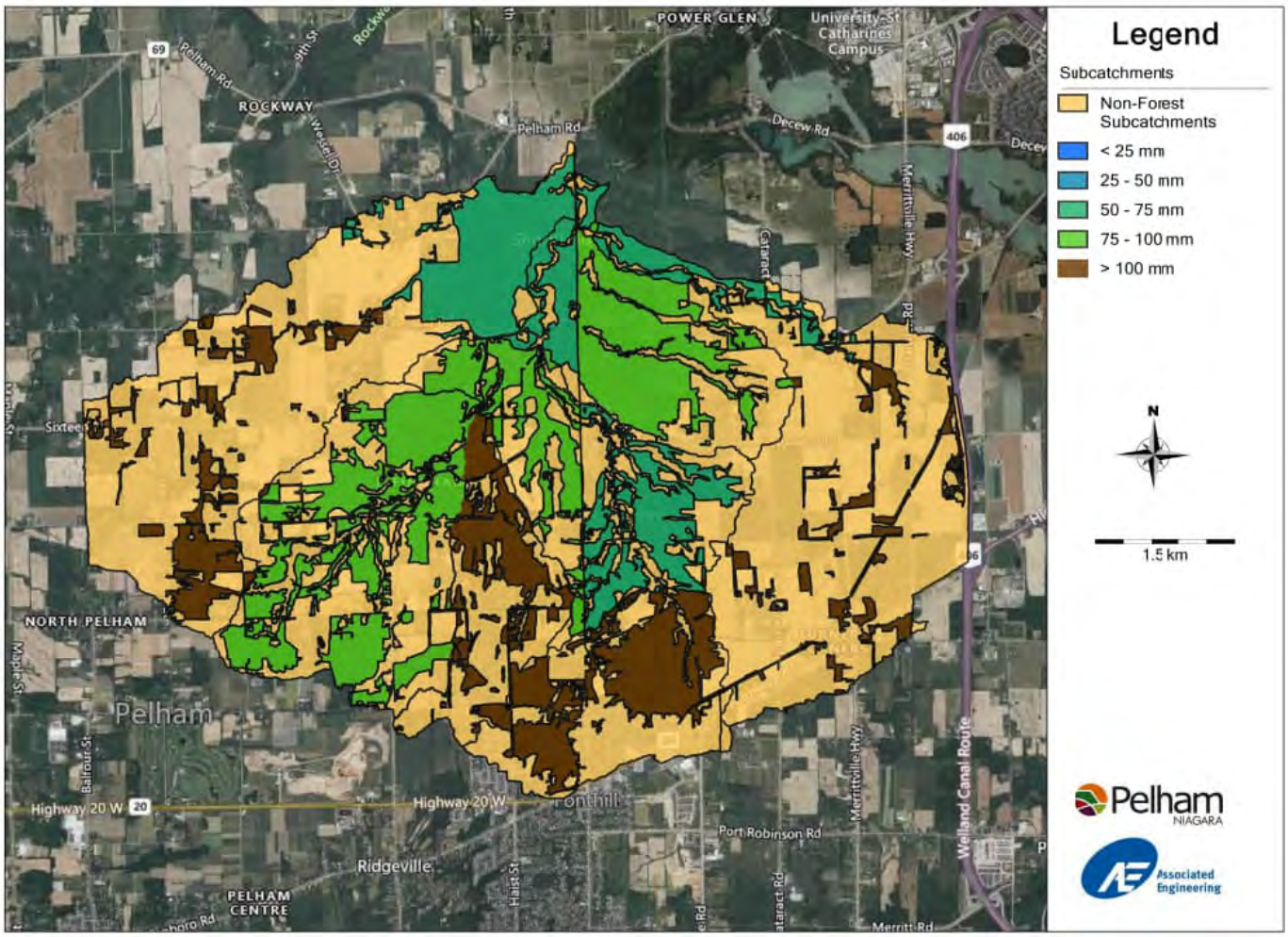
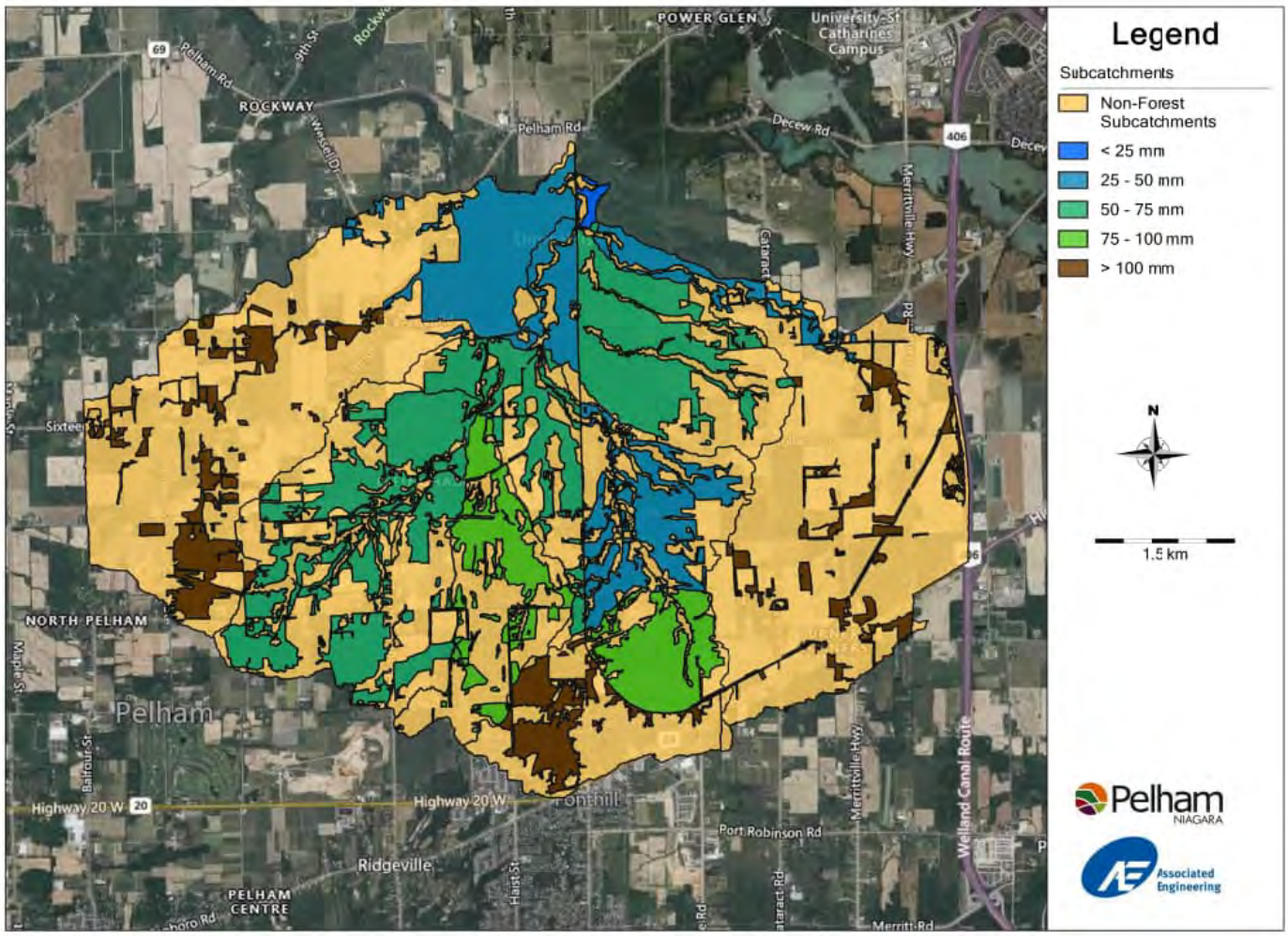


Figure 14: Runoff Depth of the Forest Natural Asset Subcatchments in Scenario 3



The runoff depth in Scenario 1 is used as the basis for comparison across the other scenarios. Since the non-natural asset subcatchments are routed onto the forest subcatchments, there is variable inflow (run-on and precipitation) to each, therefore a comparison between subcatchments would be ineffective.

Comparing Scenario 2 to Scenario 1, the runoff depth seems to increase across the watershed by approximately 25 mm. The removal of natural assets and reduction of the infiltration potential of the soil increased the amount of runoff leaving each catchment, creating higher peak flows in Twelve Mile Creek.

In Scenario 3, in comparison to Scenario 1, the LID units applied to the model were able to mimic the runoff depth of the natural assets. The LID units have approximately 700 mm of internal storage depth that can store and retain inflow and release it slowly over time as infiltration into the native soil layer.

VALUATION COSTING

This section estimates costs of the stormwater controls designed for Scenario 3 to mimic the peak flow and runoff depth of the Scenario 1 model. The purpose of this section is to provide the average cost per square metre to implement stormwater strategies, inclusive of LID units, which may conceptually replicate hydrologic functions of select natural assets within the watershed.

Methodology

The approximate costs of engineered infrastructure to manage stormwater were determined with recent construction tender prices for the construction of stormwater ponds and LID units local to Southwestern Ontario. The tender packages provide a list of tender items and unit prices supplied by contractors. The unit prices were averaged between the common tender items and a custom list of tender items was derived for stormwater ponds and LID units. The quantity of each tender item was assumed using quantities from tender packages based on their relative size and Associated Engineering's experience with SWM pond and LID unit construction projects.

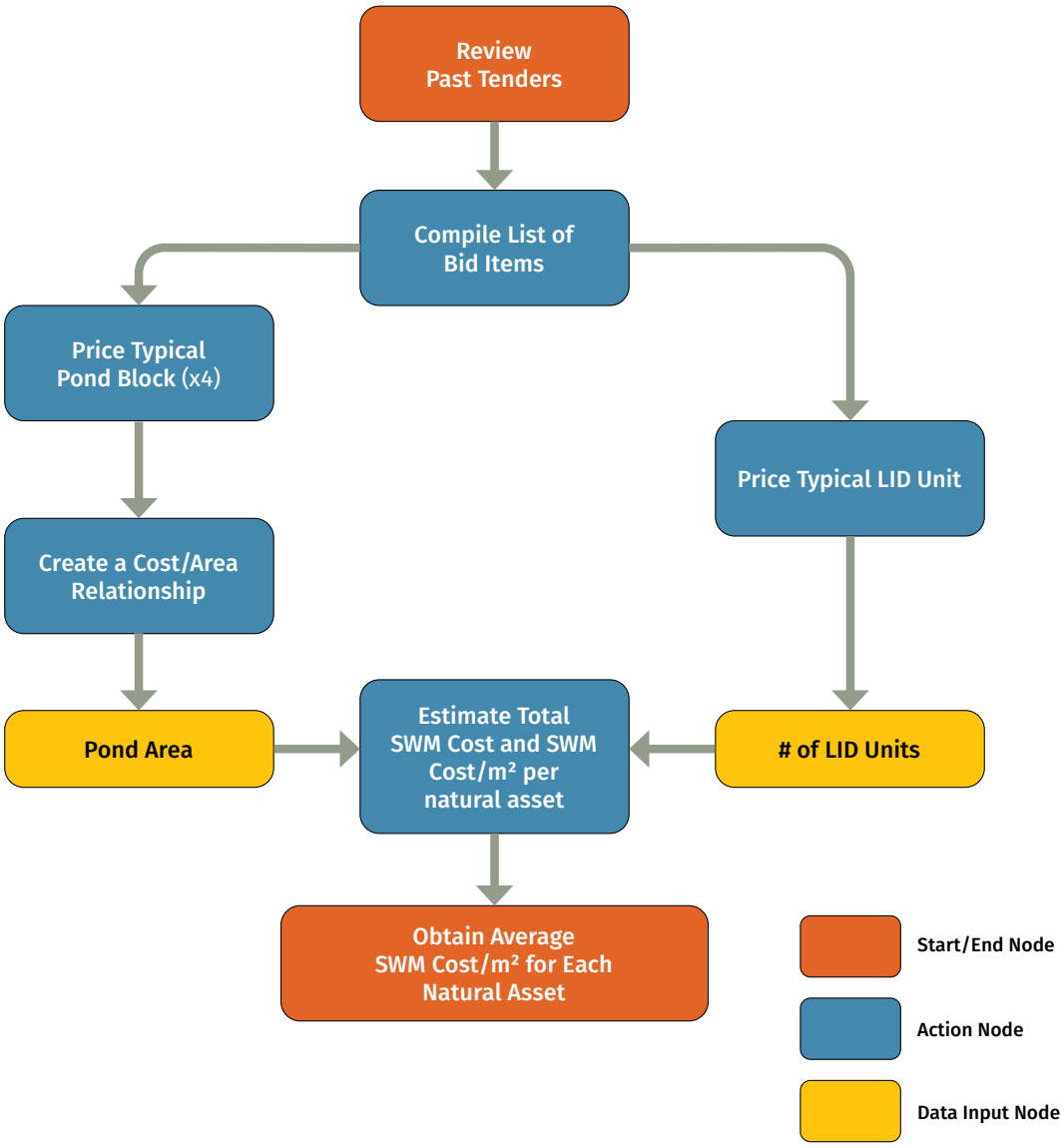
The cost of a stormwater pond was completed by defining quantities for four pond sizes (0.01 ha, 0.1 ha, 1 ha, and 20 ha) to produce a range of costs for ponds of varying sizes. Some quantities were scaled, and some quantities remained the same for each of the different pond sizes, resulting in four different SWM pond costs and four different costs per square meter. These four costs per square metre and the corresponding SWM pond size were plotted to obtain a line of best fit[18] to relate the pond costs to area. The line of best fit produces an equation that can be used to convert the total area of the SWM ponds from the modelling in Scenario 3 to a SWM cost for each pond and total SWM cost per natural asset catchment.

The cost of a LID unit was completed by defining quantities for a 1 ha LID unit. All the quantities are scalable, creating a SWM cost per LID. The number of LID units required for each natural asset subcatchment from the modelling in Scenario 3 were multiplied by the SWM cost per LID to determine the total SWM cost per natural asset catchment.

The SWM pond and LID unit cost for each natural asset subcatchment are added to get the SWM cost. The SWM cost for the natural asset is divided by the natural asset area to get the SWM cost per square metre. The SWM cost per square metre is grouped into forest and wetland natural asset types and averaged to get a singular SWM cost per square metre for each natural asset type for the purposes of presentation to the stakeholders. The workflow for completing the cost evaluation is illustrated in the flowchart in *Figure 15* below.

18 The line of best fit refers to a straight line through the maximum number of points, providing the best approximation of a data set.

Figure 15: Cost Evaluation Workflow



VALUATION RESULTS

The following preliminary conclusions from the valuation are based on results of modelling completed to date.

- Value of stormwater services provided by natural assets is $585,859,327, which is the capital cost to manage a similar capacity of stormwater with built infrastructure.
- Removal of the natural assets resulted in significant projected increase to peak flow and a significant projected increase to runoff depth.
- The SWM infrastructure in Scenario 3 was able to replicate the peak flow and runoff depth results from Scenario 1.

Based on the results of the costing analysis, the following preliminary conclusions have been made:

- The runoff depth produced from a forest natural asset may be replicated at an average value of $18.54 per square metre up to a maximum value of $28.72 per square metre with LID units.
- The peak flow reduction from a wetland natural asset may be replicated at an average value of $197.49 per square metre up to a maximum value of $242.73 per square metre with stormwater ponds.

Wetland natural assets cost more to replicate than the forest natural assets. The wetland natural assets provide peak flow reduction which is more difficult to replicate than a decrease in runoff depth due to the area and complexity of the stormwater infrastructure, resulting in a cost-difference that is ten times more than the forest natural assets.

While this study provides a quantifiable monetary value to a subset of natural asset services, this value should not be used as a method of replacing these natural assets. As noted, the natural assets provide many other benefits that cannot be replicated using stormwater infrastructure, including:

Water quality benefits — nitrogen and phosphorous exchange between groundwater and soil nourishment.

Stormwater conveyance — cold water flow suitable for trout habitat.

Air Quality — mature tree growth and vegetation communities remove carbon dioxide from the atmosphere.

Flora and fauna sustainability — unique habitat features associated with wetlands that enhance species biodiversity.

4.4 Value of Co-Benefits

NAM 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. Figure 16 provides an overview of potential benefits.

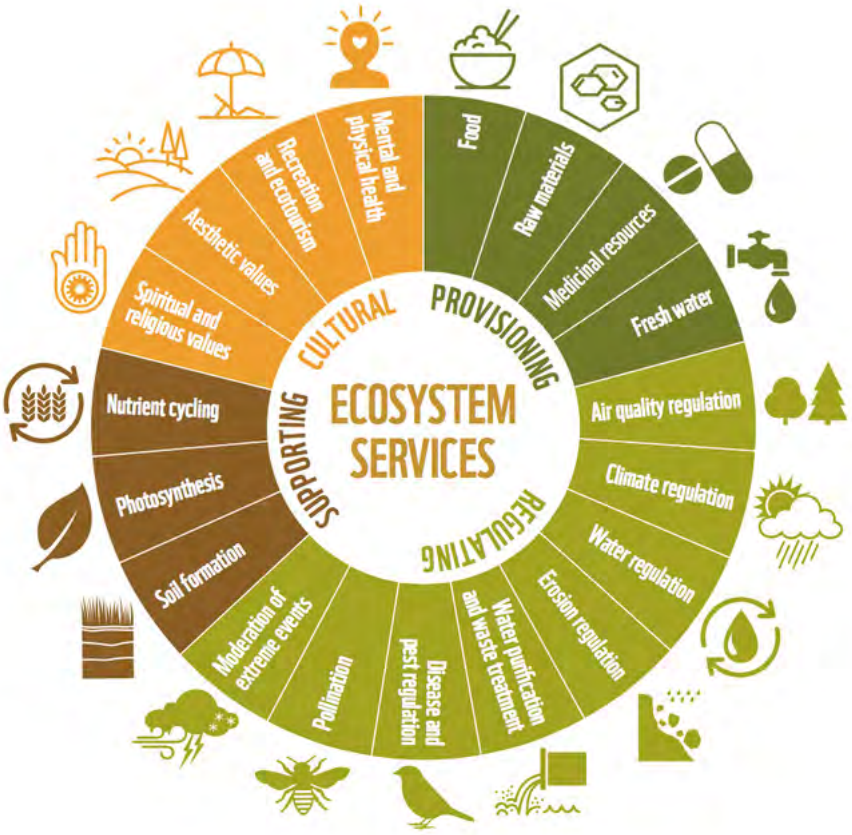
Natural Asset Type/ Service Objective	Water (Surface, Groundwater	Riparian Areas	Forest Assets	Green Open Spaces	Wetlands	water-courses	Soils	Urban Green Infrastructure
Stormwater management	■	■	■	■	■		■	■
Drinking water	■	■	■	■			■	■
Wastewater		■			■			■
Transportation			■	■				
Recreation	■	■	■	■	■	■		■
Public Health	■	■	■	■	■	■	■	■
Biodiversity	■	■	■	■	■	■	■	■
Climate mitigation or adaptation	■	■	■	■	■	■	■	■
Local Economic Development	■	■	■	■	■	■	■	■
Culture and Heritage	■	■	■	■	■	■	■	■
Other?								

Figure 16: Example of Services by Natural Asset Type[19]

Natural assets provide numerous ecosystem services that benefit communities and their residents. Figure 17 depicts a range of ecosystem services categorized by the common themes of provisioning, regulating, supporting, and cultural. The ecosystems services summarized in Figure 16 align closely with the classification used by the Economics of Ecosystem and Biodiversity (TEEB) (2010).

19 Adapted from *Developing Levels of Service for Natural Assets guidebook* (p. 17), MNAI, 2022

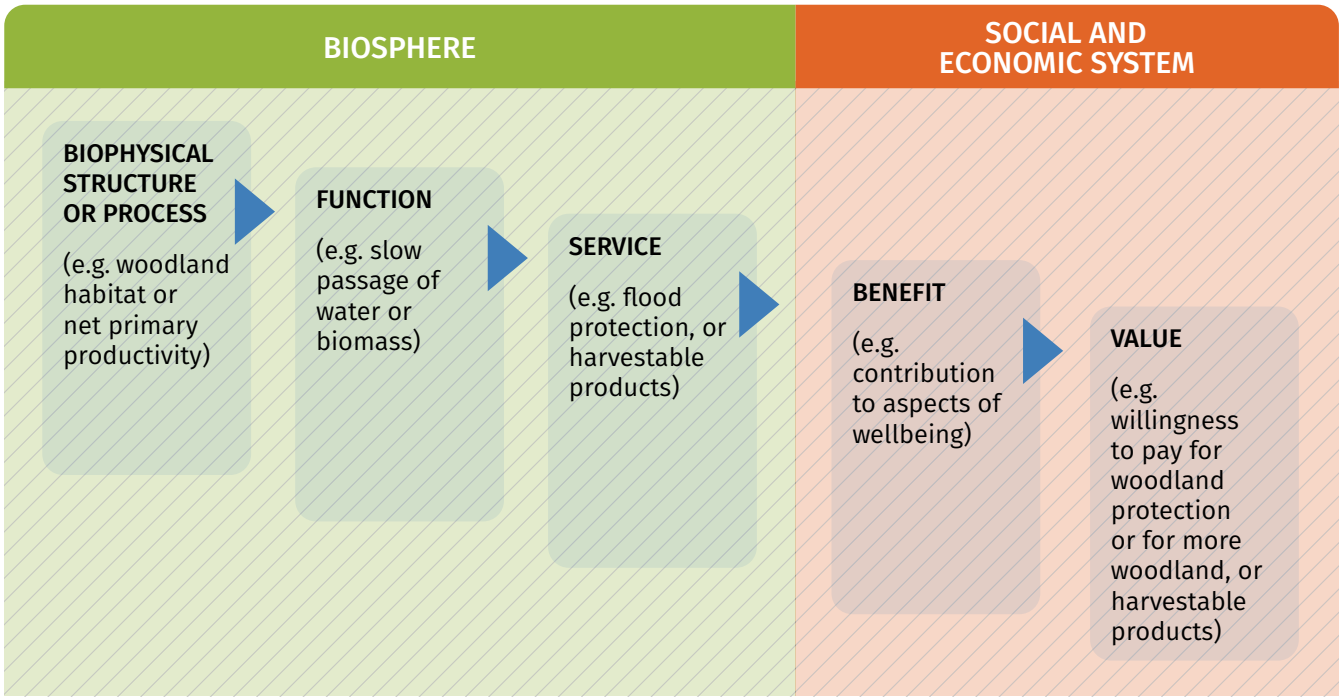
Figure 17: Ecosystem Services Diagram[20]



Several services identified in the figure above were selected for valuation for the Town of Pelham. These include climate regulation (measured as the value of carbon [C] sequestration), fresh water, and recreation services. The value of habitat provision to support biodiversity was also explored. To value ecosystem services, the focus should be on the value of the final services provided to those who benefit from the services. Figure 18 demonstrates the model upon which the approach to valuing ecosystem services is built. As is demonstrated in the figure, natural assets have biophysical structures that provide functions that result in final services. Humans benefit from these services, and the benefits derived can be valued.

20 From WWF Living Planet Report (2016)

Figure 18: The Cascade Model Depicts the Framework Used to Value Services from Natural Assets



To estimate the value of ecosystem services derived from Pelham's natural assets, a few approaches were employed. For carbon sequestration from non-forest assets, carbon sequestration multipliers (which describe the tonnes of carbon sequestered per year by landcover type) were used to establish carbon sequestration rates by asset type. For forest assets, the federal government's CBM-CFS3 model[21] was employed to establish annual carbon stock and stock change estimates that could then be used to estimate annual carbon sequestration rates (the difference in the stock of carbon one year to the next). See *Appendix B* for details on the carbon stock and sequestration analysis.

For forest and non-forest assets, a carbon value per tonne ($/tonnes) was then applied to the sequestration rates to estimate the monetary value of sequestration. For fresh water and habitat provision, a benefit transfer approach was employed. Specifically, willingness to pay (WTP) values for habitat protection and water provision were obtained from the literature and transferred to the Pelham context. WTP is commonly used to establish estimates of the value of ecosystem services.

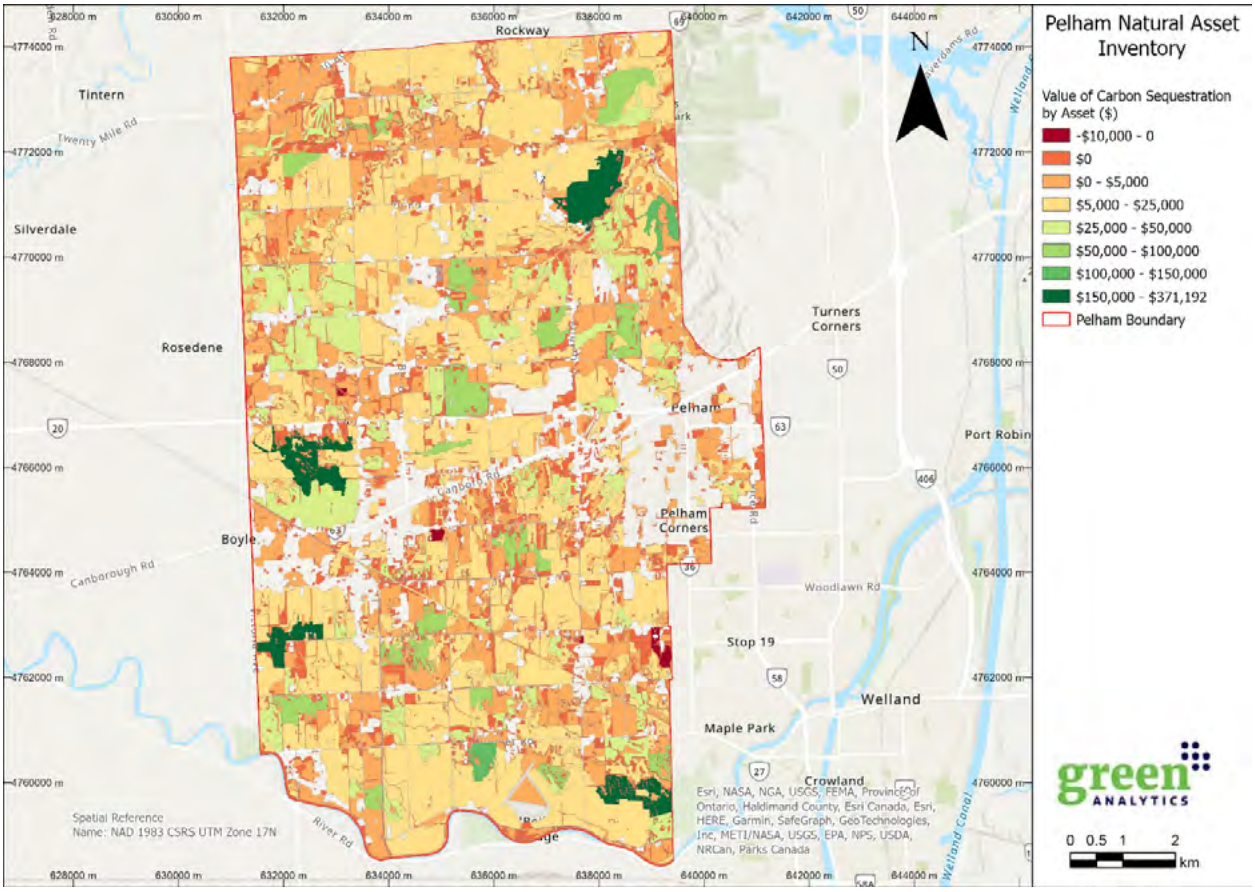
For recreation, the valuation approach relied on estimates of the number of recreation users (users per day) combined with expenditure values (spending per day). Additional details on the approaches employed to estimate the value of carbon sequestration, fresh water, habitat, and recreation, along with results of the valuation exercise, are provided in the sub-sections that follow.

21 *https://natural-resources.canada.ca/climate-change/climate-change-impacts-forests/carbon-accounting/carbon-budget-model/13107*

VALUE OF CARBON SEQUESTRATION

The value of carbon sequestration was estimated by applying the 2022 social cost of carbon (SCC) to the annual carbon sequestration rates by asset type (see *Appendix B* for details on calculating annual carbon sequestration by asset type) and then by the area of the asset. The 2022 SCC[22], after converting to dollars per tonne of carbon, is $939/tC[23] (2022 value of $256/tCO₂e multiplied by 3.67, the conversion from CO_2 to carbon, resulting in a SCC value for 2022 of $939/tC[24]). As seen in Figure 19, most of the assets within Pelham are associated with carbon sequestration values. The few assets with negative values of carbon sequestration are young forests[25] and will, assuming no significant disturbances occur within those assets in the future, become positive contributors to the value of carbon sequestration over time. The total value of carbon sequestration within the Town of Pelham in 2022 was $12.2M (CAD 2022).

Figure 19: Total Value of Carbon Sequestration by Asset in 2022



22 The social cost of carbon for 2022 was sourced from this dataset: *www.canada.ca/en/environment-climate-change/services/climate-change/science-research-data/social-cost-ghg.html*, in Table 1, column "SCC/SC-CO_2", row 2022.

23 To calculate carbon from carbon dioxide, units of CO_2 are converted to units of carbon by multiplying 1 unit of CO2 by 44/12 (3.67). The atomic weight of Carbon is 12.001115. The atomic weight of Oxygen is 15.9994. The weight of CO2 is C+2*O=43.999915. The ratio of CO_2 to carbon is 43.999915/12.001115=3.6663 or 3.67.

24 To calculate carbon from carbon dioxide, units of CO2 are converted to units of carbon by multiplying 1 unit of CO2 by 44/12 (3.67). The atomic weight of Carbon is 12.001115. The atomic weight of Oxygen is 15.9994. The weight of CO2 is C+2*O=43.999915. The ratio of CO2 to carbon is 43.999915/12.001115=3.6663 or 3.67.

25 See *appendix A* for further explanation.

VALUE OF FRESH WATER

To estimate the annual value of fresh water for households, a willingness to pay (WTP) value for sustainable and reliable water from the Dupont and Renzetti (2008) publication was applied to the number of households in Pelham. Dupont and Renzetti estimated the average WTP for sustainable and reliable water at $719 per household in 2005, which translates to $1,120 per household in 2022 dollars. The value of the fresh water supply to households was estimated at $7.9M, this is the product of 7,123 households[26] at $1,120 per household.

To estimate the value of the water supplied to the industrial, commercial, and institution (ICI) sector within the Town of Pelham, the average water values for the primary industries and commercial sectors from the Dupont and Renzetti (2008) paper were used. According to that study, the value of the water supply to primary industries was $0.33/m³ and the value of water supply to the commercial sector was $0.55/m³, with the average of the two being $0.44/m³ in 2005 dollars. Adjusting for inflation, the average value of water supplied to the ICI sector is $0.69/m³ (CAD 2002). Applying this value to the volume of water consumed by the ICI sector (124,511m³ in 2022) results in a value of freshwater for the ICI sector of $85,912. The sum of the value of the fresh water supplied to households and the ICI sectors within the Town of Pelham is thus estimated at $8.1 million annually.

The value of water for irrigation was based on the Dupont and Renzetti (2008) study which provides a value of $1.06/m³ ($CAD adjusted to 2022). To estimate the value of water for irrigation, the Dupont and Renzetti value was applied to the volume of water consumed by vineyards and greenhouses. The consumption rate used for irrigation of vineyards within the Town of Pelham was based off a technical report developed by Stantec[27] (2005). It was assumed that the "South District" within the Stantec study was representative of the Town of Pelham region.[28] Drawing data from the Stantec report, the water consumption rates for irrigation of vineyards were back calculated. Tables 3-8 and 3-9 of the Stantec study provided the framework used to back-calculate the m3 per day rate. Vineyards were estimated to consume water at a rate of 876 m3/ha/yr. This rate was applied to the 5 ha of vineyards within the Town of Pelham for a total consumption rate estimated at 4,030 m3 in 2022. Applying Dupont and Renzetti's value ($1.06 per m3) to this consumption rate yields a total value of irrigation water supply for vineyards of $4,272. Within the ICI consumption data provided by the Town of Pelham is a line-item for "Rice Road Greenhouses." Although there are additional greenhouses in Pelham, only those on Rice Road use municipal water and are here considered for valuation. The associated consumption rate for Rice Road greenhouses is 1,990 m3 for 2022. This volume was applied to the Dupont and Renzetti value for irrigation ($1.06/m³) to yield a

26 As estimated by *StatsCan (2021)*

27 Feasibility Study – Raw Water for Agricultural Irrigation Purposes. Project Report. Irrigation Demands. August 2005. Stantec.

28 Specifically, Tables 3-8 and 3-9 of the Stantec study provide the data to back-calculate a m³ per day rate.

value of $2,109 for Rice Road greenhouses. Taken together the estimated value of water for vineyards and greenhouses is $6,381.

The value of the irrigation added to the ICI and residential sectors results in an estimate of the total value of the fresh water supplied to the town of Pelham of $8.1 million per year.

VALUE OF RECREATION

The annual value of recreation was based on estimates of trail usage obtained or derived for the Town of Pelham. User data was provided by the Town for the Gerry Berkhout and Steve Bauer trails. Table 8 shows the lengths of a number of trails within the Town for which user data was not available.

Table 8: Trails In Pelham and their Distance in KM

Trail Name	Length (km)
Short Hills Trail	8.63
Swayze Falls Trail	5.96
Rice Road Multi Use Trail	1.80
Bruce Trail	1.57
East Fonthill Trail	1.00
Palaeozoic Path	0.99
Scarlet Tanager Trail	0.94
Bruce Trail - Niagara Section	0.93
Black Walnut Trail	0.87
Saffron Meadows Trail	0.80
Wetland Trail	0.66
Bruce Trail - Black Walnut Side Trail	0.65
St. Johns Ridge Trail	0.50
River Lookout Trail	0.34
Riparian Trail	0.29
Horseshoe Trail	0.20
Forest Tract	0.14
Lookout Trail	0.12
Sassafras Stroll Trail	0.11
Thorold-Fonthill Spur Trail	0.04
Total	**26.54**

For the 26.54 km of trails shown in the table above, user data was derived. To do this, user data for the Spencer Creek trail in the City of Hamilton[29] was employed. User data for the Spencer Creek trail indicate 1,758 users per kilometre of trail per year. Multiplying 1,758 by the number of kilometres of trail

29 Green Analytics and C. Talbot & Associates, 2022. Cootes to Escarpment EcoPark System Ecosystem Service Valuation. 38 pp

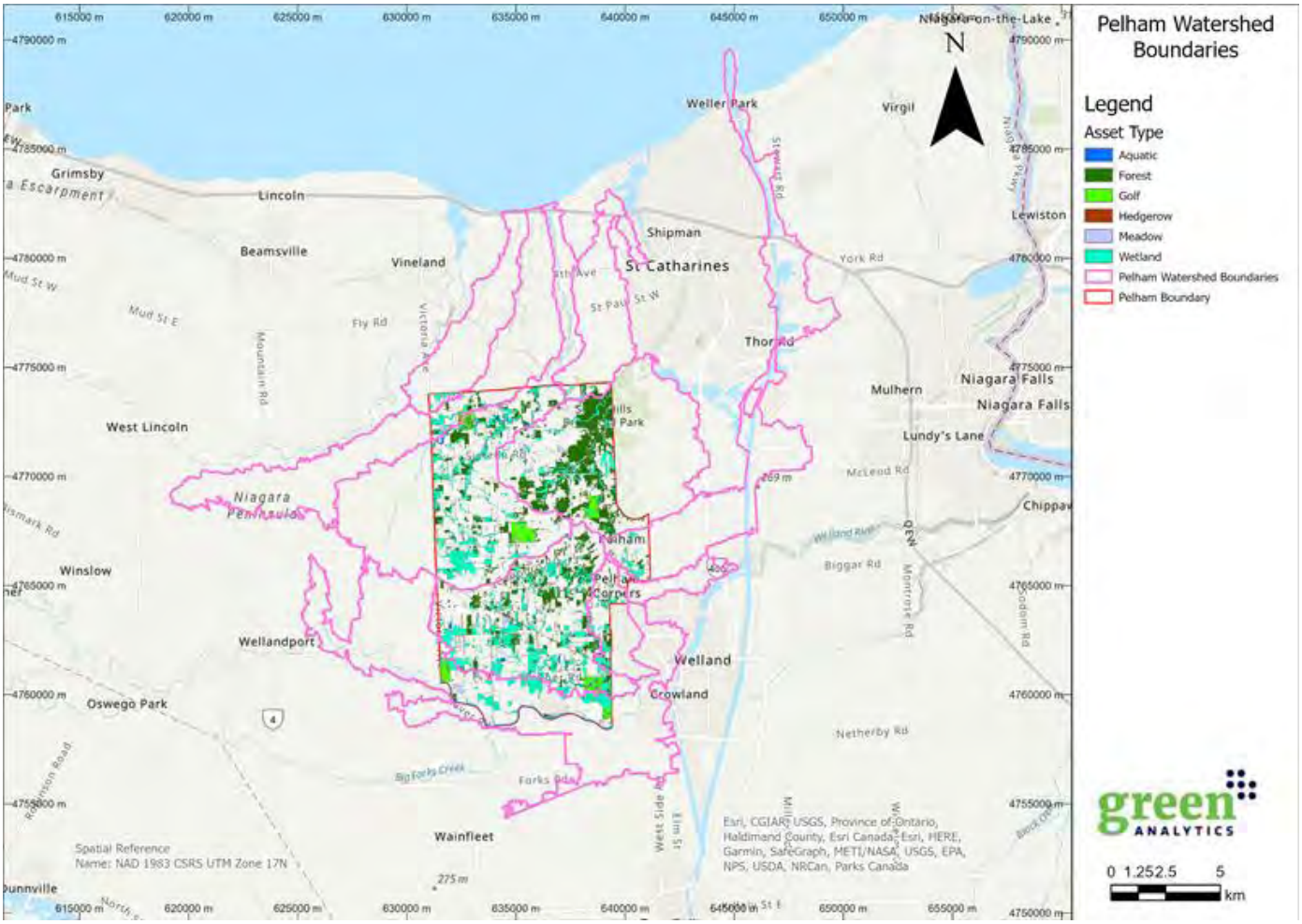
in Pelham for which user data was not available (26.54 km as per Table 8) results in an estimated 46,657 user days per year or about 127 users per day. This trail use is in addition to the Gerry Berkhout and Steve Bauer trails (for which user data was directly available from the Town). For these trails, there were an estimated 20,832 users throughout the summer months, which works out to an additional 57 users per day. The total user days for the trail networks in the Town was thus estimated at 67,489 (or 185 per day).

To derive an annual value for recreation, the estimated trail users per day (185) was multiplied by a cost per day. Two cost estimates were employed. The Canadian Nature Survey published a study in 2014 which, adjusted to current dollars, estimated a value per trail user per day of $23 (CAD 2022). Rosenberger et al. (2012) published a similar study which, adjusted to current dollars, estimated a value of $61 per user per day. Using these values, the value of recreation for the trails in Pelham is estimated to range from $1.6M to $4.1M per year.

VALUE OF HABITAT PROVISION

There are several relevant scientific articles on the WTP for biodiversity and habitat provision. This analysis uses WTP values that were originally calculated for two watersheds north of Hamilton, Ontario, based on methods established by Trenholm (2018). The methods outlined in Trenholm (2018) estimate a WTP value based on the number of households as well as the percent of habitat present within a given watershed. For the purposes of this study, asset classes that were deemed to provide habitat and biodiversity values were aquatic, golf courses, forests, hedgerows, meadows, and wetlands. The distribution of the assets providing habitat by watershed boundary is shown in Figure 20.

Figure 20: Habitat Assets Within the Town of Pelham's Watershed Boundaries



According to the Trenholm (2018) study, the WTP values per percent of watershed protected per year ($/yr/household) for the Credit and Humber watersheds are $1.63 and $2.90 (CAD 2022), respectively. To determine the percent of protected habitat provided within the Town of Pelham, the total area of the assets providing habitat (4,488 ha), shown as the filled polygons in Figure 20 above, was divided by the total area of the watersheds (34,818 ha), shown as the hollow purple polygons in Figure 20. The resulting value — 13% — is the protected habitat provided within the Town of Pelham. Taking the Trenholm approach, the value of habitat is estimated as the product of 13%, the number of households (7,123) and the WTP per household ($1.63 and $2.90). The result is a value for habitat ranging from $150,936 to $268,537 annually ($1.63 x 13 x 7123 = $150,936 and $2.9 x 13 x 7123 = $268,537).

ECOSYSTEM SERVICE VALUE SUMMARY

This analysis estimated the value of several ecosystem services provided by the natural assets within the Town of Pelham. Taken together, the combined value of recreation, carbon sequestration, freshwater and habitat was estimated to range from $22.1 M to $24.7 M per year (Figure 21). Recreational values provided between $1.6 M and $4.1 M per year, though these should be considered conservative estimates given the likelihood of additional trails and recreational

activities for which data was unavailable. The water supply of the Town of Pelham was estimated at $8.1 M per year. The value of carbon sequestration using the CAD 2022 value of the social cost of carbon was about $12.2 M per year. Habitat Provision was also estimated between $150,936 and $268,537 ($0.15 M and $0.3 M).

***Figure 21**: Annual Ecosystem Service Values within the Town of Pelham*

4.5 Assessment Phase Limitations and Gaps

NAI's assessment of the current state of natural assets contains limitations and knowledge gaps related to natural assets:

- There are currently no condition indicators for ecological condition due to limited available data.
- The PCSWMM was limited by the availability of observed data and was developed to be a relatively simplified surface hydrology model of the UTMC subwatershed. A fulsome review of model limitations is included in the modelling report and should be consulted prior to future studies.
- Ecosystem service values are based on the benefits transfer approach and as such, provide order-of-magnitude estimates.

4.6 Next Steps for Continuous Improvements in the Assessment Phase

As part of adaptive asset management and continuous improvement towards a full natural asset management project, next steps for the Town of Pelham include:

- Expanding the condition assessment to include additional metrics (e.g., relative biodiversity, riparian and wetland health, soil condition, connectivity, and others) and employ site visits to confirm and verify the condition ratings. In particular, ecological condition should be assessed as per CSA W218:23.
- Complete erosion modelling. This could be completed with the existing model by changing parameters for continuous modelling to identify erosion exceedance thresholds. Alternatively, Pelham could focus on a single site experiencing a high-level of erosion, using engineering expertise to develop a design for an erosion restoration project.
- Further detailed enhancement and expansion of the modelling analysis.
  - Calibrate the model with pollutant data to compare the water quality benefits provided by the existing natural assets and the stormwater controls.
  - Complete a detailed updated hydrologic model for the entire watershed to compliment the current study in the future and/or adjacent watersheds.
  - Use historical rainfall data from a rain gage station to create a continuous model and compare the peak flow and infiltration results.
  - Pair this model as a continuous model with a separate groundwater model.
  - Apply plans for future restoration projects to understand the impact to peak flow reduction at the subwatershed scale.
  - Modify in-stream works such as a widening a bridge or adding a dam to understand the impacts to peak flow at the subwatershed scale.
  - Pair this model with a separate hydraulic model (HEC-RAS) to understand floodplain impacts related to loss or replacement of natural assets.
  - Calibrate the model for sediment load and study the erosion impacts at a subwatershed level, including investigating the watercourse erosion thresholds.
  - Initiate separate study of wetland infiltration of watercourse overflow to further improve the accuracy and understanding of the groundwater recharge function of wetlands.
  - Incorporate climate change considerations into the model by projecting the rainfall in 2050 or 2100 and simulating the existing models with the new rainfall.
- Refinement of ecosystem valuation through primary studies, a meta-analysis or utility model for priority services.

5.0 Planning Phase of Natural Asset Management

Figure 22: Planning Phase in the Natural Asset Management Process

The NAM planning phase sets Levels of Service for natural assets and develops operations and maintenance costing. During this phase, scenarios may be explored through modelling, but was out of scope for this study. This section provides an overview of the approaches followed and describes planning phase results.

5.1 Level of Service Framework

The purpose of this section is to recommend a level of service framework for natural assets for the Town of Pelham to guide decision-making related to natural asset management.

Natural asset management touches many local government services and requires coordination and collaboration between multiple departments. Therefore, this proposed framework, and natural asset management more generally, should be considered within, and not separate from, the Town of Pelham's organization-wide approach to asset management.

This framework will evolve and be refined as the Town of Pelham strengthens its overall asset management practices. The framework includes a description of recommended corporate service objectives for natural asset management, as well as customer and technical levels of service measures that can be used to track progress on the management of priority services. It also outlines the data and information requirements for measuring progress on LOS.

The framework is based on defining levels of service for the following priority services identified in the project:

- Stormwater
- Water (for drinking and irrigation)
- Biodiversity
- Nature-based recreation
- Climate mitigation and adaptation

It was developed through:

- A review of key documents to identify the Town of Pelham's strategic service delivery objectives that depend on healthy natural assets and ecosystem services (see Section 2 below).
- One workshop with Town of Pelham staff through which the recommended performance metrics for priority services were reviewed and refined.

STRATEGIC DRIVERS OF NATURAL ASSET MANAGEMENT FOR THE TOWN OF PELHAM

Several of the Town of Pelham's guiding documents include goals, objectives or policy considerations for the protection and proactive management of natural assets, described below. These constitute Pelham's current drivers of natural asset management and the level of service framework was developed to be aligned with them.

Town of Pelham Official Plan (OP)

Pelham's OP[30] contains several goals and objectives that natural asset management should align with and that should support prioritization of natural asset management activities.

Table 9: Town of Pelham's Official Plan Goals and Objectives

Goal or objective ID	Description
A2.1.1 Goal	It is a goal of this Plan to maintain, enhance or restore ecosystem health and integrity.
A2.1.2 Objectives	To ensure that an understanding of the natural environment, including the values, opportunities, limits and constraints that it provides, guides land use decision-making in the Town.
	To make planning decisions that considers the health and integrity of the broader landscape as well as long term and cumulative impacts on the ecosystem.
	To make planning decisions that avoids negative environmental impacts as a first priority, with secondary priority given to mitigation of negative impacts.
	To restrict and regulate land uses which could impact the water quality and hydrological and hydrogeological characteristics of watercourses, aquifers and wetlands.
	To encourage the establishment of an open space system that links environmental and recreational resources both within and beyond the boundaries of the Town.
	To continue the development of an environmental data base and monitoring program to assist with decision making and public education.
b.1.5.1 Open Space Designation	access to a well-planned and accessible parkland system, which incorporates the principles of active transportation. Applies to the open space lands that are in public ownership and which are summarized as: The Steve Bauer Trail system; • All community parks in the settlements; • Passive and/or unimproved public parkland; and, • All NPCA lands Permitted uses in the Open Space designation outside of the settlement areas may include non-motorized passive and active recreational uses, festivals, special events, conservation uses, community gardens, forestry uses in accordance with good management practices and accessory uses.
B1.5.4.4	The protection of the watershed of Twelve Mile Creek and Coyle Creek is a major objective of this Plan. All NPCA lands are intended to be used on a passive basis, as most NPCA lands are characterized by environmentally sensitive features. It is the intent of this Plan to encourage the NPCA to maintain these lands in public ownership and to ensure their use is consistent with the ecological character and natural heritage features in the immediate area.
B1.66	To design a stormwater management system that is integrated with the open space system and which mitigates impacts on the natural environment

30 Access Pelham's OP at *www.pelham.ca/en/business-and-development/official-plan.aspx*

Goal or objective ID	Description
B3.4.4.1	Ecological connectivity noted; Where development or site alteration is proposed in proximity to lands in the Environmental Protection Two designation, efforts should be made, to maintain and where possible enhance linkages amongst lands designated Environmental Protection One, Environmental Protection Two, or Environmental Protection Three.
B1.7	East Fonthill Secondary Plan objective to provide a connected Greenlands System that comprises natural features, stormwater management facilities, streets, and varying sizes of public parks and parkettes. The integrated open space system shall provide access to the Steve Bauer Trail while also providing opportunities for exposure to the environmental assets of the community, while ensuring the conservation and enhancement of significant natural features. Natural heritage features include: a) Wetlands, b) Woodlands, c) Valleylands, d) Significant habitat of endangered species, threatened species and special concern species; e) Wildlife habitat; and, f) Fish habitat.[31]
	Regarding buffer areas for land designated as Environmental Protection Two: adjacent lands are defined as all lands within 50 metres of designation
	Regarding buffer areas for lands adjacent to Environmental Protection One: Lands adjacent to a natural heritage feature within which impacts must be considered and within which the compatibility of the development proposal must be addressed. Defined as all lands within: 120 metres (393.7 feet) from the boundary of a Provincially Significant Wetland (PSW); 50 metres (164 feet) from the boundary of a Provincially Significant Life Science Area of Natural and Scientific Interest (ANSI); and, 50 metres (164 feet) from the significant habitat of endangered species and threatened species. No development or site alteration shall be permitted on adjacent lands unless an Environmental Impact Study (EIS) demonstrates that there will be no negative impact on the feature or its ecological functions.
B3 NATURAL HERITAGE DESIGNATIONS	The Environmental Protection designations contained in this Plan are intended to comprise and reflect the natural heritage system in the Town. The following designations address the natural heritage policies of the Provincial Policy Statement, Niagara Escarpment Plan, Greenbelt Plan and the Regional Policy Plan: ■ Niagara Escarpment Plan (refer to Section B3.1 for the applicable policies for this designation); ■ Environmental Protection One – Regional Environmental Protection Area (EPA) (refer to Section B3.2 for the applicable policies for this designation); ■ Environmental Protection Two – Regional Environmental Conservation Area (ECA) (refer to Section B3.3 for the applicable policies for this designation); and, ■ Environmental Protection Three – Greenbelt Plan Key Natural Heritage and Key Hydrological Feature (refer to Section B3.4 for the applicable policies for this designation).
B3.4.	Outlines the policies the Environmental Protection 3 designation, related to the Natural Heritage System in the Greenbelt Plan area.

31 During the level of service workshop, staff noted that the East Fonthill secondary plan includes policies around naturalization of stormwater ponds. Staff noted that additional policies on naturalization of stormwater ponds may be developed in future.

Goal or objective ID	Description
B3.4.4.3	Expansion of Buildings or Structures The expansion of agricultural buildings or structures and residential dwellings may be permitted on lands in the Environmental Protection Three designation provided the existing buildings or the proposed expansion does not occur in a Provincially Significant Wetland (PSW) or Life Science ANSI, or the significant habitat of endangered species, threatened species and special concern species.
B3.4.4.3	Transfer of Environmental Lands into Public Ownership Council will endeavour to work with the Region and other public agencies, such as the Province, to develop and implement a land securement strategy that would result in the transfer of environmental lands into public ownership. However, given the financial limitations of every level of government, this policy does not imply that all lands within the Environmental Protection Three designation will be purchased by the Town or any other public agency.

Northwest Fonthill Secondary Plan (part of the Town of Pelham Official Plan)

Pelham's OP includes the Northwest Fonthill Secondary Plan, which defines general objectives for stormwater management:

- To maintain, and where possible, improve the health and condition of the receiving watercourses;
- The achievement of no net increase in stormwater run-off from the area to adjoining lands;
- To maintain, and where possible, improve the quality of stormwater entering surface and groundwater supplies; and,
- To promote the use of naturalized methods of stormwater management.

The Secondary Plan and related Subwatershed Study requires valuation of the Watercourse land dedication, including environmental buffers, and is subject to contributions from other benefiting landowners through front ending agreements, Development Charges By-law, or other developer's group agreements as deemed appropriate by the Town.

The Secondary Plan also includes requirements for stormwater management related to groundwater recharge, erosion control, water quantity, water quality, and water temperature control.

The Plan also notes that the monitoring provisions set out in the Subwatershed Study and Environmental Impact Study (EIS) should be considered minimum requirements only.

Niagara Escarpment Planning and Development Act (NEPDA)
The NEPDA regulates watercourses and wetlands included in the Environmental Protection 1 and Environmental Protection 2 designation areas. The designation is intended to reflect key natural heritage features and key hydrologic features identified in the Natural Heritage System of the Provincial Greenbelt Plan (2005).

The NEPDA regulates watercourses and wetlands included in the Environmental Protection areas. The Greenbelt Natural Heritage Overlay designation is intended to reflect lands within the Natural Heritage System of the Provincial Greenbelt Plan (2005)

The Niagara Escarpment Plan area is located in the north-east corner of Pelham and is the site of three land use designations and a public lands designation overlay. These include the Escarpment Protection Area, Escarpment Natural Area, and Escarpment Rural Area designations and an overlay designation identifying public lands in the Niagara Escarpment Parks and Open Space System. The policies relating to these designations can be found in the Niagara Escarpment Plan. Changes to these designations or their related policies require an amendment to the Niagara Escarpment Plan in accordance with the provisions of the Niagara Escarpment Planning and Development Act. Lands designated Floodplain and Valley land constitutes regulated areas in accordance with the Conservation Authorities Act and Regulations.

Twelve Mile Creek Watershed Plan
The Twelve Mile Creek Watershed Plan (NPCA, 2006) includes the following targets set by Environment Canada:

- **Wetlands:** wetland habitat should constitute greater than 10% of each major watershed; greater than 6% of each subwatershed; or restore to original percentage of wetlands in the watershed.
- **Forest:** at least 30% of the watershed should be in forest cover.
- **Riparian:** 75% of stream length should be naturally vegetated.

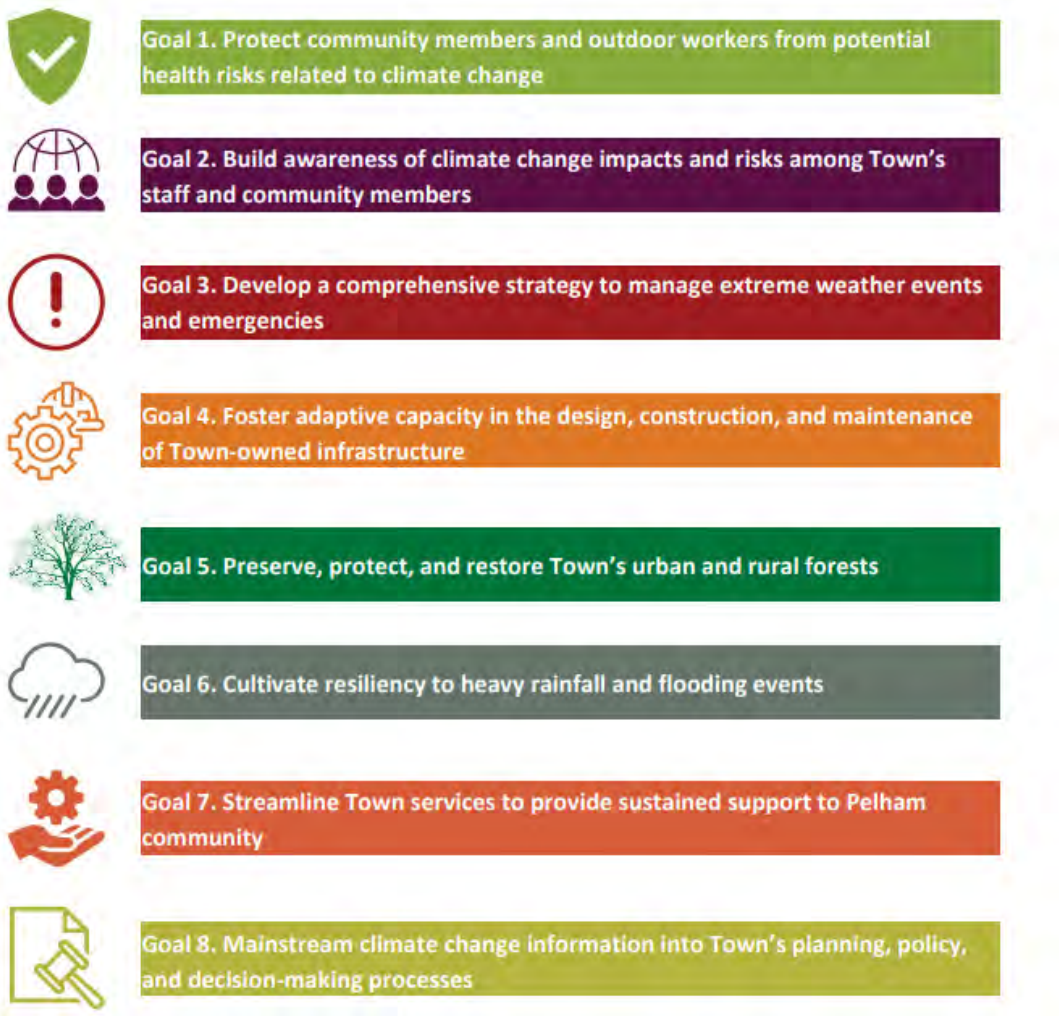
Corporate Climate Change Adaptation Plan
The Vision statement in the Town of Pelham's Corporate Climate Action Plan (2021) is:

> *"The Town of Pelham will reduce, respond to, and recover from, the unique climatic threats posed by climate change, and will embrace the opportunities that position the Town to support sustainable development by promoting cultural assets while protecting our environmental assets."*

The plan documents eight main goals, shown in the Figure 23 below.[32]

32 Town of Pelham's Corporate Climate Action Plan: *www.pelham.ca/en/resourcesGeneral/Corporate-Climate-Change/Corporate-Climate-Change-Adaptation-Plan---CCCAP.pdf*

Figure 23: Excerpt from the Town of Pelham Corporate Climate Change Adaptation Plan (p.27)



The following actions identified in the Plan are relevant to natural asset management and have been considered in the LOS measures for natural assets recommended in this project:

- **4.1** Assess the condition of the Town's stormwater management infrastructure and explore opportunities for upgrading or reinstalling infrastructure.
- **4.8** Legitimize the use of green infrastructure by incorporating the same in Capital Asset Management Plan and training the staff on the utility and benefits of green infrastructure
- **5.1** Map Town's tree cover to understand the spread of existing tree canopy and develop strategies for expanding the municipal tree canopy target.
- **5.2** Create a combined Forest Strategy and an Emergency Response Strategy to address the impacts of climate change on tree canopy cover and respond to such impacts (e.g. attack of invasive species like Gypsy Moth).
- **5.4** Support partnerships with local/national organizations to enhance preservation, protection and restoration of tree canopy cover and biodiversity.

5.5 Focus on Town's green infrastructure of parks and open spaces, green spaces, urban forests, natural heritage areas to explore opportunities to expand the use of similar nature-based solutions to adapt to climate change impacts (e.g., heat stress).

6.2 Promote the use of green infrastructure tailored to minimize the effects of flooding.

INTRODUCTION TO LEVELS OF SERVICE

What are Levels of Service?

Levels of Service (LOS) are objectives and performance measures that define the expected performance of assets and related services and are an essential pillar of asset management. They represent the service delivery commitment of a local government and inform asset management and financial plans and help local governments to prioritize capital and operational spending decisions.

Defining LOS enables municipalities to link strategic organizational objectives with technical and operational requirements of infrastructure, and is a way to guide a local government towards optimizing investments in infrastructure and service delivery.

It is the responsibility of a municipality's council to approve and monitor progress on LOS. Doing so enables them to be transparent and accountable for their decisions about service delivery. When councils share information about current LOS and associated costs with the public and other affected stakeholders, they are better able to communicate the social, environmental, and financial impacts of improving or reducing services and engage the community on their WTP for changes in service levels.[33]

Types of LOS Measures

There are three main types of LOS measures that, taken together, show how day-to-day operational activities of infrastructure will be aligned with and support a local government's strategic objectives.

1/ **Corporate LOS Objective:** a high-level performance objective used to measure progress on service delivery and informs the development of multiple customer and technical levels of service linked to that objective. For example:

- ☐ Manage natural areas to protect watershed(s), such that the quality and quantity of ground and surface water and ecosystem health is maintained or enhanced.

2/ **Customer LOS Objective/Measure:** a performance objective or measure that describes the service the community should expect to receive, expressed in terms that make sense to them. Customer LOS objectives tend to be more granular than corporate LOS objectives because

33 Source: Developing Levels of Service for Natural Assets: A Guidebook for Local Governments, Natural Assets Initiative (2022), page 6.

they refer to specific aspects of service delivery such as accessibility, capacity, etc. Examples include:

- Qualitative statements that describe how the community should expect to receive the service, such as: Source water is protected and meets regulatory standards, and related indicators that measure the community's interests or experience related to the customer level of service objective (e.g., % times annually source water quality reported to fall below thresholds outlined in BC Government water quality guidelines).

3/ **Technical LOS Measure:** a performance measure that describes the performance of the asset in relation to the service, or the operational requirements of infrastructure that will enable the local government to deliver the expected customer level of service. Examples include:

- A description of the ecosystem service provided by natural assets, such as runoff reduced by forests or water storage capacity of a wetland, and related indicators, such as volume of runoff reduced or m^3 of storage capacity; or
- A description of lifecycle management activities the municipality will undertake to manage natural assets, such as restoration of degraded natural areas, and related performance indicators, such as # hectares restored annually.

LOS Attributes

There are some key service attributes that are important to consider when developing performance indicators for natural assets. These include capacity, quality, and function:

- **Capacity:** Assets have enough capacity and are accessible to everyone
- **Quality:** Assets meet community needs while limiting impacts to health, safety, security, and nature
- **Function:** Assets perform their intended functions and are safe, secure, and sustainable

The additional attributes shown below are also important to consider when developing customer and technical LOS, because they encompass all aspects of service delivery. These are:

- **Safety:** the service is delivered safely, and risks are managed
- **Regulatory:** the service meets all regulatory requirements
- **Reliability:** the service is reliable
- **Accessibility:** the service is accessible
- **Sustainability:** the service is sustainable (social, environmental, and financial sustainability)
- **Cost/affordability:** the service is affordable
- **Customer Service:** the local government is responsive to questions or concerns about the service

RECOMMENDED LEVEL OF SERVICE MEASURES FOR NATURAL ASSETS FOR THE TOWN OF PELHAM

Overview of Natural Asset Services of Interest to the Town of Pelham

The Town of Pelham has identified priority services or co-benefits from natural assets to include storm water and flood management, water for drinking and irrigation, climate resilience services such as the mitigation of urban heat island effects, biodiversity services including habitat for species at risk, and recreation services. Below is a summary of how natural assets contribute to these services.

Storm Water and Flood Management

Natural assets play an important role in stormwater management, oftentimes at a lower cost than grey infrastructure solutions alone. Natural assets can be very effective in storing water, controlling peak flows, supporting groundwater recharge, and controlling erosion. By reducing stormwater runoff in urbanized areas, natural assets also contribute to the protection of source water and overall ecosystem health.

Drinking Water and Irrigation

Fresh water is essential for human survival and all local governments that provide drinking water services have an interest in protecting source water quality and quantity. The cleaner a community's source of drinking water, the more cost-effective service delivery will be through avoided costs of water treatment. Local governments also need to build an understanding of the *quantity* of source water available for the community (for potable use and non-potable uses, such as irrigation or firefighting) and take relevant actions to protect the supply of source water. There may be natural asset management activities (e.g., forest conservation) that support aquifer recharge for communities relying on groundwater. Taking measures to protect aquifers helps to manage the costs and risks of water service delivery and may lead to service delivery savings over the long-term. Local governments can also implement demand management programs and policies to help conserve water. With increased risk of drought from climate change, some local governments are looking into strategies to conserve drinking water, which has very stringent treatment requirements, and separate it from other uses such as emergency fire services and irrigation.

Climate Resilience Services

Ecosystems and the natural assets they contain are vital to the climate system through their role in the carbon cycle, the water cycle, and the maintenance of biodiversity. Land plays a key role in storing greenhouse gases. In Canada, the soils of the tundra, forests, wetlands, and grasslands are of heightened importance for carbon storage. However, once ecosystems are disturbed, carbon is released to the atmosphere. Ecosystems also play an important buffering role in reducing the severity of climate change, including through services such as flood attenuation, urban heat island reduction, and storm surge protection. Maintaining, restoring, and managing ecosystems to address climatic and non-climatic stressors are key strategies for reducing their vulnerability and the vulnerability of communities in the face of climate change, by enhancing their

resilience to changing conditions.

Biodiversity Services

Biodiversity is the diversity among living organisms. It is essential to support functioning ecosystems. Changes in biodiversity can influence the supply of ecosystem services, and for the Town of Pelham, can negatively impact agriculture and food production, important aspects of the Pelham's economy. Urbanization drives the loss of biodiversity, most directly through habitat loss and fragmentation and Pelham plays an important role in implementing solutions.

Nature-based Recreation Services

Recreation services play a vital role in fostering healthy, engaged and socially cohesive communities and is a primary service offered by the Town of Pelham. Natural assets provide opportunities for nature-based recreation activities and are critical to the local economy and health and well-being of the community. While the use of natural assets provides many benefits to the community, Pelham has an important role in balancing their use with their conservation and management to ensure ecosystem services can be provided sustainably over the long-term. To determine that balance, it needs to consider how risks like climate change, pollution, and land-use change from development pressure affect natural assets and their ability to provide ecosystem services to the community.

PROPOSED CORPORATE LEVEL OF SERVICE OBJECTIVES FOR NATURAL ASSETS

As mentioned, corporate LOS measures sit towards the top of the asset management hierarchy of decision making. They broadly describe the natural asset services the Town of Pelham aims to provide to the community. Municipalities typically document only a small number of corporate LOS measures for each service area or asset class. The six corporate LOS measures proposed below for the Town of Pelham are therefore high-level and encompass the key service objectives related to protection and management of natural assets.

***Table 10**: Proposed Corporate LOS Objectives*

#	Proposed Corporate LOS Objectives
1/	Promote the use of naturalized methods to support stormwater management.
2/	Protect and enhance natural assets to support biodiverse natural habitats and ecosystems.
3/	Leverage natural areas to mitigate and adapt to climate change.
4/	Protect source water quality and quantity by sustaining hydrological and hydrogeological characteristics of watercourses, aquifers and wetlands (watershed protection).
5/	Control erosion to protect watershed health and property.
6/	Provide access to nature for passive recreation and cultural activities.

The next sub-sections include proposed customer and technical level of service measures for Pelham that can be used to prioritize and plan for natural asset management investments.

PROPOSED CUSTOMER LOS FOR NATURAL ASSETS

As mentioned, customer LOS measures are performance measures that describe how the community should expect to receive natural asset-related services, in terms that make sense to them. They refer to aspects of service delivery that are important to the community, such as accessibility to the service, reliability of the service, and quality of the service. In this LOS framework, the customer LOS measures recommended below relate to corporate LOS objectives # 3 and #6 that relate to climate mitigation and adaptation and recreation. All other LOS measures recommended are technical measures.

Table 11: Proposed Customer LOS Measures

Level of Service Measures	Service attribute	Indicators
C.1 Provide access to nature-based recreation	Capacity	C.1a # hectares natural areas accessible to the public
	Accessibility	C.1b % residents within a 15-minute walk of a publicly owned natural area
	Accessibility	C.1c # km sanctioned trails accessible to the public
C.2 Quality of nature-based recreation	Quality	Satisfaction with quality of nature-based recreation (survey, frequency TBD)
C.3 Value of nature-based recreation and tourism	Cost/value	$ value of nature-based recreation and tourism[34]
C.4 Climate mitigation and adaptation benefits of natural assets	Sustainability	C.4a % tree canopy[35]
	Cost/ Sustainability	C.4b Value of stormwater services provided by natural assets

PROPOSED TECHNICAL LOS FOR NATURAL ASSETS

The technical LOS below are broken down into the categories of ecosystem service LOS (performance of the natural assets) and operational LOS (performance of the municipality).

34 Consider using results of co-benefits valuation as the “current level of service”.

35 Currently being tracked by the Town of Pelham.

ECOSYSTEM SERVICE LOS[36]

Table 12: Proposed Ecosystem Service LOS Measures

Level of Service Measures	Service attribute	Indicators
T.1 Extent of the natural assets that provide ecosystem services	Function	# hectares natural assets, broken down by asset type and by location within or outside the Greenbelt[37]
T.2 Extent of protected natural areas	Function	# hectares natural heritage system under public ownership
T.3 Ecological condition of the natural assets	Quality	% of natural assets in very good or good condition, broken down by asset type in the inventory
T.4 Biodiversity of native species	Quality	Currently no monitoring program or data. Continuous improvement measure[38]
T.5 Annual carbon sequestration	Capacity	T.5a Kg/m³ sequestered, broken down by natural asset type
	Cost	T.5b Value of carbon sequestered annually, broken down by natural asset type
T.6 Watershed protection: riparian buffers	Function/ Regulatory	% of watercourse length and wetlands with required buffer of natural riparian cover as per regulatory requirements (ENV protection zones 1, 2 and 3); potentially broken down to include naturalized stormwater ponds[39]
T.7 Stormwater services provided by natural asset sub-catchments	Capacity	Reduced peak flows from natural asset sub-catchments; Reduced runoff depth from natural asset sub-catchments[40]
T.8 Extent of pervious cover to support stormwater management	Capacity	% pervious cover in the Town[41]
T.9 Source water quality	Function	% times annually source water quality reported to fall below regulatory thresholds

36 LOS measures in this table focus on intact natural areas and do not naturalized stormwater ponds or low impact development installations in the urban area, except potentially T.6.

37 Note: The Town of Pelham's natural asset inventory includes a layer showing natural assets within the Greenbelt.

38 Could refer to NPCA assessment from 2009/2010, where biodiversity is part of the natural heritage inventory; however, data is outdated and did not consider diversity of fauna.

39 During the LOS workshop with Pelham staff, there was interest in tracking vegetated buffers around naturalized stormwater ponds, some policies currently exist in the East Fonthill Secondary plan.

40 These metrics were used to assess stormwater services provided by natural assets, so current LOS (2024) can be documented by referring to the study results.

41 Data may be limited to some parts of Pelham, to be determined. Included as a continuous improvement measure.

OPERATIONAL LOS

Table 13: Proposed Operational LOS Measures

Level of Service Measures	Service attribute	Indicators
O.1 Monitor change in extent and condition of natural assets	Function	Inventory updates; implementation and reporting on monitoring framework (annually? Every 5 years?)
O.2 Monitor change in extent of native species and biodiversity	Quality	Data limitations. Noted as an area for continuous improvement.
O.3 Town of Pelham-managed ecological habitat creation and/or restoration in priority areas.	Function/ Sustainability	# ha restored, broken down by type of restoration/ habitat creation; by location
O.4 Annual spending habitat creation and/or restoration in priority areas.	Cost	$/hectare restoration, broken down by funding source
O.5 Monitoring and management of erosion sites	Safety/ Sustainability	O.5a total # priority erosion sites identified and mapped
	Safety/ Sustainability	O.5b # erosion sites reduced (rehabilitated).[42]
O.6 Targeted management of invasive species	Quality/ Sustainability	Data limitations; noted here as an area for continuous improvement.
O.7 Monitor change in level of stormwater services provided by natural asset sub-catchments	Function	Modelling update every 5 years.[43]
O.8 Natural areas stewardship program (Include description of programs, partnerships, stewardship activities)	Quality	Annual spending on stewardship program; results, where possible, e.g. # hectares maintained, restored or created
O.9 Public securement of priority habitat areas	Function	O.7a # hectares of priority habitat areas secured
		O.7b % change in priority habitat areas protected, broken down by public or privately owned land

DATA AND INFORMATION REQUIREMENTS TO TRACK LOS

A wide range of natural asset types provide services to communities. The level of detail of data and information required for NAM will depend on the Town of Pelham's final selection of LOS to track for natural assets. Collecting, managing, and mapping natural asset data is integral to decision making. Well-defined and mapped indicators, such as the condition of a natural area, can help ensure decisions are evidence-based, and actions are targeted in priority areas to manage risks.

42 Staff noted that key erosion sites within 12 Mile Creek have been identified; areas in headwaters of 12 Mile Creek and five areas across town. Some have management plans. Pelham staff noted interest in tracking erosion sites and their management.

43 Noted as realistic during the LOS workshop with Pelham staff.

The table below provides a summary of the data and information requirements to measure the LOS included in the framework.

Table 14: LOS Data and Information Requirements

Type of data	Details	Gaps
Natural asset inventory, by natural asset type, Spatial data needs include watercourses[44], land cover detailing natural features	■ Include ownership layer ■ Include priority habitat area layer ■ Include priority restoration areas layer ■ Include Greenbelt layer ■ Include invasive species layer (e.g. polygons where invasive species dominate)	Priority restoration areas need to be mapped in the inventory Polygons where invasive species dominate could be added to the inventory as part of continuous improvement efforts.
Condition of natural assets, by type	■ As per condition rating system	As per condition rating system
Erosion sites	■ Priority erosion sites should be mapped and documented	Priority erosion sites should be mapped and documented
Stewardship	■ Track activities and cost of education, partnerships, stewardship program	Track activities and cost of education, partnerships, stewardship program
Water storage capacity, reduced runoff	■ Track for forests and wetlands ■ May require stormwater modelling that is updated periodically	Study has provided initial data and current LOS; update how often?
Carbon sequestration data	■ Track for all natural asset types	Study provided current LOS
Water quality data	■ As per monitoring framework	What water quality data exists?
Monitoring data	■ As per monitoring frameworks; set targets for monitoring ■ Biodiversity of native species	Monitoring frameworks in place? Document established monitoring programs and protocols
Flood-related data	■ Flood extent (or depth), digital elevation data	Relevant for AM in general, less specific to natural assets role
O & M data	■ Track activities and costs	
Restoration data	■ Track activities and costs	
Recreation data	■ Spatial mapping of trails, ■ Satisfaction survey, updates ■ Value of nature-based recreation	

44 A spatial analysis will determine how much of the watercourse has natural riparian areas.

The next step for the Town of Pelham will be to select which indicators in the framework to measure over the short-term, and which should be identified as part of continuous improvement when data becomes available. The Town of Pelham should document the following information related to each indicator it plans to track:

- Current LOS being provided
- Desired trend (increase or decrease)
- Desired LOS (target, if possible)
- Data and information gaps

Current and desired levels of service indicators are needed to inform the development of fully costed natural asset management plans that guide investment and operational decisions over a minimum 10-year period.

The Town of Pelham may wish to update its natural asset inventory to include LOS over time as part of continuous improvement efforts on natural asset management. Pelham should also document the following information:

- How the data will be stored and updated, and whether the data will be stored in one or multiple asset registers;
- Data management protocols (related to accountability for data, accessing and updating data, frequency of updates); and
- Description of financial data about natural assets, including valuation approach where a value has been placed on natural assets.

STAKEHOLDER ENGAGEMENT

Stakeholders and rightsholders are individuals or groups that can affect, be affected by, or perceive themselves to be affected by a Town of Pelham decision or activity. Desired or expected levels of service will be set by Council and should reflect stakeholder and rightsholder needs and interests in the services natural assets provide, while also considering the community's ability to pay for services. The Town of Pelham will be required to engage with multiple stakeholders and rightsholders to help meet its service delivery objectives.

Table 15 below shows specific stakeholder groups or rightsholders that should be consulted about or engaged in natural asset management. These groups include those who depend on or influence ecosystem services at the scale of the entire watershed(s) in and around Pelham. They were identified during the level of service workshop with Pelham staff.

The Town of Pelham has some information about the interests of the groups below through previous planning and engagement exercises. Existing policies and strategies reflect engagement conducted to date. Stakeholder engagement is an ongoing process and natural asset management plans should be updated periodically to reflect new information collected about the community's interests and needs, including their interests in natural asset management stewardship activities.

Table 15: LOS Stakeholders and Interests

Type of stakeholder group or rightsholder	Interests
Recipients	Residents, tourists, visitors, pedestrians, cyclists, swimmers, children, seniors, youth, adults, nature lovers, fish, wildlife, insects (flora and fauna)
Rightsholders[45]	Mississauga's of the Credit First Nation, Six Nations, Haudenosaunee Nation (Treaty rights are specific to water)
Regulatory Agencies	Province of Ontario, Federal Government, Niagara Region, Niagara Escarpment Commission, Town of Pelham, Niagara Peninsula Conservation Authority
Wider Community	business owners, farmers, Friends of 12 Mile Creek, Pelham Advocacy for Tree Health, private property owners (e.g., golf course owners), schools (e.g., green living classroom next to Short Hills provincial park), Nature Conservancy of Canada (own Lathrop Nature Preserve), Brock University, Niagara College
Neighbouring Municipalities	St. Catharines, Thorold, Region of Niagara, Town of Lincoln, Welland
Other Service Providers	Short Hills Provincial Park

5.2 Operations and Maintenance Costing for Natural Assets

"Most natural assets in an urban setting can be sustained for many decades, and longer, with the correct biophysical conditions and the adoption of appropriate management actions."[46]

Like engineered assets, natural assets need to be managed proactively to avoid deterioration of the services they provide. Operations and maintenance (O&M) costs for natural assets are frequently lower than engineered infrastructure since ecological functioning occurs independent of human assistance. With proper monitoring, maintenance, and rehabilitation today, natural assets can provide services for a period longer than that for engineered infrastructure, minimize service disruptions, provide a wide range of co-benefits, and promote long-term resilience.

O&M plans are an essential component of asset management and, in the case of natural asset management, may include monitoring, maintenance, acquisition, and restoration. Well-structured lifecycle management of natural assets should include:

45 Indigenous Peoples are rights holders and not stakeholders. It will be important for the Town of Pelham's natural asset management efforts to align with and support the UN Declaration on the Rights of Indigenous Peoples and, over time, interweave First Nations worldviews, knowledge and perspectives. There are early efforts in Canada that could inform this.

46 Credit Valley Conservation, 2020.

- Monitoring of natural assets' hydrological and ecological functions to inform their condition, or the ability to provide services.
- Maintenance activities to ensure natural assets are intact and self-sustaining.
- Acquisition activities to balance natural assets for critical services and risks.
- Restoration activities to bring degraded assets to an intact ecological state.

APPROACH

To arrive at estimates, the following steps were completed:

- The Town of Pelham was provided with a template for O&M activities, to identify activities, their frequency, who is responsible for their completion (staff or contractors) and the level of effort required.
- Reviewed Credit Valley Conservation (CVC) lifecycle costing report and Pelham stormwater management needs report[47] to develop annual estimates for natural assets on public lands.
- Presented results of O&M costing during Implementation workshop.
- Refined estimates and provided to the Town of Pelham for review and feedback.

OPERATIONS AND MAINTENANCE ACTIVITIES

For the natural assets on public-owned land identified in this project, which include wetlands (both natural and constructed), forests (both urban and street trees) and watercourses, common O&M activities were estimated over a 10-year period for those assets on public lands. The estimates below provide ideal O&M costing to maintain natural assets in a high condition but will vary by ecosystem location and health. Table 16 below provides annual estimates for each natural asset class and described further below.

Table 16: *Natural Asset O&M Activities and Costing*

Type of Natural Asset	Sub-class	O&M Activities	Estimated Annual Cost
Wetland (natural and constructed)	N/A	■ Sediment Cleanout ■ Design ■ Replace Clay Liner ■ Scour Removal/Outlet ■ Spillway Repair	$250,800

47 Town of Pelham. (2023). Stormwater Management Facilities Needs Program Report. Prepared by Matrix Solutions.

Type of Natural Asset	Sub-class	O&M Activities	Estimated Annual Cost
Forest	Street trees	■ Tree purchase and planting ■ Mulching & watering for first 3 years ■ Annual inspections ■ Pruning ■ Tree pest control[48] ■ Basic risk management[49]	$129,000 - $160,000
	Urban forests	■ Vegetation monitoring[50] ■ Forestry assessment[51] ■ Tree pest control[52] ■ Targeted invasive species management[53] ■ Targeted re-plantings[54] ■ Selective thinning[55]	$116,000 - $977,000
Watercourses	Small stream rehabilitation	■ Data collection for water level, flow and quality monitoring[56] ■ Channel form and morphology monitoring ■ Vegetation cover and structure monitoring[57] ■ Localized in-stream channel feature rehabilitation[58] ■ Localized bank stabilization[59]	$250 - $25,000
Total			**$811,356 - $1,726,867**

48 Tree pest control was estimated to address 1/3 of trees every 5 years

49 Basic risk management was estimated for 1/3 of trees every 10 years

50 Vegetative monitoring assumed to happen once every 5 years.

51 Forestry assessment assumed to occur once every 5 years.

52 Pest control is assumed to be applied to 50% of area every 10 years.

53 Targeted invasive species management is assumed to be completed over a 5 year period, with 20% of public forest lands managed on year 1, 10% of forest in years 3 and 4, and 5% in year 5. This process is anticipated to occur every 20 years.

54 Replanting is assumed to occur in 20% of area once every 10 years.

55 Selective thinning is assumed to apply to 15% of area once every 10 years

56 Water level, flow and quality monitoring; channel form and morphology monitoring; and vegetation cover and structure monitoring every 5 yrs

57 Estimated to occur every 5 years

58 Assumed rehabilitation required for 10% of length once every 10 years

59 Assumed localized bank stabilization completed for 20% of stream length every 10 years.

WETLANDS

The Town of Pelham recently retained the services of Matrix Solutions Limited (Consultant) to determine sediment and maintenance requirements for 21 Stormwater Management Facilities. The assessment considered both wet ponds (i.e., ponds that provide a permanent pool volume to allow sediment to settle before moving through the stormwater facility) and dry ponds (i.e., ponds designed to drain completely when there is no inflow of stormwater). Pelham does not perform O&M activities on wetlands that are not managed for stormwater.

Annual O&M costing estimates were determined using Pelham's 2024 budget forecast based on the recommendations provided in the Consultant's report.

FORESTS

Annual O&M costs were estimated for street trees and upland forests.

- **Street tree** costs were tailored for planting in hardscapes (i.e., within sidewalks and boulevards), based on the estimated number of tree plantings per year, which was incorporated into annual costing. An estimate range is provided. The low end of the range is for the planting of 24 trees per year and the high end of the range is for 30 the planting of 30 trees per year.
- **Upland forests** estimates were based on the extent of forest assets on public lands (241 ha). The range in estimated annual O&M costs reflect a range of O&M options. It should be noted that it is unlikely that Pelham would manage all public forests each year. A more practical estimate may be based on managing a lesser percentage per year (e.g, 10 - 20% per year), targeting management activities to upland forests in fair or poor condition, or only those intersecting the Upper Twelve Mile Creek subwatershed. Table 17 below provides alternative options for consideration.

Table 17: Natural Asset O&M Options for Forests

Option	Annual cost
All forests on public lands	$977,000
Forests on public lands in fair or poor condition	$116,000
20% of forests on public lands managed / year	$196,000
TMC forests that intersect with public lands	$406,000

WATERCOURSES

- Annual O&M costs were estimated for small watercourses, given the vast majority of watercourses in Pelham are small. Estimates were completed for watercourses rehabilitation on public lands. The range in estimated annual O&M costs reflect a range of O&M options. Like the forest estimates, it is unlikely that Pelham would manage the full length of watercourses each year. A more reasonable estimate may be based on managing a lesser percentage of stream length per year (e.g., 10 - 20% per year), targeting management activities to watercourses in fair or poor condition or only those intersecting the Upper Twelve Mile Creek subwatershed.. Table 18 below provides alternative options for consideration.

Table 18: *Natural Asset O&M Options for Small Watercourses*

Option	Annual cost
All small watercourses on public lands	$25,000
All small watercourses in fair or poor condition	$2,000
TMC small watercourses that intersect with public lands	$250

5.3 Planning Phase Limitations and Gaps

NAI's Planning Phase of natural assets management contains limitations and knowledge gaps related to natural assets:

- Natural asset O&M costing incurred by Pelham should be consolidated and compared against engineered assets to inform future planning
- Natural asset O&M costing be refined through Pelham expenses associated with O&M activities

5.4 Next Steps for Continuous Improvements in Planning Phase

As part of adaptive asset management and continuous improvement, next steps may include:

- Expansion and refinement of the LOS framework as Pelham strengthens its overall asset management practices
- Select LOS indicators to measure over the short-term and identify data requirements (as per Table 14). The Town of Pelham should document the following information related to each indicator it plans to track:
  - ☐ Current LOS being provided
  - ☐ Desired trend (increase or decrease)
  - ☐ Desired LOS (target, if possible)
  - ☐ Data and information gaps

- Complete updates to the natural asset inventory to include LOS over time. The natural asset inventory should also document the following information:
  - How the data will be stored and updated, and whether the data will be stored in one or multiple asset registers;
  - Data management protocols (related to accountability for data, accessing and updating data, frequency of updates); and
  - Description of financial data about natural assets, including valuation approach where a value has been placed on natural assets.
- Engage with multiple stakeholders and rightsholders to help meet service delivery objectives
- Integrate O&M costing into the development of Natural Asset Management Plan.

6.0 Conclusions and Recommendations

Results from the Pelham Project are summarized here along with management actions for consideration.

The Project provided the Town of Pelham with insight into the state of natural infrastructure in its jurisdiction, with specific emphasis on the land within the Greenbelt. It has also estimated the value of stormwater services and other co-benefits the natural assets provide to the community. The recommendations below suggest next steps Pelham may wish to take to better protect and proactively manage natural assets. They take into consideration the project results as well as actions identified in a natural asset management roadmap the Town completed in 2023 (see *Appendix C*).

Recommendation #1: Review Policies and Governance to Protect and Manage Natural Assets

Nature-based solutions can build resilience to climate change impacts. Pelham should seek to ensure that large tracts of intact natural assets present in the Ontario Greenbelt are protected and proactively managed where possible, as they provide essential services such as stormwater management and source water protection, and many co-benefits of value to the community. It will be important for the Town of Pelham to ensure that future land use change considers the value of existing natural assets and their role in service delivery.

Pelham's zoning was updated in recent years to align with the current Official Plan, which means that natural heritage is better protected than it had been previously. That said, Pelham is in the process of updating its OP and in doing so is updating its policies to support protection and enhancement of natural assets in the town. It is recommended that Pelham review these policy updates before finalizing the new OP to ensure they are aligned with and support the project results and recommendations below. A future step will be to update zoning to align with the new OP. In addition, Pelham will need to develop a new Secondary Plan for its growth area in South Fonthill and complete the Secondary Plan for East Fenwick. Those plans should also seek to align with the recommendations from this project.

In addition, the Town of Pelham's natural asset management roadmap (*Appendix C*) includes the following actions that Pelham plans to undertake to strengthen policy and governance related to natural asset management:

- Over the medium-term, the Town will update its asset management policy to include objectives to strengthen natural asset management;

- The Town will ensure that updates to strategic documents will include relevant objectives to strengthen natural asset management;
- The Town will ensure that roles and responsibilities for natural asset management are formalized and that a staff person with responsibilities for natural asset management will be included in the Town's asset management group or committee; and
- The Town will formalize reporting to Council on natural asset management in its reporting on asset management.

Below are some examples of current supportive natural asset management-related policies being applied in other municipalities.

1/ EXPLICIT REFERENCE TO NATURAL ASSETS IN ASSET MANAGEMENT POLICIES

Some municipalities, like the City of Revelstoke, BC, have explicitly included natural assets within the scope of their overall asset management policy. This helps to ensure natural assets are considered as part of the municipality's infrastructure system and are integrated into decision making about infrastructure investments. Asset management policies like Revelstoke's establish formal governance and accountability for the practice of asset management. They define principles for asset management that should guide how the local government will deliver services with long-term sustainability and affordability in mind.[60]

2/ SPECIFIC NATURAL AREAS POLICY

Some local governments have specific policies to support healthy ecosystems, conservation and biodiversity goals. The City of Edmonton has a Natural Area Systems Policy (C-531)[61] that states that "The City of Edmonton will balance ecological and environmental considerations with economic and social considerations in its decision making and demonstrate that it has done so." The City of Edmonton recognizes that it can accomplish the work required to achieve conservation more efficiently and effectively by supporting and developing partnerships to achieve effective conservation results. Therefore, Edmonton will lead by example — by engaging the public in natural area issues, and encouraging businesses, residents, and the community to secure new natural area systems and steward what they have effectively. The Policy is supported by a City Procedure, which outlines roles and responsibilities for its implementation by key city branches.

3/ SUPPORTIVE BYLAWS

Natural assets provide essential ecosystem services regardless of who owns them, and bylaws are a tool to support land stewardship and good practices natural asset management to achieve desired levels of service. Some examples include:

60 See example on page 25 in *How to Develop and Asset Management Policy, Strategy and Governance Framework*, Federation of Canadian Municipalities, 2018.

61 See *Natural Area Systems Policy C-531 (edmonton.ca)*.

- **Urban forest or tree-protection bylaws:** Several local governments have policies or by-laws to protect or enhance the urban forest and tree canopy. The City of Ottawa Tree Protection By-Law[62], adopted in 2021 and the Northumberland County Forest Conservation By-Law[63] are two examples. The City of Ottawa's by-law came into effect in January 1, 2021, and consolidated two others: an urban tree Conservation By-Law and a Municipal Trees and Natural Areas Protection By-Law. The new bylaw provides protection to all City-owned trees, and all City-owned natural areas throughout the urban and rural area. The goal of Northumberland County's bylaw is to promote good forestry practices and the maintenance of woodlands, and it applies to properties larger than one hectare. The bylaw notes that maintaining forest cover benefits the community by providing many ecosystem services such as: water retention and filtration, air filtration, beneficial insects and wildlife, and climate regulation. The bylaw helps ensure that forest resources are maintained throughout the community over the long-term. It is noted that the Region of Nagara does have a Regional Woodland Conservation By-law that does provide for the protection of trees on properties larger than 1 ha in area and Pelham is covered by that by-law.
- **Invasive species policies or bylaws:** The District of Squamish adopted two bylaws in 2021, an Invasive Species Management Bylaw and a Pesticide and Herbicide Use Bylaw.[64] These bylaws are designed to prevent the use and spread of invasive species and greatly reduce the use of cosmetic pesticides, thereby meeting objectives and policies within the District's Official Community Plan.
- **Development cost charges bylaw:** The Town of Gibsons Development Cost Charges Bylaw[65] enabled the town to decrease the fees charged to developers to cover costs of municipal infrastructure to support their projects because the natural assets that provide stormwater services to Upper Gibsons do so at lower costs than engineered alternatives. As a result, the DCCs for drainage services were reduced by 74%.
- **Environmental reserve fund bylaw:** The District of West Vancouver's Environmental Reserve Fund Bylaw[66] serves as a financing mechanism for actions to protect natural assets and ensure their sustainability. The Bylaw enables the District to collect an environmental levy as a proportion of annual property taxes collected. Any use of reserve funds must be included in the District's financial plans.

62 See *Tree Protection By-law | City of Ottawa.*

63 See *Forest Conservation Tree By-Law - Northumberland County*.

64 See *Invasive Species and Pesticide Bylaws - District of Squamish - Hardwired for Adventure*.

65 See *Town of Gibsons Development Cost Charges Guide*.

66 See *Environmental Reserve Fund Bylaw | District of West Vancouver*.

4/ Procurement Policy

The City of Rossland, BC has begun to integrate natural asset management practices into overall planning, finance, and strategy efforts. In 2023, the City approved an innovative new procurement policy that specifically requires staff to consider climate action commitments and use a natural asset-based approach when they acquire products or services.[67]

5/ Strengthen language and commitment to natural asset management in Official Plans

The City of Courtney's new Official Community Plan[68] is a good example of a plan that sets natural asset-related goals. It states that natural assets will be recognized as powerful allies in climate action and essential to citizen quality of life and will therefore be protected, reclaimed, and expanded throughout Courtenay. It also states that nature will be invited into its neighbourhoods by making space for it, increasing opportunities for residents to recharge and connect.

The Official Community Plan commits to increasing green infrastructure, reclaiming, and restoring natural areas and the ecological connections between them, designing development to better fit the land (site adaptive design), as well as intentional urban design attention to increase human connection to and encourage an ethic of care of the natural world. The Plan also establishes priorities for collaboration with the K'ómoks First Nation. The KFN Chief, Council, and staff provided perspective, priorities, and guidance on numerous policy topics in the Plan, which also sets a priority to implement the United National Declaration on the Rights of Indigenous People as the framework for reconciliation.

Recommendation #2:
Proactively Monitor and Manage Erosion Sites

The Town of Pelham is aware of erosion sites along its roadsides and trails. The erosion sites typically occur along watercourses adjacent to roads and can lead to road failures. Funding for geotechnical work to assess the sites has been approved by Council for 2024, however, Pelham has no dedicated funding to monitor erosion, nor does it have a management plan in place to restore the sites or manage erosion.

It is recommended that the Town of Pelham conduct a high-level risk identification to determine the extent to which the sites present risks to the natural assets themselves, or to the public and other infrastructure. Pelham should also seek ongoing budget support to monitor erosion sites on Town properties. Finally, Pelham would benefit from collaborating with NPCA on management of erosion sites. In some cases, the NPCA has requested Pelham to

67 See NAI blog: *Accounting for nature: meet the champions leading natural asset management in Rossland, BC – NAI | Natural Assets Initiative (mnai.ca)*

68 See *Official Community Plan | City of Courtenay*.

undertake restoration of erosion sites, but it has not had the capacity or budget to undertake the work. NPCA and Pelham may wish to collectively seek funding opportunities for the necessary restoration work and develop an agreement that articulates which party will undertake the work when funding becomes available. It should be noted that NPCA does not have dedicated funding for restoration through its funding agreement with the Ontario Government.

Recommendation #3:
Formalize Invasive Species Management

Invasive species has been identified as a high risk to natural assets in the Niagara Region, but Pelham does not yet have a comprehensive invasive species monitoring program or a biodiversity monitoring program, and invasive species management is done on an ad hoc basis. The focus to date has been on managing specific species such as spongy month and oak wilt. For the past 4 years, the Town of Pelham has undertaken egg mass surveys of the spongy moth on public lands to monitor this invasive species. The data is fairly limited on prevalence of other invasive species.

It is recommended, as part of continuous improvement efforts, that Pelham make use of existing studies and monitoring programs in the region to support the management of invasive species. Over time, it should consider formalizing monitoring and proactive management of invasive species. The commitment of resources to undertake removal of invasive species will be required on an on-going basis. In addition, while the Town of Pelham does have a policy intended to limit the spread of invasive species, Pelham's 2023 natural asset management roadmap identified the need to update the policy over the medium-term.

Recommendation #4:
Identify Priority Areas for Naturalization

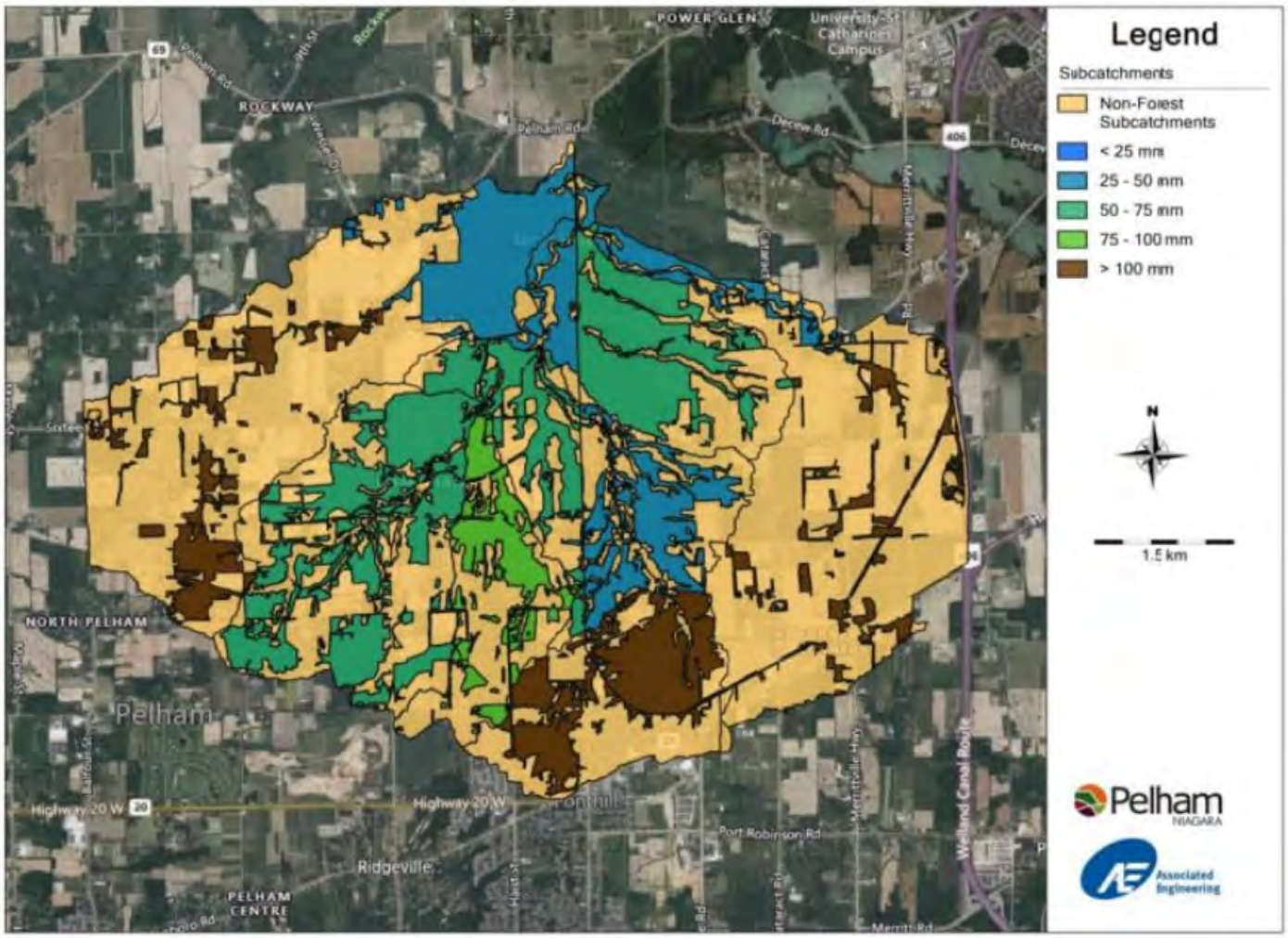
One of Pelham's corporate service objectives for natural assets is to protect and enhance natural assets to support biodiverse natural habitats and ecosystems. The Town of Pelham may wish to identify priority areas for naturalization, which would enhance the ecosystem services provided by natural areas. One consideration for determining priority areas should be local climate projections, which may indicate growing vulnerability in some areas. The modelling report for Scenario 3 showed areas with increased infiltration over the base case when LIDs are added to replace the loss of natural areas. This is because modelling of LIDs target an additional 5% of capacity for added resiliency. It may be possible for the Town to achieve the higher level of service provided in Scenario 3 by enhancing existing natural areas.

Staff identified the areas in brown above Highway 20 on the map below (from the modelling report) as areas characterized by steep slopes, valley lands, and some agricultural land, most of which is privately owned. Some of these areas may benefit from naturalization to enhance ecosystem services, or restoration

to limit erosion. The area in brown above north Pelham is primarily farmland and may or may not be suitable for naturalization.

Given most of the land suitable for naturalization may be privately owned, Pelham will need to develop land stewardship programs or partnerships with landowners to naturalize these areas, as well as develop policies to support best management naturalization practices on agricultural land.

***Figure 24**: Map of Subcatchment Areas*



Recommendation #5:
Continue to Secure or Protect Priority Forests and Wetlands

Land securement is an important way to ensure that ecosystem services will be sustained over the long-term. The Town of Pelham has already secured some land in the urban area through the development process, where lands have been designated for Environmental Protection. It is more challenging to secure land in the rural Greenbelt area because there are no mechanisms in place to acquire the land. Historically, all the development in the rural area has been agriculture-related, which limits the ability to secure land through the development process.

To protect additional land in the Greenbelt area, where public land securement is not possible, Pelham should explore mechanisms such as conservation easements and tax credits to property owners for implementing conservation measures. There may be opportunities to provide tax or other financial incentives to woodlot management organizations to better manage their woodlots.

Pelham also benefits from land securement undertaken by NPCA, so it should share the results of this study to determine whether there are priority areas that NPCA may be able to secure through its existing mechanisms. Recently (January 2024) the NPCA was successful in securing ownership of an 18-ha site containing a mix of ecological features include cold water fish habitat and significant woodlands with species at risk.

The Town of Pelham may also wish to work with the Province of Ontario to determine whether there are opportunities to expand Short Hills Provincial Park. In addition, the Nature Conservancy of Canada has already acquired some land north of Highway 20 and Pelham may wish to explore whether there are opportunities for the NCC to acquire additional land.

Recommendation #6:
Review Opportunities to Proactively Manage Riparian Areas along Watercourses

One of the Town of Pelham's corporate service objectives for natural assets is to protect source water quality and quantity by sustaining hydrological and hydrogeological characteristics of watercourses. The NPCA currently regulates development around watercourses, and Pelham must ensure the required buffers are in place to support the health of riparian areas as part of the development application approval process. Currently, the NPCA does not maintain the watercourses themselves (e.g., clearing them of debris) or the adjacent vegetation in buffer areas. Pelham is only responsible to maintain the riparian areas on its owned lands, and private property owners are responsible to maintain these areas on private properties. The Town of Pelham has not typically had the capacity or resources to undertake the level of maintenance or restoration requested by the NPCA and particularly not on private property.

Through Ontario's Municipal Drainage Act (1990), Pelham can proactively designate certain watercourses as municipal drains, such that it gains access privileges to maintain watercourses in areas that are experiencing drainage issues. Pelham has municipal drains in the southern part of the municipality and where those exist, it can maintain the municipal drains. Twelve Mile Creek is not currently considered a municipal drain. It is recommended that Pelham engage in discussions with NPCA to determine how best to facilitate its management. Funding opportunities to support maintenance and restoration should also be explored. It should be noted that most natural assets are on private land so Pelham may, together with the NPCA and NGOs, need to focus on delivering education, stewardship programs and incentives on private property to support their management.

Recommendation #7:
Support Collaboration and Develop Partnerships to Advance Natural Asset Management in the Town of Pelham

Many of the natural assets that provide ecosystem services to the community in the Town of Pelham are not owned by Pelham, and it does not have direct control over their management. To be effective, natural asset management will require a whole of community effort.

The table below shows the range of key individuals and groups in the community that have interests in nature and the services it provides. Some groups noted in the wider community may be able to support land stewardship or support data collection. For example, Brock University may be able to support data collection, and Niagara College has a restoration program and could be a beneficial partner supporting restoration work. Pelham can also leverage the studies conducted by community groups or non-profits such as Trout Unlimited, which identify actions needed to manage erosion and protect habitat in the Twelve Mile Creek. These groups can support Pelham in prioritizing natural asset management activities and help build the case for the necessary investments, particularly because capacity and resources in the municipality are limited to undertake natural asset management.

The Town of Pelham should consider how it might collaborate with the Mississaugas of the Credit First Nation, Six Nations, and the Haudenosaunee Nation on watershed protection.

Table 19: *Key Entities with Interest in Natural Asset Services*

Type of stakeholder group or rightsholder	Interests
Recipients	Residents, tourists, visitors, pedestrians, cyclists, swimmers, children, seniors, youth, adults, nature lovers, fish, wildlife, insects (flora and fauna)
Rightsholders[69]	Mississauga's of the Credit FN, Six Nations, Haudenosaunee Nation (Treaty rights are specific to water)
Regulatory Agencies	Province of Ontario, Federal Government, Niagara Region, Niagara Escarpment Commission, Town of Pelham, Niagara Peninsula Conservation Authority
Wider Community	Business owners, farmers, Friends of 12 Mile Creek, Pelham Advocacy for Tree Health (PATH), private property owners (e.g., golf course owners), schools (e.g., green living classroom next to Short Hills provincial park), Nature Conservancy of Canada (own Lathrop Nature Preserve), Brock University, Niagara College, Trout Unlimited
Neighbouring Municipalities	St. Catharines, Thorold, Region of Niagara, Town of Lincoln, Welland
Other Service Providers	Short Hills Provincial Park

69 Indigenous Peoples are rights holders and not stakeholders. It will be important for the Town of Pelham's natural asset management efforts to align with and support the UN Declaration on the Rights of Indigenous Peoples and, over time, interweave First Nations worldviews, knowledge and perspectives. There are early efforts in Canada that could inform this.

Recommendation #8:
Strengthen Assessment of Natural Assets and Related Services in the Town of Pelham

Through this project, Pelham completed a basic natural asset inventory that mapped the extent and condition of natural assets in the town. This was a high priority action it had identified in its 2023 natural asset management roadmap. As a next step, the Town of Pelham could improve its understanding of the condition of natural assets, the risks to them and the services they deliver to better inform natural asset management investments.

The condition of natural assets in Pelham has been documented based on a high-level desktop condition assessment. Pelham would benefit from ground truthing the condition of natural assets through field verification should resources become available. However, Pelham currently has limited resources to undertake annual monitoring of changes to extent and condition of natural assets, and changes to biodiversity of native species. For this to be a priority, additional resources, including staff resources and budget approvals, will be required.

Some monitoring is currently undertaken by the NPCA. The Town of Pelham could work together with the NPCA to develop a monitoring framework and a data sharing agreement to enable it to update its natural asset inventory and natural asset management plans. A five-year monitoring cycle is recommended for monitoring changes in extent and condition of natural areas and changes to biodiversity of native species. Over time, the natural asset inventory could be deepened with the addition of soils and groundwater recharge zones.

In terms of understanding risks to natural assets and services they provide, this study has considered the results of a natural asset risk identification exercise conducted by Niagara Region when it developed its own natural asset inventory. Those risks apply to the whole region, including the Town of Pelham. A recommended next step for Pelham is to review the region-wide risk identification and determine whether the same risks and risk scores apply to natural assets specifically in its jurisdiction. Conducting a risk identification and risk mitigation strategy for natural assets was identified as a short-term action to undertake, in Pelham's 2023 natural asset management roadmap.

The stormwater modelling done in this study was based on existing conditions and did not include a climate change scenario. Pelham may wish to better understand the impacts of climate change on stormwater management to help prioritize protection and management of natural assets. The Project also did not model water quality. 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.

Pelham's 2023 natural asset management roadmap also identified the need to update the design guidelines for design and maintenance of stormwater management facilities, over the medium-term.

Recommendation #9:
Include a Costed Lifecycle Management Strategy for Natural Assets in Updates to the Town's Asset Management Plan

The Ontario asset management regulation (O. Reg 588/17) requires that municipalities document the lifecycle management requirements and current levels of service of all non-core municipal infrastructure assets, including green infrastructure assets, in their asset management plans by July, 2024. By July, 2025, the plans must also document proposed levels of service and a financial strategy to achieve levels of service.

It is recommended that the Town of Pelham include the information from this study about the state of natural infrastructure in the July 2024 asset management update to Council. It should seek to develop proposed levels of service for natural assets and a financial strategy to achieve levels of service by the July 2025 deadline. This recommendation is consistent with Pelham's 2023 natural asset management roadmap, which identified an action to incorporate natural asset management considerations into asset management plan updates. Pelham also identified an action to develop a specific natural asset management plan over the medium-term, including key performance measures (levels of service) to measure progress on natural asset management.

The study has estimated a range for operations and maintenance costs required to maintain wetlands[70] at approximately $250,800 per year, and $116,000 to $977,000 to maintain an estimated 240 hectares of forests on public lands. For small watercourses, the cost estimate ranges from approximately $250 to $25,000 annually for rehabilitation of 1.4 hectares of publicly owned small streams.

Pelham does not currently have dedicated funding for natural asset management, other than approximately $230,000 for tree planting, maintenance, hazard tree limb removal and invasive species monitoring and removal. Pelham's 2023 natural asset management roadmap identifies an action to develop a funding strategy to support the lifecycle management of natural assets. A first step will be to allocate some dedicated funding for proactive management of natural assets. The level of funding approved may be limited to begin with and could be phased in over time as funding becomes available.

70 Internal priorities for wetland O&M provided by the Town of Pelham, based on Matrix Solutions recommendations.

Recommendation #10:
Develop a Communications Plan and Presentation to Build Awareness of the Value of Natural Asset Management Needs in the Watershed

Pelham's natural assets, when managed proactively, can provide ecosystem services and benefits to the community and to downstream communities. It will be important for Pelham to communicate the results of this study and ongoing results of natural asset management activities throughout the region to build support for and collaborate on future initiatives to sustain the services they provide. To progress on natural asset management, resources and commitment will be required on an ongoing basis. As a starting point, the Town of Pelham should seek opportunities to present the results of this study across the region, which will also demonstrate its leadership in natural asset management.

Recommendation #11:
Build Staff and Council Awareness of and Support for Natural Asset Management

Pelham's 2023 natural asset management roadmap identified a need over the short-term to strengthen staff and Council awareness of and support for natural asset management, because knowledge within the organization is currently limited. Actions identified include:

- Provide an introductory presentation to Council on the role of natural assets in service delivery (including the results of this report), to coincide with the July 2024 asset management update to Council;
- Allocate resources for natural asset management-related professional development and peer learning opportunities for staff with responsibilities for asset management generally or natural asset management specifically; and
- Disseminate new knowledge to staff about natural asset management, including the results of this report, and support ongoing related communications.

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Appendix A: Description of Natural Asset Indicators

Natural Area Patch Size

INDICATOR: The relative size and shape of contiguous natural asset areas, with larger patches that are more round or square rather than linear being considered of higher quality than smaller patches that are more linear with little or no "interior" habitat (i.e., all edge).

RATIONALE: The objective of this indicator is to create a proxy for condition based on the relative size and shape of contiguous patches of natural assets. In general, larger blocks of habitat (whether they be meadow, forest, and/or wetland) tend to support a greater diversity of plants and wildlife, including habitat specialists that require or benefit from conditions only found somewhat removed from a non-natural land cover type (e.g., roads, residential, institutional, or commercial development). In an urban or urbanizing context, as the distance from the edge of a natural area to the interior of that area decreases the penetration of noise and other human-related disturbances and encroachments that can negatively impact certain species associated with those habitats increases (*Environment Canada, 2013*).

Given this context and recognizing the landscape ecology principle that large "blocks" of habitat generally provide a greater range of habitats of better quality, it was proposed to develop a scoring system based on established federal guidance but tailored to allow for meaningful application in Pelham.

APPROACH: "Interior" habitat — at least in woodlands — is typically measured starting at 100 m inwards from the feature or "patch" edge (e.g., Environment Canada 2013). The first step is thus to establish the "patch" edge, which can be defined at level 1 (no distinction between asset types) or level 2 (distinguishing between asset types). In urban settings, level 1 is used because the distribution of land cover in such heavily segmented environments will result in smaller slivers of areas.

SCORING: Ratings were allocated as follows:

- **Very Good:** An asset within a habitat patch with an interior area measured 100 m from the feature edge
- **Good:** An asset within a habitat patch with an interior area measured 75 m from the feature edge and not already captured as "very good"
- **Fair:** An asset within a habitat patch with an interior area measured 50 m from the feature edge and not already captured as "very good" or "good"
- **Poor:** An asset within a habitat patch with an interior area measured 25 m from the feature edge and not already captured as "very good", "good", or "fair"

- **Very Poor:** Any asset with no interior area measured at 25 m from the feature edge

Natural Asset Proximity to Watercourses

INDICATOR: The distance between each asset and the nearest watercourse line was measured.

RATIONALE: In addition to a natural area's intrinsic size and shape, its location in relation to other natural assets, and features within a given area also influence the types of ecological functions it can provide. Proximity of a terrestrial natural asset to water, or having a hydrologic feature within a terrestrial asset, is generally considered positive. Environmental Canada's habitat guidelines for southern Ontario (EC 2013) and the Province's Natural Heritage Reference Manual (MNRF 2010) ascribe ecological significance to terrestrial habitats that contain or are close to hydrological features such as wetlands that occur within floodplains (which are associated with watercourses), woodlands with wetlands and/or watercourses within them, and grassland/meadow habitats adjacent or close to riparian and/or wetland habitats. Specific distances / thresholds cited in these documents as heightening feature functions are as follows:

- Naturalized riparian habitat within at least 30 m of a watercourse edge (i.e., top of bank) (EC 2013), and;
- Woodlands within 50 m of a watercourse (MNRF 2010).

In addition, 120 m is the standard distance used for considering adjacency to an identified natural asset in terms of the lands within which negative impacts to an asset may occur.

APPROACH: The closest distance between watercourse lines and level 3 assets was measured.

SCORING: Ratings were allocated as follows:

- **Very Good:** Asset directly intersects watercourse
- **Good:** Asset is within 30 m of a watercourse but does not directly intersect it
- **Fair:** Asset is within 30 - 120 m of a watercourse
- **Poor:** Asset is within 120 – 240 m of a watercourse
- **Very Poor:** Asset is greater than 240 m away from a watercourse

Forest Proximity

INDICATOR: A measure of the proximity of level 2 forest assets to other level 2 forest or wetland assets.

RATIONALE: According to research documented by Environment Canada (2013):

- For forest birds, habitats near other natural areas support more species than isolated habitats of the same size, and that some species with large home ranges may use several patches instead of one large area.
- In landscapes with relatively low forest cover overall, species diversity and survivorship increase when the remaining habitat patches are larger and more clumped or aggregated.
- Based on the limited available science, the isolation between forest patches for forest birds generally occurs at about five kilometres, but for amphibians at between one and two kilometres. For forest plants, some level of immediate proximity is required.

APPROACH: Each level 2 forest asset was buffered by the condition rating thresholds noted below and the appropriate rating applied based on the closest buffer where another level 2 forest or wetland asset was found.

SCORING: Based on the research noted by Environment Canada (2013) and the associated proximities, condition rating are:

- **Very good:** Level 2 forest assets < 1 km from any other level 2 forest or wetland asset
- **Good:** Level 2 forest assets within 1 to 2km from any other level 2 forest or wetland asset
- **Fair:** Level 2 forest assets within 2 to 3km from any other level 2 forest or wetland asset
- **Poor:** Level 2 forest assets within 3 to 5km from any other level 2 forest or wetland asset
- **Very poor:** Level 2 forest are > 5km from any other level 2 forest or wetland asset

Wetland Proximity

INDICATOR: A measure of the proximity of level 2 wetland assets to other level 2 wetland or forest assets

RATIONALE: According to research documented by Environment Canada (2013):

- Fragmentation of wetland habitats degrades their functions by reducing habitat for species that are less tolerant of disturbances, that require more contiguous habitat, or both.
- Some of these negative impacts of fragmentation can be offset, at least for some species, by maintaining concentrations of natural habitat fragments in close proximity.

- The importance of adjacent natural areas, as well as proximity between patches of wetland, has been recognized for several wildlife species.
- Proximity distances range depending on the species from less than 500 m for turtles and spotted salamanders to as large as 3 km for birds.

APPROACH: Each level 2 wetland asset was buffered by the condition rating thresholds noted below and the appropriate rating applied based on the closest buffer where another level 2 forest or wetland asset was found.

SCORING: Based on the research noted by Environment Canada (2013) and the associated proximities, condition rating are:

- **Very good:** Level 2 wetland assets < 0.5 km from any other level 2 forest or wetland asset
- **Good:** Level 2 wetland assets within 0.5 to 1 km from any other level 2 forest or wetland asset
- **Fair:** Level 2 wetland assets within 1 to 2 km from any other level 2 forest or wetland asset
- **Poor:** Level 2 wetland assets within 2 to 3 km from any other level 2 forest or wetland asset
- **Very poor:** Level 2 wetlands are > 3 km from any other level 2 forest or wetland asset

Extent of Adjacent Complementary Land Uses

INDICATOR: The extent of complementary land uses within 120 m of an asset was measured.

RATIONALE: How and the extent to which a given natural area is influenced by drainage in the adjacent landscape varies depending on factors such as local topography and soils, where the feature "sits" in the landscape (e.g., upland versus lowland) and the size and nature of the feature itself. However, it is well-established that the condition of a terrestrial natural feature (including wetlands) in an urban context tends to be negatively impacted when more of the surrounding land uses are impervious (i.e., paved, concrete or buildings) — this tends to alter pre-existing drainage and infiltration pathways, which can cause a natural area to receive more, or less, drainage than prior to being in the urban context. Urban runoff also typically carries a host of sediments and contaminants, and when such runoff is directed to natural areas and not properly treated, it can also negatively impact the feature and its functions.

Increases in the extent of impervious surfaces within a given watershed or catchment area are generally known to have negative impacts to natural features in that watershed or catchment area, particularly for features downstream of the impervious areas, resulting in a push towards planning that limits impervious surfaces and incorporates low impact development measures that facilitate local infiltration (e.g., Government of Ontario 2006, Government of Ontario 2018). Environment Canada's (2013) guidance for streams/watercourses

in urbanized watersheds in southern Ontario states that "*impairment in stream water quality and quantity is highly likely above 10% impervious land cover and can often begin before this threshold is reached. In urban systems that are already degraded, a second threshold is likely reached at the 25 to 30% level*".

However, land cover types with extensive pervious surfaces that are not "natural" per se but occur in the lands adjacent to natural areas, such as manicured parks/open spaces and agricultural lands, are recognized as potentially supportive of the functions of nearby natural areas in some regards by providing one or more of the following:

- Permeable surfaces (and therefore potentially supporting hydrologic regimes),
- temporary or permanent vegetation (e.g., isolated or small groupings of trees/landscaped areas, agricultural crops), and/or;
- intervening lands uses between natural areas and built areas that are used less frequently and/or less intensively by people.

Therefore, having, for example, a school ground between a wooded area and a high-density residential area is generally considered preferable to having the high-density residential area directly abutting the natural area.

APPROACH: A 120 m buffer (exclusive of asset area) was drawn around each natural asset "patch" at level 2 of the inventory. The extent of landcover associated with complementary land uses and natural assets was estimated in hectares within each buffer. Areas of complementary uses include Agriculture, Built-up Pervious, and Golf Course land cover. These areas have vegetated cover but are not natural in the true sense of the definition. The area of the 120 m buffer was estimated in hectares (excluding the area of the asset itself from counting towards this estimate), and the percentage of each buffer that consists of these natural area/complementary land uses was estimated. A ranking was then applied to each buffer and linked to the relevant natural assets.

SCORING: A rank was assigned to each asset based on what percentage of the asset's adjacent lands (i.e., measured at 120 m) is composed of identified pervious and complementary land uses (e.g., passive parklands, golf courses, or agricultural lands) as per the following:

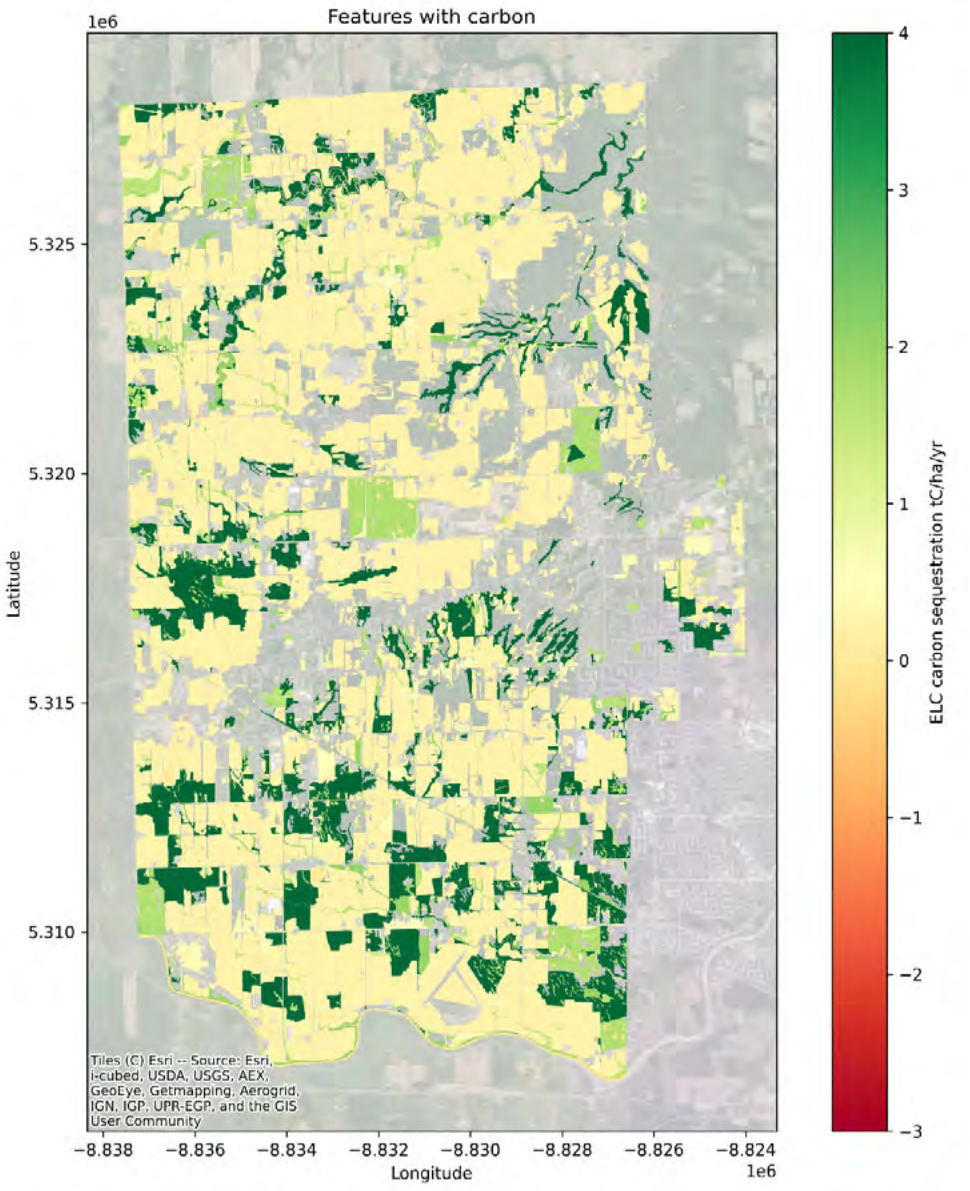
- **Very Good:** 51 to 100% complementary land uses
- **Good:** 31% to 50% complementary land uses
- **Fair:** 16% to 30% complementary land uses
- **Poor:** 1% to 15% complementary land uses
- **Very Poor:** 0% complementary land uses

Appendix B: Carbon Modelling

CARBON SEQUESTRATION IN NON-FOREST ASSETS

The carbon sequestration rates in the non-forest assets within the Pelham region were estimated by applying sequestration rates by land cover type as determined by several scientific publications. Figure B1 displays the carbon sequestration rates of the non-forest assets within the Town of Pelham.

***Figure B1**: Carbon Sequestration Rates in the Non-Forest Assets*



For each of the ELC Classes which were present within the Town, a specific carbon sequestration rate was sourced from the literature. For example, all assets categorized as “Deciduous Swamp” were given a sequestration rate of 4.73 tC/ha/yr. This value was taken from Bernal and Mitsch, (2011) who found a sequestration rate of 473 gC/m²/yr (which converts to 4.73 tC/ha/yr) in Quercus palustris forest wetland communities. Quercus palustris is a swamp oak commonly found in southern Ontario.

CARBON SEQUESTRATION IN FORESTED FEATURES

The carbon sequestration rates of the forested features within the Town of Pelham were estimated using the Carbon Budget Model of the Canadian Forest Sector 3 (CBM-CFS3)[1]. The table below describes the ELC classes which were included as forested assets.

Table B1: *Forested Assets and their Area in Hectares*

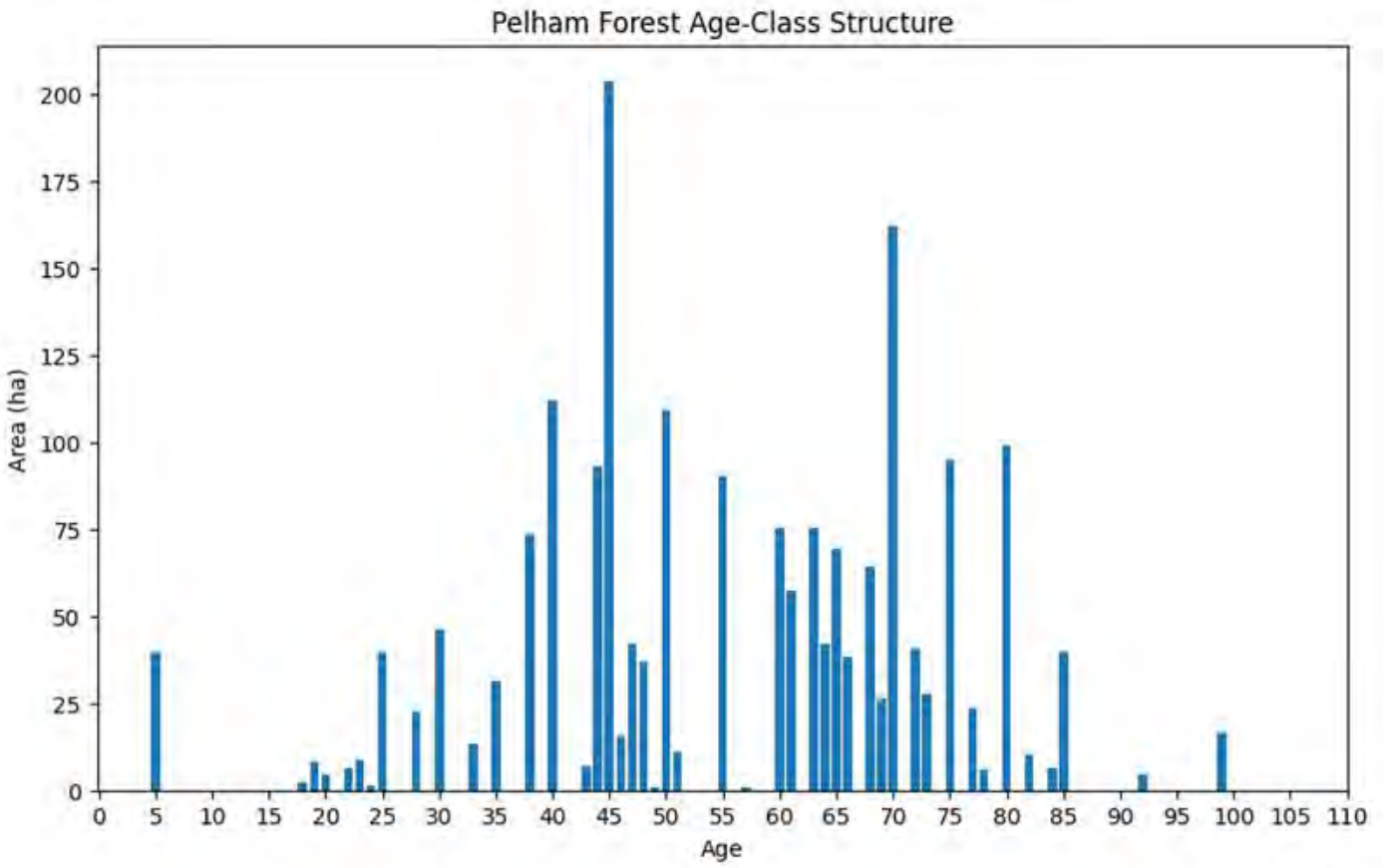
Forested ELC Class	Area (ha)
Deciduous Forest	959
Mixed Forest	388
Deciduous Thicket	157
Treed Agriculture	121
Deciduous Hedgerows	85
Deciduous Woodland	82
Coniferous Forest	75
Mixed Woodland	57
Mixed Thicket	31
Coniferous Savanna	27
Coniferous Woodland	25
Coniferous Hedgerows	19
Coniferous Thicket	4
Deciduous Savanna	2
Mixed Hedgerows	2
Mixed Savanna	1

The CBM-CFS3 is a stand-level model which estimates the carbon stocks and stock changes of forested stands. The estimates are defined by forest growth rates and species composition. Each forested asset within Pelham was associated with a volume yield expectation. As forests grow, the trees within forest stands get bigger and accrue volume. Each of the forested assets within the Town of Pelham inventory was assigned a specific yield table (volume growth over time). The maximum growth rate as expressed in $m^3/ha/yr$ in the region was 5.5 $m^3/ha/yr$ (meaning a 100-year-old forest feature would have 550 m^3/ha). The minimum growth rates used were about 2 $m^3/ha/yr$ (200 m^3/ha at age 100).

The CBM-CFS3 requires an age variable to simulate carbon values of forested assets. For the most part, the forest stands within the inventory had an estimated age value stored in the attribute “FRI_Age”. In instances with no data provided for the age of the stands we assigned an age of 75 which was based off randomly sampled satellite images of forested assets with no age attribute. *Figure B2*, displays the age and area of the forested features within the Town of Pelham.

1 *https://cfs.nrcan.gc.ca/publications?id=29137*

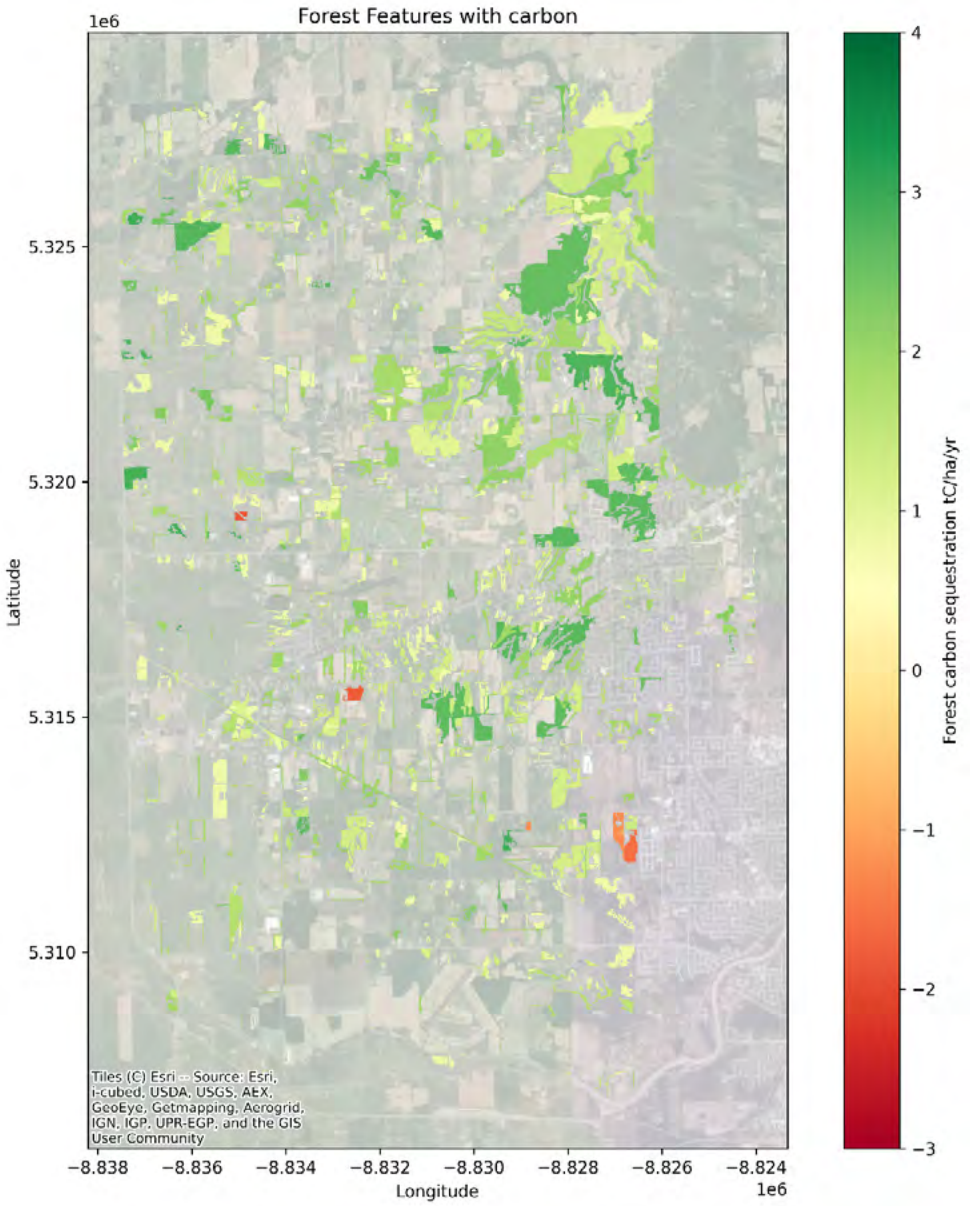
Figure B2: Age-Class Structure of the Forested Features Within the Town of Pelham



As seen in Figure B2 there was nearly 200 hectares of 45-year-old forest assets. The oldest of the forested assets was nearly 100 years old and the youngest patches were 5 years old. With the age of the forest assets, it was then possible to combine all these variables — species, age, and volume — as inputs to the CBM-CFS3. The CBM-CFS3 was then used to simulate the carbon dynamics of each of the forested assets.

The carbon sequestration rate was calculated as the difference between the Net Primary Production (NPP) (the net growth) and the Heterotrophic Respiration (Rh) (the net decomposition of organic matter) of each of the forested assets. The difference between the NPP and the Rh results in the rate of change in carbon within each of the assets. Positive values denote an actively sequestering forest feature, or a sink (meaning that growth outweighs decay). Negative values indicate forests which are releasing carbon, likely due to a young age (growth does not outweigh decay). Figure B3 displays the carbon sequestration rates of the forested features in tC/ha/yr.

Figure B3: Carbon Sequestration Rates in Forested Assets



Of note, perhaps, are the few forest features which are acting as carbon sources. The sequestration rates of each of the forested features is displayed in *figure B4*, below. As the figure shows, the features with sequestration rates below 0, carbon sources, were all assets with an age value of 5 (young forests).

Figure B4: Carbon Sequestration Rate tC/ha/yr by Age of Feature

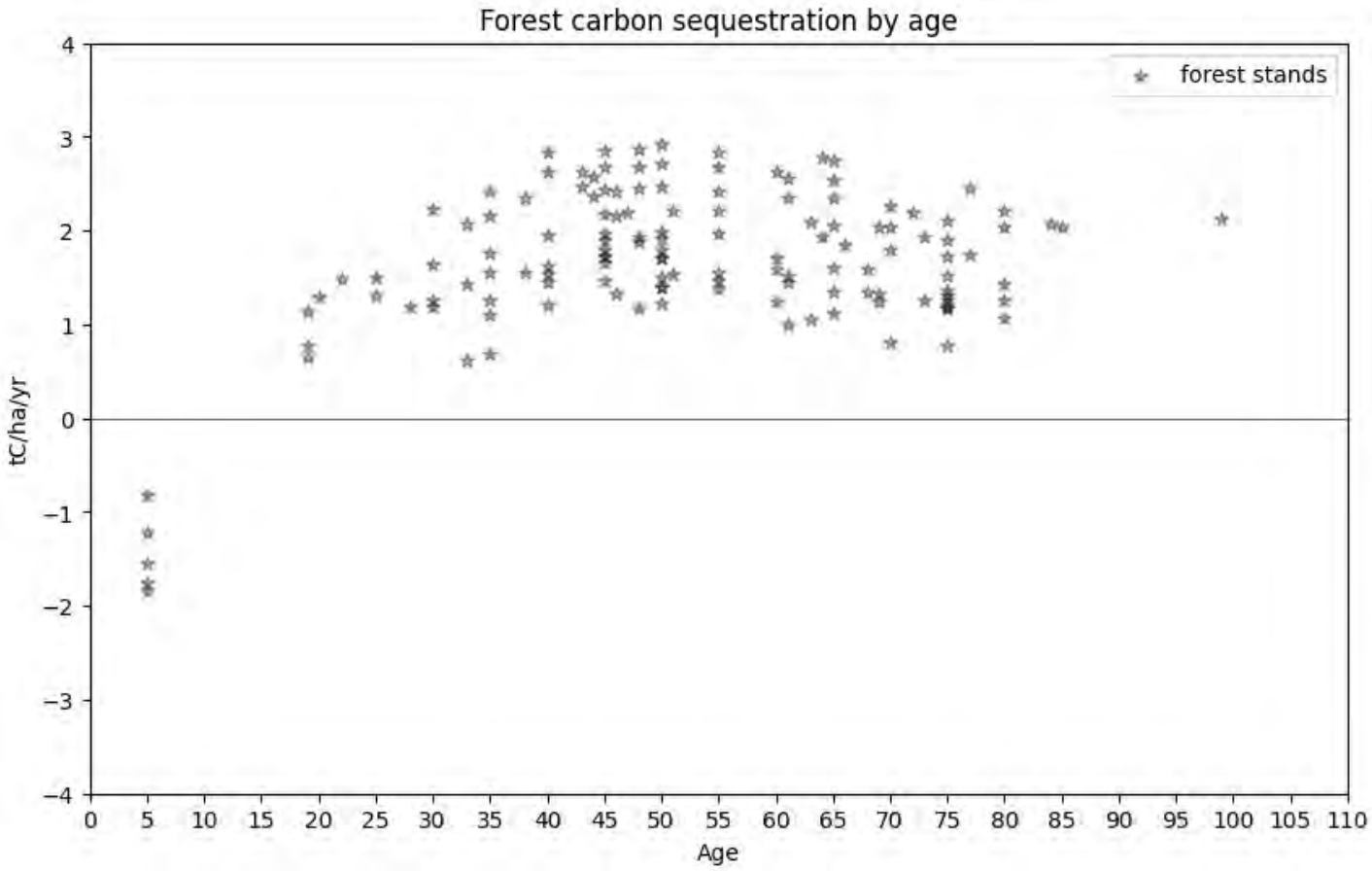
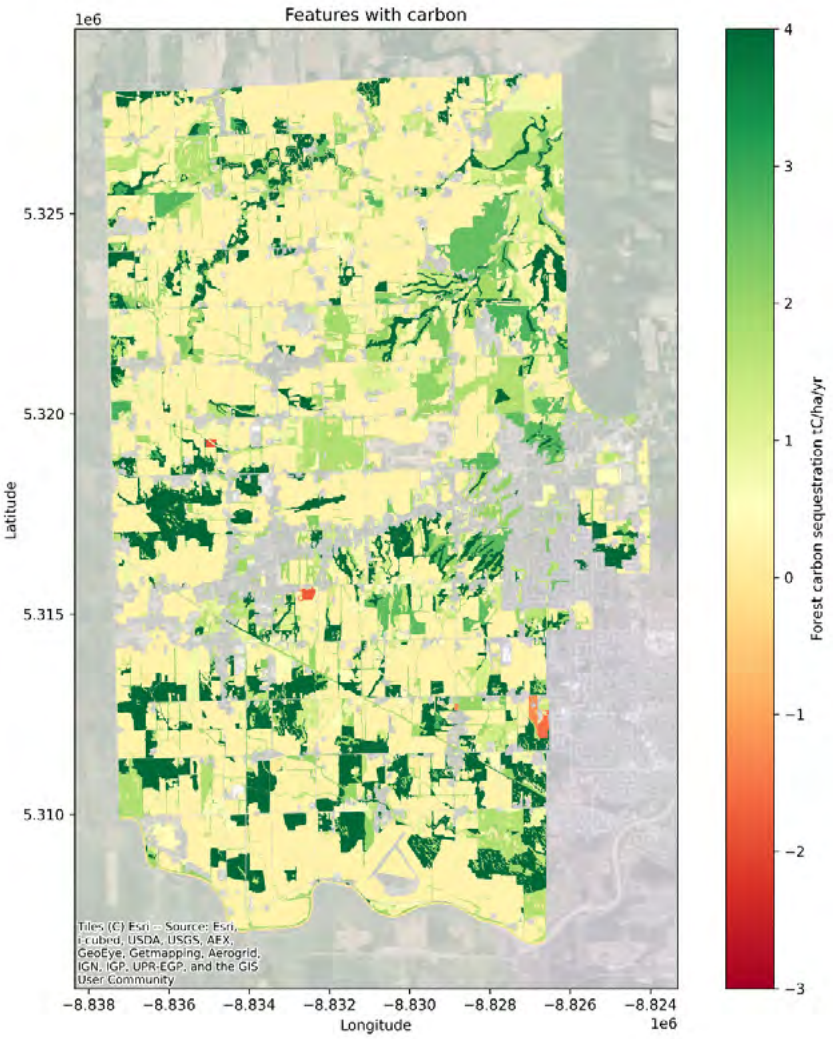


Figure B5, below, displays the carbon sequestration rate of all the assets, forested and non-forested, within the Town of Pelham.

Figure B5: Carbon Sequestration Rates in t C / ha / yr



Appendix C: Pelham Natural Asset Management Roadmap

List the actions that you identified in your workshop that you'll be including in your roadmap.

Note whether they are linked to other actions in the roadmap, who will be responsible for the action, who should be involved, and whether the action requires council approval.

COMPETENCY 1: POLICY AND GOVERNANCE

Recommended actions:	Priority H, M, L	Timing S-T or M-T	Responsible (bold) Involved (not bold)	Council approval (Y/N)
1.1 Develop a natural asset management roadmap	H	S-T	**Barbara Wiens, Shannon Larocque** Derek Young, John Raso	N
1.2 Update an asset management policy to include objectives to strengthen natural asset management.	H	M-T	**John Raso** Barbara Wiens, Derek Young, Shannon Larocque	Y
1.3 Identify strategic documents that should include objectives for natural asset management when updated.	H	M-T	**Barbara Wiens, Shannon Larocque** Derek Young, John Raso	N
1.4 Include key performance indicators to measure progress on natural asset management in new or updated asset management strategies or plans. (see action 4.2)	H	M-T		Y
1.5 Formalize reporting on progress on natural asset management to Council.	H	M-T		N

COMPETENCY 2: PEOPLE AND LEADERSHIP				
Recommended actions:	**Priority** H, M, L	**Timing** S-T or M-T	**Responsible (bold)** **Involved** (not bold)	**Council approval (Y/N)**
2.1 Include someone who is responsible for incorporating natural asset management considerations on your asset management group or committee, if one exists, or when you establish a formal group. This will ensure people responsible for managing natural assets are connected formally to the asset management planning process	H	M-T	**Barbara Wiens, Shannon Larocque** John Raso, Derek Young	N
2.2 Ensure responsibilities for incorporating natural asset management are included in the terms of reference for the asset management group or committee.	H	M-T	John Raso, Derek Young	N
2.3 Develop a funding strategy for work required.	M	M-T		
2.4				
2.5				

COMPETENCY 3: DATA AND INFORMATION				
Recommended actions:	**Priority** H, M, L	**Timing** S-T or M-T	**Responsible (bold) Involved** (not bold)	**Council approval (Y/N)**
3.1 Identify key stakeholders in the community that should be part of consultation.	H	S-T	**Barbara Wiens, Shannon Larocque**	N
3.2 Develop or strengthen asset data by incorporating it into an asset register/inventory. Includes high-level desktop condition assessment of natural assets to determine where addition field verification of natural assets condition may be beneficial. Consult MNAI project scope	H	S-T	**Barbara Wiens, Shannon Larocque with MNAI**	N
3.3 Conduct a risk identification exercise to estimate risks to natural assets and relevant service; develop a risk mitigation strategy.	H	S-T	**Barbara Wiens, Shannon Larocque with MNAI**	N
3.4 Define level of service desired from natural assets to guide policies and guidelines and future capital investment required.	H	S-T	**Barbara Wiens, Shannon Larocque with MNAI**	N
3.5 Update invasive species policy for monitoring performance and condition of natural assets.	M	M-T	**Derek Young** Barbara Wiens, Shannon Larocque	Y
Update guidelines for design and maintenance of stormwater management facilities.	M	M-T	**Derek Young** Barbara Wiens, Shannon Larocque	Y

COMPETENCY 4: PLANNING AND DECISION-MAKING				
Recommended actions:	**Priority** H, M, L	**Timing** S-T or M-T	**Responsible (bold)** **Involved** (not bold)	**Council approval (Y/N)**
4.1 Integrate natural asset management considerations into asset investment plan updates or new plans across service areas.	H	M-T	**John Raso**	Y
4.2 Develop a specific natural asset management plan that considers multiple service areas, will inform budget process and enable it to be more proactive. Plan will support an organization-wide approach to managing natural assets, including a consistent approach to assessing condition	H	M-T	**Barbara Wiens, Shannon Larocque** John Raso Derek Young	Y
4.3				
4.4				
4.5				

COMPETENCY 5: CONTRIBUTION TO ASSET MANAGEMENT PRACTICE				
Recommended actions:	**Priority** H, M, L	**Timing** S-T or M-T	**Responsible (bold)** **Involved** (not bold)	**Council approval (Y/N)**
5.1 Provide an introductory presentation to council to build awareness of the role of natural assets in service delivery. This should be included as part of the July reporting on asset management.	H	S-T M-T	**Barbara Wiens** **Shannon Larocque** **John Raso**	N
5.2 Higher level of training for key individuals that support asset management. Allocate resources for training or professional development related to natural asset management to staff with natural asset management responsibilities, ie. workshop in September	H	S-T M-T	**Barbara Wiens** **Shannon Larocque** John Raso Derek Young	N
5.3 Disseminate new knowledge about natural asset management internally (e.g., the natural asset management roadmap). Potentially at an all staff meeting or email blast.	H	M-T	**Barbara Wiens, Shannon Larocque**	N
5.4 Participate in peer learning groups to advance knowledge about natural asset management.	M	S-T	**Barbara Wiens** **Shannon Larocque** **John Raso** **Derek Young**	N
5.5 Communication activities from MNAP work plan.	H	S-T	**Barbara Wiens** **Shannon Larocque with MNAI**	N


Natural
Assets
Initiative
MAKING NATURE COUNT