



State of Infrastructure Report – Town of The Blue Mountains

February 5, 2025

Executive Summary

This State of Infrastructure Report provides an assessment of the natural assets within Town of The Blue Mountains. The report covers 6 topics related to natural asset management including:

- A natural asset inventory that describes the range of assets located within the municipal boundary.
- A natural asset condition assessment.
- A natural asset risk assessment.
- Replacement costs for the natural assets.
- A valuation of ecosystem services provided by the natural assets.
- Identification of priority natural assets.

Key findings from the assessment are as follows:

- **Natural Asset Inventory:** A natural asset inventory for Town of The Blue Mountains was created using GIS to compile data on the type, location, and extend of assets within the municipal boundary. Assets were categorized into agriculture, natural, and enhanced assets, with agriculture and natural assets comprising close to 98% of the total. Within the total area of 25,375 hectares, natural assets account for approximately 62%, agriculture assets cover approximately 35%, and enhanced assets make up approximately 2%.
- **Condition Assessment:** Natural assets in Town of The Blue Mountains were evaluated using criteria such as patch size, proximity to watercourses, and permeability of surrounding land uses. Most assets were found to be in good condition, with approximately 77% of the assets rated as good and no asset rated as very poor.
- **Risk Assessment:** A systematic evaluation of potential hazards such as invasive species, pests, flooding, and erosion was conducted. Hazards were ranked based on their impact and likelihood, with most of the assets being categorized as facing moderate risks.
- **Asset Replacement:** Replacement costs for natural assets were estimated using ecosystem restoration costs. The total replacement cost for major natural asset types, including woodland, meadow, shoreline and wetland assets, was calculated to be approximately \$4.03 billion. More relevant for the Town's asset management implications, are the natural asset under their ownership or management which have an estimated replacement cost of \$146.2 million.
- **Ecosystem Services:** The economic value of some ecosystem services provided by natural assets was estimated, including recreation, carbon sequestration, air quality regulation, stormwater management, habitat preservation, and regulation of extreme heat events. The total annual value of these services was estimated to be between \$75 million and \$92 million.
- **Natural Asset Prioritization:** Natural asset prioritization was assessed based on their condition, risk, and ecosystem service value, distinguishing between Town-owned and privately owned assets. 5,139 ha of natural assets in good and very good condition with high risk were identified for preservation and monitoring, with 1.1% being Town-owned. For assets in poor condition but with high risk, 242 ha were identified for restoration or enhancement, with 11% being Town-owned assets. Assets connected to watercourses covered 9,053 ha and were identified for preservation, with 0.6% being Town-owned assets. High service value assets in poor condition included 276 ha of assets that were identified for restoration or enhancement, and high service value assets with high risk covered 1,425 ha were identified for monitoring.

About the Authors

Green Analytics was commissioned, in collaboration with North-South Environmental, to complete a State of the Infrastructure report and conduct an ecosystem services valuation for the natural assets within Town of The Blue Mountains. Founded in 2011 by Mike Kennedy (PhD) and Jeff Wilson (MSc), Green Analytics is an employee-owned, independent consulting firm with offices in Edmonton, AB and Guelph, ON. Green Analytics informs the development of natural resource management policy that protects the environment and provides economic returns through objective social science research and analysis of the highest caliber. Green Analytics has advanced analytical capabilities including knowledge and experience in statistical analyses, spatial analytics and survey design and implementation. In recent years, Green Analytics has also developed advanced capabilities in highly responsive web-based applications to support environmental data initiatives. Green Analytics' owners, Mike Kennedy and Amy Taylor (MRM), and staff include policy analysts, professional economists, life cycle researchers, GIS technicians, and programmers. Green Analytics strives to exceed clients' needs through state-of-the-art research and analysis - on par with academic and scientific standards. For more information: www.greenanalytics.ca.

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1 Introduction

Municipalities across Canada provide services to local citizens through use of built assets. This includes, for example, stormwater management dikes, erosion control structures and drinking water infrastructure. The 2019 Canadian Infrastructure Report Card found the country’s infrastructure at risk with a considerable amount in poor or very poor condition. The state of Canada’s infrastructure poses a financial challenge to municipalities.

The term “municipal natural assets” refers to the stock of natural resources or ecosystems that is relied upon, managed, or could be managed by a municipality, regional district, or other form of local government for the sustainable provision of one or more local government services. Natural assets provide a cost-effective, resilient, alternative to some built infrastructure. Indeed, when managed properly, natural assets provide several valuable services including stormwater management, urban heat reduction, air quality improvements, and recreation.

Despite their ability to deliver services and ease the infrastructure burden for local governments, the adoption of natural asset management is not widespread in Canada. A key factor contributing to this limitation is the lack of information and data pertaining to the assets and the services that natural assets provide. To overcome this, there is a need to undertake natural asset management that parallels the approach used for built assets. This includes the creation of a natural asset inventory that quantifies the natural assets within municipal boundaries along with the services those assets deliver. By conceptualizing nature as an asset, we can codify, measure, and track the ways in which we depend on it. If natural assets are not managed properly, their value can depreciate and their ability to provide services diminishes.

Recent developments in analytical approaches for assessing and valuing natural assets allow for more ecosystem- and location-specific, rigorous, and defensible estimates. Such estimates can be replicated and incorporated into traditional asset management frameworks and compared across jurisdictions and regions. The outcomes of doing so include reduced risks, enhanced services, increased climate resilience and climate change mitigation.

This report contains the results of an assessment of Town of The Blue Mountains' natural assets. Figure 1-1 depicts key components of natural asset management that were undertaken for Town of The Blue Mountains (the Town).



Figure 1-1. Overview of the focus of this report.

In the sections that follow, the results of the tasks above are presented. The report is organized as follows:

- Section 2 provides the **natural asset inventory** describing how data was obtained and employed to delineate the range of assets located in Town of The Blue Mountains.
- Section 3 contains the approach and results of the **natural asset condition assessment**.
- Section 4 describes the approach and results of the **natural asset risk assessment**.

- Section 5 houses **replacement costs** for the natural assets.
- Section 6 describes the approach and results of a **valuation of ecosystem services**.
- Section 7 provides the results of an exercise to identify **priority natural assets**.
- Section 8 summarizes the findings and **concludes the report**.

2 Asset Inventory

This section provides an overview of the approach and outputs associated with establishing an inventory of assets for Town of The Blue Mountains. Figure 2-1 demonstrates the range of assets that may be managed by a local government including different types of green and grey infrastructure. The figure also demonstrates the relationships between terms commonly used when referring to green infrastructure (GI) including nature-based solutions (NbS), nature-based climate solutions (NbCS) and low impact development (LID). The figure distinguishes between three sub-types of GI, namely natural assets, enhanced assets, and engineered assets, with examples of each. This classification structure was used to inform the asset inventory structure for Town of The Blue Mountains, which is focused on natural and enhanced assets.

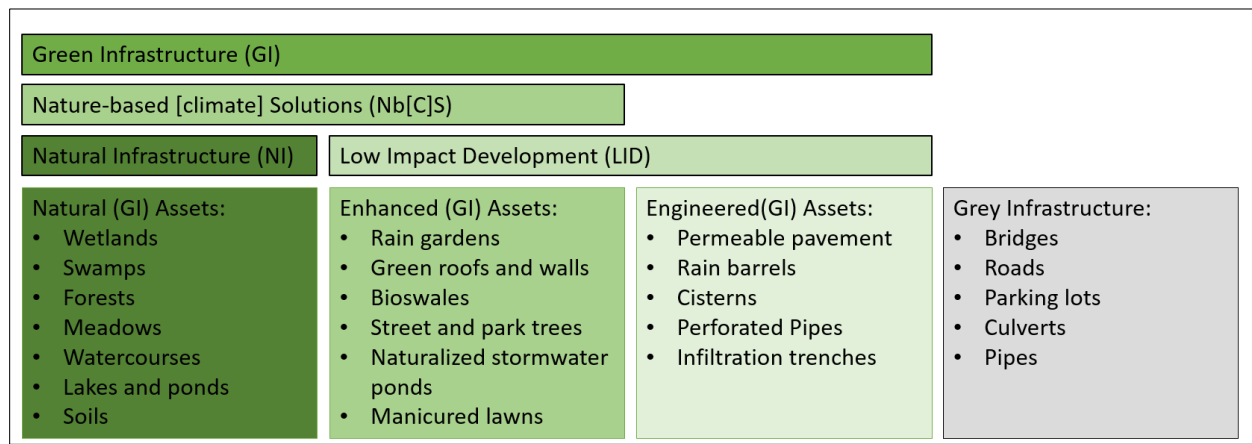


Figure 2-1. Defining natural assets.

2.1 Approach

The asset inventory forms the foundation upon which all other asset management tasks are based. The inventory is housed in a tabular registry that is created in GIS where relevant data was amalgamated to get a complete picture of the type, location, and extent of assets within the municipal boundary. While a distinction is made within the asset inventory between publicly and privately owned assets, for the purposes of this report, inventory outputs are presented for all assets within Town of The Blue Mountains municipal boundary. Publicly owned assets do not function in isolation from the natural areas on nearby lands owned by others, which also provide a range of services. Therefore, all assets within the municipal boundary have been included in the asset inventory.

For the purposes of this report, the term “assets” refers to the three asset types contained within the inventory:

1. **Natural assets**, which are comprised of natural features as detailed in Table 2-1.
2. **Enhanced assets**, which are comprised of semi-natural features that are more manicured and actively maintained as detailed in Table 2-2.
3. **Agricultural assets**, which were included to provide a complete picture of non-built landcover within the municipal boundary. These assets are not included in the condition or risk assessments or included in the valuation.

The asset types included in the inventory are delineated at three levels according to an asset hierarchy. At **Level 1**, an asset is defined as a continuous area of land cover regardless of the land cover type. Level 1 corresponds to the asset types identified above - natural, enhanced and agriculture assets. At **Level 2**, an asset is defined as a continuous area of the same land cover type. At Level 2, for example, natural assets are differentiated as forest, water, and wetland assets. At **Level 3**, differentiation is made within the types of assets at Level 2. At Level 3, for example, forest assets are defined by their species composition. Table 2-1 demonstrates the various levels of the inventory for natural assets. Table 2-2 shows the levels of the inventory for agriculture and enhanced assets.

Table 2-1. Natural asset hierarchy.

Level 1	Level 2	Level 3	
Natural	Aquatic	Open Aquatic	
	Hedgerow	Hedgerow	
	Meadow	Meadow	
	Wetland		Meadow Marsh
			Swamp
			Treed Swamp
	Woodland		Coniferous Plantation
			Cultural Woodland
			Deciduous Plantation
			Thicket
			Treed Area
			Woodland
	Shoreline		Beach
			Rocky
	Watercourse		Permanent Stream
			Intermittent Stream
			Virtual Connector
Virtual Flow			

Table 2-2. Other land asset hierarchy.

Level 1	Level 2	Level 3
Agriculture	Agriculture	Active Orchard
		Open Agriculture
Enhanced	Built-up Pervious	Golf
		Park
		Ski Hill
	Street and Park Trees	

A range of spatial data sources were used to establish the asset inventory. Appendix A provides a complete list of data sources used to define the location and extent of each level of the natural, enhanced and agriculture assets.

2.2 Summary of Inventory Outputs

The remainder of this section provides outputs derived from Town of The Blue Mountains' asset inventory. Table 2-3 has area values for the assets within Town of The Blue Mountains at Level 1.

Table 2-3. Level 1 area breakdown of inventory.

Natural Area Type (Level 1)	Total Area (ha)	Percent (%) of Inventory
Agriculture	8,936	35.2
Enhanced	596	2.3
Natural	15,843	62.4
Total Area (ha)	25,375	100

Percentages do not add up to 100% due to rounding

The location and extent of the assets within Town of The Blue Mountains at Level 1 are depicted in Figure 2-2. As per the table above, at this level the distinction is between natural assets (62%), agricultural assets (35%) and enhanced assets (2%).

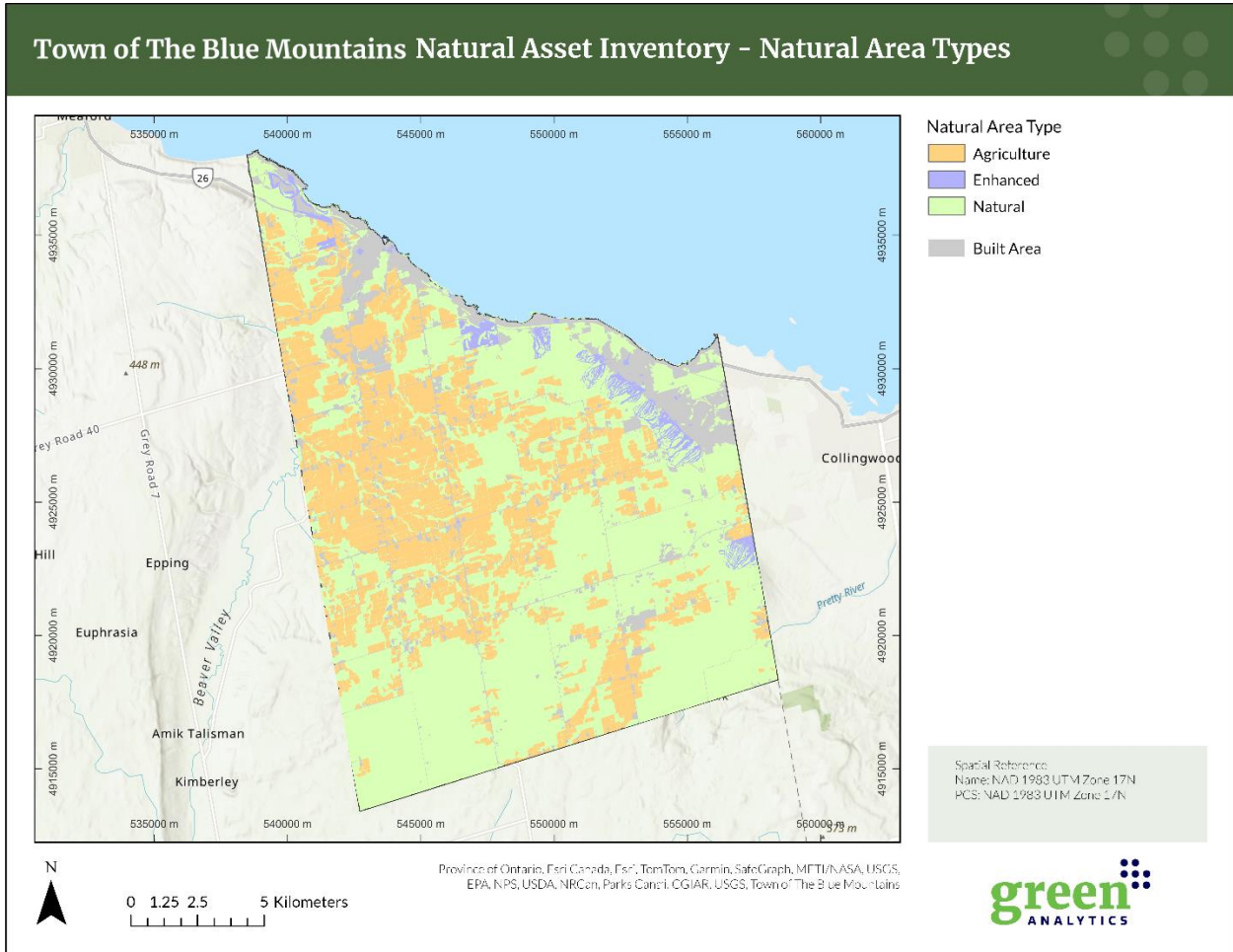


Figure 2-2. Map of natural asset inventory categorized by natural area type (Level 1).

Table 2-4 demonstrates the distribution of Town of The Blue Mountains’ assets by type at Level 2. Here, the contribution of wetlands, woodlands and built-up pervious is evident. Figure 2-3 shows the location and extent of natural, enhanced and agricultural assets at Level 2. See Appendix B for inventory outputs at Level 3.

Table 2-4. Level 2 area breakdown of inventory.

Natural Area Type (Level 1)	Asset Type (Level 2)	Total Area (ha)	Percent (%) of Total Inventory
Agricultural Assets			
	Agriculture	8,936	35.2
Natural Assets			
	Open Aquatic	233	0.9
	Hedgerow	314	1.2
	Meadow	990	3.9
	Shoreline	33	0.1
	Wetland	1,156	4.6
	Woodland	13,116	51.7
Natural Assets Total		15,843	62.4
Enhanced Assets			
	Built-up Pervious	596	2.3
All Assets Total Area (ha)		25,375	100

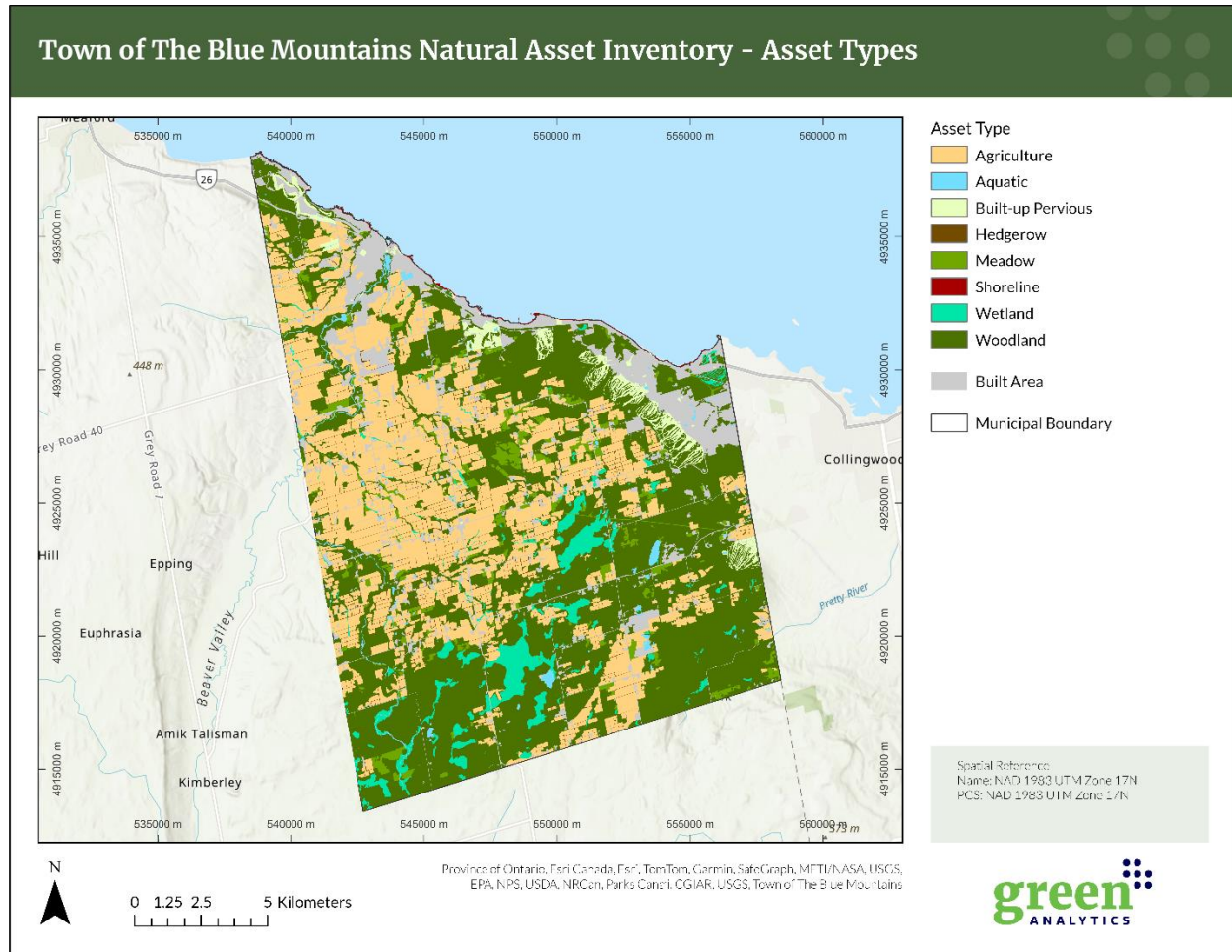


Figure 2-3. Map of natural asset inventory categorized by asset type (Level 2).

While the focus of this assessment is on assets located within Town of The Blue Mountains, it is useful to consider those assets within the municipal boundary that are owned by the municipal government. These are assets over which the local government has jurisdictional control. Table 2-5 and Figure 2-4 show the assets by type that are owned by Town of The Blue Mountains. Of the 25,375 ha of assets within the Town boundary, approximately 182 ha are Town-owned. These are largely comprised of woodland assets (92 ha), built-up pervious assets (48 ha), and open aquatic assets (20 ha). These assets are integral parts of the larger landscape of assets within Town of The Blue Mountains.

Table 2-5. Level 2 area breakdown of inventory within Town-owned land.

Natural Area Type (Level 1)	Asset Type (Level 2)	Total Area in Town-Owned Land (ha)	Percent (%) of Total Inventory in Town-Owned Land
Agricultural Assets			
	Agriculture	15	8.2
Natural Assets			
	Open Aquatic	20	10.9
	Hedgerow	1	0.5
	Meadow	6	3.3
	Shoreline	0	0.0
	Wetland	1	0.5
	Woodland	92	50.3
Natural Assets Total		120	65.6
Enhanced Assets			
	Built-up Pervious	48	26.2
All Assets Total Area (ha)		183	100

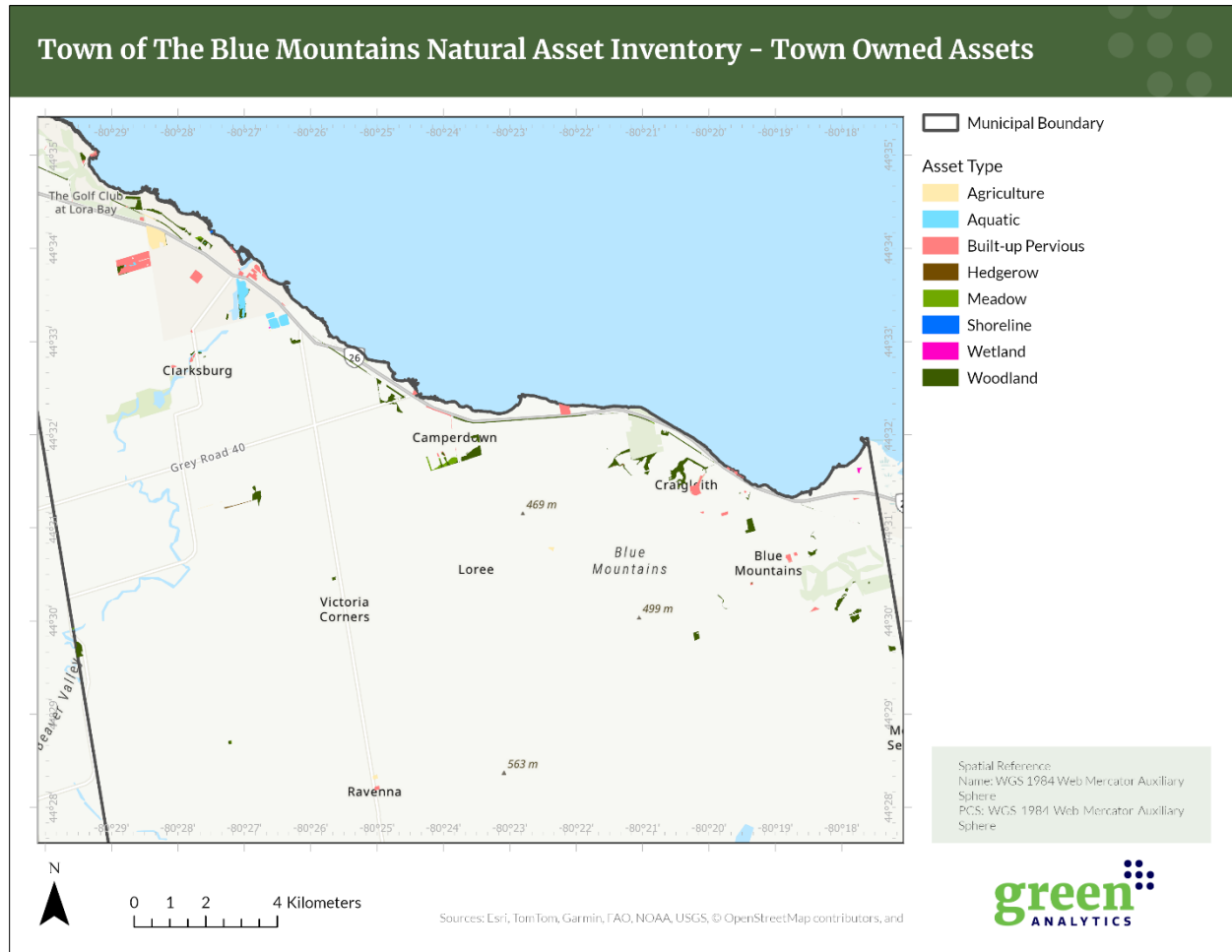


Figure 2-4. Map of Town-owned natural asset inventory categorized by asset type (Level 2).

Watercourse and individual tree assets are not measured using area-based metrics. Because of this, it is not possible to represent them in the same map format as other natural assets. The tables and figures below present inventory results for the watercourse and individual tree assets. Table 2-6 shows the total length (km) of watercourse assets, which are measured by length rather than area, within Town of The Blue Mountains.

Table 2-6. Level 2 watercourse asset inventory.

Natural Area Type (Level 1)	Asset Type (Level 2)	Asset Type (Level 3)	Total Length (km)
Natural Assets	Watercourse	Permanent Stream	341.34
		Intermittent Stream	19.45
		Virtual Connector	6
		Virtual Flow	35.14
All Assets Total Length (km)			401.93

Figure 2-5 illustrates the watercourse assets within Town of The Blue Mountains. Within the municipal boundary, there are a total of 402 kms of watercourse assets.

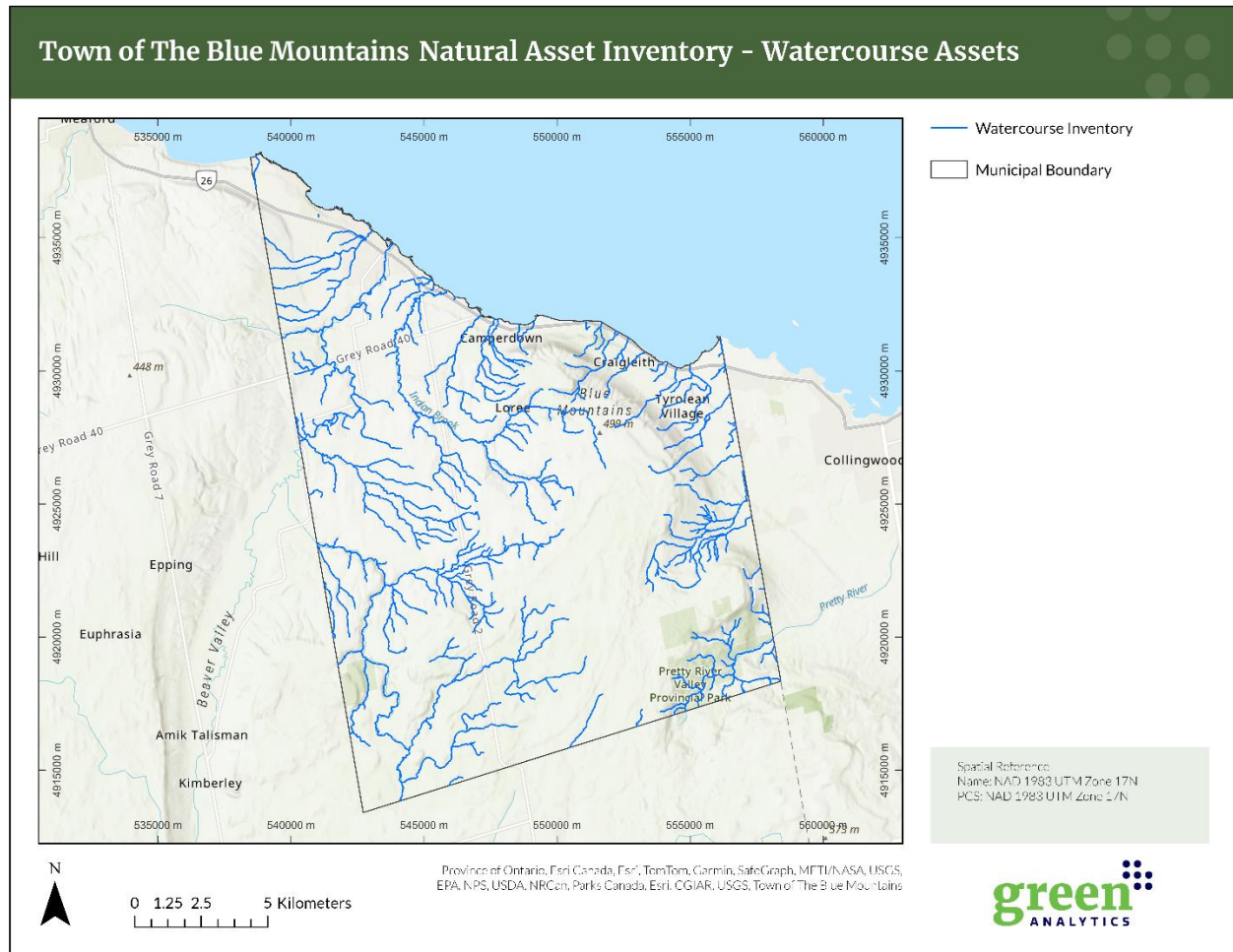


Figure 2-5. Watercourse assets within Town of The Blue Mountains.

An initial tree inventory was developed for Town of The Blue Mountains through the processing of available LiDAR data. The processed data established a point location for each tree within the study area boundary. Figure 2-6 shows the point locations for all identified trees within the municipal boundary.

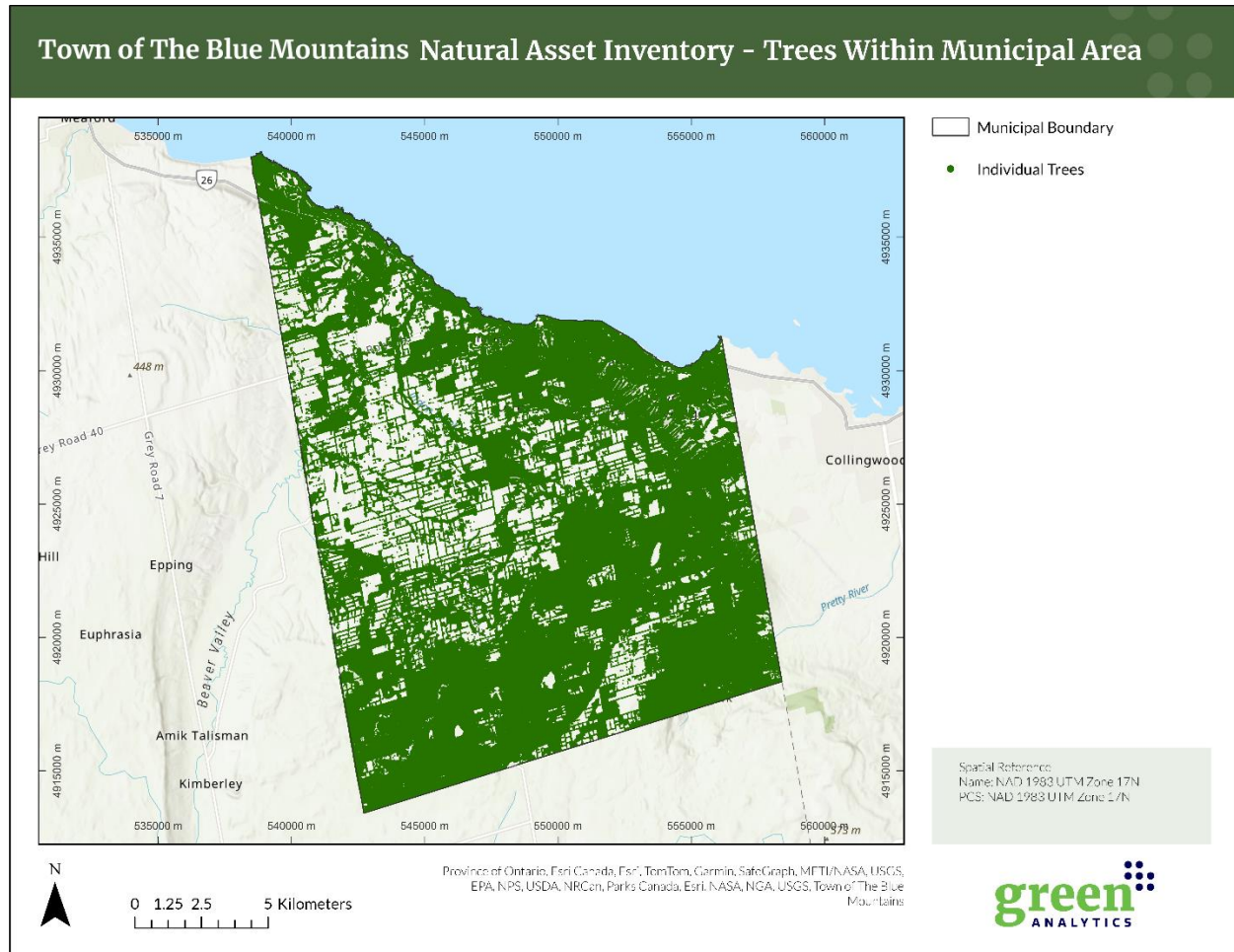


Figure 2-6. Trees within Town of The Blue Mountains.

To give context to the map above, Table 2-7 demonstrates the count of trees within Town of The Blue Mountains by settlement area. There are over 3 million trees within the municipal boundary of which 31,051 trees are within Town-owned land. Removing any trees associated with existing natural asset features implies that on Town-owned land, there are approximately 11,545 individual trees that may need active Town management. Looking at the tree counts by settlement area and removing any counts associated with existing natural assets, the total number of individual trees that may require active management is estimated to be 99,488. However, many of these would occur on private land and therefore not be under the direct responsibility of the Town.

Similarly, to approximate the number of street trees that may require active Town management, the number of trees within the road right-of-way was examined. The analysis suggests that the number of street trees along the roadside range from 24,498 (based on no buffer) to 50,971 (based on 5 m buffer). However, many of these trees can be linked to existing natural assets (i.e. are part of forested areas along roadsides). Removing any trees associated with these assets refines the estimated number of street trees from 15,282 (based on no buffer) to 25,916 (based on 5 m buffer). Since this estimate captures trees across the entire boundary and many of these trees are likely associated with rural properties, this is likely an overestimate of the number of trees requiring direct management by the Town. Refining this further to

only trees along the road right-of-way within the settlement boundaries and outside of known natural asset boundaries, a conservative estimate of street trees that could require active management by the Town is 6,994 to 15,226. Figure 2-7 shows the location and extent of individual trees by settlement area and Figure 2-8 shows the location and extent of individual trees that are Town-owned.

As is noted above, the tree inventory was derived using LiDAR data. Using height information, LiDAR data can be used to approximate the number of individual trees in a given location. The vast majority of the trees identified from the LiDAR data are trees associated with existing forested natural assets. These trees are not managed individually. To identify the trees that would be managed as individual assets, we have narrowed the outputs and approximated the number of street trees. There is a margin of error associated with the data processing and the estimated number of trees is not exact. For example, some of the identified street trees will exist on private property and therefore will not be the responsibility of Town of The Blue Mountains. To confirm the exact number of trees, a field-based inventory of the identified street trees could be undertaken. Such a study could focus on street and roadway trees as these trees are planted and managed as individual trees (as opposed to trees that collectively form forest assets). Such a field-based exercise would also obtain data on species, age, size, and condition.

Table 2-72-7. Count of trees within Town of The Blue Mountains by administrative area.

Administrative Area	Count of Trees	Count of Trees (excluding natural and enhanced areas)
Municipal Boundary (Total Count)	3,069,389	157,867
Town-Owned Areas (within Town Lands polygon)	31,051	11,545
Trees by Settlement Area		
Banks	2,740	394
Camperdown	77,501	19,439
Clarksburg Settlement	14,782	7,354
Craigleith	149,437	45,493
Gibraltar	2,696	453
Heathcote	1,029	414
Lora Bay	44,367	9,609
Ravenna	395	352
Redwing	280	35
Slabtown	752	363
Swiss Meadows	8,846	2,638
Thornbury East	4,620	3,456
Thornbury West	15,582	9,488
Total Settlement Area Trees	323,027	99,488
Street Trees		
Road ROW – 0m buffer	24,498	15,282
Road ROW – 5m buffer	50,971	25,916
Road ROW – 10m buffer	73,244	33,398
Unopened Road ROW – 0m buffer	21,012	2,357
Unopened Road ROW – 5m buffer	31,750	2,973
Unopened Road ROW – 10m buffer	41,834	3,464
Road ROW within Settlement Areas – 0m buffer	8,174	6,994
Road ROW within Settlement Areas – 5m buffer	18,750	15,226
Road ROW within Settlement Areas – 10m buffer	27,341	21,383



Figure 2-7. Trees within Town of The Blue Mountains by settlement area.

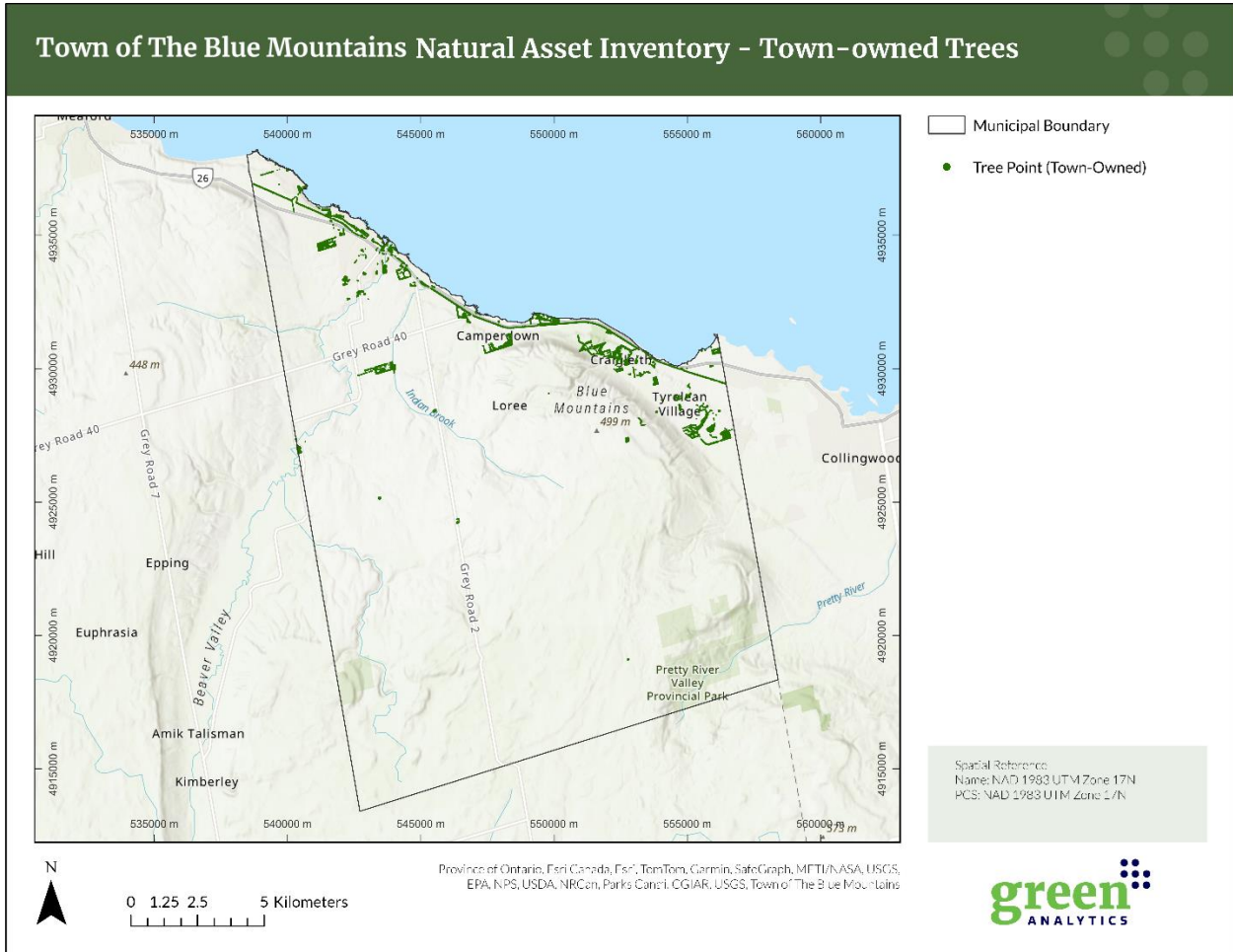


Figure 2-8. Trees within Town of The Blue Mountains on Town-owned land (excludes street trees).

3 Condition Assessment

The objective of a natural asset condition assessment is to assess, at a high-level, an asset’s ability to provide ecological services, which are valued by municipalities and communities (e.g., air pollution filtration, storm water attenuation, carbon sequestration, nature-based recreation, etc.). The assumption underlying the natural assets condition assessment 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.

While the desktop condition assessment that was completed for the natural assets within Town of The Blue Mountains is grounded in landscape ecology metrics, it is recommended that field-based verification of the condition of natural assets be completed overtime to support and improve natural asset condition monitoring.

Note that the condition indicators were applied to the natural assets defined in Table 2-4. The other land assets (enhanced and agricultural land) are included in the inventory to provide a complete picture of the land-based assets within Town of The Blue Mountains and to recognize their important contribution to community services such as stormwater management and recreation. However, the condition of agricultural lands from an asset management perspective has limited relevance since those lands are largely managed by private landowners. For built-up pervious assets, condition ratings can be useful from a management perspective. However, such ratings require input from field staff on each individual property, which is beyond the scope of this project.

The process used for the condition assessment in this project aligns with the process outlined in the Canada-wide standards and specifications for natural asset inventories (Figure 3-1) (CSA 2022). As noted above, the focus of the condition assessment is on the natural assets. For those assets, indicators are chosen that relate to three criteria namely landscape context, physical context and ecological condition. For each of the indicators, a scoring system is established to allow the results of the assessment to be positioned within a ranking system ranging from very good to very poor.

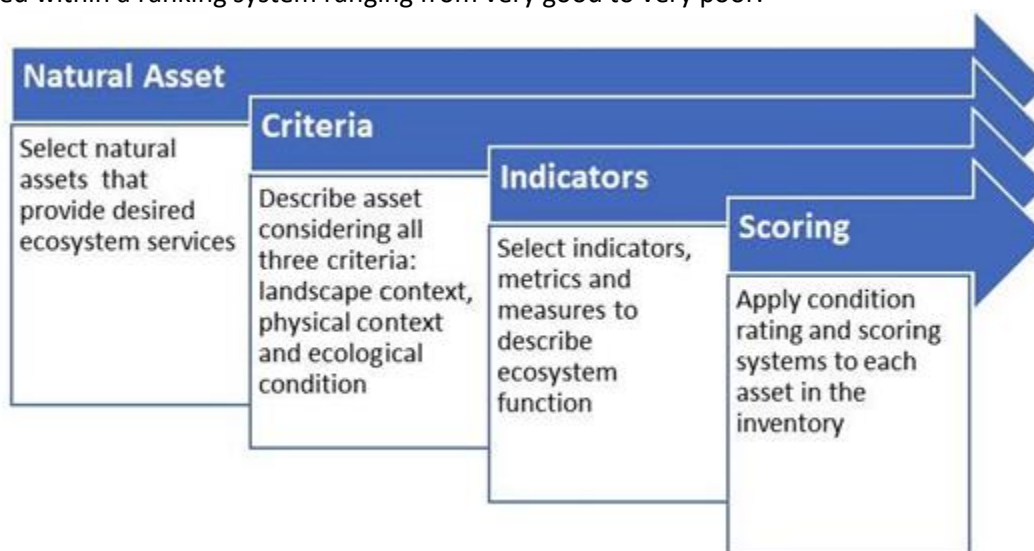


Figure 3-1. The natural asset condition assessment process (Source: CSA 2022)

The condition indicators applied to Town of The Blue Mountains' natural assets are categorized into two criteria (i.e., landscape context and physical context):

CRITERIA FOR PHYSICAL CONTEXT

1. Interior habitat
2. Natural area patch size
3. Natural area patch shape
4. Natural asset proximity to watercourses
5. Woodland proximity to other natural assets
6. Wetland proximity to other natural assets

CRITERIA FOR LANDSCAPE CONTEXT

7. Extent of adjacent permeable land uses
8. Percent of woodland cover within subwatersheds
9. Percent of wetland cover within subwatersheds

Appendix C describes the approaches employed for each of the indicators identified above. Note that in the context of Town of The Blue Mountains, suitable indicators for evaluating Ecological Condition were not found. Future data collection focused on species diversity, invasive species or habitat quality would help respond to this gap. In this regard, Town of The Blue Mountains could work with existing partners such as the Niagara Escarpment Commission and, Conservation Authorities and the Ministry of Natural Resources.

3.1 Summary of Condition Assessment Results

To give an overall picture of the condition of Town of The Blue Mountains' natural assets according to the condition indicators employed in this assessment, Figure 3-2 demonstrates the combined results of all indicators (assuming equal weighting of each indicator).

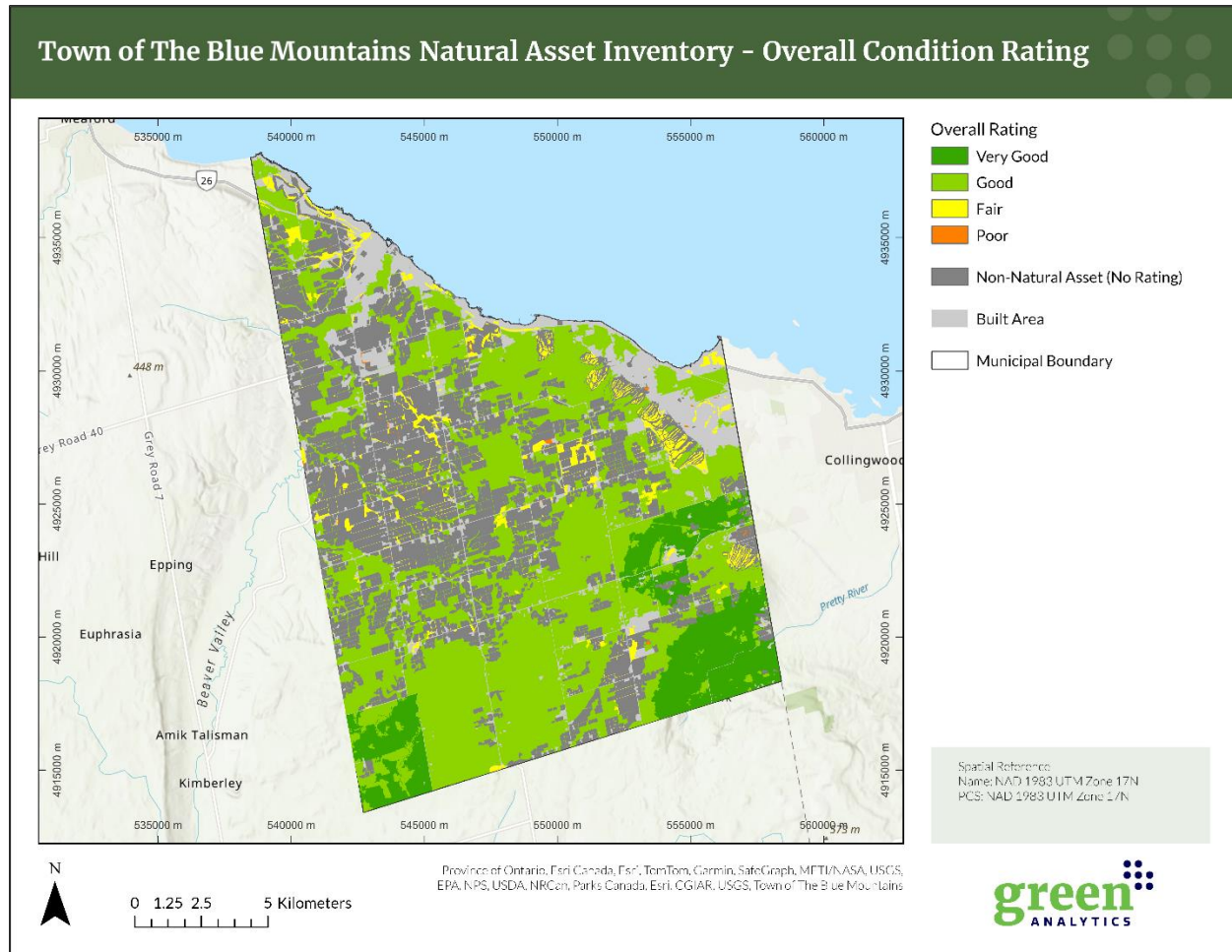


Figure 3-2. Natural assets overall condition rating.

As is evident in the figure above, the vast majority of the natural assets within Town of The Blue Mountains are ranked as good. Almost 77% of the inventory’s assets rate good according to the indicators considered in this condition assessment (Table 3-1), with no areas ranked as very poor.

Table 3-1. Area of natural assets by overall condition rating.

Overall Condition Rating	Asset Area (ha)	Percent (%)
Very Good	2,713	17.2
Good	12,099	76.5
Fair	969	6.1
Poor	29	0.2
Very Poor	0	0
Total	15,809.85	100

It is useful to consider the condition of assets by type. To that end, Figure 3-3 shows the condition results by asset type and condition rating. The majority of woodland assets (over 70%) rate good as do the open aquatic assets. The wetland assets almost entirely (95.5%) rate good with a minor proportion being fair

(4.5%). Shoreline assets were not rated for condition as the condition indicators employed would not be suitable to this asset type.

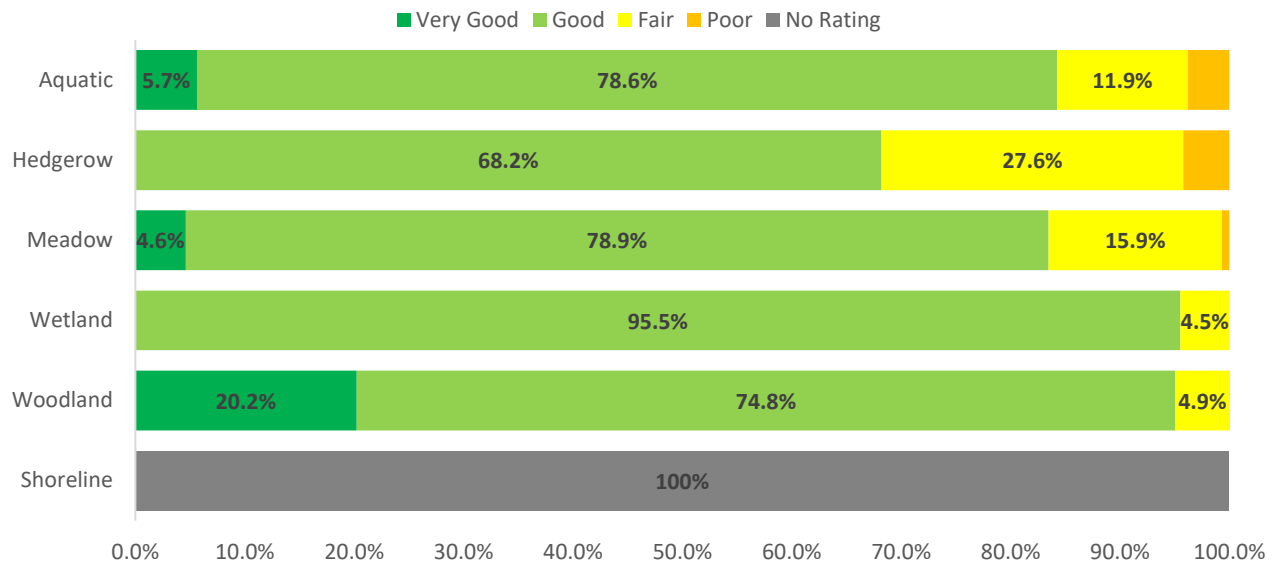


Figure 3-3. Condition breakdown by asset types for natural assets in Town of The Blue Mountains.

4 Risk Assessment

The goal of conducting a natural asset risk assessment is to systematically identify and prioritize potential hazards to natural assets based on their relative impact and likelihood. These hazards, if not properly managed, could adversely affect a community's natural assets and hence service delivery. The steps to undertaking a risk assessment are:

1. Identify the range of applicable hazards
2. Rank hazards for relative impact
3. Rank hazards for relative likelihood
4. Calculate a risk score for each hazard
5. Allocate risk scores to relevant natural assets

By following these steps, a natural asset risk assessment provides a structured approach to understanding and managing the risks to natural assets and aids in decision-making.

4.1 Identify the Range of Hazards

The first step involves identifying the various hazards that have the potential to adversely affect the natural assets. This task was undertaken in consultation with representatives from Town of The Blue Mountains. The following hazards pertinent to Town of The Blue Mountains' natural assets were identified:

- Invasive species
- Pests and disease
- During construction impacts
- Unauthorized edge encroachments / disturbances
- Flooding
- Erosion – Shoreline
- Extreme wind – Trees
- Ice storm / freezing rain – Trees, woodland
- Extreme Heat and Drought – Trees
- Contamination / Pollution
- Fire
- Poor management Practices
- Sedimentation – Wetlands, watercourse, open water
- Sedimentation – Storm ponds

4.2 Rank Hazards for Relative Impact

Once the hazards that negatively impact natural assets has been established, the next step is to rank the hazards for their relative impact. The rankings were established in consultation with Town of The Blue Mountains project team considering financial, socio-economic, and environmental impacts.

Table 4-1 outlines the impact rating scale used to guide the ranks assigned to the identified hazards. The scale ranges from 1 (Very Low) to 5 (Very High). A "Very High" impact involves remediation costs exceeding the annual budget by over 100 times, permanent service loss, and long-term damage to natural assets. At the other end of the scale, a "Very Low" impact indicates manageable remediation costs within the annual budget, negligible service disruption, and non-lasting damage to natural assets.

Table 4-1. Impact rating for consequence of hazards.

Scale	Impact	Financial	Socio-economic	Environmental
5	Very High	Cost of remediation exceeds annual budget > 100 times	Permanent loss of related services	Potential to cause long term damage to the condition of the natural assets
4	High			
3	Moderate	Cost of remediation exceeds annual budget > 10 times	Temporary loss of related services	Potential to cause short term repairable damage to the condition of the natural asset over a large area
2	Low			
1	Very Low	Cost of remediation falls within annual budget	Little to no effect on related services	Potential to cause non-lasting damage to natural assets

Table 4-2 demonstrates the impact ratings assigned to the hazards for Town of The Blue Mountains.

Table 4-2. Town of The Blue Mountains risk impact ratings.

Potential Hazards / Issue to Natural Assets	Risk Impact Rating
Invasive species	3
Pests and disease	4
During construction impacts	1.5
Unauthorized edge encroachments/disturbances	3
Flooding	2
Erosion	2
Extreme wind	2
Ice storms / freezing rain	3
Extreme Heat and Drought	3
Contamination / Pollution	3.5
Fire	2.5
Cumulative impacts from land use change	4.5
Water level fluctuation - shoreline / rivers	3

4.3 Rank Hazards for Relative Likelihood

The next step in the risk assessment process is allocating a likelihood rating to each identified hazard. Table 4-3 provides a framework for assigning likelihood to various hazards impacting natural assets. “Rare” hazards occur every 50 years or less, with an annual probability of $\leq 2\%$, while at the other end of the spectrum, “Almost Certain” hazards are those occurring annually or more frequently, with a $\geq 50\%$ probability.

Table 4-3. Likelihood ratings for hazards.

Likelihood ranking	Description	Annual probability	Return period
Rare (1)	Likely to occur every 50 years or less	≤2%	1:50 or less
Unlikely (2)	Likely to occur between once every 21 years and once every 50 years	2 to < 5%	1:21 to 1:50
Possible (3)	Likely to occur between once every 5 years and once every 20 years	5 to < 20%	1:5 to 1:20
Likely (4)	Likely to occur between once every 2 years and once every 5 years	20 to < 50%	1:2 to 1:5
Almost certain (5)	Likely to occur annually or several times per year	≥ 50%	1:1 or more

Table 4-4 demonstrates the likelihood ratings assigned to the hazards for Town of The Blue Mountains.

Table 4-4. Town of The Blue Mountains likelihood ratings.

Potential Hazards / Issue to Natural Assets	Risk Likelihood Rating
Invasive species	5
Pests and disease	5
During construction impacts	3
Unauthorized edge encroachments/disturbances	4
Flooding	3
Erosion	2
Extreme wind	2
Ice storms / freezing rain	2
Extreme Heat and Drought	2
Contamination / Pollution	4
Fire	1
Cumulative impacts from land use change	4.5
Water level fluctuation - shoreline / rivers	4

4.4 Calculate Risk Scores

Risk scores were calculated for each hazard by multiplying the likelihood rating by the impact rating. For example:

$$RiskScore_{hazard\ i} = ImpactRating_{hazard\ i} * LikelihoodRating_{hazard\ i}$$

Table 4-5 presents the outcomes of steps 2 to 4 in the risk assessment process.

Table 4-5. Risk impact and likelihood ratings as well as overall risk score by hazard.

Potential Hazards / Issue to Natural Assets	Risk Impact Rating	Risk Likelihood Rating	Risk Score
Invasive species	3	5	15
Pests and disease	4	5	20
During construction impacts	1.5	3	4.5
Unauthorized edge encroachments/disturbances	3	4	12
Flooding	2	3	6
Erosion	2	2	4
Extreme wind	2	2	4
Ice storms / freezing rain	3	2	6
Extreme Heat and Drought	3	2	6
Contamination / Pollution	3.5	4	14
Fire	2.5	1	2.5
Cumulative impacts from land use change	4.5	4.5	20.25
Water level fluctuation – shoreline / rivers	3	4	12

4.5 Allocate Risk Scores to Natural Assets

With the risk scores established for each hazard, the next step was to determine which natural assets are most likely to be impacted by those hazards. This was done by first identifying the type of natural asset that will be subject to the particular risk (Table 4-6).

Table 4-6. Hazard application by asset type.

Potential Hazards to Natural Assets	Woodlands	Wetlands	Meadow	Open Aquatic	Hedgerows	Shoreline
Invasive species	X	X	X		X	
Pests and disease	X				X	
During construction impacts	X	X	X		X	
Unauthorized edge encroachments/disturbances	X	X	X			
Flooding	X	X	X		X	
Erosion						X
Extreme wind	X				X	
Ice storms / freezing rain	X				X	
Extreme Heat and Drought	X	X	X		X	
Contamination / Pollution	X	X	X		X	
Fire	X					
Cumulative impacts from land use change	X	X	X	X	X	X
Water level fluctuation – shoreline / rivers				X	X	X

Of the asset types applicable to the hazards, assets were then selected based on spatial distribution assumptions (Table 4-7). For example, while a broad range of asset types have the potential to be relevant to encroachment, those that are located within 20 m of private properties will ultimately be subject to this risk. The allocation assumptions allow for the combined risk scores (Table 4-7) to be allocated to specific natural assets within the inventory. This resulted in the 13 hazards having a unique field in the asset inventory registering the associated risk score.

Table 4-7. Hazard spatial distribution assumptions.

Potential Hazards to Natural Assets	Spatial Distribution Assumptions
Invasive species	Assigned to all applicable asset classes
Pests and disease	Assigned to all applicable asset classes
During construction impacts	Applicable assets intersecting development related zoning areas
Unauthorized edge encroachments/disturbances	Applicable assets directly abutting, or within 5m of any residential land use
Flooding	Applicable assets within flood zone (defined as 100 m around GSCA 100 year flood line)
Erosion	Assigned to all applicable asset classes
Extreme wind	Assigned to all applicable asset classes
Ice storms / freezing rain	Assigned to all applicable asset classes
Extreme Heat and Drought	Assigned to all applicable asset classes
Contamination / Pollution	Applicable assets within 30m of industrial zoned land use
Fire	Assigned to all applicable asset classes
Cumulative impacts from land use change	Applicable assets within 100m of built up area within settlement areas
Water level fluctuation	Assigned to all applicable asset classes

The final step in the risk assessment process was to combine the risk scores to get an overall risk score for each asset.

4.6 Risk Assessment Results

Figure 4-1 displays the overall risk scores for Town of The Blue Mountains' natural assets. The overall risk scores were derived by summing the individual risk scores applicable to each asset. The greater the number of high and very high risks applicable to a particular asset, the higher the overall risk score for that asset. As is evident in the map, most of the assets within Town of The Blue Mountains are subject to moderate or high risk. See appendix D for maps of each of the risks considered in the risk assessment.

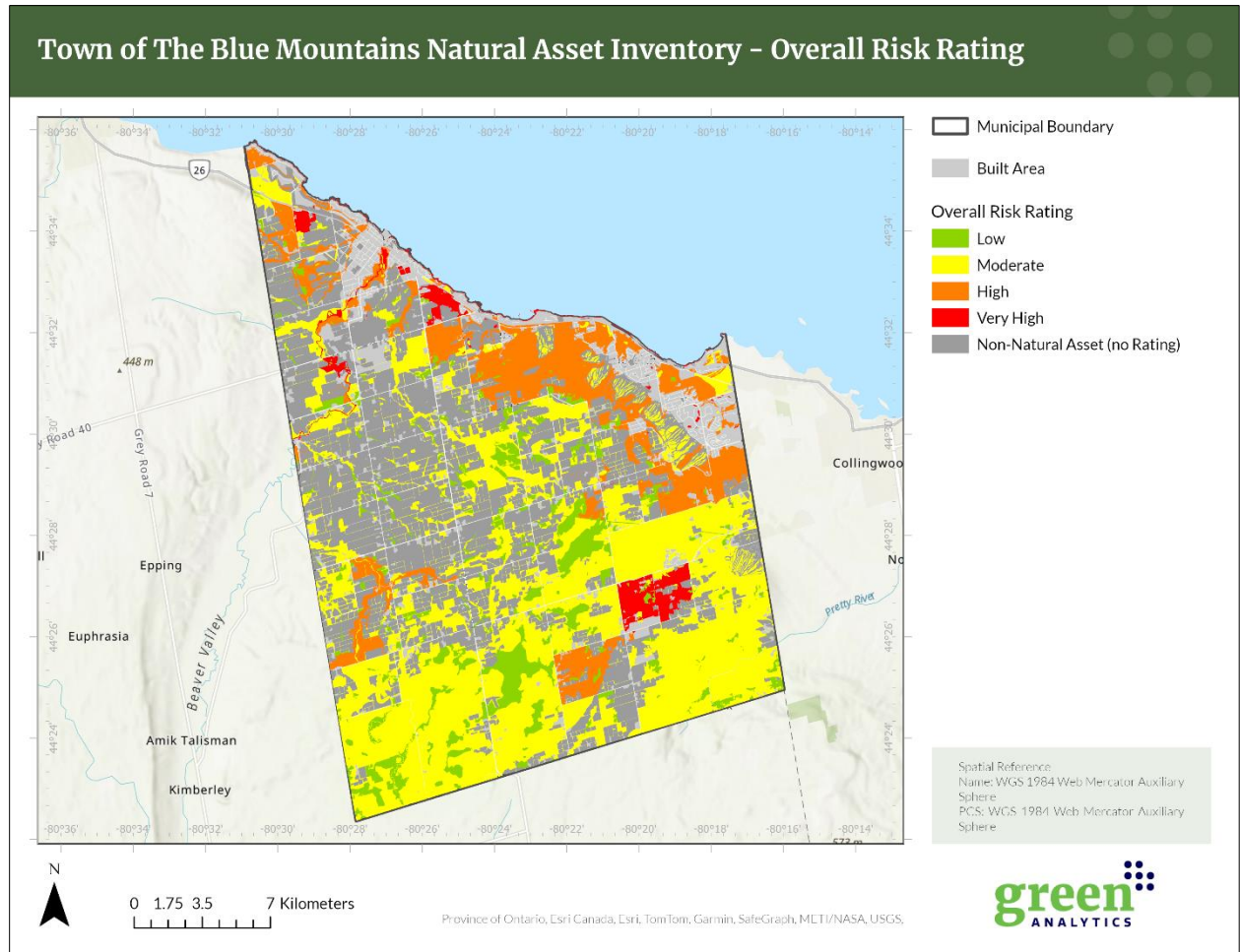


Figure 4-1. Natural assets mapped by overall risk rating.

Table 4-8 shows the area of Town of The Blue Mountains’ assets associated with each risk category. The vast majority of Town of The Blue Mountains’ assets face moderate risk of being negatively impacted by hazards. Figure 4-2 illustrates the overall risk category breakdown by asset types.

Table 4-8. Town of The Blue Mountains’ assets by overall risk score.

Risk Category	Asset Area (ha)
Very Low	0
Low	1,947
Moderate	10,035
High	3,248
Very High	613
Total	15,843

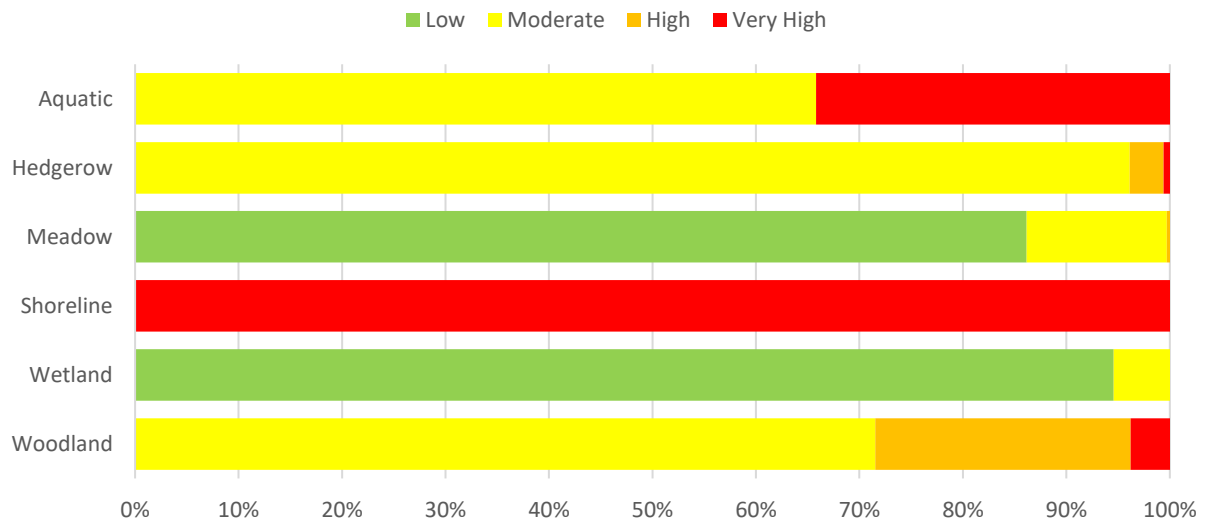


Figure 4-2. Risk category breakdown by asset types.

5 Asset Replacement Costs

Replacement cost is a widely recognized component of asset management. It serves as a key indicator for determining the value of an asset. To establish replacement costs, the costs associated with replacing an existing asset with a new one of equivalent functionality and capacity are assigned to each asset in the inventory. An asset replacement cost encompasses not only the purchase price of the asset but also a range of additional costs including site preparation, delivery and installation, as well as the expenses incurred in initial maintenance and monitoring activities. When it comes to natural assets, the replacement process is notably more intricate compared to grey infrastructure. This complexity arises from the time-intensive nature of establishing natural assets, which can span several decades. Unlike grey infrastructure, natural assets such as wetlands or urban forests require a significant period of time to reach full maturity and functionality, making their replacement a long-term and dynamic process.

Except for shoreline and street and park trees, replacement cost values for natural assets were derived from CVC (2020). To establish a replacement cost from CVC (2020) lifecycle costs, only expenses related to planning, creation, and inspection and maintenance were included. For watercourses, CVC (2020) provides an approximate estimate of stream corridor rehabilitation. It should be noted that costs for stream rehabilitation projects can vary widely depending on several factors such as site access and extent of flow management required. The CVC (2020) rehabilitation costs are based on stream corridor segments assumed to be 500 m long and 20 m wide. For shorelines, the City of Barrie’s assumed replacement cost for beaches was used (City of Barrie 2023). The Barrie cost is based on beach nourishment costs and may not fully reflect the replacement costs of all shoreline assets within Town of The Blue Mountains. For street and park trees, replacement costs reported by the Town of Fort Erie were used. Such costs are equal to \$2,160 per tree and capture costs associated with planting and various follow-up maintenance actions over 2 to 3 years to ensure survival of an urban tree, plus an additional \$2,500 per tree for the removal and stumping of the tree being replaced (Town of Fort Erie 2024). Replacement cost values for all natural assets and Town-owned natural assets are presented in Table 5-1.

Table 5-1. Per unit replacement costs and total replacement costs for major natural asset types in Town of The Blue Mountains.

Asset Type	Per Unit Replacement Cost	All Assets		Town-Owned or Managed Assets	
		Units	Replacement Cost (Million\$)	Units	Replacement Cost (Million\$)
Woodland	214,959 (\$/ha)	13,116 ha	2,819.4	92 ha	19.8
Meadow	184,635 (\$/ha)	990 ha	182.8	6 ha	1.1
Wetland	385,113 (\$/ha)	1,156 ha	445.2	1 ha	0.4
Shoreline	34,100 (\$/ha)	33 ha	1.1	0 ha	0
Watercourses	1,700,000 (\$/km)	341 km	579.8	-	-
Street Trees	4,665 (\$/tree)	-	-	15,226 trees	71
Park Trees	4,665 (\$/tree)	-	-	11,545 trees	53.9
Total Replacement Cost			4,028.3		146.2

Across the jurisdiction of Town of The Blue Mountains the replacement cost of natural assets (specifically for those that a replacement cost was able to be established) is estimated to be \$4.03 billion. More

relevant for the Town's asset management implications, are the natural asset under their ownership or management. For these assets, the replacement cost is estimated to be \$146.2 million.

6 Ecosystem Services for Valuation

Ecosystem services are the benefits that nature provides to humans. Ecosystem services contribute to human well-being and economic health by providing clean air and water, food, materials for shelter and clothing, and natural resources for economic development. Additionally, these services play a crucial role in reducing environmental risks and regulating natural cycles in ways that sustain life (WWF Living Planet Report 2016). Figure 6-1 depicts numerous ecosystem services categorized by the common themes of provisioning, regulating, supporting and cultural. The ecosystems services summarized in Figure 6-1 align closely with the classification used by the Economics of Ecosystem and Biodiversity (TEEB) which is aligned with the Millennium Ecosystem Assessment Framework that helped standardize the way we understand and assess ecosystem services.

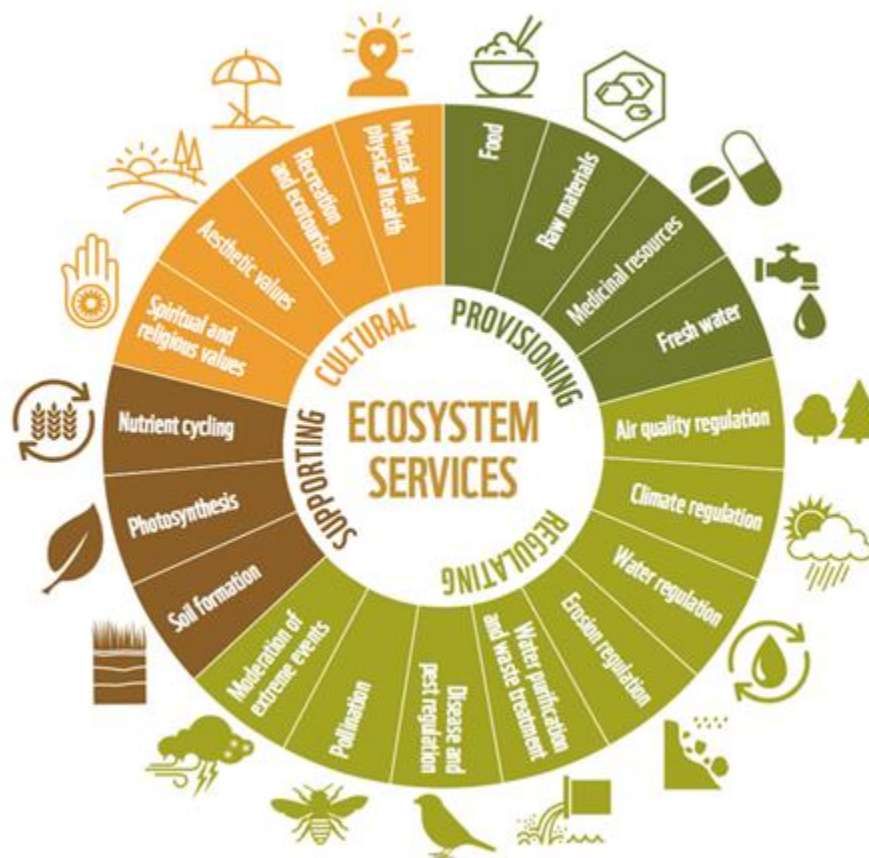


Figure 6-1. Ecosystem services diagram (Source: WWF Living Planet Report 2016)

From the range of services identified in the figure above, the project team identified those most amenable to valuing for Town of The Blue Mountains. Valued services include the provision of recreational opportunities, carbon sequestration, air quality regulation, stormwater regulation, habitat preservation, regulation of extreme heat and contribution to crop productivity.

Once the priority ecosystem services were identified, the value of those services could be established. The approaches employed varied by service type but at a high-level were based on existing norms and standards. In this regard, the valuation of the ecosystem services focused on the value of the *final* services provided to those who *benefit* from the services. This concept is demonstrated in the Cascade Model (Figure 6-2). As can be seen in the figure, natural assets have biophysical structures that provide functions

which result in final services and benefits. Humans benefit from these biologically-driven services, and the benefits can be valued.

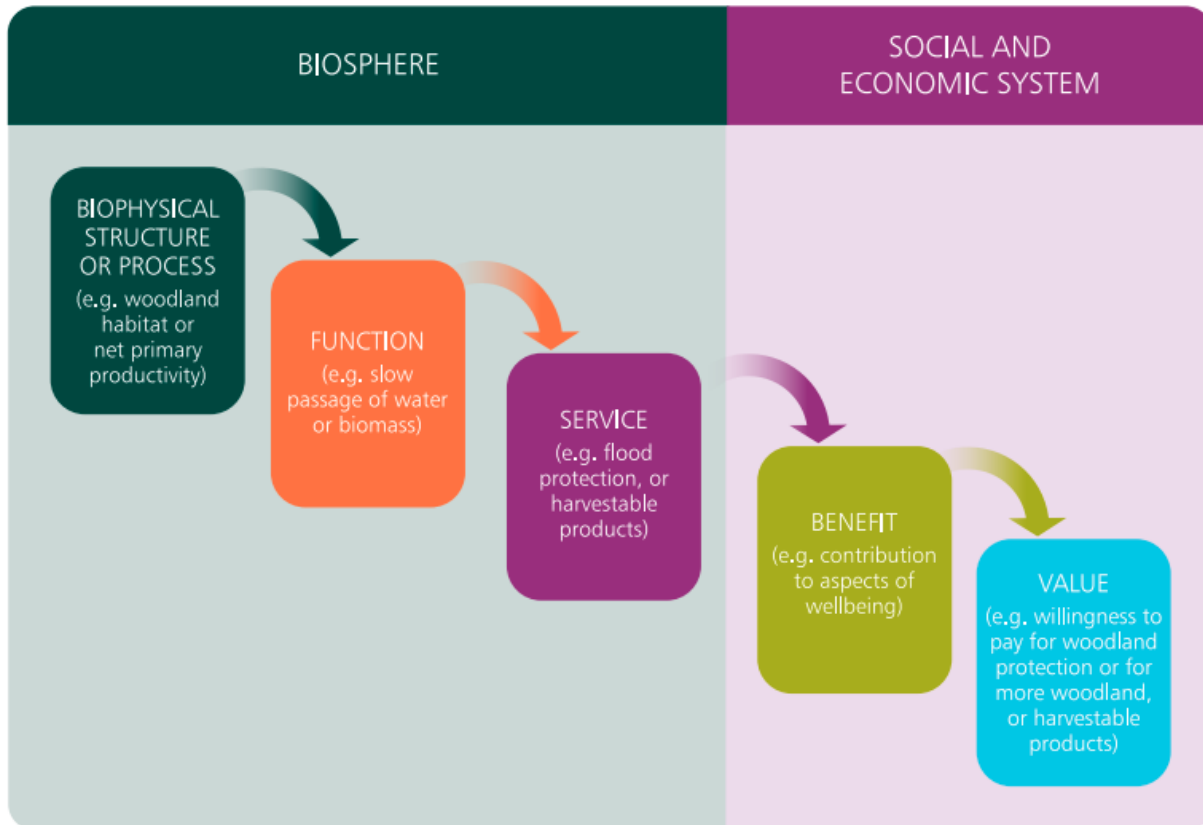


Figure 6-2. The cascade model depicts the framework used to value services from natural assets.

Willingness to pay (WTP) is the common convention used to establish values for ecosystem services. To establish WTP, economists employ stated preference, revealed preference, or benefits transfer approaches. Given the budget and timeline for the current project, and the complexity of stated and revealed preference approaches, which rely on surveys, a benefits transfer approach was employed for the current analysis. The specific method employed varied depending on the service under consideration. The simplest approach is to apply a dollar per hectare transfer from one location to another. In the case of valuing recreation, a dollar per unit approach is generally more appropriate. For example, the value of recreation can be estimated by applying a dollar per recreation user to the number of recreation users for a given set or sub-set of natural assets. Benefits functions are increasingly sophisticated as they account for a greater number of local characteristics and parameters. They are well suited to valuing air quality regulation where the distance between natural assets and population can be considered.

Table 6-1 summarizes the ecosystem services that were the focus of the valuation for Town of The Blue Mountains. For these services, values were established considering the full suite of natural assets located within the municipal boundary of Town of The Blue Mountains regardless of ownership. The Town-owned assets are part of a larger integrated system of natural assets, which collectively deliver services to Town citizens. The approaches employed to valuing the specific services are described in the sections that follow.

Table 6-1. Ecosystem services valued as well as the focus of the valuation exercise.

Ecosystem Service	Focus of the Valuation
Provision of Recreation Opportunities	Enjoyment of recreation activities.
Carbon Sequestration	Avoided atmosphere carbon concentrations.
Air Quality Regulation	Avoided costs associated with health issues from air pollution.
Stormwater Regulation	Avoided stormwater management infrastructure costs.
Habitat Preservation	Value people place on knowing habitat (and associated biodiversity) is preserved.
Extreme Heat Regulation	Avoided health impacts associated with extreme heat provided by proximity to natural areas.
Contribution to Crop Productivity	Improved crop productivity generated from wild pollinators.
Aesthetic Appreciation	Value of aesthetic appreciation due to presence of natural assets.

6.1 Provision of Recreational Opportunities

The value of recreational opportunities was estimated by using expenditures associated with trail use. A Canadian Nature Survey report from 2012 (Federal, Provincial, and Territorial Government of Canada 2014), determined a value of recreating per day. After adjusting the value to 2023 dollars, a rate of \$23 per day was assigned to the number of people recreating on Town of The Blue Mountains’ trail network. There are an estimated 285 km of trails within Town of The Blue Mountains¹ and an estimated user rate of 1,758² people per km of trail per year. Applying \$23 per user to the trail network user rate results in a total recreation value per year of \$11.8 M in \$2023 CDN (1,758 people/km x 285 km x \$23/person = \$11.8 M).

6.2 The Value of Carbon Sequestration

Two approaches were used to estimate a value for carbon (C) sequestration, depending on the type of natural assets. One approach was used for the woodland assets and another method was used for the non-woodland assets.

C sequestration values for woodland assets within Town of The Blue Mountains were estimated using the Carbon Budget Model of the Canadian Forest Service (CBM-CFS3).³ This model requires inputs for woodland assets in terms of growth rates, ages, and species compositions. These were populated drawing on the expert knowledge of the project team. The CBM-CFS3 model estimates tonnes of C per hectare per year sequestration rates as well as tonnes of C per hectare for each woodland asset.

For non-woodland asset classes, the project team drew from experience and a literature review to assign sequestration rates. Non-woodland asset types were cross-referenced with a database of average sequestration rates by land cover type. Over 30 peer-reviewed papers informed the employed C sequestration rates. Using this approach, each non-woodland natural asset class gets its own estimated C

¹ <https://www.thebluemountains.ca/recreation-culture/beaches-parks-trails/trails-hiking>

² The 1,758 users per km of trail was taken from statistics derived from the “Full Report Cootes to Escarpment EcoPark System Ecosystem Service Valuation” study which found trail usage in the Spencer Creek trail network at 1,758 users per km.

³ <https://natural-resources.canada.ca/climate-change/climate-change-impacts-forests/carbon-accounting/carbon-budget-model/13107>

sequestration rate. See Appendix E for the specific carbon sequestration rates for the land cover types contained within Town of The Blue Mountains.

The sequestration rates for woodland and non-woodland assets were then valued by applying the Canadian social cost of carbon (SCC) (upper bound) and the “Minimum National Carbon Pollution Price” (lower bound) to the sequestration rates. The SCC is defined as:

“The SCC ... estimates include damages from a variety of climate change impacts, including, but not limited to, changes in net agricultural productivity, human health effects, property damage from increased flood risk, disruption of energy systems, and the value of ecosystem services. Given that climate change damages are a function of the cumulative stock of GHG emissions, the SCC estimates increase over time as GHG emissions accumulate in the atmosphere. The SCC price increases over time because: a) there are larger incremental damages from future emissions as physical and economic systems become more stressed from greater climatic change, and b) income grows over time, meaning future impacts affect more wealth, and as income grows there is a higher willingness to pay to avoid economic damages.”

The value of the SCC used in this analysis was \$291/tCO₂e in 2023 Canadian dollars. The second carbon price corresponds to the Minimum National Carbon Pollution Price of \$65/tCO₂e (in 2023 dollars). The Minimum National Carbon Pollution Price is defined as:

“The Government of Canada published the Pan-Canadian Approach to Pricing Carbon Pollution (the federal ‘benchmark’) on October 3, 2016, which established Canada’s approach to carbon pricing for the 2018-2022 period. It set out the principles on which the pan-Canadian approach to pricing carbon pollution is based, and established minimum national stringency criteria that all systems must meet to ensure they are comparable and effective.

It also indicated that the federal carbon pollution pricing system (the ‘backstop’) would be applied in provinces and territories that request it or that do not implement a system that meets the benchmark. The federal backstop is an explicit price-based system composed of two parts, a fuel charge and an output-based pricing system for large industry. Where the federal backstop system is applied, all carbon pricing proceeds are returned to the jurisdiction of origin.”

Each natural asset had a specific sequestration rate measured in tonnes C per hectare, which was multiplied by the SCC and the minimum national carbon pollution price. As seen in Figure 6-3, most of the assets within Town of The Blue Mountains generated a carbon value. Low carbon values are associated with the presence of young forests. Young forests, created by replacement of older forests,⁴ usually lose carbon as the growth of young trees and accumulation of biomass is less than the amount of carbon released due to respiration and the decay of organic matter. Given enough years of growth, young forests become sinks of carbon as the accumulation of biomass is much higher than the rate of respiration and decay of organic matter. The most valuable assets in terms of carbon sequestration in Town of The Blue Mountains were treed wetlands (mixed wood swamps, broadleaved swamps, and deciduous swamps). The spatial distribution of the value of C sequestration is displayed in Figure 6-3.

⁴ Afforestation projects where bare land is planted behave differently than cutovers. In this analysis young forests were assumed to be replacements of old forests.

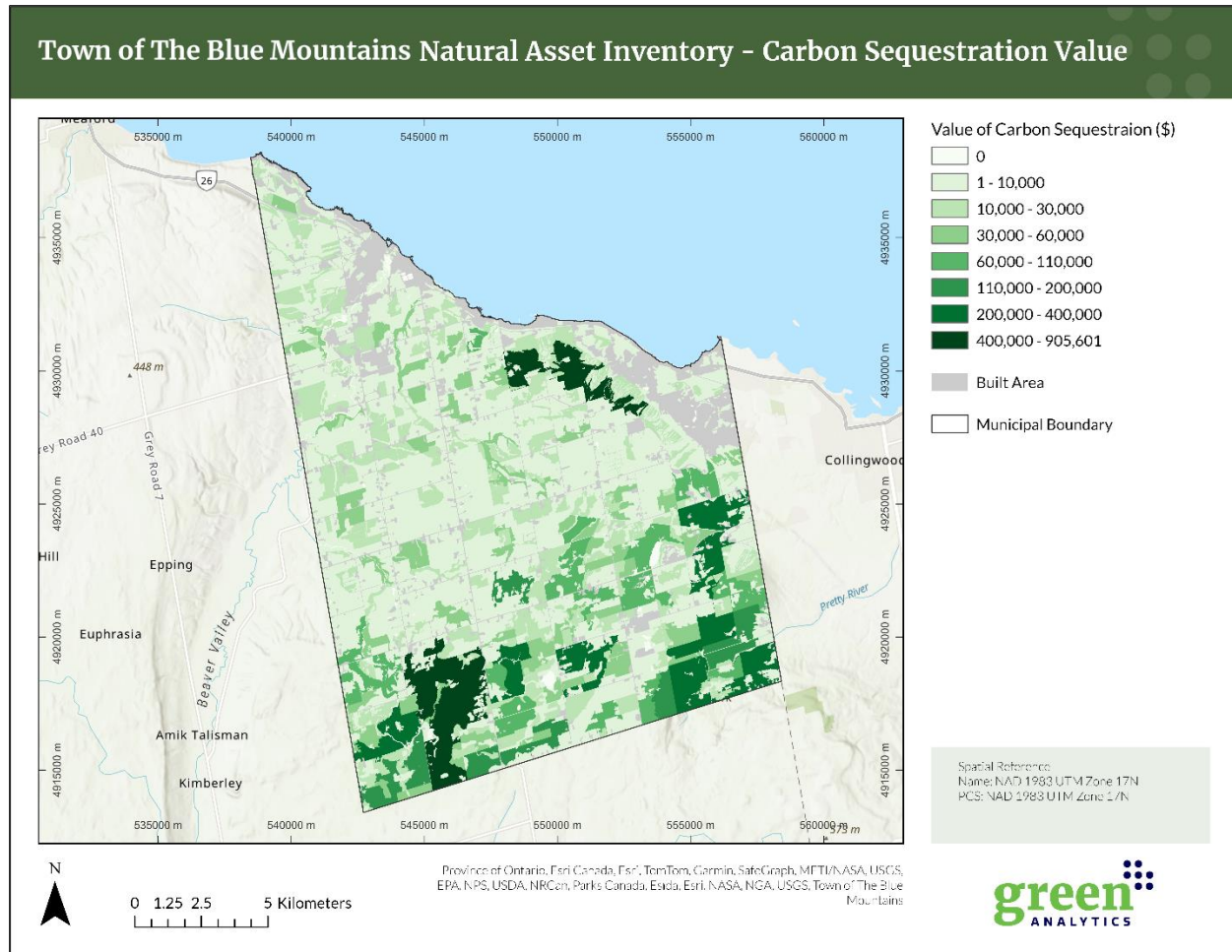


Figure 6-3. The yearly value of carbon sequestration with Town of The Blue Mountains.

The total value of carbon sequestration within the municipal boundary of Town of The Blue Mountains was estimated at between \$5M and \$22M in 2023 dollars depending on which price of carbon was used.

6.3 The Value of Air Quality Regulation

The value of air quality regulation was based on an estimate of the avoided health care costs associated with exposure to air pollutants (NO₂, O₃, PM_{2.5}, and SO₂). To establish an estimate for Town of The Blue Mountains, a value function transfer was used (Nowak et al. 2014). The value function transfer accounts for population density to scale the avoided health care costs according to the number of people exposed to the surrounding air quality. Pollution removal rates per area of tree cover were used to estimate the avoided air pollution provided by treed natural assets. Table 6-2 summarizes the key results from Nowak et al. (2014) used for these estimates. The results were based on tree cover and population density determined at the census subdivision level capturing the spatial variation in population densities and tree cover.

Table 6-2. Nowak et al. (2014) equations and assumptions used in Town of The Blue Mountains analysis.

Pollutant	Kg removed per ha of tree cover	Value function y = dollars per tonne x = people per km ²
NO2	5.5	$y = 0.7298 + 0.6264x$ (r2 = 0.91)
O3	54.9	$y = 9.4667 + 3.5089x$ (r2 = 0.86)
PM2.5	2.7	$y = 428.0011 + 121.7864x$ (r2 = 0.83)
SO2	3.5	$y = 0.1442 + 0.1493x$ (r2 = 0.86)

The total value of air quality regulation by the 14,218 hectares of treed natural assets in Town of The Blue Mountains in 2023 dollars was \$371,576 per year (Figure 6-4).

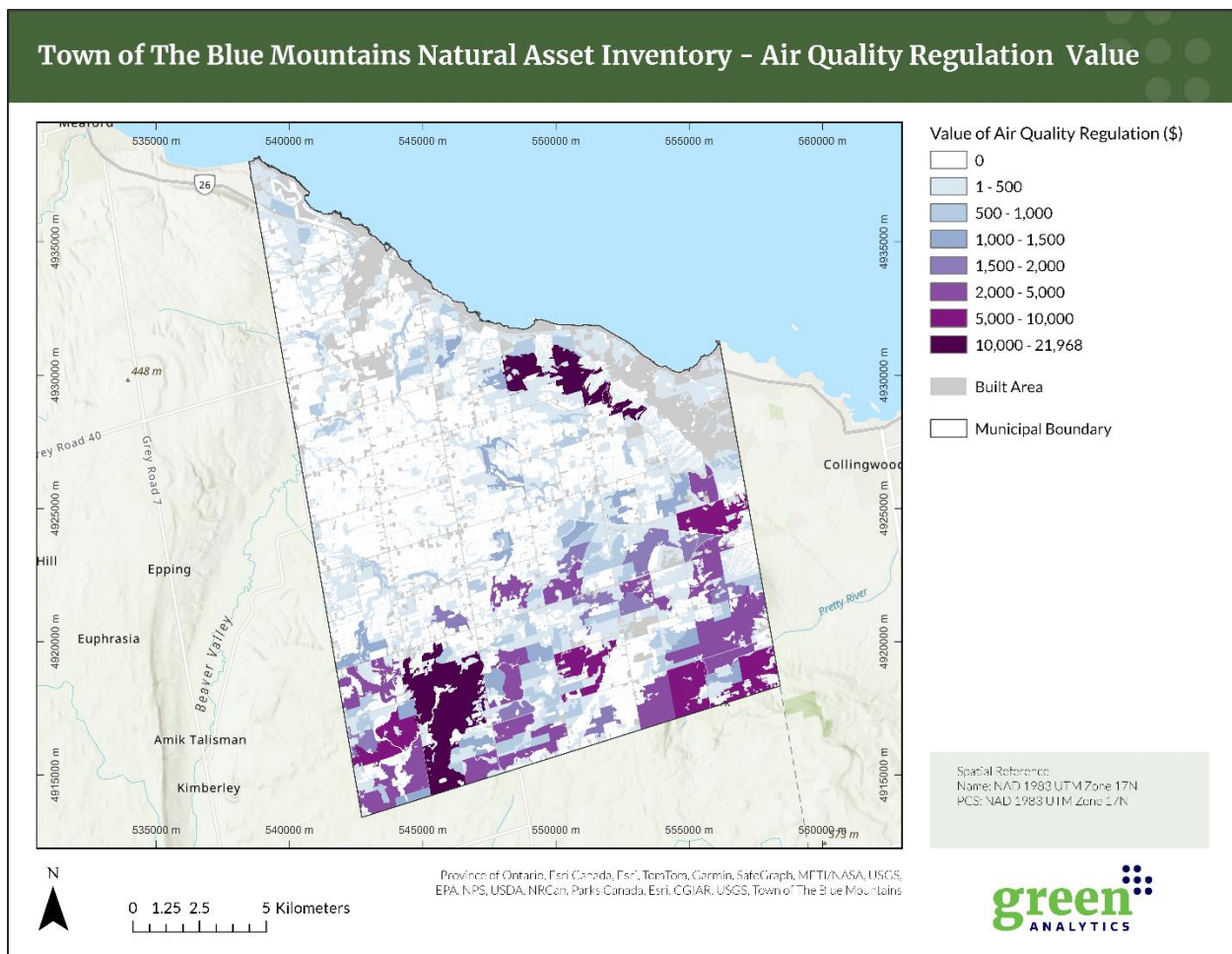


Figure 6-4. The value of air quality regulation within Town of The Blue Mountains.

6.4 The Value of Stormwater Regulation

The value of stormwater regulation is based off the ability of natural assets to control and absorb water during low frequency heavy rain events. Woodland, grassland and wetland assets were assigned a value per hectare given their ability to abate stormwater modelled off the work done by Saini et al. (2018) from the Peel Pilot Study.

Trees and forests reduce stormwater runoff by capturing and storing rainfall in the canopy and releasing water into the atmosphere through evapotranspiration. Additionally, tree roots and leaf litter create soil conditions that promote the infiltration of rainwater into the soil. This helps to replenish the groundwater supply and maintain stream flow during dry periods. The presence of trees also helps to slow down and temporarily store runoff, which further promotes infiltration, and decreases flooding and erosion downstream (Saini et al. 2018).

“Open green spaces” are spaces partly or completely covered with grass, trees, shrubs, or other vegetation. They can include parks, community gardens, and open fields. Such spaces provide pervious surfaces in otherwise urbanized catchments and stormwater draining to these spaces has a chance to be filtered before reaching receiving streams (Saini et al. 2018). Wetlands receive stormwater from upland sources and hold large volumes of water in situ before slowly releasing it to streams, lakes, and rivers. They act as an important buffer system to stormwater regulation.

Applying the values per asset class to the area of assets within Town of The Blue Mountains resulted in about \$30 million per year in value for stormwater management as seen in Table 6-3. These results are mapped in Figure 6-5.

Table 6-3. Value of stormwater regulation based off natural asset types updated to 2023 Canadian dollars.

Asset Type	\$ / Hectare / Year	Hectares of Assets	\$ / Year
Forests and Hedgerows	\$2,062	13,430	\$27,692,660
Open Green Spaces	\$740	990	\$732,600
Wetlands	\$1,445	1,156	\$1,670,420
Total Value	N/A	N/A	\$30,095,680

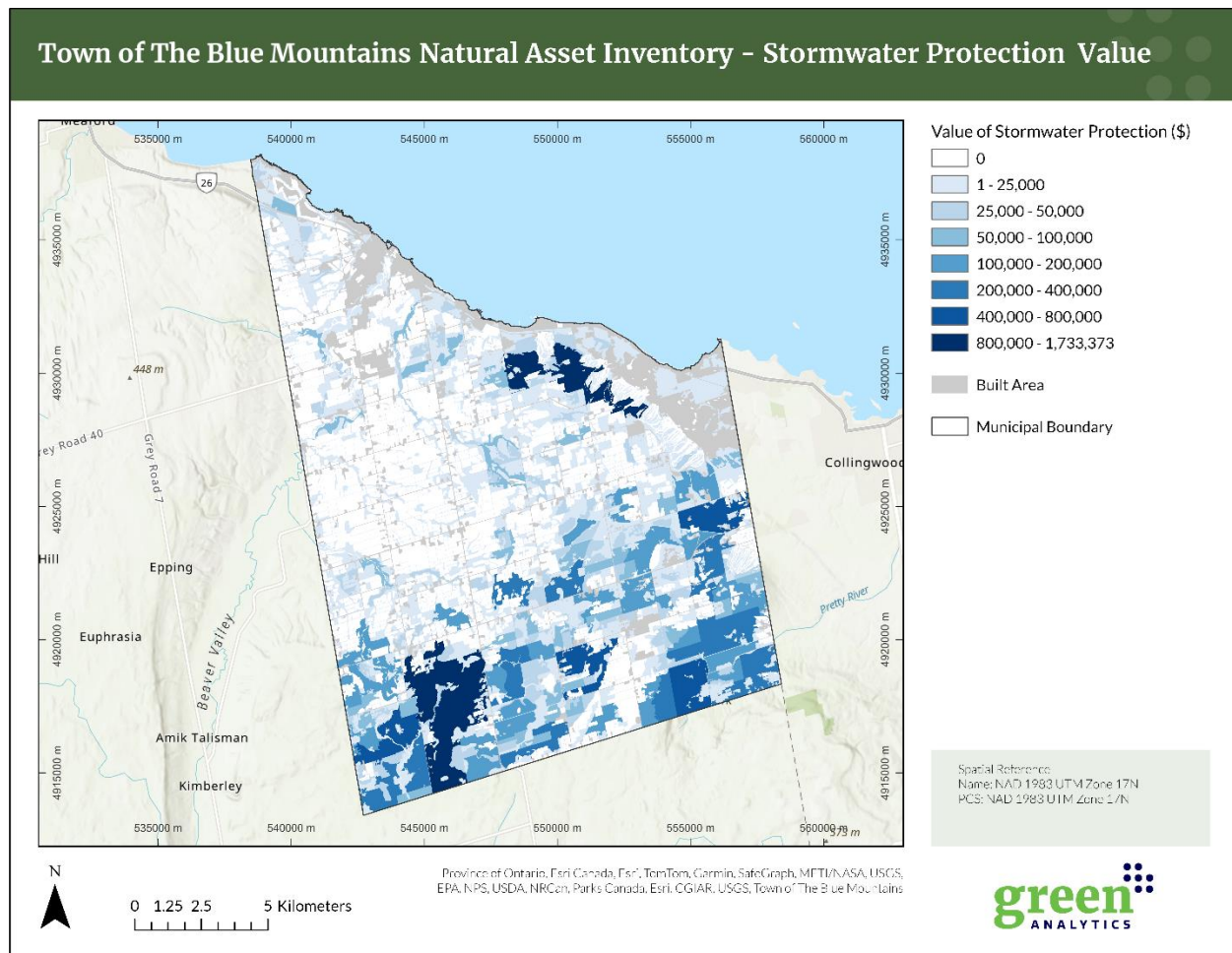


Figure 6-5. The assets within Town of The Blue Mountains mapped by stormwater quality regulation value.

6.5 The Value of Habitat Preservation

A review of the literature identified a study that estimated the value people place on urban open spaces. The study by Brander and Koetse (2011) defined urban open spaces as urban parks, forests, green spaces, undeveloped lands, and agriculture lands⁵ The authors use regression analysis to articulate a mathematical function that can be used to estimate the value of open spaces in other jurisdictions. They note that the results of their analyses can be used to estimate the value of the area of open space by substituting the parameter values with data for an alternative location. It was within this context that the regression equation was applied to the natural assets within Town of The Blue Mountains. The key independent variables that feed into the equation are area of open spaces, gross domestic product per capita and population density. To apply the regression equation to Town of The Blue Mountains' natural assets, these variables were populated with Town of The Blue Mountains data. The result was an estimate of the value

⁵ Brander, Luke and Mark Koetse. (2011). The value of urban open space: Meta-analyses of contingent valuation and hedonic pricing results. *Journal of Environmental Management*, 92, 2763-2773.

of open spaces measured in dollars per hectare, which can be applied to the hectares of open space within Town of The Blue Mountains.

Table 6-4. Area of natural assets that provide habitat.

Asset Type - ELC Class	Area (ha)
Woodland	13,116
Agriculture	8,936
Wetland	1,156
Meadow	990
Hedgerow	314
Open Aquatic	233
Shoreline	33
Total	24,779

There are 24,779 hectares of natural assets within Town of The Blue Mountains that may provide suitable habitat for biodiversity. A value of \$443 per hectare was applied to the total area of assets resulting in a total value of habitat preservation estimated at \$11.0 million per year.

NOTE – this value was not mapped but is presented as a system value.

6.6 The Value of Regulation of Extreme Heat Events

The value associated with the regulation of extreme summertime heat events was estimated as the reduction in mortality in natural asset adjacent residential neighbourhoods stemming from the anticipated reduction in maximum daily air temperatures attributed to the assets. A with-without approach was used to estimate mortality due to extreme heat given the current distribution of natural assets and the anticipated change in this mortality after removing the natural assets' influence on air cooling. The economic value of the resulting estimated change in mortality serves as the value of the regulation of extreme heat events associated with the assets.

In general, the approach relied on data from Kroeger et al. (2018) to estimate the cooling influence of natural assets in °C on the summer air temperature of park adjacent residential neighbourhoods (summer corresponds with the months of June, July, and August).⁶ Changes in air temperatures were linked to changes in population mortality in Town of The Blue Mountains using a relationship from Chen et al. (2016). Finally, the estimated change in mortality was valued using the value of a statistical life. Details are outlined in the following steps:

1. The cooling influence of natural assets depends on their size, with larger assets cooling the air more than smaller assets. Following Kroeger et al. (2018) GIS was used to first group contiguous assets together to create larger asset conglomerations. The resulting asset areas were then divided into four size classes depending on their park width distance (PWD), which was measured as the square root of their area (Table 6-5). Each size class yields a different level of maximum daily

⁶ Kroeger et al. (2018) focus their analysis on treed areas but the data they sourced to estimate the relationship between tree cover and temperature was gathered from studies assessing the influence of multiple cover types on air temperatures. Their approach and relationships were applied, therefore, to non-treed assets.

air temperature reduction within and beyond the asset area, which Kroeger et al. (2018) refers to as the park cooling intensity (PCI). The intensity of a park's influence on reducing air temperatures is highest within its boundaries and declines with distance from its edge (Figure 6-6).

Table 6-5. Asset size classes and associated air cooling intensity within and beyond the asset.

Size Class	PWD (m)	PCI (°C)	Level of Cooling Intensity Beyond Asset Edge (m)		
			High	Medium	Low
1	<30	1.055	0 to 30	None	None
2	30 to <90	2.143	0 to 30	30< to 40	40< to 50
3	90 to <270	2.445	0 to 50	50< to 80	80< to 160
4	>=270	3.283	0 to 150	150< to 250	250< to 500

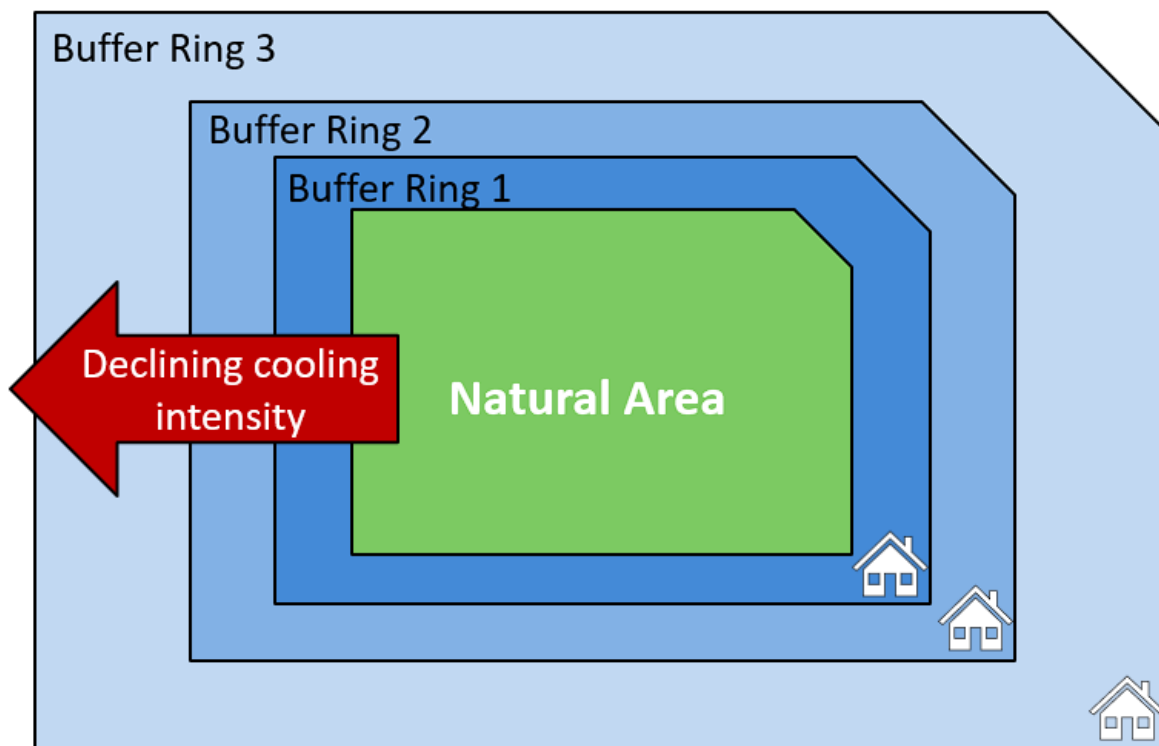


Figure 6-6. Air Cooling in Natural Assets and Asset-Adjacent Areas.

2. The air cooling that extends beyond the edge of the natural assets is most important for this analysis as this area intersects with neighbourhoods where people live. The distance beyond the asset's edge as well as the intensity of this cooling — which Kroeger et al. (2018) categorize as high, medium, or low — both depend on the asset's area (Table 6-5 and Figure 6-6). As such, using GIS, the contiguous groups of assets were buffered with three rings of varying widths and distance from the asset edges to represent the areas experiencing the different levels of air cooling. Cooling from the smallest assets (size class 1) is only experienced in the high intensity buffer and does not extend beyond 30 m from the asset's edge. Kroeger et al. (2018) estimate the reduction in maximum daily air temperatures experienced beyond the edge as the percentage of the PCI remaining in each buffer, which can be converted to degrees Celsius (Table 6-6).

Table 6-6. Air cooling intensity experienced in each buffer beyond the asset’s edge.

Size Class	Remaining PCI in Percent			Remaining PCI in °C		
	High	Medium	Low	High	Medium	Low
1	39%	None	None	0.411	None	None
2	49%	27%	20%	1.050	0.579	0.429
3	59%	40%	26%	1.443	0.978	0.636
4	59%	40%	26%	1.937	1.313	0.854

3. The next step involved estimating the population of buildings within buffer ring areas through population numbers within the respective dissemination areas (DAs). To estimate spatial distribution of population, the population of each DA was divided by the total area footprint of buildings within it. This produced a person per building area. This value was multiplied by the area of each building within the DA. Each building was then intersected with its closest ring buffer, which determined a count of population within each buffer (and thus the residents experiencing the different levels of summertime air temperature cooling). The total population forecasted to experience some park-related air cooling at their place of residence was 8,817.
4. It was then necessary to estimate the influence of the park-related air temperature cooling on mortality in these neighbouring residential populations. The current annual non-accidental mortality in park adjacent residential populations was first estimated. This involved multiplying the estimated population in the buffer rings by the average annual mortality rate from non-accidental causes for the years 2013 to 2022 in Ontario, which was 689.9 per 100,000 people (Statistics Canada 2023a).⁷ This yielded total annual estimated non-accidental mortality for the population of all three buffers of 44.7 per year. However, since this analysis is focused on summertime air temperatures, data from Statistics Canada (2023b) on the monthly distribution of deaths from all causes for Ontario averaged from 2013 to 2022 was used to estimate mortality for the months of June, July, and August (this distribution was assumed to reflect that of non-accidental deaths). On average, 23.2% of deaths occurred during these months yielding an estimate of total summertime mortality of 10.4 within the study area.

It was assumed that this mortality already incorporates the influence of the existing park assets on air cooling and thus deaths related to extreme heat. Therefore, the analysis estimated how removing the influence of the park assets on air cooling calculated in the prior steps might increase non-accidental mortality in the adjacent residential populations using data from Chen et al. (2016). They related maximum daily summertime (June, July, and August) air temperature in °C to percent change in non-accidental mortality for residents of Ontario, finding that with every 5°C increase in maximum temperatures this mortality increased by 2.2 percent daily (or 0.44% for every °C). This relationship was used to estimate the increase in non-accidental mortality in the residential populations within the buffers associated with removing the park-related air cooling measured

⁷ Causes thought less likely to be linked to air temperatures including homicides, suicides, deaths due to medical or surgical care, and those from unknown causes were not included when estimating the non-accidental mortality rate. Non-accidental deaths included in the analysis account for 93% of deaths that comprise the average annual mortality rate.

earlier. It was forecasted that removing this cooling yields an increase in non-accidental mortality of 0.07 individuals per year which is the reduction in mortality attributable to the network of assets.

It is likely that many residents influenced by the cooling of natural assets live in homes with air conditioning and can take refuge from high air temperatures inside their houses. The estimated population can therefore be adjusted to account for air conditioning penetration. Statistics Canada (2023c) estimates that 90% and 84% of homes in Barrie (the nearest Census Metropolitan Area) and Ontario, respectively, had some form of air conditioning in 2021 (the latest year available). While estimates could be adjusted using these penetration rates, this would likely result in too large a change. Since Chen et al. (2016) used population mortality data it is likely that their findings already incorporate the influence of some level of air conditioning on summertime temperature-related mortality in Ontario; this level increased between 1996 and 2010 the time during which their mortality data was collected (Statistics Canada 2023c). It is possible that heat related deaths have declined as a result, making some adjustment necessary, although at the same time, any reduction in heat-related deaths is potentially already incorporated into the contemporary non-accidental death rate for Ontario offsetting the need for adjustment.

Within this context attempts were made to adjust for differences in air conditioning. Determining the proper adjustment to apply to the analysis was difficult given that the available data for Ontario only covers the years 2003, 2007, and 2009 of Chen et al.'s (2016) period of study (Natural Resources Canada Office of Energy Efficiency 2006, 2010; Sawicz 2011).⁸⁹ Thus, American data on air conditioner penetration from the Middle Atlantic (Northeast) and East North Central (Midwest) census sub-regions, bordering Ontario, from the years 1997, 2001, and 2005 was used to estimate air conditioner use in Ontario for these years (USEIA, n.d.). These estimates were used, in combination with the aforementioned data for Ontario, to estimate an average household penetration rate during the 1996 to 2010 period. It was estimated that the average annual air conditioner penetration rate over this period was 70% which is only 0.83 times the penetration rate for Ontario in 2021 (84%). Further, and key for the current analysis, the share of households in the province with no air conditioning dropped from an average of around 30% during Chen et al.'s (2016) period of study to 16% in 2021. Adjusting the earlier estimate of mortality, 0.07 deaths per year, for the reduction in the share of households with no air conditioning by multiplying by 0.54 yields a reduction in mortality of 0.04 deaths per year.

5. The final step was to assign a monetary value to the estimated change in mortality. To do this the value of a statistical life of \$6.5 million (2007 CAD [\$9.24M 2023 CAD]) per deceased individual from the Treasury Board Secretariat of Canada's (2022) Cost-Benefit Analysis Guide for Regulatory Proposals was used.

⁸ There are other instances of the Survey of Household Energy Use in the 1990s but this data is mostly not accessible and the summary report for the 1997 survey does not clearly break out air conditioner use for Ontario (Natural Resources Canada Office of Energy Efficiency 2000).

⁹ Since Chen et al.'s (2016) study use provincial-level data adjustments for air conditioner penetration use data for all of Ontario.

The total value of extreme heat reduction associated with Town of The Blue Mountains' network of natural assets differs depending on the treatment of changes in air conditioner use. With no accounting for changes in air conditioner penetration the estimated value is \$0.70 million per year (2023 CAD), mapped in Figure 6-7. Accounting for air conditioner penetration changes yields a value of \$0.37 million per year (2023 CAD), which is shown in Figure 6-8.

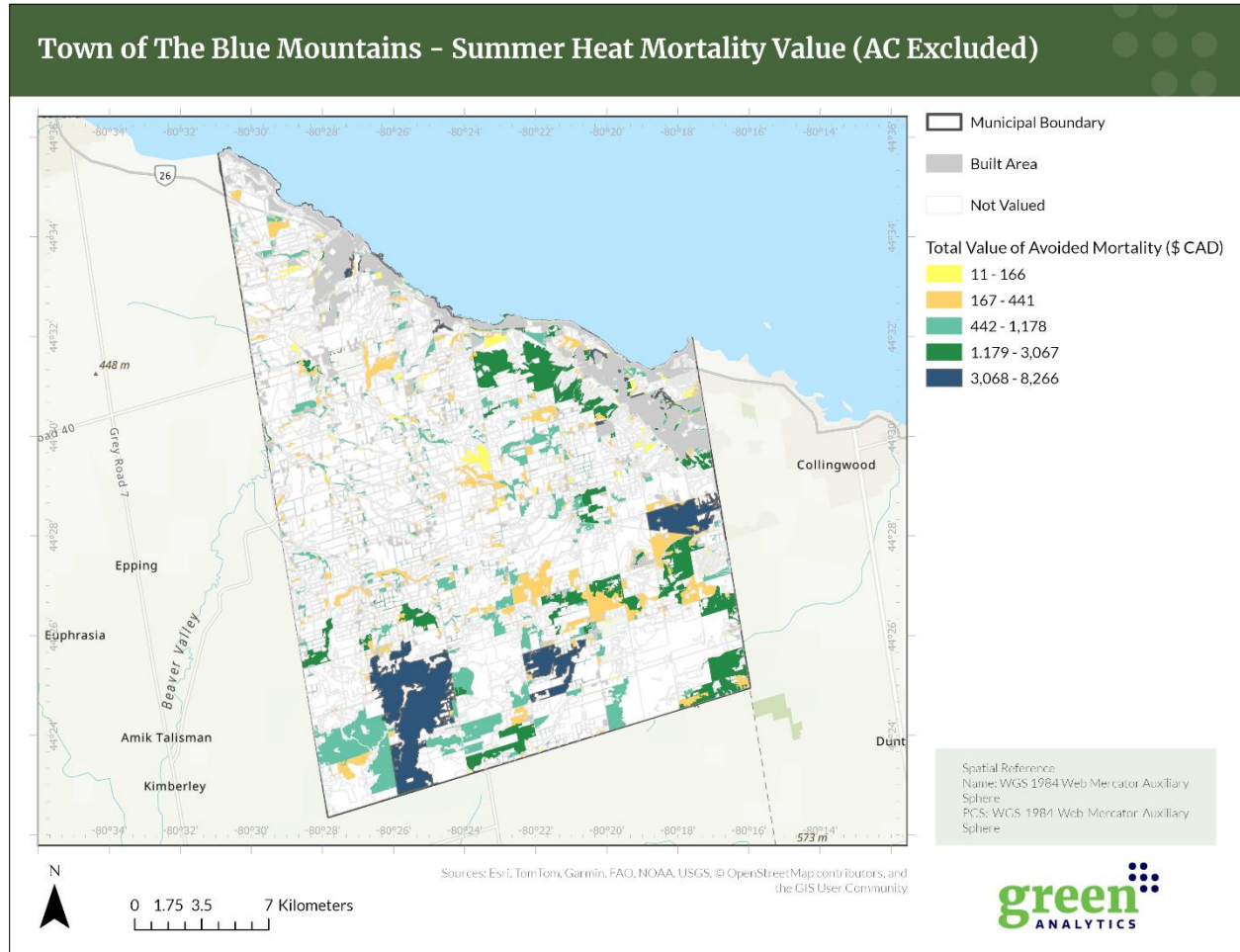


Figure 6-7. The assets within Town of The Blue Mountains mapped by urban heat reduction value.

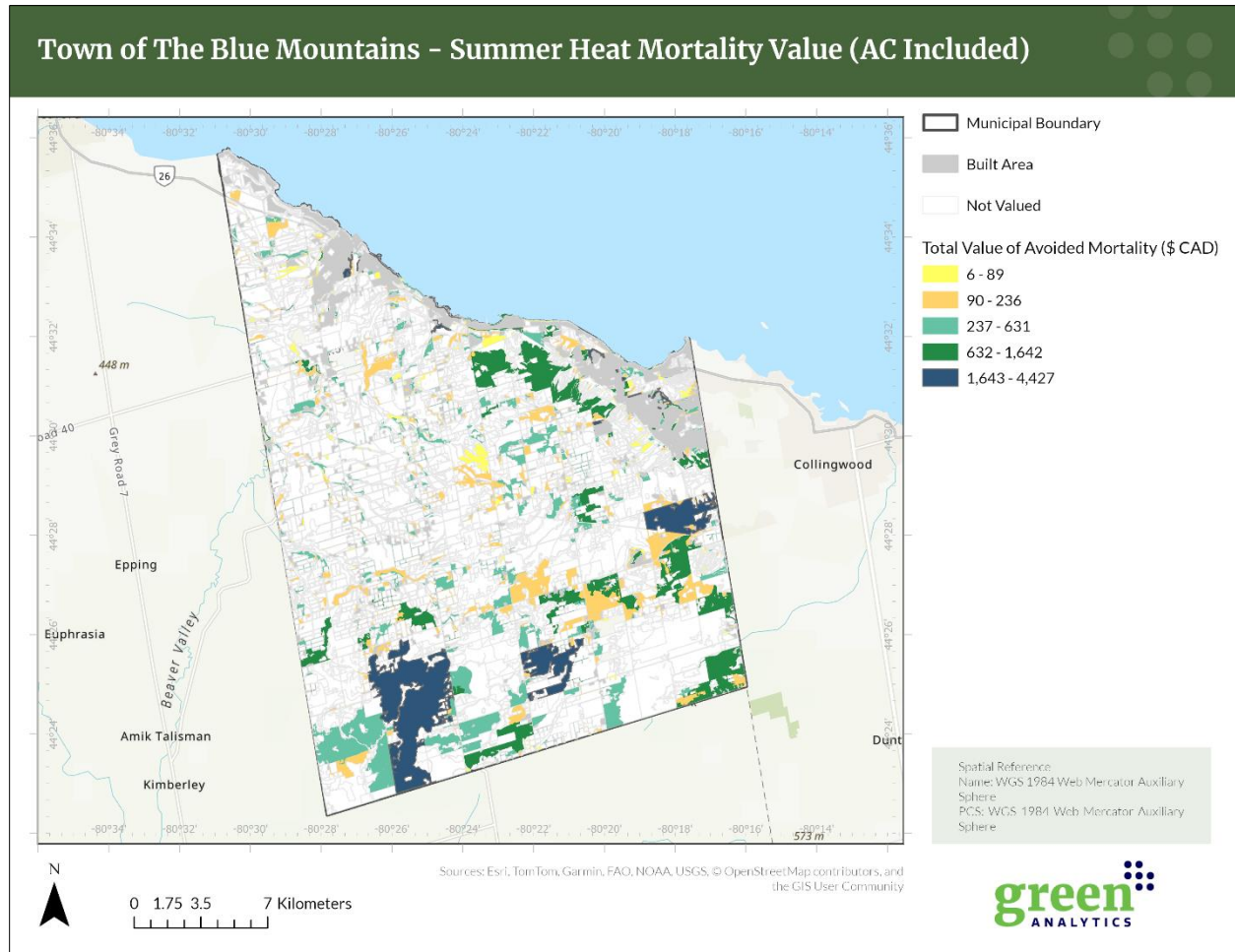


Figure 6-8. The assets within Town of The Blue Mountains mapped by urban heat reduction value.

6.7 The Contribution to Crop Productivity (Wild Pollination)

The assets which provide habitat to wild pollinators within Town of The Blue Mountains were buffered by an assumed pollinator foraging range of 1,500 m (AAFC 2014) to estimate the contribution of these assets to crop productivity. The area of crop types within the pollinator foraging range of each asset was then established (Table 6-7). This was informed by the latest version of AAFC crop inventory data.¹⁰ The crops were scoped to those that are dependent on insect pollination and allocated an animal pollination impact rating based on Aizen et al. (2019) and Klien et al. (2007).

¹⁰ <https://open.canada.ca/data/en/dataset/5d3ab93e-324a-41db-8d29-0f0813d0e9cd>

Table 6-7. Crop types and area in Town of The Blue Mountains.

Crop Type	Area (ha)
Barley	5
Canola/rapeseed	70
Corn	888
Oats	94
Orchards	1,298
Other grains	142
Pasture/forages	3,759
Peas	2
Rye	7
Soybeans	1,727
Spring wheat	265
Winter wheat	656
Total	8,914

Not all crop types are dependent on wild pollination (Klein et al. 2007). Canola/rapeseed, orchards, pasture/forage and soybeans were assumed dependent, and their dependence assumptions are shown in Table 6-8.

Table 6-8. Crops and assumed dependence to pollinators within Town of The Blue Mountains.

Crop Type	Pollinator Dependence Level	Upper Yield Impact	Lower Yield Impact	Mid-point Yield Impact
Canola/rapeseed	Modest	40%	10%	25%
Orchards	High / Modest ¹¹	90%	10%	45%
Pasture/forages	Little	10%	0%	5%
Soybeans	Modest	40%	10%	25%

Agriculture statistics were used to establish average Ontario crop production values.¹² Average production values (\$/ha) for each crop noted in the above table were established based on a 5-year average 2017-2021. Total crop values were approximated by multiplying the average production value by the areas of each crop within the wild pollinator foraging radius to establish a total crop value influenced by pollinators. Finally, the pollination yield impacts mid-point factor was applied to each crop's production value to establish the contribution to crop productivity provided by wild pollinators. Using average yields and prices for crops, a value of the contribution of natural assets to pollination was established to be \$16.3 million per year. Figure 6-9 shows the spatial distribution of the crops that benefit from wild pollination within Town of The Blue Mountains.

¹¹ Orchards were assumed to produce peaches, apples, pears and plums.

¹² <https://www.ontario.ca/page/horticultural-crop-statistics>

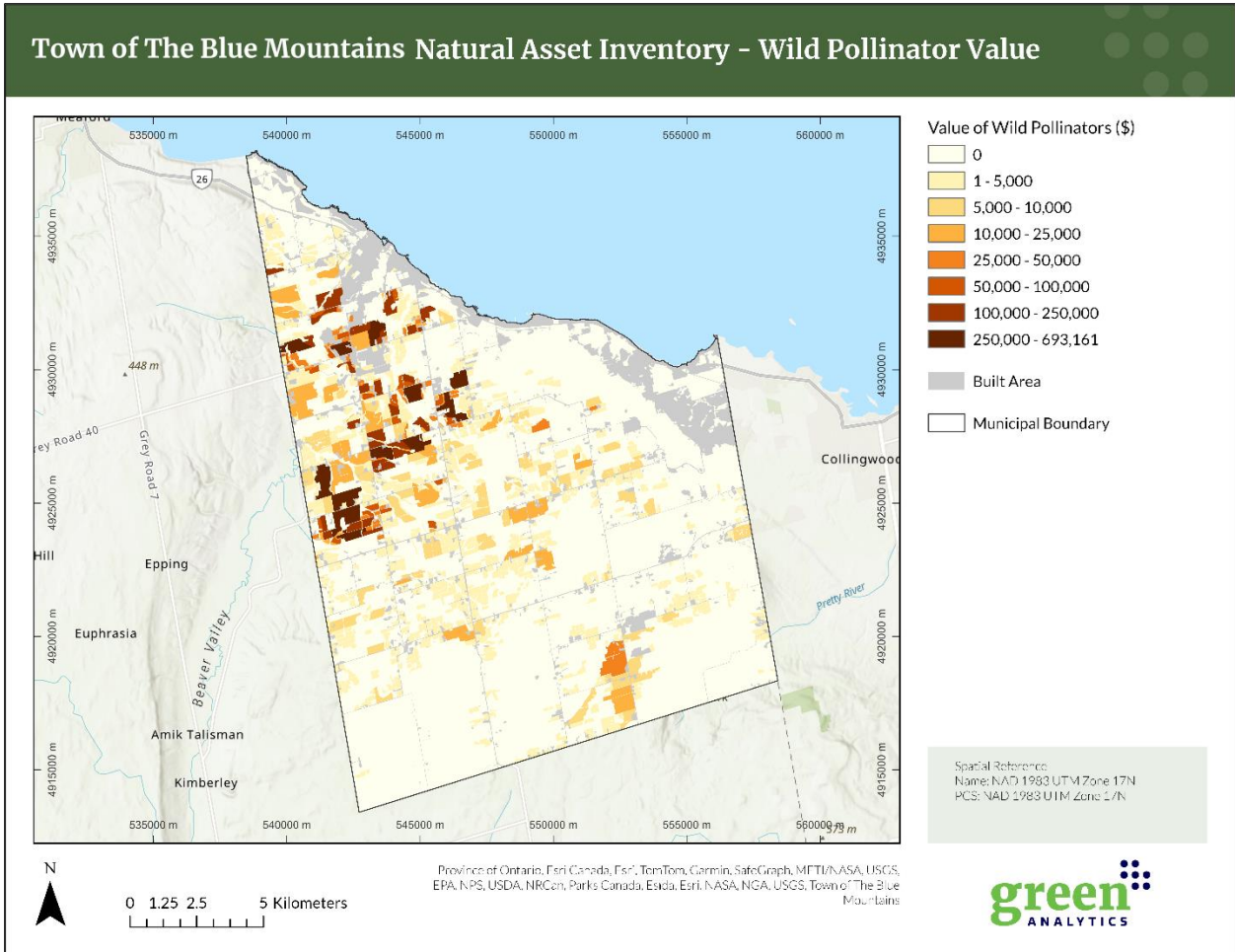


Figure 6-9. The value of crops within Town of The Blue Mountains that benefit from wild pollination.

6.8 Ecosystem Service Summary

Ecosystem services enhance human health and wellbeing in Town of The Blue Mountains. The total value of some of the services provided by the natural assets within Town of The Blue Mountains was estimated to be between \$75 million and \$92 million per year (Figure 6-10)

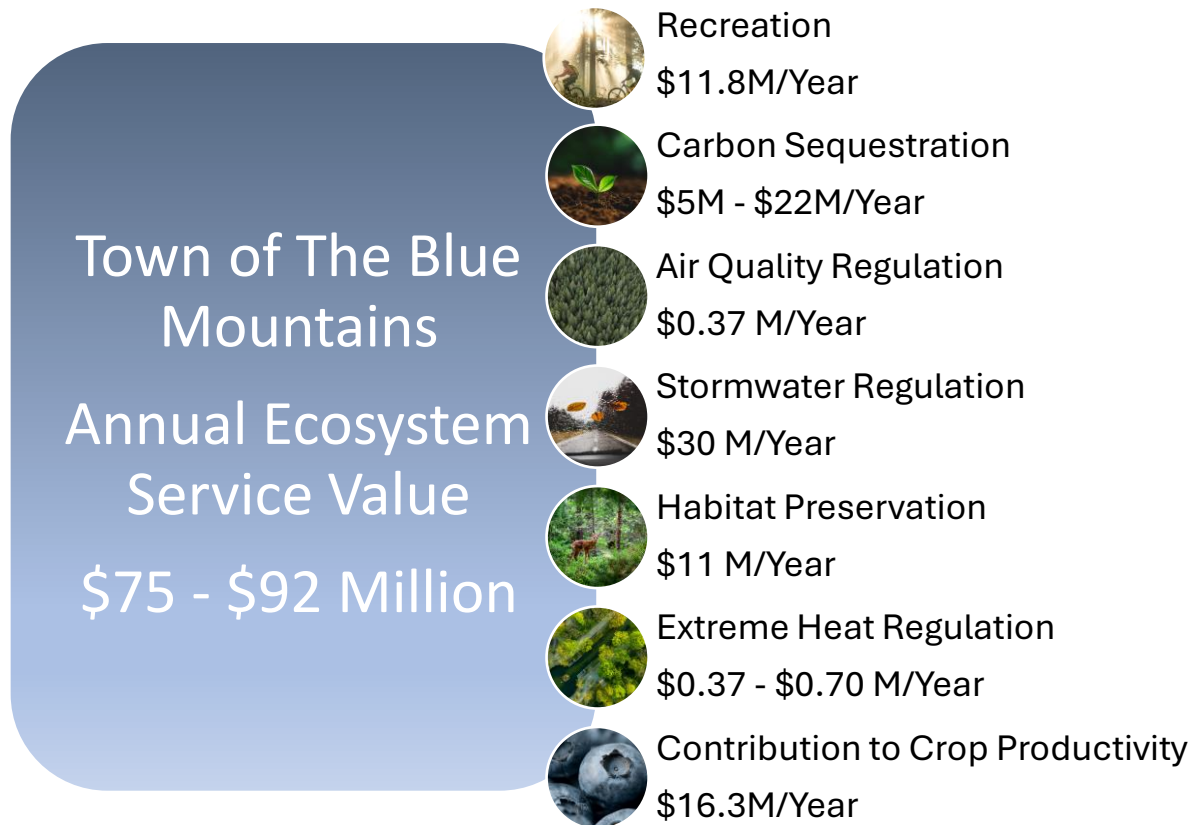


Figure 6-10. Summary of ecosystem service values for some of the services provided by natural assets within Town of The Blue Mountains.

7 Natural Asset Prioritization

The final task in the scope of work for Town of The Blue Mountains was to complete a natural asset prioritization exercise. There were two streams to the prioritization. One focused on identifying specific settlement areas within the municipal boundary that have relatively lower canopy cover. The other was informed by the combined results of the condition assessment, risk assessment and ecosystem service valuation. To identify areas with lower canopy cover, canopy cover by settlement area was established and compared with existing canopy cover targets in other jurisdictions. Several municipalities in Ontario have established long-term tree canopy cover targets. These targets are part of broader urban forestry management strategies for municipalities aiming to enhance urban green spaces and deliver services to local citizens. Examples of some existing tree canopy targets are demonstrated in Table 7-1.

Table 7-1. Tree canopy cover targets for select Ontario municipalities.

Municipalities	Tree Canopy Cover Target
City of Hamilton	30% by 2050
City of Kitchener	30% in each ward by 2050 and a target of 33% across Kitchener by 2070
City of London	34% by 2065
City of Guelph	40% by 2070
City of Cambridge	30% by 2034
City of Burlington	35% by 2041
City of Richmond Hill	30% in the short term
City of Toronto	40% by 2050

Using 30% as the minimum target (given that it is the lowest target identified in the table above), priority settlement areas for investments in canopy cover were identified. Settlement areas with canopy cover lower than 30% that are priority areas for canopy cover improvements include Craigeleith, Heathcote, Ravenna, and Thornbury East and West (Table 7-2).

Table 7-2. Tree canopy cover by settlement area.

Settlement	Settlement Area (ha)	Canopy Area (ha)	Percent Canopy Cover
Banks	25	10	40%
Camperdown	734	274	37%
Clarksburg	191	80	42%
Craigeleith	1,467	422	29%
Gibraltar	23	11	48%
Heathcote	24	5	21%
Lora Bay	437	166	38%
Ravenna	12	2	17%
Redwing	3	1	33%
Slabtown	11	4	36%
Swiss Meadows	62	31	50%
Thornbury East	99	21	21%
Thornbury West	307	76	25%

In addition to priority areas for canopy cover improvements, the results of the condition, risk and valuation exercises were used to identify priority areas for preservation, monitoring, restoration, and/or enhancement. This prioritization also considered the sub-set of assets that are Town-owned. This distinction was made because the Town has a greater ability to manage Town-owned assets relative to privately owned assets. Thus, in the context of prioritizing specific natural assets, identifying those that are Town-owned was deemed relevant. These assets nonetheless need to be considered within the larger ensemble of natural assets that exist inside the Town's municipal boundary. Within this context, to identify high priority assets, the following combination of assets were identified:

1. Natural assets that are in **good and very good condition and with a high or very high risk rating**. These assets were identified as priority areas for **preservation and monitoring**. There are 5,139 ha of natural assets in Town of The Blue Mountains labeled as priority areas for preservation and monitoring, with Town-owned areas accounting for 1.1% (54 ha) of these assets. See Figure 7-1 for the spatial distribution of these priority assets.
2. Natural assets that are in **poor and fair condition and with a high or very high risk rating**. These assets were identified as priority areas for **restoration or enhancement**. There are 242 ha of natural assets identified as priority areas for restoration or enhancement, with 11% of these priority areas being Town-owned assets. See Figure 7-2 for the spatial distribution of these priority assets.
3. Natural assets that are **connected to the watercourse network**. These assets were identified as priority areas for **preservation**. There are 9,053 ha of natural assets categorized as priority areas for preservation, with Town-owned areas accounting for 0.6% (50 ha). See Figure 7-3 for the spatial distribution of these priority assets.
4. Natural assets with **high and very high service values and with a poor or fair condition ratings**. These assets were identified as priority areas for **restoration or enhancement**. There are 276 ha of natural assets identified as priority areas for restoration or enhancement, of these, 7% (19 ha) are Town-owned. See Figure 7-4 for the spatial distribution of these priority assets.
5. Natural assets with **high and very high service values and with a high or very high risk ratings**. These assets were identified as priority areas for **monitoring**. There are 1,425 ha of natural assets identified as priority areas for monitoring, with Town-owned areas making up 3% (40 ha) of these areas. See Figure 7-5 for the spatial distribution of these priority assets.

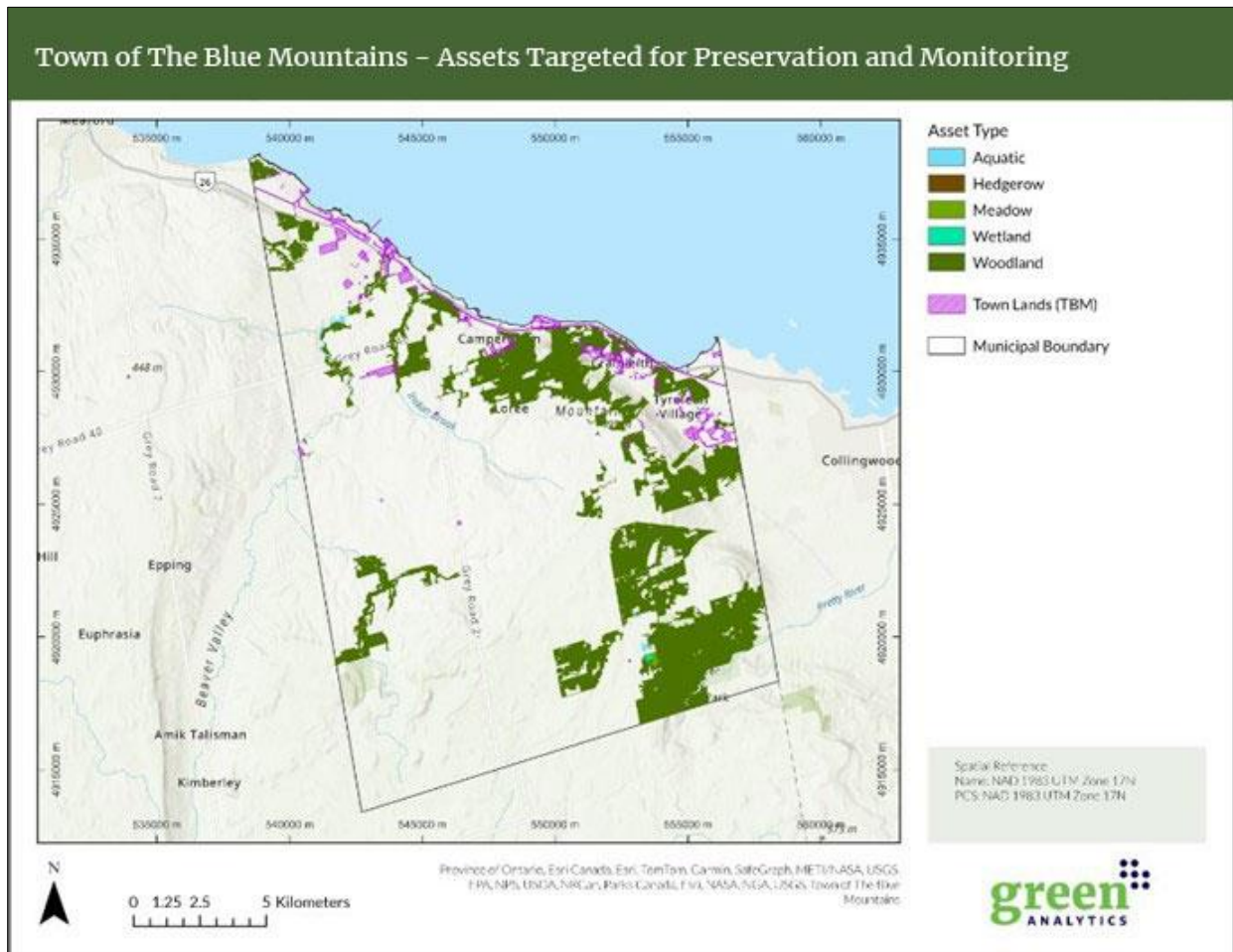


Figure 7-1. Town of The Blue Mountains assets targeted for preservation and monitoring; these assets are in good and very good condition assets with risk ratings of high or very high.

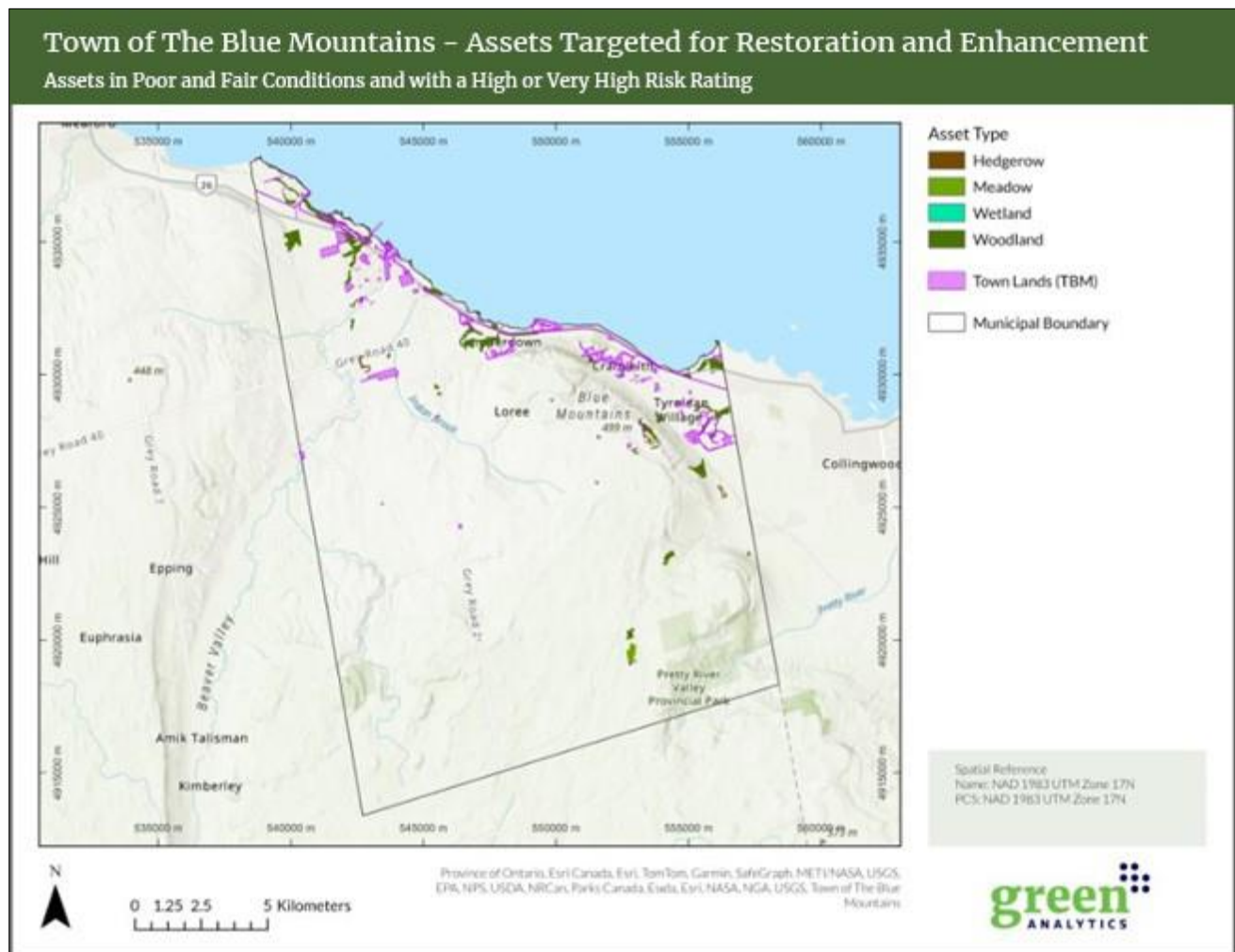


Figure 7-2. Town of The Blue Mountains Natural assets targeted for restoration and enhancement; these assets are in poor and fair condition assets with risk ratings of high or very high.

Town of The Blue Mountains – Assets Targeted for Preservation

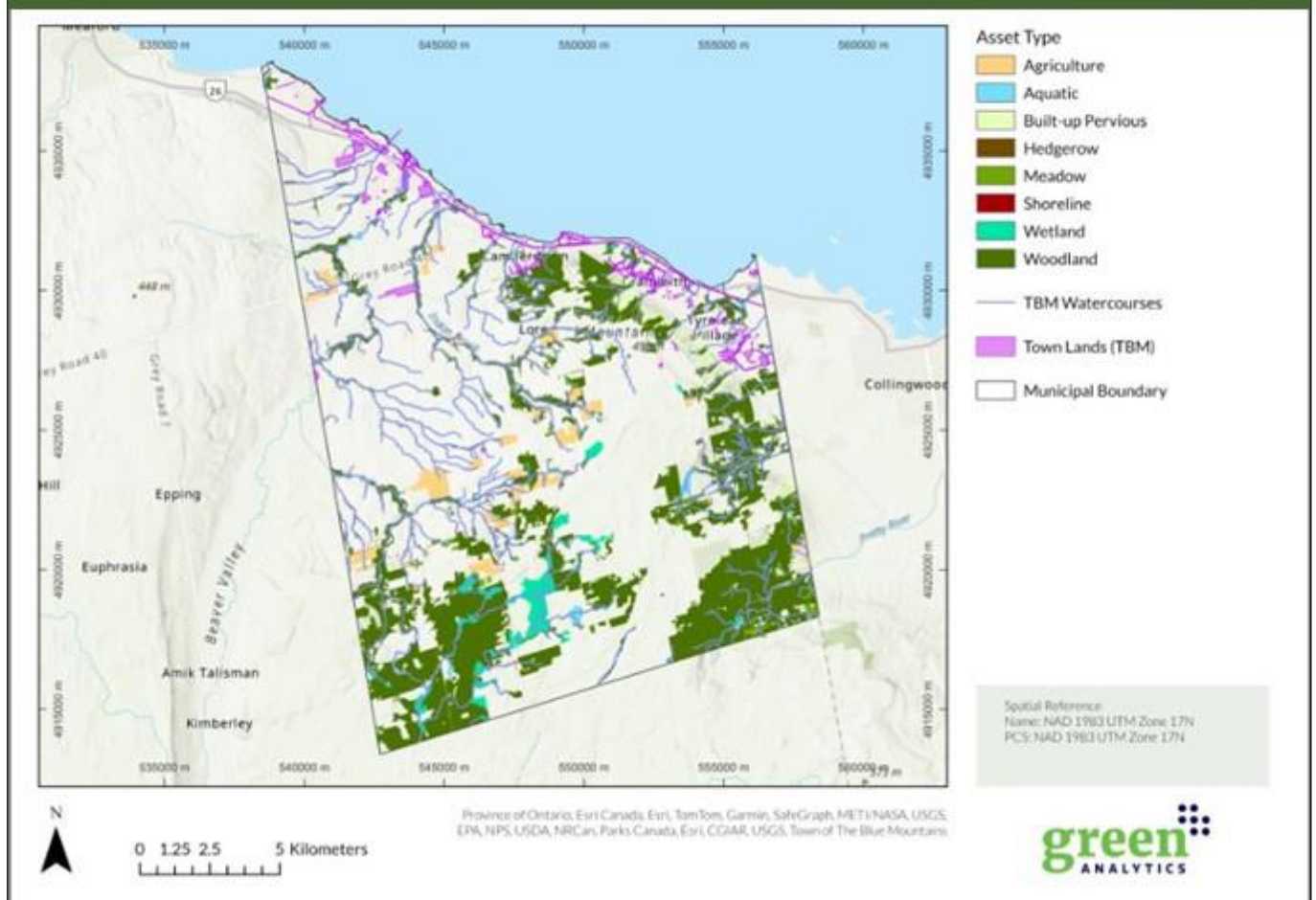


Figure 7-3. Town of The Blue Mountains natural assets that are targeted for preservation; these assets intersect watercourses.

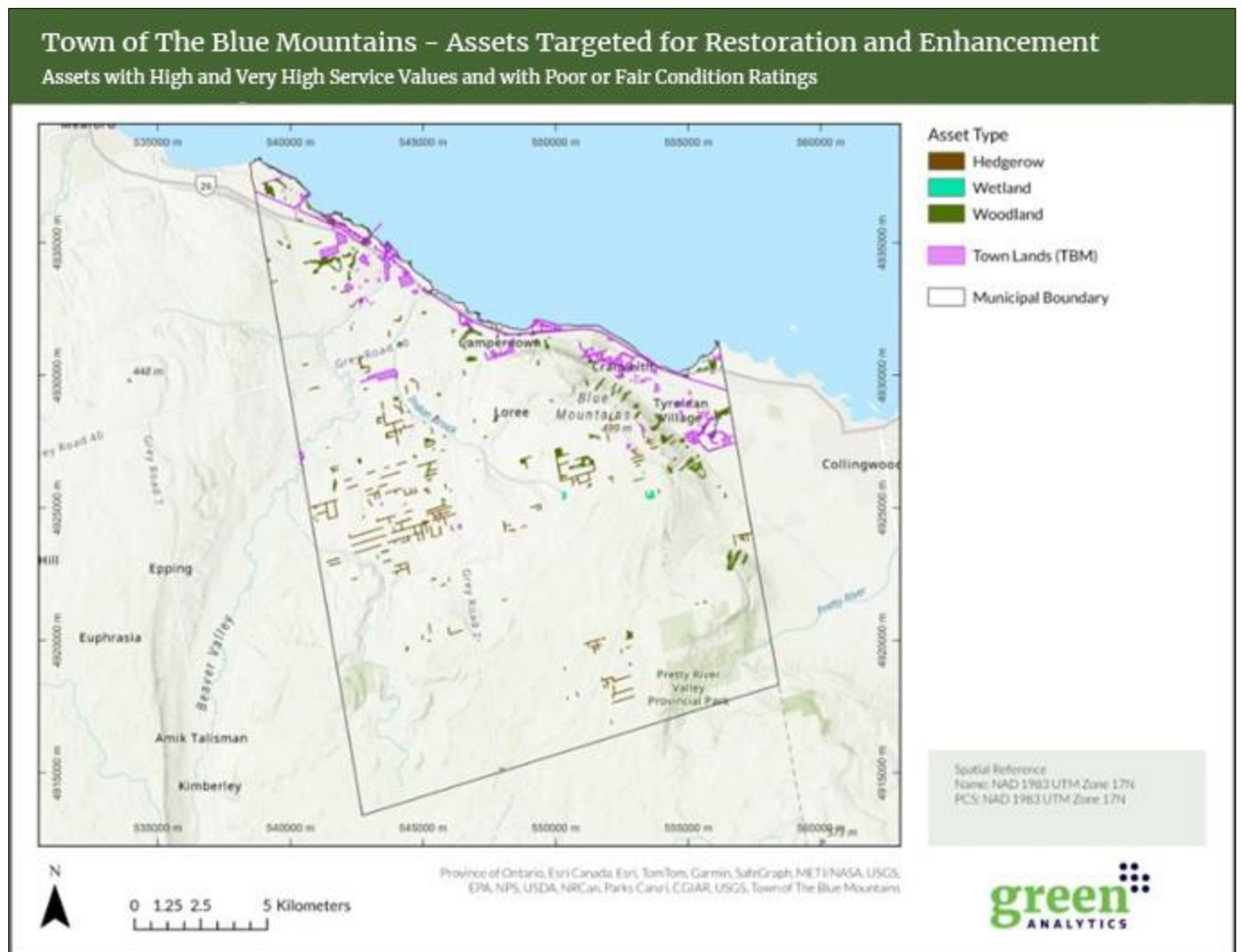


Figure 7-4. Town of The Blue Mountains assets targeted for restoration and enhancement; these assets are high and very high service assets with condition ratings of poor or fair.

Town of The Blue Mountains – Assets Targeted for Monitoring

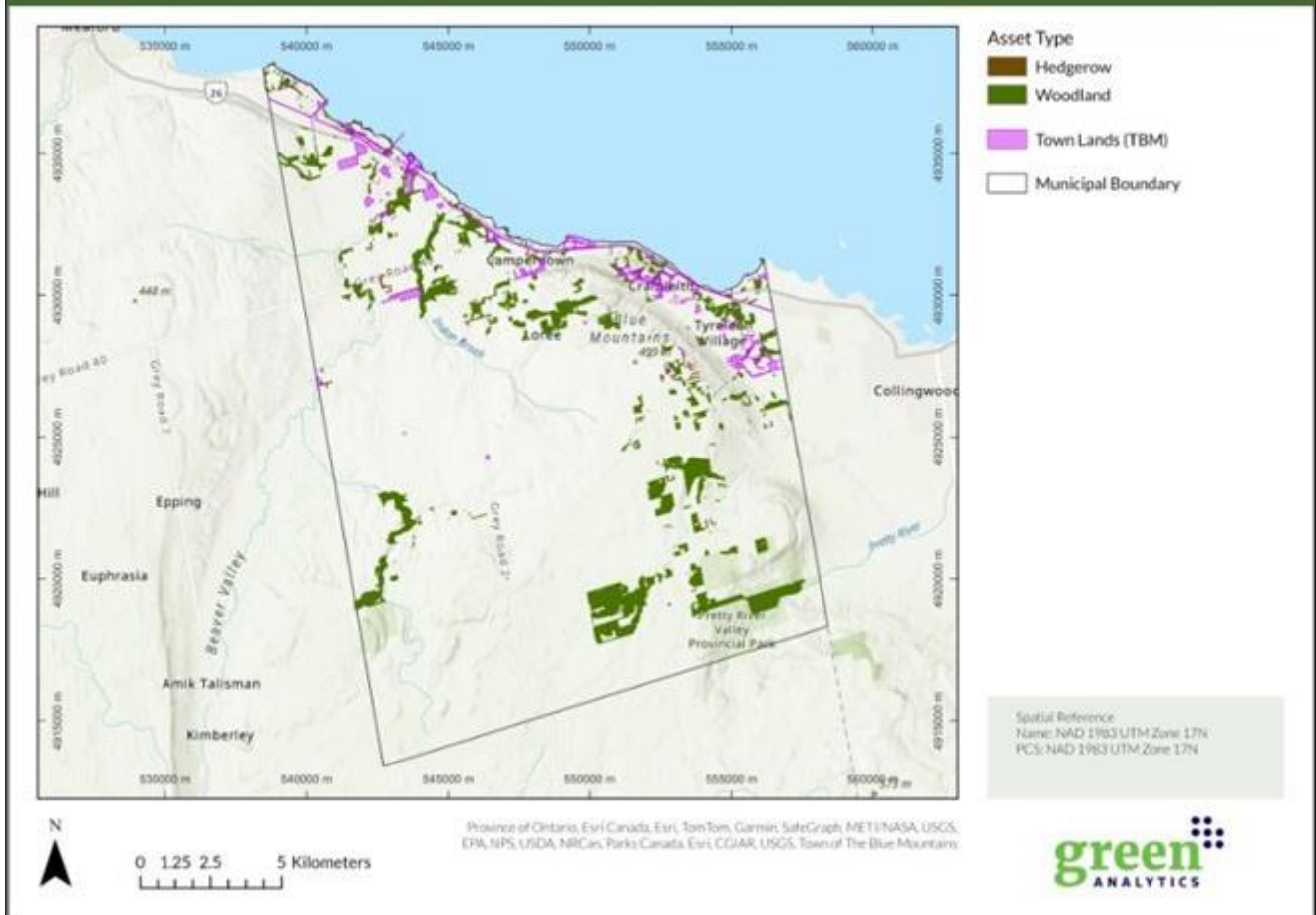


Figure 7-5. Town of The Blue Mountains assets targeted for monitoring; these are high and very high service assets with risking ratings of high or very high.

8 Natural Assets and Strategic Priorities

Natural assets provide a cost-effective, resilient, alternative to some built infrastructure. Indeed, when managed properly, natural assets provide several valuable services such as stormwater management, urban heat reduction, air quality improvements, and recreation. Natural asset management, including the creation of a natural asset inventory that quantifies the natural assets within municipal boundaries along with the services those assets deliver, provides a framework for measuring and monitoring the ways people depend on and benefit from nature. In so doing, natural asset management ensures the services provided by natural assets are maintained or enhanced over time.

8.1 Overview of Natural Asset Findings

This report contains the results of an assessment of Town of The Blue Mountains' natural assets. Town of The Blue Mountains' natural asset assessment resulted in the following findings:

- **Natural Asset Inventory:** A natural asset inventory for Town of The Blue Mountains was created using GIS. The inventory describes the type, location, and extent of natural, enhanced and agriculture assets within the municipal boundary. As is demonstrated in the asset inventory, within Town of The Blue Mountains:
 - Agricultural assets span 8,936 ha or 35.2% of the total area of assets.
 - Natural assets cover 15,843 ha or 62.4% of the asset area.
 - Enhanced assets cover 596 ha or 2.3% of the total area of assets.
 - There are 401.15 km of watercourses.
 - There are over 3 million trees.
- **Condition Assessment:** Natural assets in Town of The Blue Mountains were evaluated using criteria such as patch size, proximity to watercourses, and permeability of surrounding land uses. The results revealed most assets to be in good condition.
 - The majority of the Town's assets were rated as either very good or good, with approximately 17% and 77% of the assets, respectively falling into these categories.
 - Woodland assets show high condition relative to other asset types, with over 20% rated as very good and approximately 75% rated as good.
 - Most (96%) of the wetlands in the Town were rated in good condition.
 - Open aquatic and meadow assets demonstrated similar condition, with around 5% rated as very good and over 78% rated as good.
 - Approximately 68% of the hedgerow assets were rated as good, with 27% rated as fair.
- **Risk Assessment:** A systematic evaluation of potential hazards such as invasive species, pests, flooding, and erosion was conducted. Hazards were ranked based on their impact and likelihood, with most of the assets being categorized as facing moderate risk levels.
 - The majority (about 65%) of the aquatic assets were estimated to be at moderate risk, while the remainder of such assets were deemed to be at very high risk.
 - Meadow and wetlands assets were largely rated with low risk (about 85% and 95%, respectively).
 - Over 70% of woodland assets were estimated to be at moderate risk, with the remaining portion being at high or very high risk.
 - Hedgerow were deemed to predominately (over 95%) be at moderate risk.
 - Shoreline assets were rated with very high risk.

- **Asset Replacement Cost:** Replacement costs for natural assets were estimated using restoration costs:
 - The total replacement cost for major natural asset types, including woodlands, meadows, shoreline and wetlands, was calculated to be approximately \$4.03 billion.
 - Municipal owned or managed assets had an estimated replacement cost of \$146.2 million.
- **Ecosystem Services:** The economic value of some ecosystem services provided by natural assets was estimated. The valuation included recreation, carbon sequestration, air quality regulation, stormwater management, habitat preservation, contribution to crop productivity and regulation of extreme heat events.
 - The total annual value of these services was estimated to be between \$75 M and \$92 M.
- **Natural Asset Prioritization:** A natural asset prioritization exercise was completed to identify areas for priority investments in canopy cover as well as priority assets for preservation, restoration monitoring or enhancement. Settlement areas with canopy cover lower than 30% that are priority areas for canopy cover improvements include Craighleith, Heathcote, Ravenna, and Thornbury East and West. Priority assets identified include:
 - Natural assets that are in good and very good condition but with a high or very high risk rating were identified for preservation and monitoring: 5,139 ha of such assets were identified with 1.1% (54 ha) being Town-owned assets.
 - Natural assets in poor and fair condition with a high or very high risk rating were identified for restoration or enhancement: 242 ha of such assets were identified for with 11% being Town-owned.
 - Natural assets connected to the watercourse network were identified for preservation: 9,053 ha of such assets were identified with 0.6% (50 ha) being Town-owned.
 - Natural assets with high and very high service values and with poor or fair condition ratings were identified for restoration or enhancement: 276 ha of such assets were identified with 7% being Town-owned.
 - Natural assets with high and very high service values and with high or very high risk ratings were identified for monitoring: 1,425 ha of such assets were identified with 3% being Town-owned.

As is demonstrated in the foregoing findings, this natural asset assessment provides Town of The Blue Mountains with foundational information on the state of the natural assets within the municipal boundary as well as the value of some of the services those assets provide. The assessment can support many existing strategic priorities and goals established by the Town.

8.2 Linking Natural Assets to the Town’s Strategic Priorities

Strategic priorities identified in [Town of The Blue Mountains Corporate Strategic Plan 2020-2024](#), as well as several actions under the priorities are directly supported by natural asset management. Related to environmental resilience and sustainability, the Corporate Strategic Plan identifies priorities for an integrated community sustainability plan, climate change, tree canopy, and natural heritage.

The [Integrated Community Sustainability Plan 2022](#) emphasizes the need to integrate environmental, social, and economic sustainability into Town planning. Including natural assets in Town of The Blue Mountains’ asset management portfolio is an appropriate first step in integrating environmental sustainability into Town planning. The plan itself includes numerous goals related to the Town’s natural

environment. Specifically, as per the Sustainability Plan, the goals for Town of The Blue Mountains are that the Town:

- Is carbon neutral, and continuously reducing its carbon footprint
- Is adaptive and resilient to the impact of climate change and extreme weather
- Has a strong and well-managed tree canopy
- Has a renowned network for parks and green spaces across settlement areas and within the Niagara Escarpment
- Is celebrated for the prevalence of regenerative land relationships in food production and other sectors
- Has pristine water in Georgian bay and throughout the connected watersheds
- Is celebrated for its healthy biodiversity as a key feature of the community
- Is renowned for its pristine air
- Has healthy soils, wildlife, and vegetation within all of its watershed

Such goals cannot be achieved without intentional planning, management, and policy. Natural asset management can directly support a number of these goals. Natural assets store and sequester carbon and natural asset management can provide the basis for measuring carbon storage and sequestration from natural assets. As is described in more detail below, natural assets increase climate resilience and natural asset management provides a means to measure, manage and enhance tree canopy, agriculture lands and parks and greenspaces. Natural assets deliver improved air and water quality and natural asset management provides a framework for quantifying and tracking the role of natural assets in such service provision.

Under the Climate Emergency Declaration (Section 3.5) of Town of The Blue Mountains' Corporate Strategic Plan there is a commitment to the Town's Climate Emergency Declaration, which involves protecting and enhancing natural ecosystems. Natural ecosystems can play an important role in increasing climate resilience. Resilience as it relates to natural assets refers to their ability to recover quickly from serious environmental stressors (such as an ice storm) or catastrophic events (such as a forest fire), and their ability to adapt to longer term trends in the changing climate. Natural systems generally have an inherent ability to both recover from short-term impacts and adapt to longer term changes. An example of an asset management project to improve resilience is restoring a degraded watercourse (e.g., with natural meanders, wetland pools and naturalization using a diversity of native species) to better attenuate flood waters, while also improving local biodiversity and providing an amenity for the community. The value provided by natural assets such as watercourses can be significant and has been shown, in the face of climate change, to increase over time as the frequency and intensity of extreme weather events increases.¹³

Related to tree canopy and natural heritage features, the Corporate Strategic Plan notes the need to review the Town's natural heritage features, including the tree canopy. Natural asset management provides a means to monitor and manage natural heritage features within a municipality. In the context of tree canopy, natural asset management provides a framework for establishing current canopy cover, measuring canopy cover over time and planning for targeted investments in the maintenance and/or enhancement of canopy cover.

¹³ [MNAI Peel-final.pdf](#)

In addition to environment and sustainability, the Town's Corporate Strategy Plan identifies actions related to organizational excellence and strategic planning. Here, the strategic plan calls for the development of a comprehensive asset management plan. A comprehensive asset management plan will position Town of The Blue Mountains for compliance with O.Reg. 588/17 and address core and non-core assets, including natural assets. Integrating a street tree inventory into natural asset management is a good starting place in the pursuit of a comprehensive natural asset management plan as these assets are more easily measured and monitored, have well defined replacement costs and deliver a number of services (e.g. urban heat reduction, carbon storage and sequestration) to local citizens. The strategy speaks to the need for long-term financial planning. Including natural assets in the financial planning process helps ensure that investments in the monitoring, maintenance, assessment and enhancement of natural assets for continued service delivery are planned for over time.

Finally, the Corporate Strategy Plan speaks to priorities related to community engagement and quality of life. Strengthening relationships within the community can be supported by involving citizens in the natural asset management process. In the context of Town of The Blue Mountains, community engagement in natural asset management is highly applicable because of the significant portion of natural assets within the municipal boundary that are privately owned. The management of privately owned assets will come from the actions of local residents. From a quality of life perspective, natural asset management helps ensure that natural assets, which provide numerous services that enhance quality of life such as recreational opportunities, aesthetic appreciation, improved air quality and urban heat reduction, are well-managed and protected.

8.3 Natural Assets and Official Planning

Like the Corporate Strategic Plan, [Town of The Blue Mountains Official Plan](#) is a mechanism the Town can use to support natural asset management on public and private lands. It is important to note that a natural asset inventory is separate from the official plan and associated natural heritage mapping. However, as was the case in this report the natural heritage features helped inform the natural asset inventory. Generally, the official plan guides development and sets the requirements for avoided specific natural features. Whereas a natural asset inventory is a point in time picture of the natural assets used to inform and guide management of those assets. The official plan can be a mechanism to help manage the sustained provision of services from natural assets by including provisions that can protect important natural features. The 2016 plan provides several strategic objectives and commitments that can be supported by natural asset management. Examples of strategic objectives that relate to natural asset management are provided below.

Natural Environment (Section A3.2), includes the following relevant strategic objectives:

- Protect significant natural heritage and hydrologic features and their associated habitats and ecological functions.
- Ensure that an understanding of the natural environment, including the values, opportunities, limits and constraints that it provides, guide land use decision-making in the Town.
- Make planning decisions that contribute to the protection, conservation and enhancement of water and related resources on a watershed and sub watershed basis.
- Maintain and enhance surface and groundwater resources in sufficient quality and quantity to meet existing and future needs on a sustainable basis.
- Discourage the loss or fragmentation of significant woodlands and the habitats and ecological

functions they provide.

- Recognize that an interconnected system of open spaces and natural heritage features contributes to the health and character of a community.
- Prohibit the loss or fragmentation of Provincially Significant Wetlands and significant habitat of endangered and threatened species.
- Maintain and enhance significant areas of natural and scientific interest, significant valleylands, escarpment slopes and related landforms, and significant wildlife habitat areas.¹⁴
- Promote and establish programs to increase the forest cover of the Town.

Rural and Open Space Character (Section A3.5) includes the following relevant strategic objectives:

- Protect and enhance the natural character of the Georgian Bay shoreline.
- Preserve and enhance the Niagara Escarpment as a unique and important feature of the Town.
- Preserve and improve access to open space and shoreline areas, including the Niagara Escarpment, Nipissing Ridge and the Georgian Bay Shoreline.
- Encourage the development of passive low-intensity recreational and eco-tourism uses in the Town.
- Protect the natural and cultural heritage features.

Public Parkland and Open Space (Section D6) includes the following relevant strategic objectives:

- Establish and maintain a system of public open space and parkland areas that meet the needs of present and future residents.
- Enhance existing parkland areas wherever possible to respond to changing public needs and preferences.
- Ensure that appropriate amounts and types of parkland, and land along the shoreline and for access thereto, are acquired by the Town.
- Protect and enhance public open space and parkland.
- Promote the establishment of a continuous linear open space system connecting natural, cultural and recreation land uses within the Town.
- Encourage the development of a walking and cycling trail system within the open space system.

Sustainable Development – Tree Canopy (Section D8) includes the following relevant strategic objectives:

- Encourage the planting of native or non-native non-invasive tree species and vegetations that are resilient to climate change and provide a high level of carbon sequestration.
- Implement measures to protect, enhance and expand the tree canopy.
- Consider the establishment of a forest resource stewardship program.

¹⁴ Note that these lands are captured in the natural asset inventory and hence the valuation of ecosystem services.

9 Conclusion and Next Steps

There are numerous strategic priorities and goals that speak to the benefits of natural asset management within Town of The Blue Mountains. Indeed, as shown in Section 8, the Town's Corporate Strategic Plan, the Integrated Community Sustainability Plan and the Official Plan contain several priorities, goals and objectives that directly relate to natural asset management. These foundational documents put Town of The Blue Mountains on excellent footing for continuing to pursue natural asset management in the future.

This report and the associated natural asset inventory allow the Town to begin the process of better accounting for their natural assets. More specifically:

- This study and the supporting data provide a starting point for integrating natural assets into the Town's broader asset management planning process.
- The estimated replacement cost values can be used to support investments in management actions.
- This document establishes the connection between natural heritage and asset management planning. Natural heritage planning and policy can and should be one of the key policy mechanisms used to protect and maintain the condition of natural assets within the Town's municipal boundary. At the same time, a natural asset management plan can provide the overall justification for the use of those policy tools through the demonstration of natural asset service provision.

Town of The Blue Mountains faces several challenges that impact and limit what the Town can do to effectively monitor and manage natural assets:

1. Most of the Town's natural assets are privately owned. As a result, many assets and services provided by the Town's natural assets are outside the Town's direct control. Therefore, effective management of natural assets and the community services they provide requires a combination of strong natural heritage policy along with stewardship, education, and outreach programming.
2. The Town currently has limited capacity to actively monitor and manage natural assets through a formal natural asset management program. The Town must carefully prioritize specific actions.
3. The Town is currently under significant development pressure. This combined with (i) the largely privately owned natural assets and (ii) limited management capacity has the potential to lead to irreversible losses of the Town's natural assets and undermine the services they provide as well as the Town's strategic sustainability priorities.

Within the context of the points above, the following recommendations for next steps related to natural assets and natural asset management are provided.

Short-term Actions:

- Amend the asset management plan to include natural asset. Amendments should focus on reviewing the existing plan and incorporating wording that supports the consideration of natural assets and the level of services they provide.
- Focus on building and maintaining a street and park tree inventory. These assets have operational and financial implications for the Town as the Town has direct ownership and management responsibility for these trees. Their inclusion into standard asset management planning is reasonably straightforward. The processes and lessons learned from establishing an asset management plan for street and park trees can then provide a good foundation for expanding to other important natural assets. The inventory should identify the number, type, age and condition of trees.

- Develop an urban tree strategy to increase canopy cover in settlement areas. This should be informed by a comprehensive tree inventory as described in the previous action. Investments in the maintenance of canopy cover (where it is high) and increased canopy cover (where it is low) could then occur over time. To manage costs, a schedule for investments in maintaining existing trees and planting new trees can be articulated. The urban tree strategy could also consider establishing a minimum canopy cover target as well as a tree compensation bylaw as has been done in other jurisdictions (see text boxes below). Outreach and stewardship programs are recommended to support maintaining and enhancing canopy cover on privately owned lands.
- Focus available management capacity on assets known to be at high risk, particularly those associated with high service delivery that are Town-owned to help ensure continued service delivery from the assets over which the Town has direct control.
- Explore options for immediate financing support. For instance, the Federation of Canadian Municipalities has recently ramped up funding opportunities focused on natural assets, green infrastructure, and nature-based infrastructure solutions.
- Investigate funding available for managing the street canopy through development charges and asset replacement reserves.
- Establish levels of service provided by natural assets and then identify and cost a range of management actions that can be compared with budget allocations to support funding for asset management.

Mid- to long-term actions:

- Undertake field-based condition assessments of the natural assets, prioritizing those that are Town-owned, to confirm the state of the assets and inform future management and investment decisions.
- The existing stock of natural assets within the municipal boundary should be monitored and maintained. This is particularly important for the limited assets that are Town-owned to ensure that service delivery from the assets over which the Town has direct control continues over time.
- For the assets that are privately owned, pursue education, outreach and stewardship programs. Partnerships with landowners and managers, including the agriculture community will be important in this regard. Establishing a collaborative strategy with key partners such as Conservation Authorities, the Niagara Escarpment Commission, or others to collectively monitor and maintain the rural and natural condition of the Town.
- Explore options for long-term sustainable financing of natural asset management. This might include development charges, environmental reserve funds or bonds. The box below highlights some funding options pursued by other municipalities that may help inform financing options for Town of The Blue Mountains.
- Consider and pursue to the extent possible, the acquisition of priority natural heritage features to expand the Town-owned natural assets.

Financing Natural Asset Management

The Town of Gibsons uses **development cost charges** (DCCs) to fund natural asset restoration and enhancement projects. In British Columbia, DCCs offset costs for local governments for services required to support new developments. This includes costs related to roads, sewage, water, drainage, and parkland acquisition and improvement. The Gibsons Council amended its DCC bylaw after recognizing nature as an asset, enabling the Town to collect charges for improvements to natural assets, effectively directing more resources toward the protection and restoration of natural assets (MNAI 2019; Town of Gibsons 2017).

Environmental Reserve Funds can also support the pursuit of natural asset management. The District of West Vancouver in British Columbia established an Environmental Reserve in 2022. The fund is used to protect the natural environment, respond to climate change through mitigation and adaptation strategies, sustain the district’s natural capital assets, and reduce greenhouse gas emission from both municipal operations and the broader community. The fund is financed by a combination of an annual environmental levy, interest earned on the fund, external grants, and other contributions designated by the Council of the Corporation of the District of West Vancouver (District of West Vancouver 2022).

The Municipality of Durham, Ontario, adopted an environmental reserve fund, referred to as the Climate Change Mitigation and Environmental Initiatives Reserve Fund, to support programs and services aimed at mitigating climate footprints and greenhouse gas emissions. The fund was financed by a \$5 million transfer from the General Levy Stabilization Reserve Fund. Additional allocations are determined by the Regional Council (Municipality of Durham 2023).

Investments in natural assets can be supported by the issuance of **bonds**, such as the Ontario Green Bond and the Ontario Sustainable Bond. The Ontario Green Bond program was initiated in 2014 and has funded 29 projects through 15 bond issues, supporting a range of programs, such as clean transportation, energy efficiency and conservation, clean energy and technology, forestry, agriculture and land management, and climate adaptation and resilience (Government of Ontario 2024a). Ontario’s Sustainable Bond program was established under the Sustainable Bond Framework in January 2024 to replace the 2014 Green Bond Framework. This new framework expands the scope of supported projects to include environmentally sustainable management of living natural resources, terrestrial and aquatic biodiversity, and more comprehensive climate change adaptation measures, alongside the existing project categories (Government of Ontario 2024b).

Tree Compensation Bylaw Examples

The City of Toronto's Tree Bylaw sets up tree compensation requirements for tree removal and injury. For any city trees removed, city tree removal permit holders are required to plant one tree or provide \$583 per tree in lieu of replanting if the replanting condition (i.e., do not have enough space) is not met (Romeo-Beehler 2018). Private tree removal permit holders face different requirements, as they need to plant a tree for every tree removed for non-construction purposes, and replant 3 trees for every tree removed for construction purposes. Similarly, the applicants may pay a fee of \$583 per tree in lieu of replanting if the replanting requirement is not met. For private trees within a ravine area, the replanting ratio is more stringent, as the permit holders need to replant either 3 trees or 10 shrubs for every tree that has been removed. If any tree is injured, the permit holders are responsible for replanting 1 tree or shrub. Additionally, permit holders are required to replant 1 tree for each additional 25 m² of hardscaping.

The City of Markham Tree By-law regulates and prohibits injury and destruction of city-owned and private trees. The Tree Permit Requirement specifies the private tree replacement requirements based on the DBH (diameter at breast height) of the removed trees. For any trees that are removed with a DBH between 20 – 40 cm, a replacement ratio of 2:1 is required. For trees with a DBH of 41 – 60 cm, 3 replacement trees are required for each tree removed. For trees with a DBH of 61 – 80 cm, and DBH of 81 cm or greater, the replacement ratio increases to 4:1 and 5:1, respectively (City of Markham 2022).

The City of Kingston's By-Law Number 2018-15 regulates the destruction or injuring of trees in the city. A permit is required for tree removal or injury, especially in designated areas. Violation of the bylaw or permit conditions will result in various levels of penalties such as orders to stop the offense and fines. Fines can range from \$10,000 to \$25,000 for individuals and \$50,000 to \$100,000 for corporations. The by-law states that if tree replacement is not possible, the tree permit applicant is required to pay financial compensation (City of Kingston 2017).

The Town of Oakville has specific by-laws governing both city-owned and private trees. For city-owned trees, regulations cover planting, care, maintenance, and removal. For private trees that are 15 cm or greater in diameter, the by-law mandates that for every 10 cm of a healthy tree removed, one replacement tree must be planted, up to a maximum of 12 trees (Town of Oakville, n.d).

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11 Appendix A: Data Sources

Employing the data identified in Table 10-1, a natural asset inventory was developed for Town of The Blue Mountains. To create a natural asset inventory, the location, type and extent of natural assets are delineated and quantified. The asset inventory forms the foundation upon which all other asset management tasks are based.

Table 11-1. Inventory of data sources.

Descriptive Name	Source	Purpose
Ecological Land Classification (ELC)	North South Environmental (NSE)	Used as the baseline dataset to classify and identify land cover types for the inventory.
National Road Network (NRN) Road Dataset	Government of Canada	Used to delineate road and railway land cover and to subdivide areas using roads.
Building Footprints	Town of The Blue Mountains	Used to distinguish buildings from other land cover.
Shoreline Delineation	NSE	Used to delineate and add shorelines to the inventory.
Parks	Town of The Blue Mountains	Used to add and identify parks as assets to the inventory.
Open Street Map Traffic Data (Parking Lot) Features	© OpenStreetMap, Available with Open Database license	Used to erase parking lots from the extent of park assets.*
Open Street Map Building Footprint Features	© OpenStreetMap, Available with Open Database license	Used to erase building footprints from the extent of park assets.*
Town Boundary	Town of The Blue Mountains	Used to delineate shoreline and assess the boundary of study area.
ESRI 2023 Land Cover Data	ESRI	Used to account for natural/non-natural land cover outside of ELC extent.
Ownership Parcels	Town of The Blue Mountains	Used for avoided mortality cost calculations.
Heritage Designation	Town of The Blue Mountains	Used to assign heritage designation attributes to assets in the inventory.
Tree Preservation Area	Town of The Blue Mountains	Used to designate whether an attribute falls inside or outside of Town of The Blue Mountains tree preservation areas.
Subwatershed	Town of The Blue Mountains	Used to subdivide area by subwatershed boundary.
Conservation Areas	Town of The Blue Mountains	Used to subdivide areas by conservation areas.
Provincial Park Boundaries	Province of Ontario	Used to subdivide areas by provincial park extent and bounds.
Town Owned Areas	Town of The Blue Mountains	Used to subdivide areas by properties owned by Town of The Blue Mountains.
Settlement Boundaries	Town of The Blue Mountains	Used to subdivide areas by settlement boundaries.
Zoning	Town of The Blue Mountains	Used to subdivide areas by zoning boundaries. Categories also used for risk assessment.

Descriptive Name	Source	Purpose
Watercourses	NSE	Used for watercourse proximity assessments and as the basis for watercourse inventory.
Canopy Height Map	NSE	Used to determine canopy coverage and average canopy height within natural assets in the inventory.
Tree Point Locations	NSE	Used as the basis for tree inventory.

*Fewer than 100 polygons within OSM datasets were used to classify inventory land cover. For licensing purposes, this is interpreted to be insubstantial.

12 Appendix B: Inventory at Level 3

Table 12-1. Level 3 area breakdown of inventory.

Ecological Land Classification (ELC) Class (Level 3)	Area (ha)	Percent of Total Inventory
Active Orchard	1,412	5.6
Beach	27	0.1
Coniferous Plantation	610	2.4
Cultural Woodland	42	0.2
Deciduous Plantation	22	0.1
Golf	185	0.7
Hedgerow	314	1.2
Meadow	990	3.9
Meadow Marsh	265	1.1
Open Agriculture	7,525	29.7
Open Aquatic	233	0.9
Park	29	0.1
Rocky	6	0.0
Ski Hill	382	1.5
Swamp	103	0.4
Thicket	1,442	5.7
Treed Area	73	0.3
Treed Swamp	788	3.1
Woodland	10,927	43.1
Total Area (ha)	25,375	100

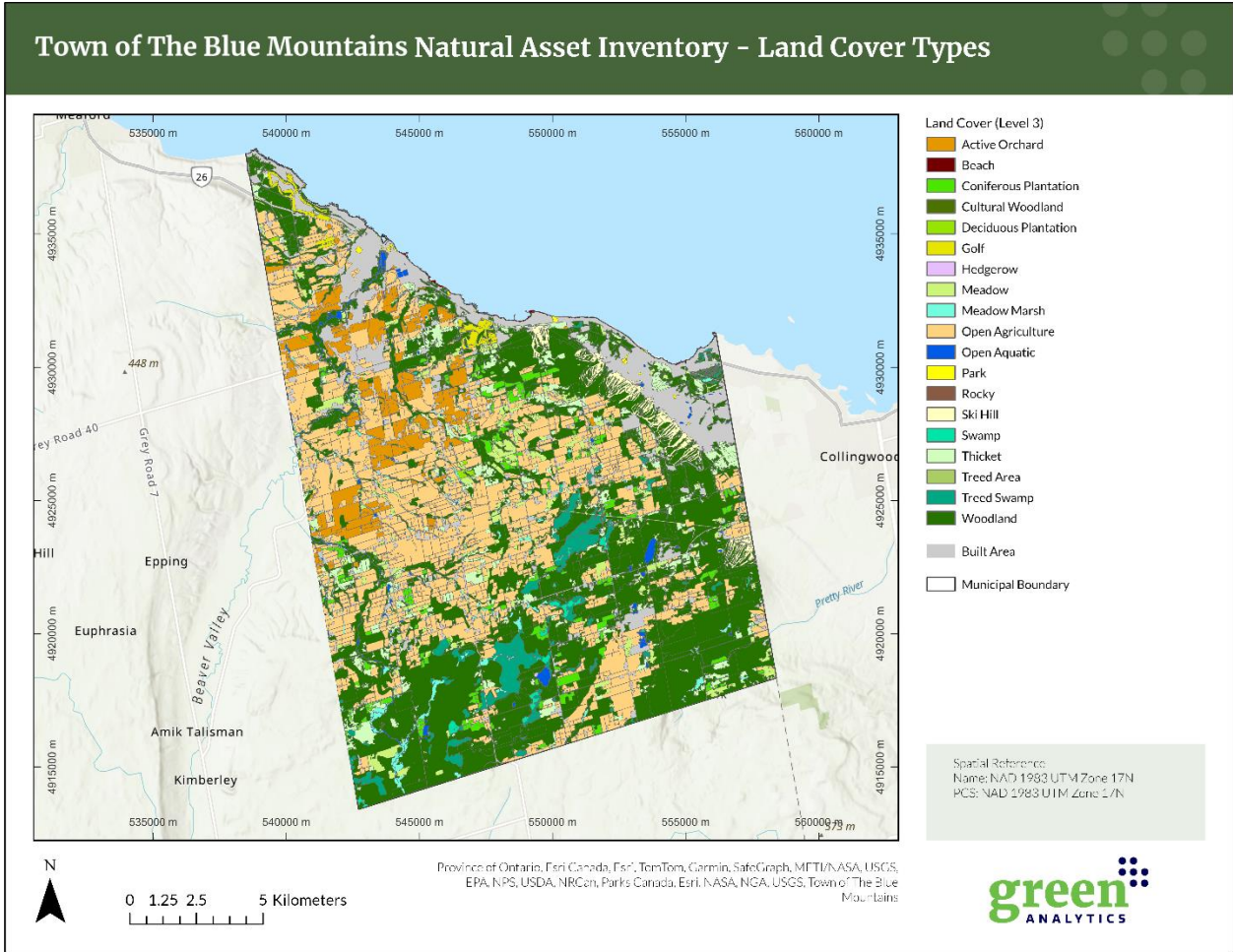


Figure 12-1. Town of The Blue Mountains natural asset inventory at Level 3 land cover.

13 Appendix C: Condition Assessment Approach and Detailed Results

13.1 Interior Habitat Rating

INDICATOR: The amount of interior habitat, with larger patches with more interior habitat being considered of higher quality than smaller patches 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 amount of interior habitat. In general, larger blocks of habitat (whether they be meadow, woodland, 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 of large “blocks” of habitat generally provide a greater range of habitats of better quality, a scoring system was established based on federal guidance.

APPROACH: “Interior” habitat – at least in forests/woodlands - is typically measured starting at 100 m inwards from the feature or “patch” edge (e.g., Environment Canada 2013). The first step was thus to establish the “patch” edge, which was defined at Level 1 (not distinguishing between asset types). Once the patch edge was established, an interior buffer of 100 m was applied and the remaining area within the patch was measured.

SCORING: Ratings were allocated as follows:

- Very good: >20 ha
- Good: 20 ha – 8 ha
- Fair: 8 ha – 2 ha
- Poor: 2 - 0
- Very poor: 0

Figure 13-1 shows the spatial distribution of the interior habitat indicator results. The majority of Town of The Blue Mountains' natural assets are in very good condition from the perspective of this indicator.

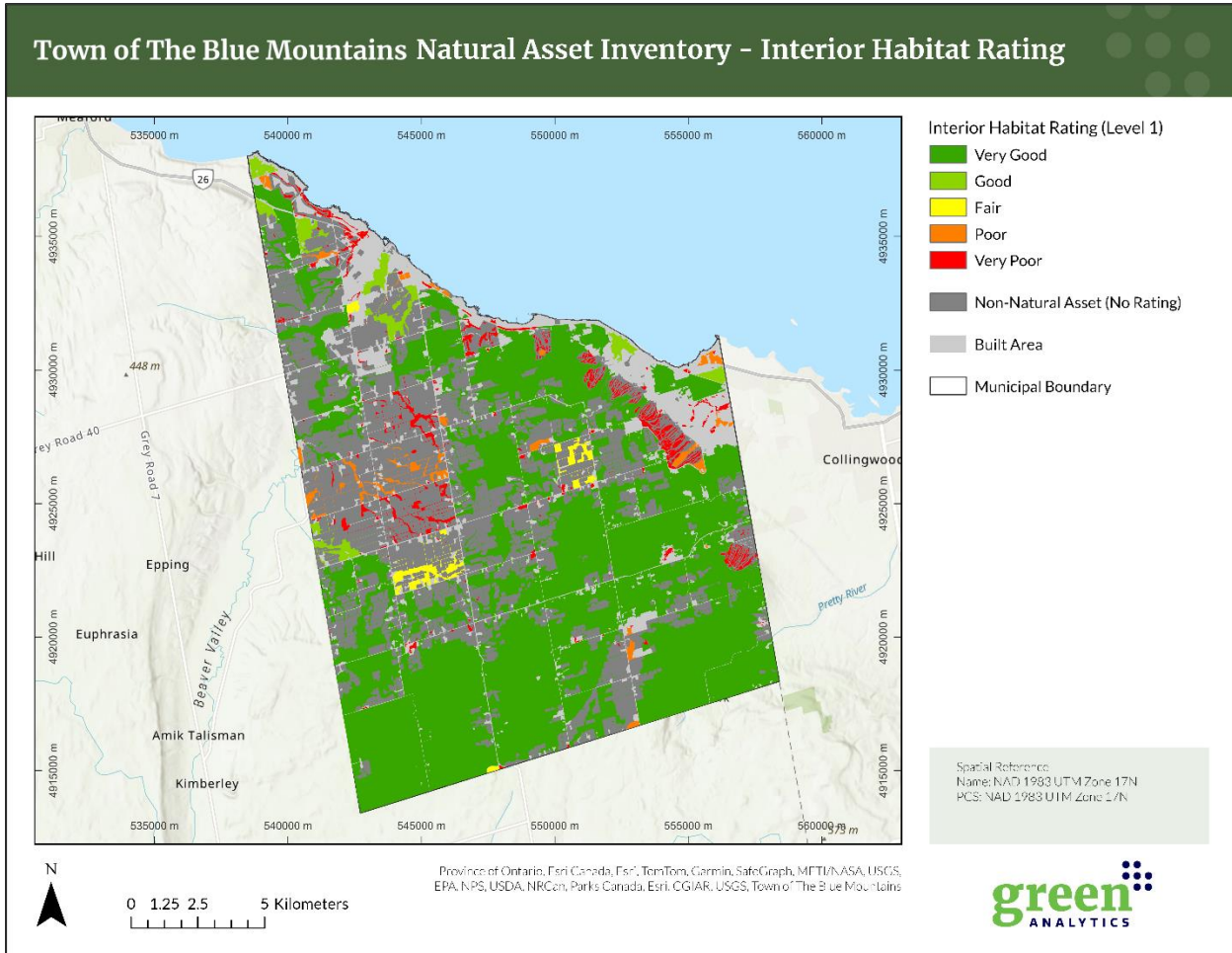


Figure 13-1. Map of natural asset inventory categorized by interior habitat rating.

Table 13-1 demonstrates the area of assets in the study area by condition rating for this indicator. Most of the areas ranked as very good.

Table 13-1. Area of natural assets by interior habitat rating.

Condition Rating	Asset Area (ha)
Very Good	14,148
Good	480
Fair	211
Poor	319
Very Poor	652
Total	15,810

13.2 Natural Area Patch Size Rating

INDICATOR: Measures the absolute size of contiguous natural areas with larger contiguous areas assumed to be of higher quality than smaller areas.

RATIONALE: The objective of this indicator is to create a proxy for condition based on the absolute size of contiguous patches of natural assets. In general, larger blocks of habitat (whether they be meadow/grassland, 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).

Given this context and recognizing the landscape ecology principle of large “blocks” of habitat generally provide a greater range of habitats of better quality, a scoring system was established based on federal guidance.

APPROACH:

Natural asset patches were assessed based on their absolute size (area). Measured at Level 1 based on the complete contiguous natural patch size (i.e., may be a complex of woodland, wetland, etc. to create a single patch).

SCORING:

Condition Scores for Patch Size:

- Very Good: Area > 50 ha (as per <https://digitalcommons.unl.edu/natrespapers/522/>)
- Good: Area is > 30 and =< 50 ha
- Fair: Area is > 20 and =< 30 ha
- Poor: Area is > 10 and =< 20 ha
- Very Poor: Area is =< 10 ha

Figure 13-2 shows the spatial distribution of the natural patch size indicator results.

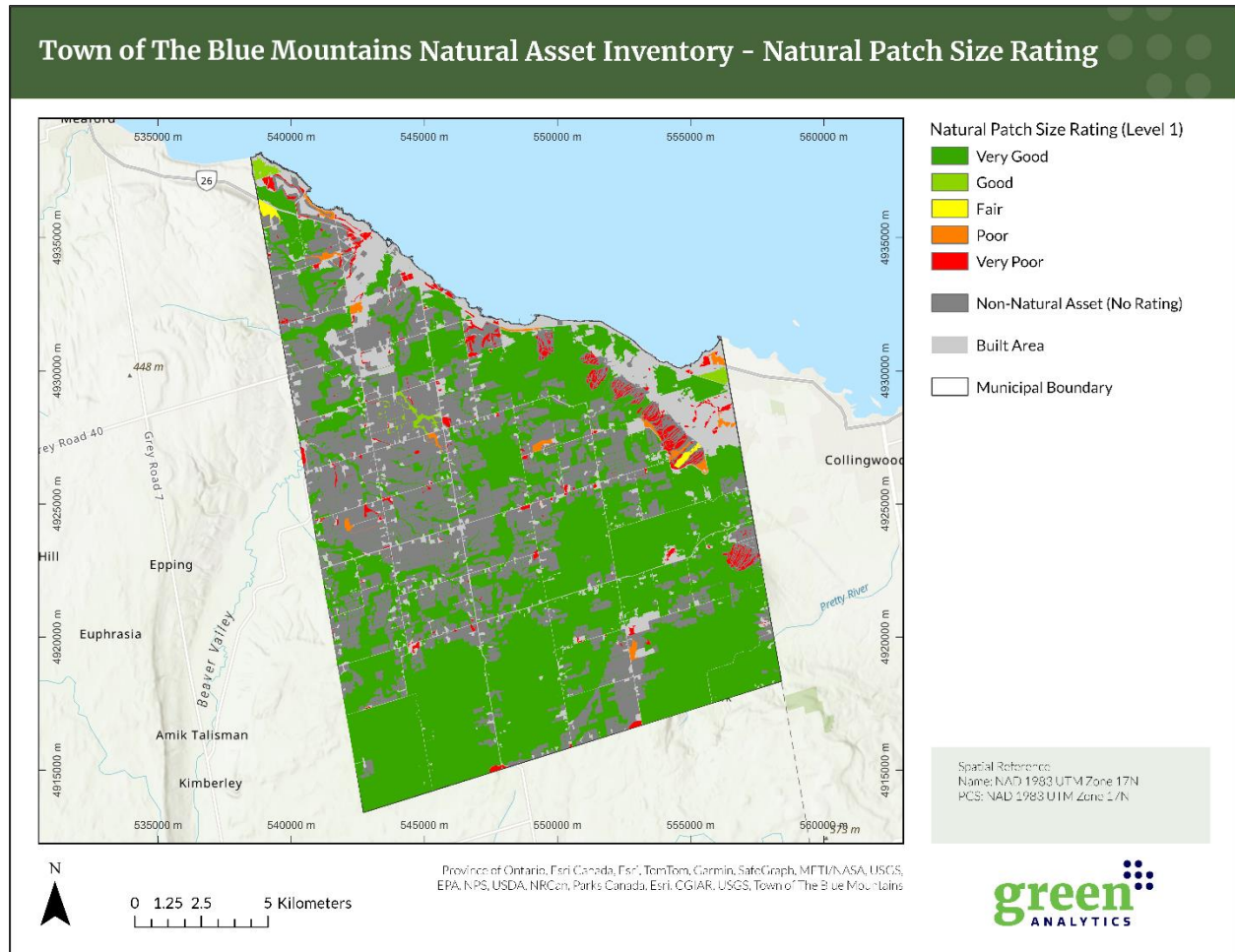


Figure 13-2. Map of natural asset inventory categorized by patch size rating.

Table 13-2 demonstrates the area of assets in the study area by condition rating for this indicator. Most of the areas ranked as very good, although there is a sizeable proportion of areas ranked very poor that are closer to urban areas and the ski hills.

Table 13-2. Area of natural assets by patch size rating.

Condition Rating	Asset Area (ha)
Very Good	14,910
Good	130
Fair	51
Poor	1
Very Poor	542
Total	15,810

13.3 Natural Area Patch Shape Rating

INDICATOR: The 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: This metric is predicated on the fact that we want to minimize edges. This is an interpretation associated with landscapes where edges are typical locations for impacts from adjacent human uses. Complex shapes in a natural matrix can be a good thing and indeed edge habitats are preferred by some species. However, from a position of 'limitations' on the landscape, edge habitats are not limited. Areas away from edges or unaffected by edge effects are a limited commodity.

APPROACH: This indicator is applied at Level 1 based on the complete contiguous natural patch area (i.e., may be a complex of woodland, wetland, etc. to create a single patch).

A compactness ratio formula determines the square root of the area of the patch divided by the area of a circle with the same circumference:

$$\sqrt{\text{patcharea}/(C^2/(4 * \pi))}$$

With this approach, resulting values are between 0 and 1.

SCORING: Condition scores based on compactness ratio:

- Very Good: >0.8 and =< 1.0
- Good: > 0.6 and =< 0.8
- Fair: > 0.4 and =< 0.6
- Poor: > 0.2 and =< 0.4
- Very Poor: =< 0.2

Figure 13-3 shows the spatial distribution of the natural patch shape indicator results.

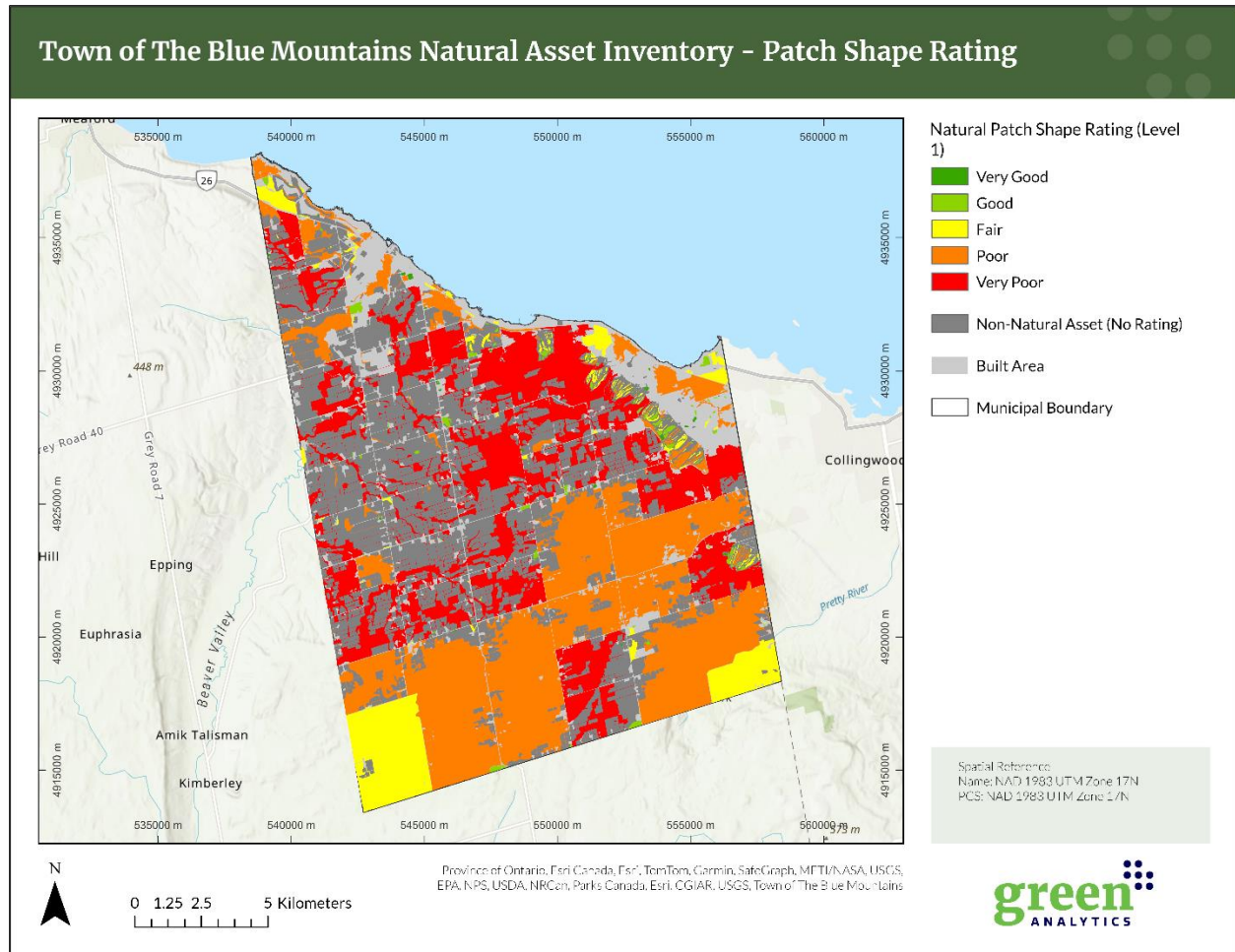


Figure 13-3. Map of natural asset inventory categorized by patch shape rating.

Table 13-3 demonstrates the area of assets in the study area by patch shape rating. Most of the areas ranked as very poor.

Table 13-3. Area of natural assets by patch size rating.

Condition Rating	Asset Area (ha)
Very Good	32
Good	156
Fair	1,747
Poor	7,762
Very Poor	6,111
Total	15,810

13.4 Natural Asset Proximity to Watercourses

INDICATOR: The distance between each asset and the nearest watercourse 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 influences 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. Environment 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
- Forests 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.

Figure 13-4 shows the spatial distribution of the proximity to watercourses indicator results.

Town of The Blue Mountains Natural Asset Inventory - Watercourse Proximity Rating

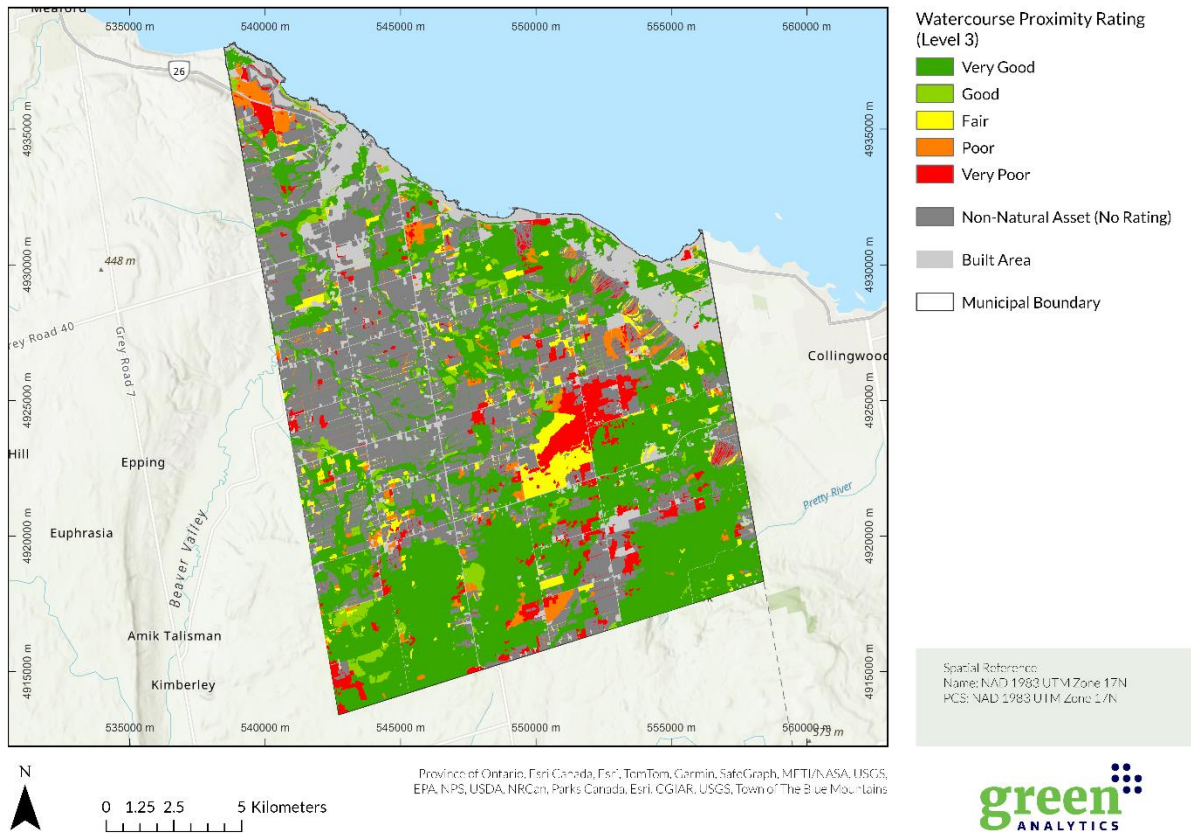


Figure 13-4. Map of natural asset inventory categorized by watercourse proximity rating.

Table 13-4 demonstrates the area of assets across the various condition ratings for the proximity to watercourses indicator. In this case there is a large portion of assets rated very good, but there is still a sizeable portion of assets ranked fair, poor or very poor.

Table 13-4. Area of natural assets by proximity to watercourse rating.

Condition Rating	Asset Area (ha)
Very Good	11,557
Good	889
Fair	987
Poor	840
Very Poor	1,536
Total	15,810

13.5 Woodland Proximity to Other Natural Assets

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

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

- For forest birds, research has found that habitats near other natural areas support more species than isolated habitats of the same size, and 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 5 km, but for amphibians at between 1 and 2 km. For forest plants, some level of immediate proximity is required.

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

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

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

Figure 13-5 shows the spatial distribution of the woodland proximity to other natural assets indicator results. For this indicator, all natural assets rated as very good. There are no assets within Town of The Blue Mountains that are more than 1 km from a woodland or wetland asset.

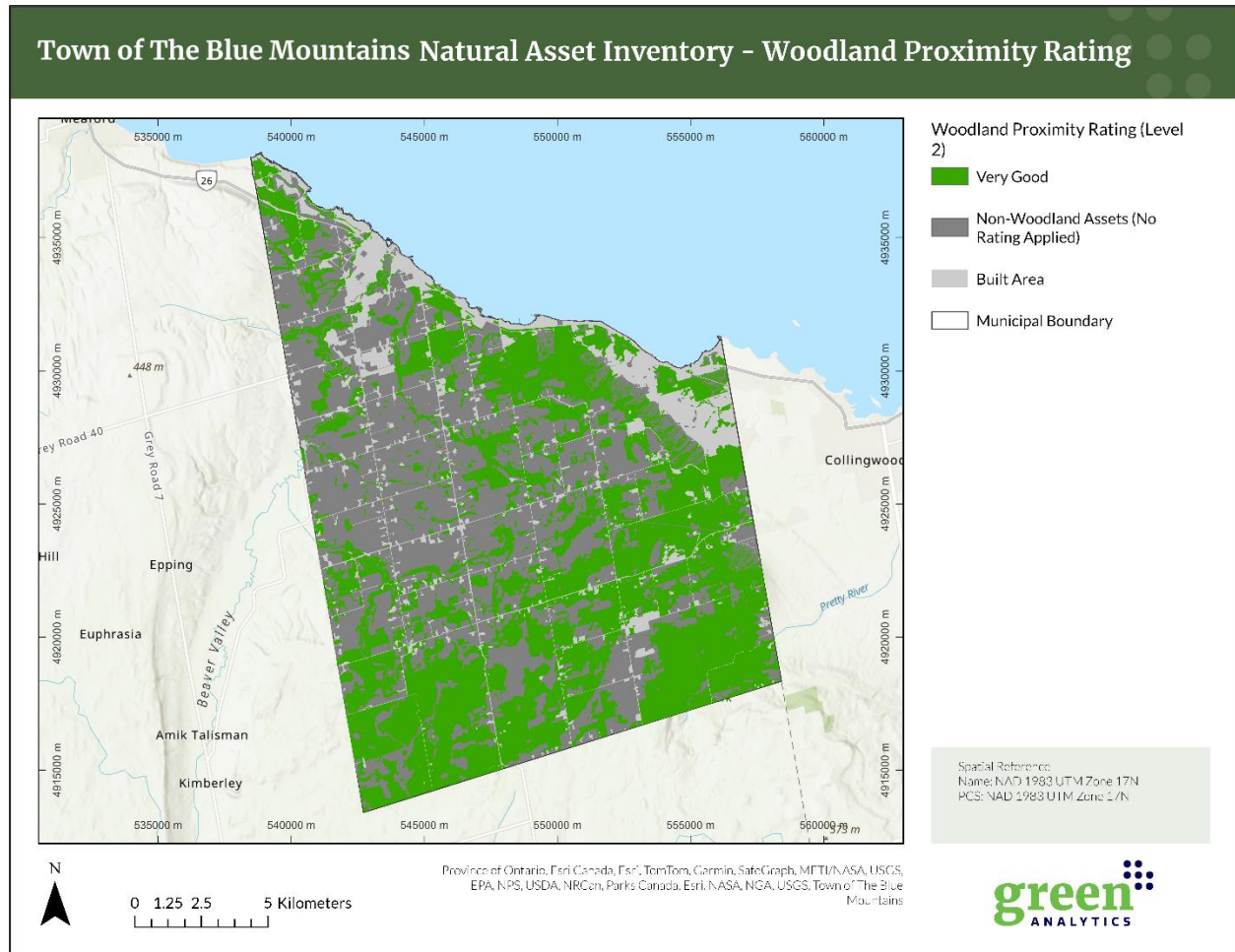


Figure 13-5. Map of natural asset inventory categorized by woodland proximity rating.

Table 13-5 demonstrates the area of assets that are rated very good according to this indicator. Due to both the large presence of woodland areas, and the close proximity of many of them to each other, the ratings were all very good for this indicator.

Table 13-5. Area of natural assets by woodland proximity rating.

Condition Rating	Asset Area (ha)
Very Good	13,116
Good	0
Fair	0
Poor	0
Very Poor	0
Total	13,116

13.6 Wetland Proximity to Other Natural Assets

INDICATOR: A measure of the proximity of Level 2 wetland assets to other Level 2 wetland or woodland 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 was applied based on the closest buffer where another Level 2 woodland or wetland asset was found.

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

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

Figure 13-6 shows the spatial distribution of the wetland proximity indicator results. As was the case with the woodland proximity indicator, in the case of wetlands, all assets ranked very good for this indicator.

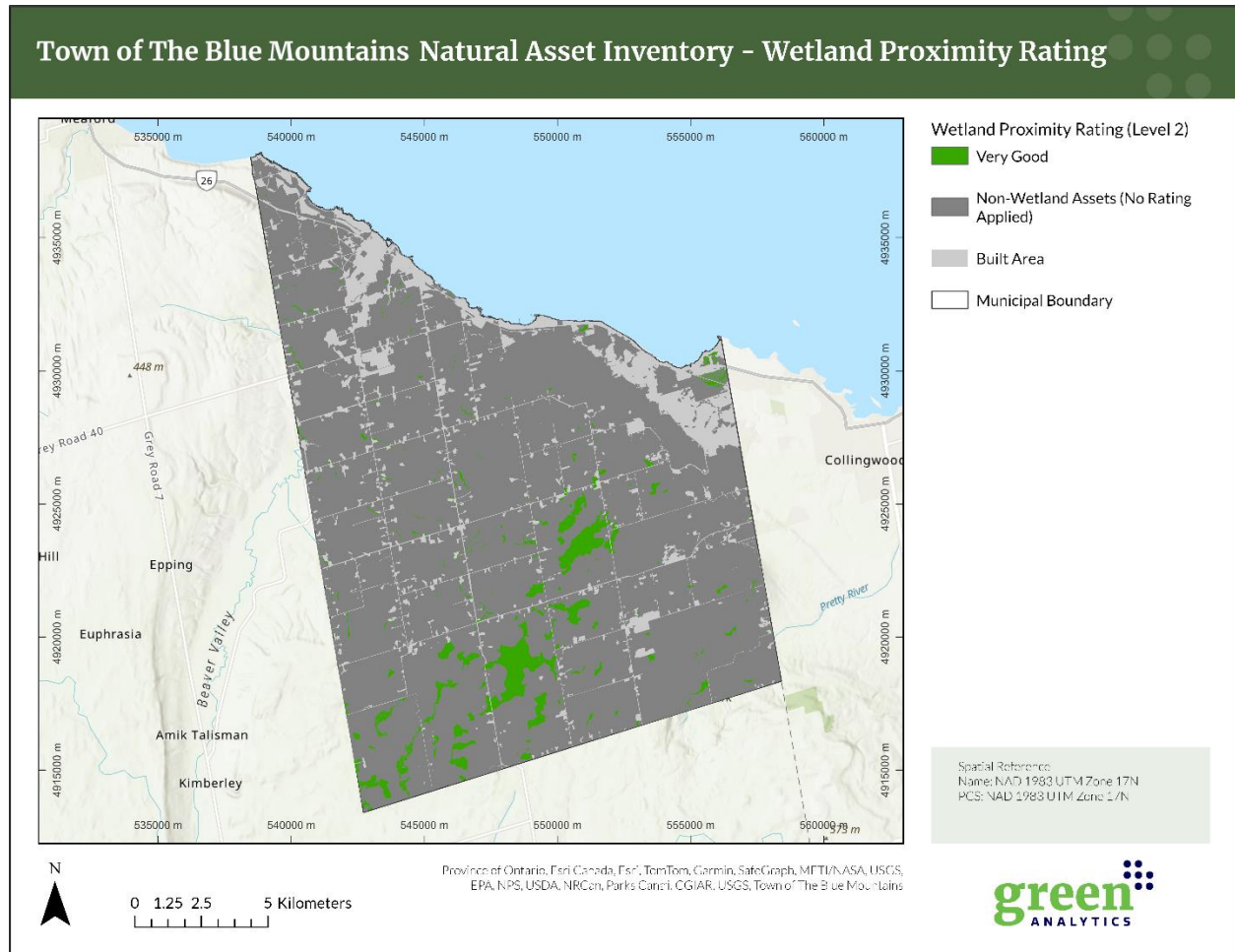


Figure 13-6. Map of natural asset inventory categorized by wetland proximity rating.

Table 13-6 demonstrates the area breakdown of wetlands for the wetland proximity indicator. All wetlands within Town of The Blue Mountains ranked very good for this indicator meaning that all of the wetlands within Town of The Blue Mountains are located within 0.5 km of another woodland or wetland asset. This is primarily due to the heavy presence of woodland assets surrounding the wetlands.

Table 13-6. Area of natural assets by proximity to wetland proximity rating.

Condition Rating	Asset Area (ha)
Very Good	1,156
Good	0
Fair	0
Poor	0
Very Poor	0
Total	1,156

13.7 Extent of Adjacent Permeable Land Uses

INDICATOR: The extent of permeable 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) as 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 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 supporting 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 permeable land uses and natural assets was estimated in hectares within each buffer. Areas of permeable 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/permeable land uses was estimated. A ranking was then applied to each buffer and linked to the relevant natural assets.

SCORING: A ranking 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 permeable land uses (e.g., passive parklands, golf courses, or agricultural lands). Scores were assigned as follows:

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

Figure 13-7 shows the spatial distribution of the adjacent permeable land use indicator results. The majority of Town of The Blue Mountains' assets rated very good for this indicator.

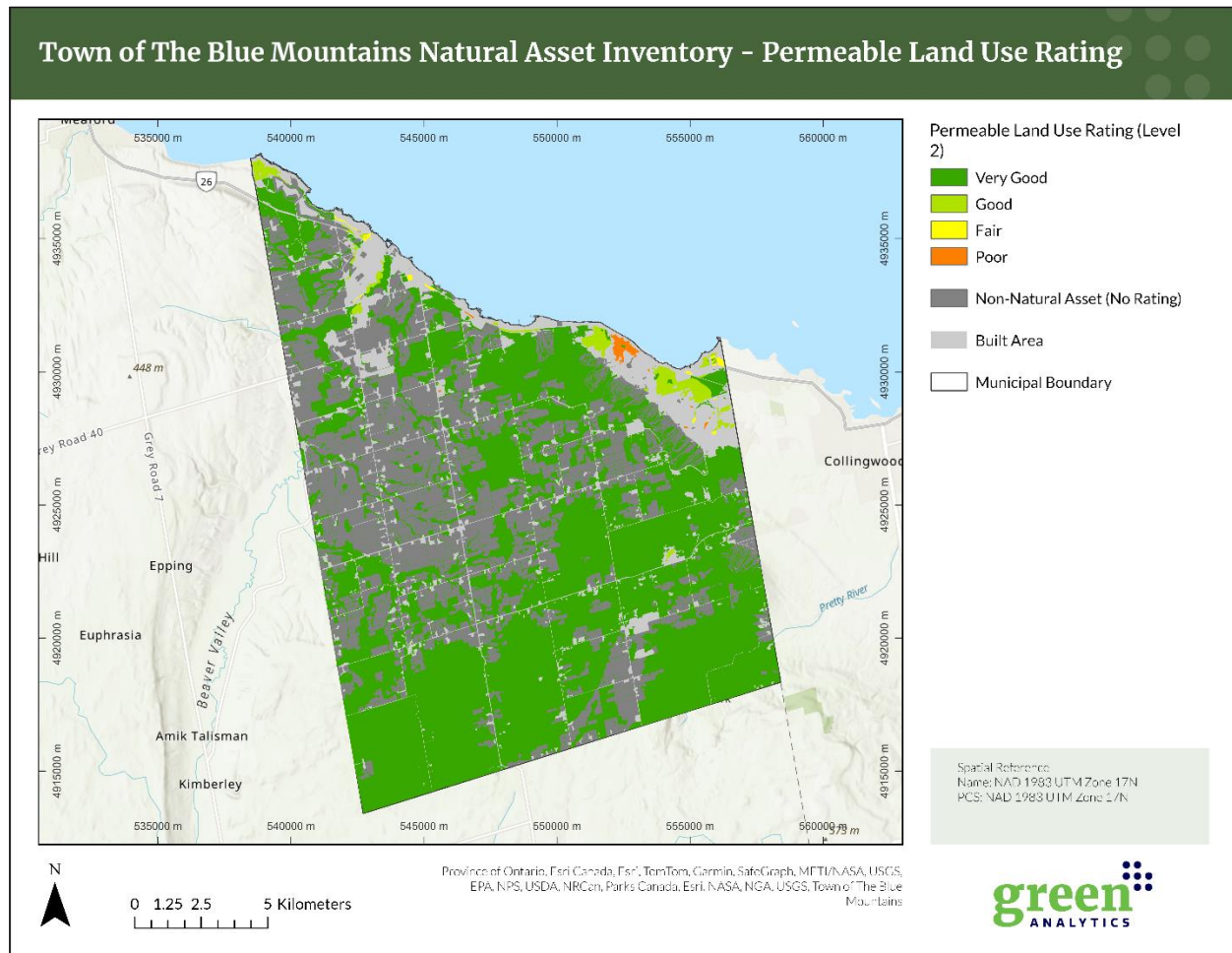


Figure 13-7. Map of natural asset inventory categorized by permeable area rating.

Table 13-7 demonstrates the area of assets within each condition rating for adjacent permeable land uses. As is shown in the table, the vast majority of Town of The Blue Mountains' assets ranked very good or good for this indicator. No asset rank very poor, and even the lower categories have extremely low extents.

Table 13-7. Area of natural assets by adjacent permeable land use rating.

Condition Rating	Asset Area (ha)
Very Good	15,360
Good	354
Fair	37
Poor	59
Very Poor	0
Total	15,810

13.8 Percent of Woodland Cover within Subwatersheds

INDICATOR: A percentage assigned to the watersheds, and by extension the woodland assets within them, related to the amount of woodland cover within each watershed.

RATIONALE: According to Environment Canada (2013) research, it is recommended that between 30-50% of watersheds be forests/woodland. The greater the percent of forest cover the greater the conservation and habitat quality of the watershed. While this metric is focused on a broader watershed level, each individual forest asset within a subwatershed was allocated the corresponding condition rating since those assets are contributing to the overall subwatershed condition. From a management perspective, any forest asset within a subwatershed with a high degree of forest cover will generally require less management intervention.

APPROACH: Subwatershed boundaries were overlayed on the natural asset inventory. The total area of all woodland/forest assets were estimated and compared against the total subwatershed area to establish the percent of woodland/forest cover within the subwatershed. All individual woodland assets within the subwatershed were allocated the same condition rating based on the scoring thresholds noted below.

SCORING: The area of woodland assets within each watershed area was estimated as a percent of the watershed's area. Watersheds, and by extension the woodland assets within them, were rated as follows:

- Very Good: subwatersheds with > 50% woodland cover
- Good: subwatersheds with 41 to 50% woodland cover
- Fair: subwatersheds with 31 to 40% woodland cover
- Poor: subwatersheds with 16 to 30% woodland cover
- Very poor: subwatersheds with <16% woodland cover

Figure 13-8 shows the spatial distribution of the woodland cover within subwatersheds indicator results. For this indicator the majority of the assets ranked good, meaning the subwatersheds are 41 to 50% woodland cover.

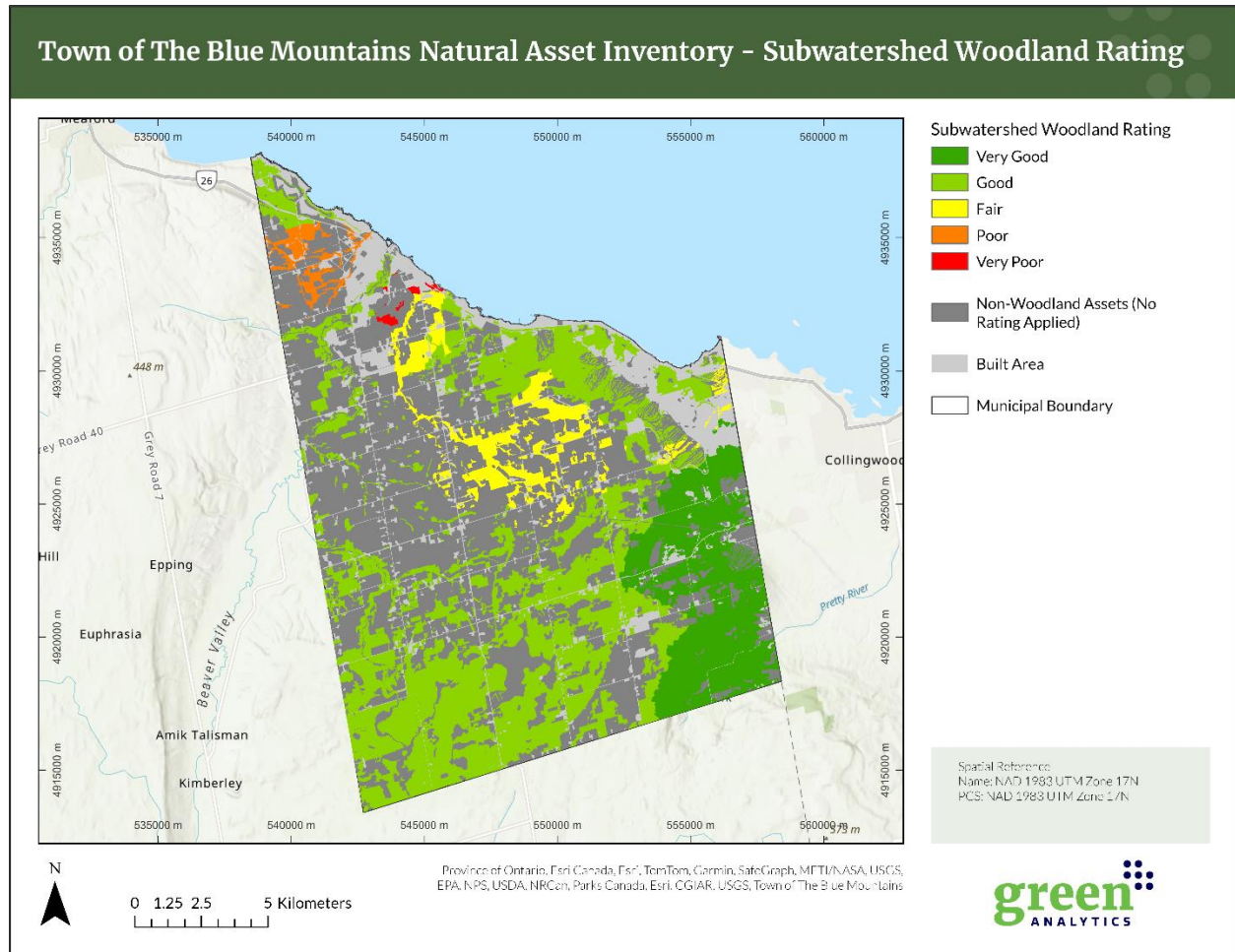


Figure 13-8. Map of natural asset inventory categorized by subwatershed percent woodland rating.

Table 13-8 demonstrates the area of assets by condition rating. Most areas ranked as good or very good, but those in the centre and NW areas, close to the towns and shoreline, had lower ratings. Also, the heavy presence of agriculture reduced the rating.

Table 13-8. Area of woodland natural assets by woodland cover rating.

Condition Rating	Asset Area (ha)
Very Good	2,946
Good	8,584
Fair	1,227
Poor	312
Very Poor	47
Total	13,116

13.9 Percent of Wetland Cover within Subwatersheds

INDICATOR: A percentage assigned to the watersheds, and by extension the assets within them, related to the amount of wetland cover within each watershed.

RATIONALE: According to Environment Canada (2013) the guideline for percent of wetland cover within a watershed is described as: *At a minimum, the greater of (a) 10% of each major watershed and 6% of each subwatershed, or (b) 40% of the historic watershed wetland coverage, should be protected and restored.*

APPROACH: Subwatershed boundaries were overlaid on the natural asset inventory. The total area of all wetland assets was estimated and compared against the total subwatershed area to establish the percent of wetland cover within the subwatershed. All individual wetland assets within the subwatershed were allocated the same condition rating based on the scoring thresholds noted below.

SCORING: The area of wetland assets within each subwatershed was estimated as a percent of the subwatershed's area. Watersheds, and by extension the wetland assets within them, were rated as follows:

- Very Good: subwatersheds with > 10% wetland cover
- Good: subwatersheds with 7 to 10% wetland cover
- Fair: subwatersheds with 5 to 7% wetland cover
- Poor: subwatersheds with 3 to 5% wetland cover
- Very poor: subwatersheds with <3% wetland cover

Figure 13-9 shows the spatial distribution of the percent wetland cover within subwatersheds indicator results. Unlike the woodland cover indicator presented above, in the case of wetlands, Town of The Blue Mountains' assets largely ranked exclusively very poor or fair for this indicator, due to the absence of wetlands in the various subwatersheds.

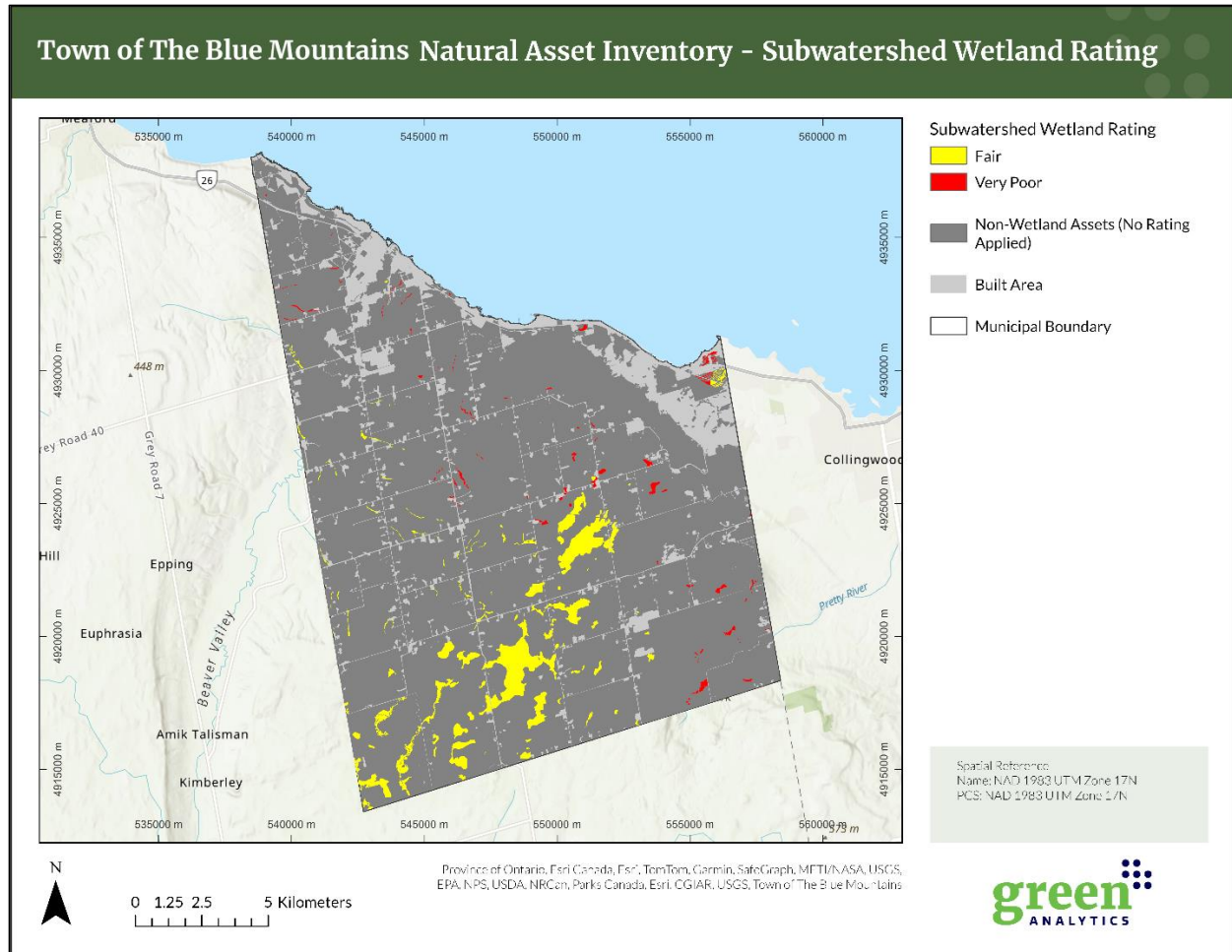


Figure 13-9. Map of natural asset inventory categorized by subwatershed percent wetland rating.

Table 13-9 demonstrates the area of assets across the condition ratings for this indicator. The vast majority of the assets within Town of The Blue Mountains ranked fair for this indicator.

Table 13-9. Area of wetland natural assets by wetland cover rating.

Condition Rating	Asset Area (ha)
Very Good	0
Good	0
Fair	1,038
Poor	0
Very Poor	119
Total	1,156

14 Appendix D: Individual Risk Maps

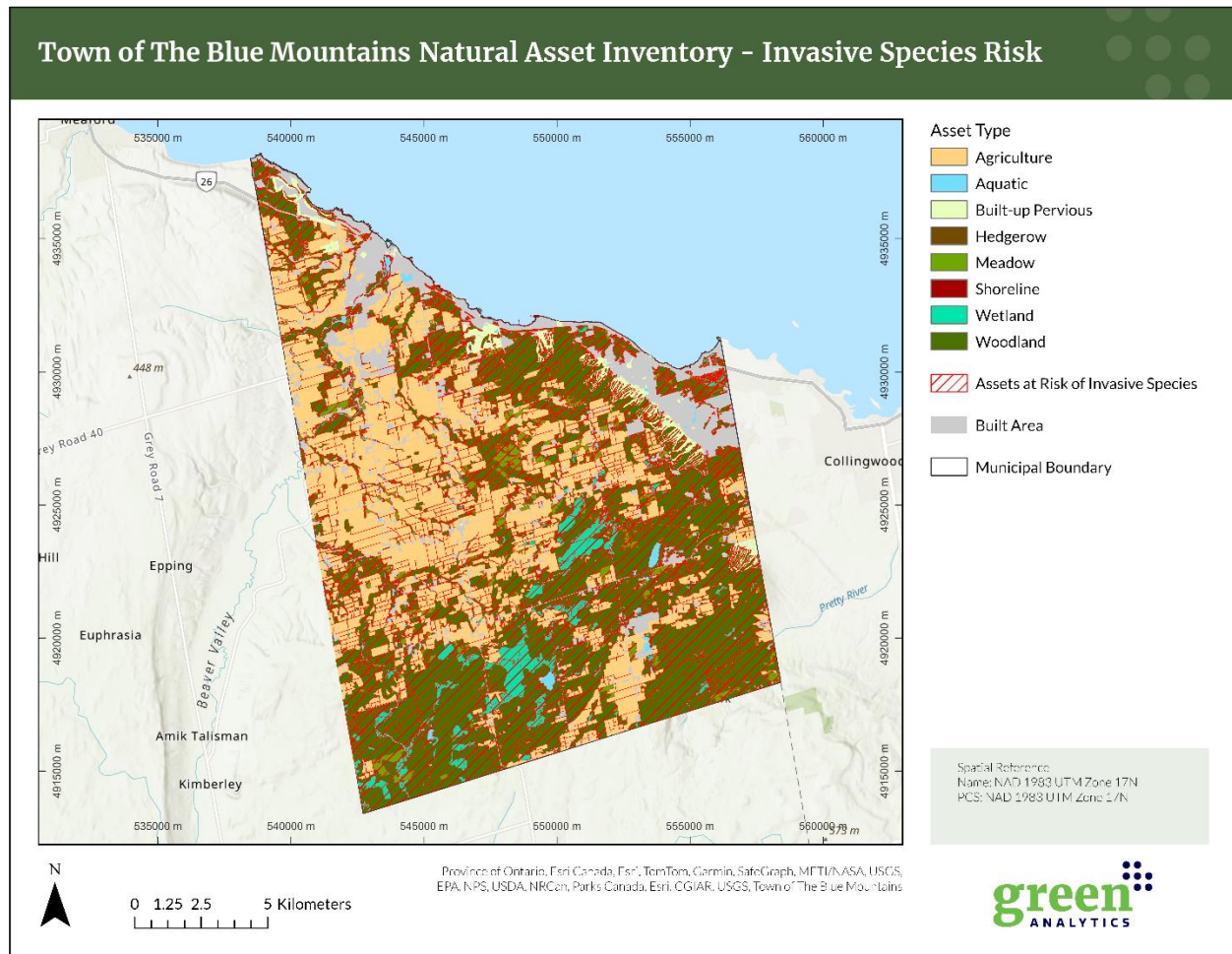


Figure 14-1. Map of assets in Town of The Blue Mountains vulnerable to invasive species risks.

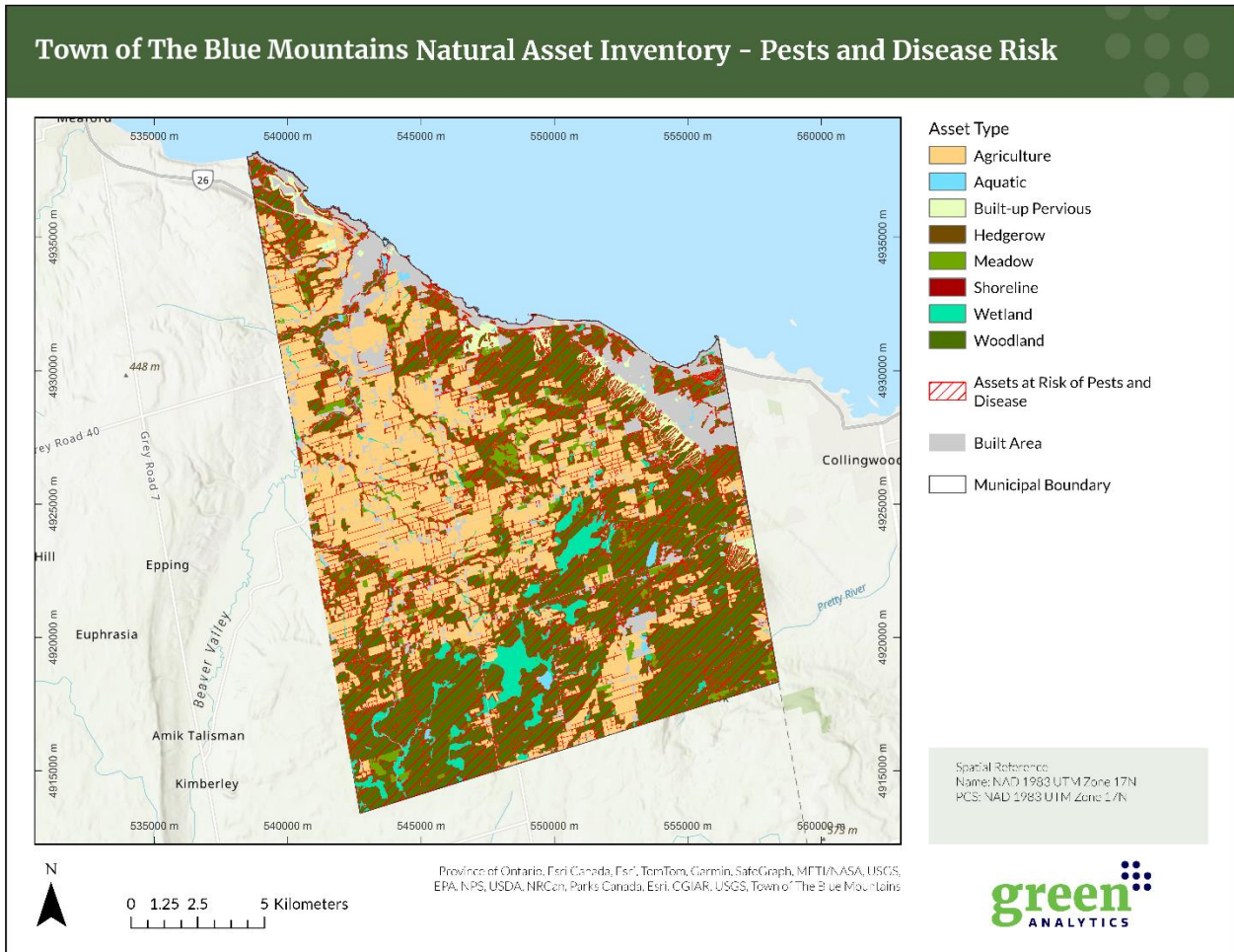


Figure 14-2. Map of assets in Town of The Blue Mountains vulnerable to pests and diseases risks.

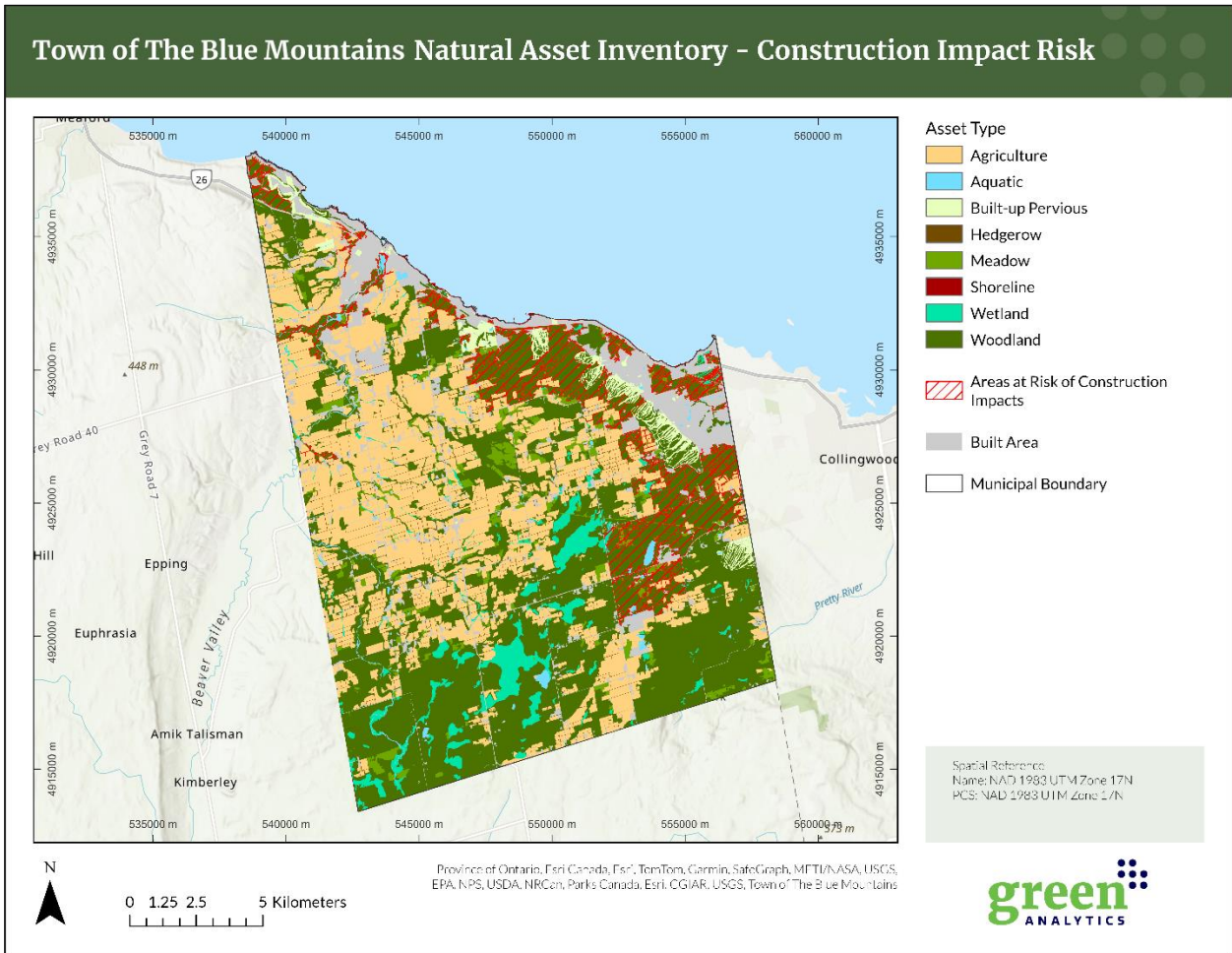


Figure 14-3. Map of assets in Town of The Blue Mountains vulnerable to construction impact risks.

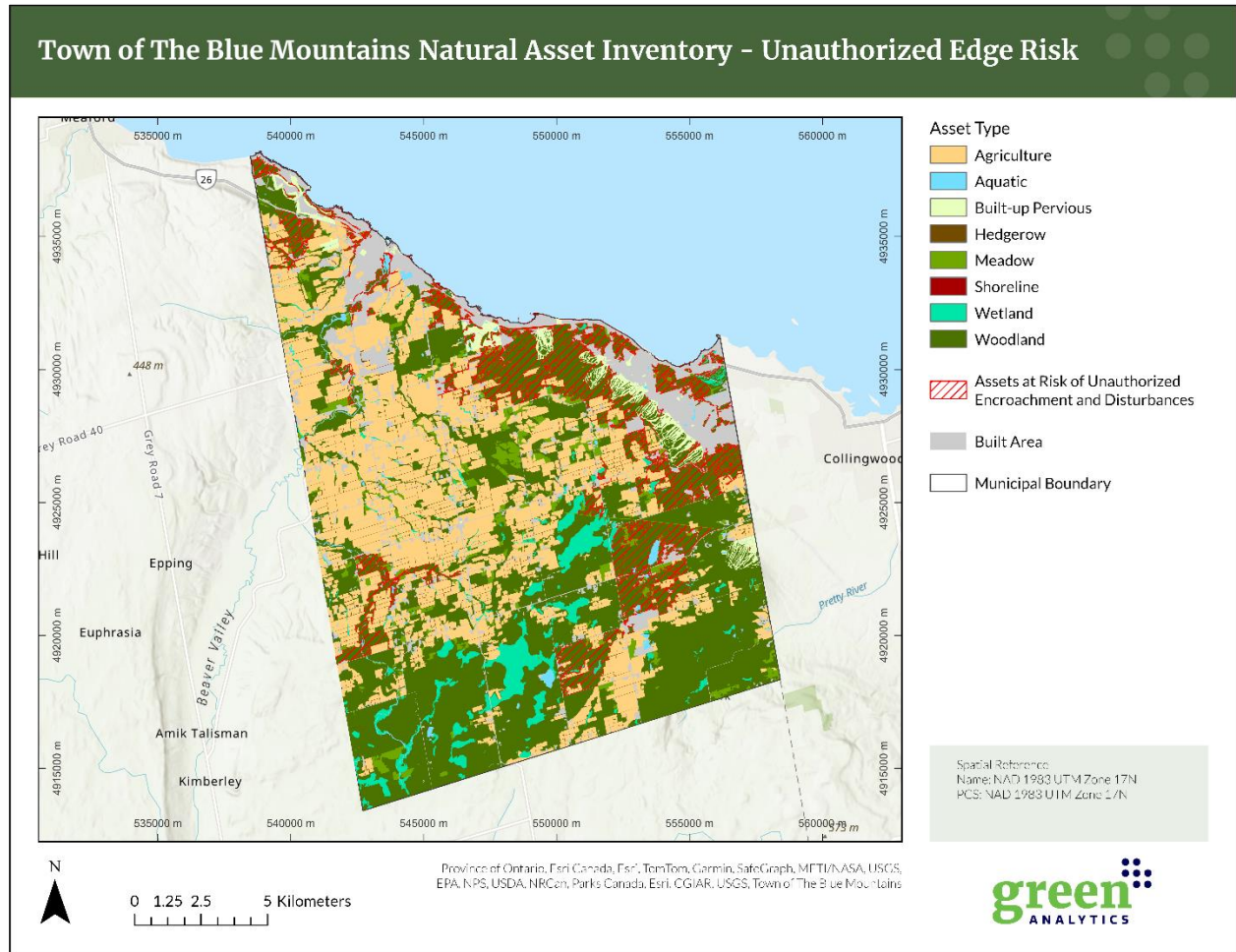


Figure 14-4. Map of assets in Town of The Blue Mountains vulnerable to unauthorized edge encroachments/disturbances risks.

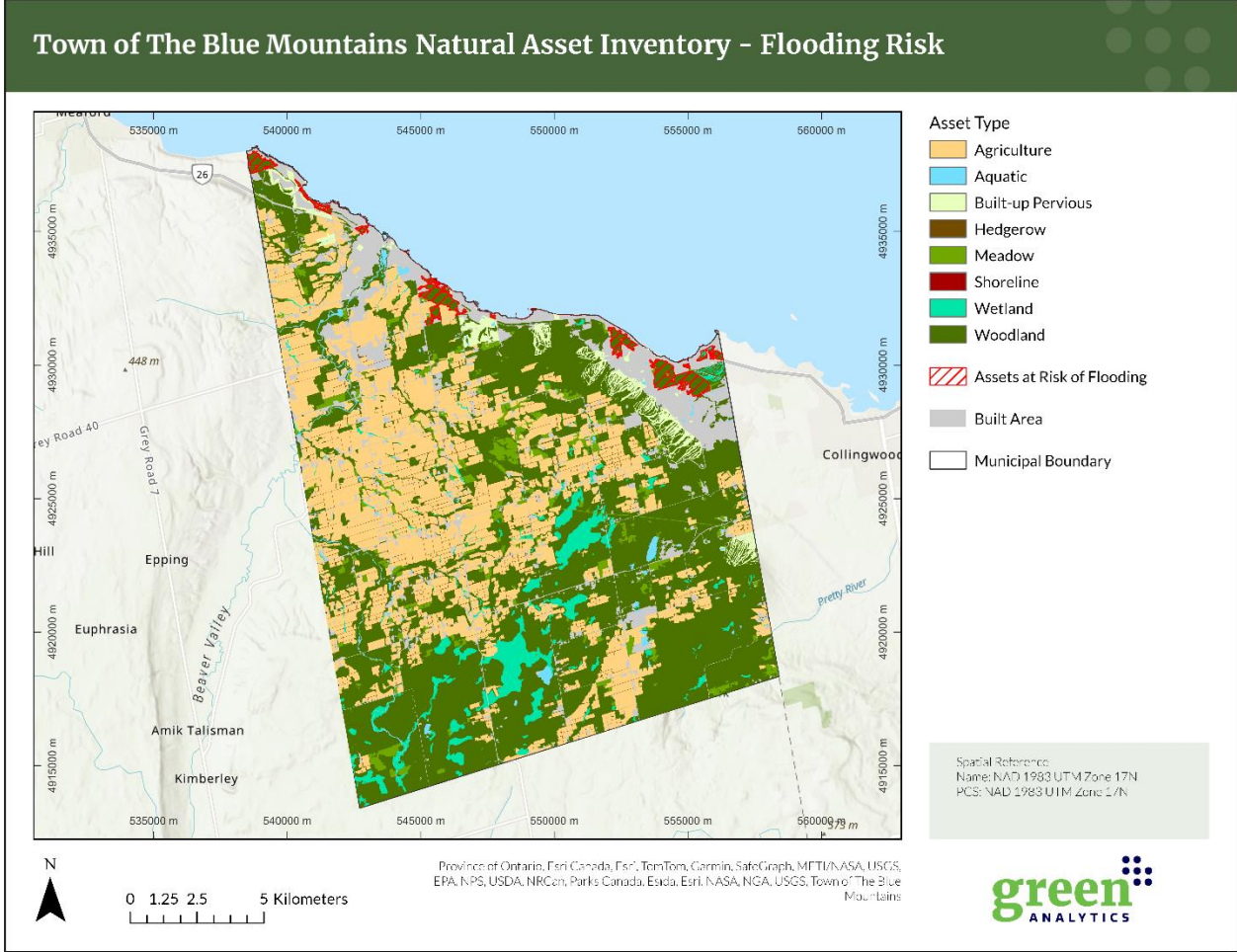


Figure 14-5. Map of assets in Town of The Blue Mountains vulnerable to flooding risks.

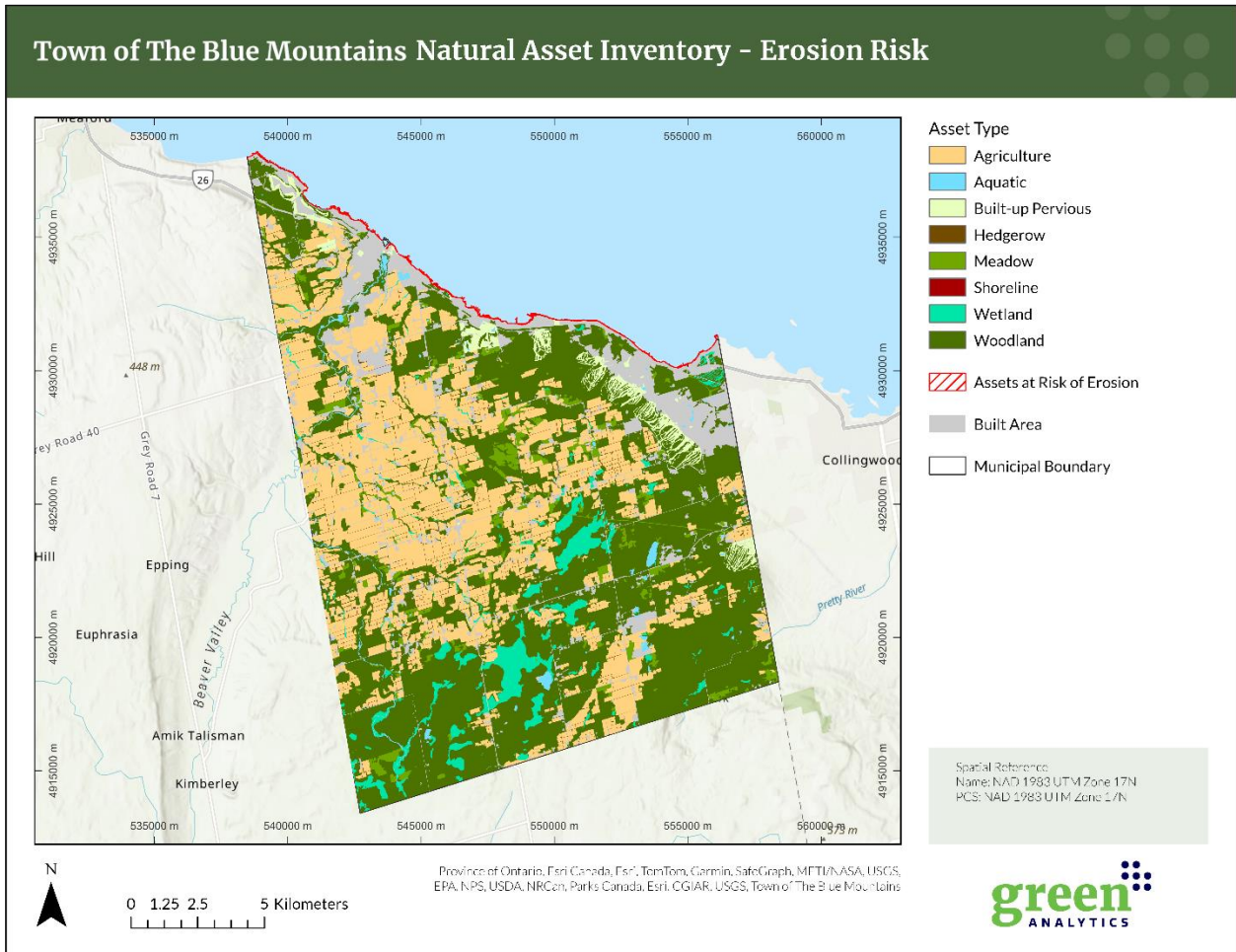


Figure 14-6. Map of assets in Town of The Blue Mountains vulnerable to erosion - shoreline risks.

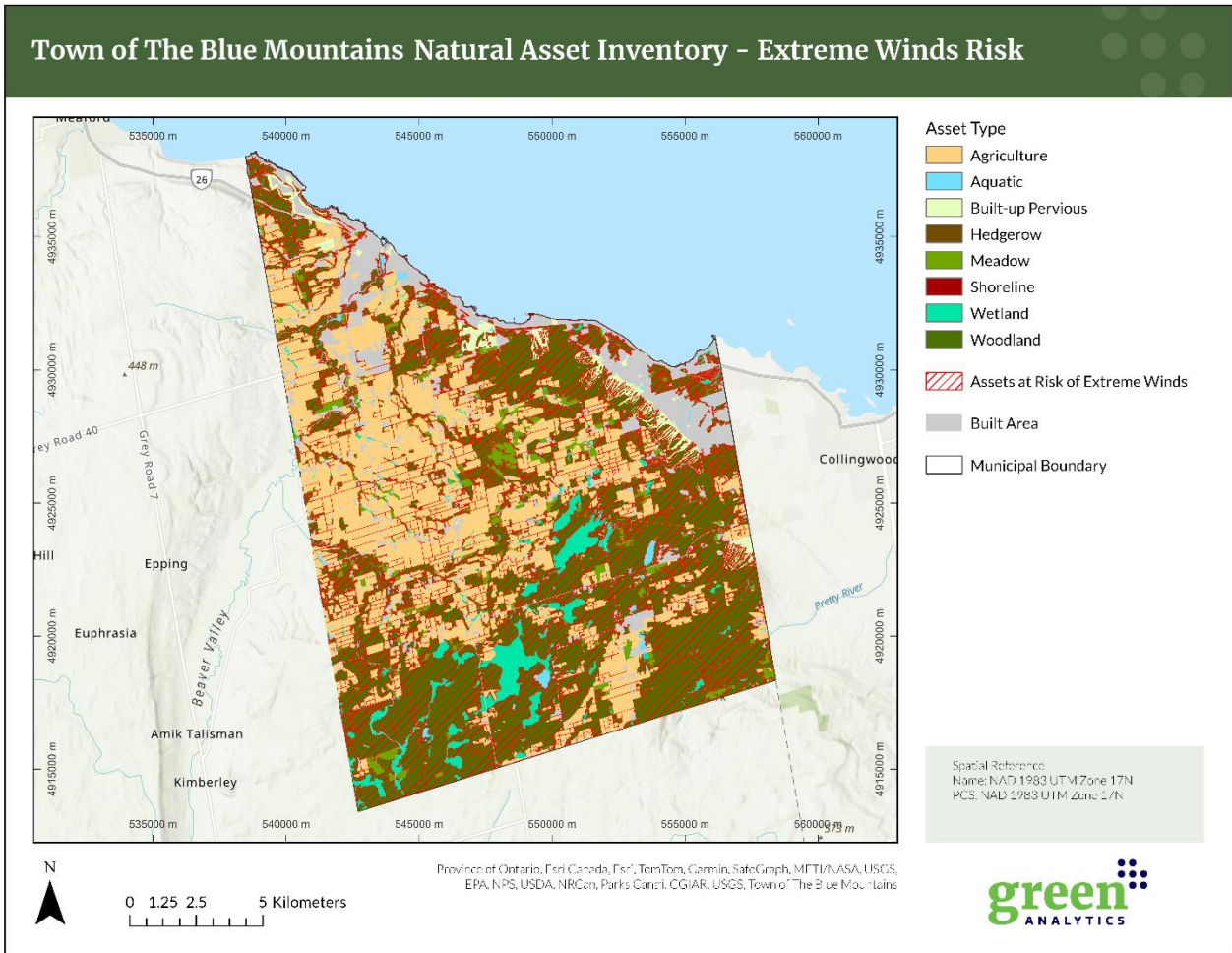


Figure 14-7. Map of assets in Town of The Blue Mountains vulnerable to extreme wind risks.

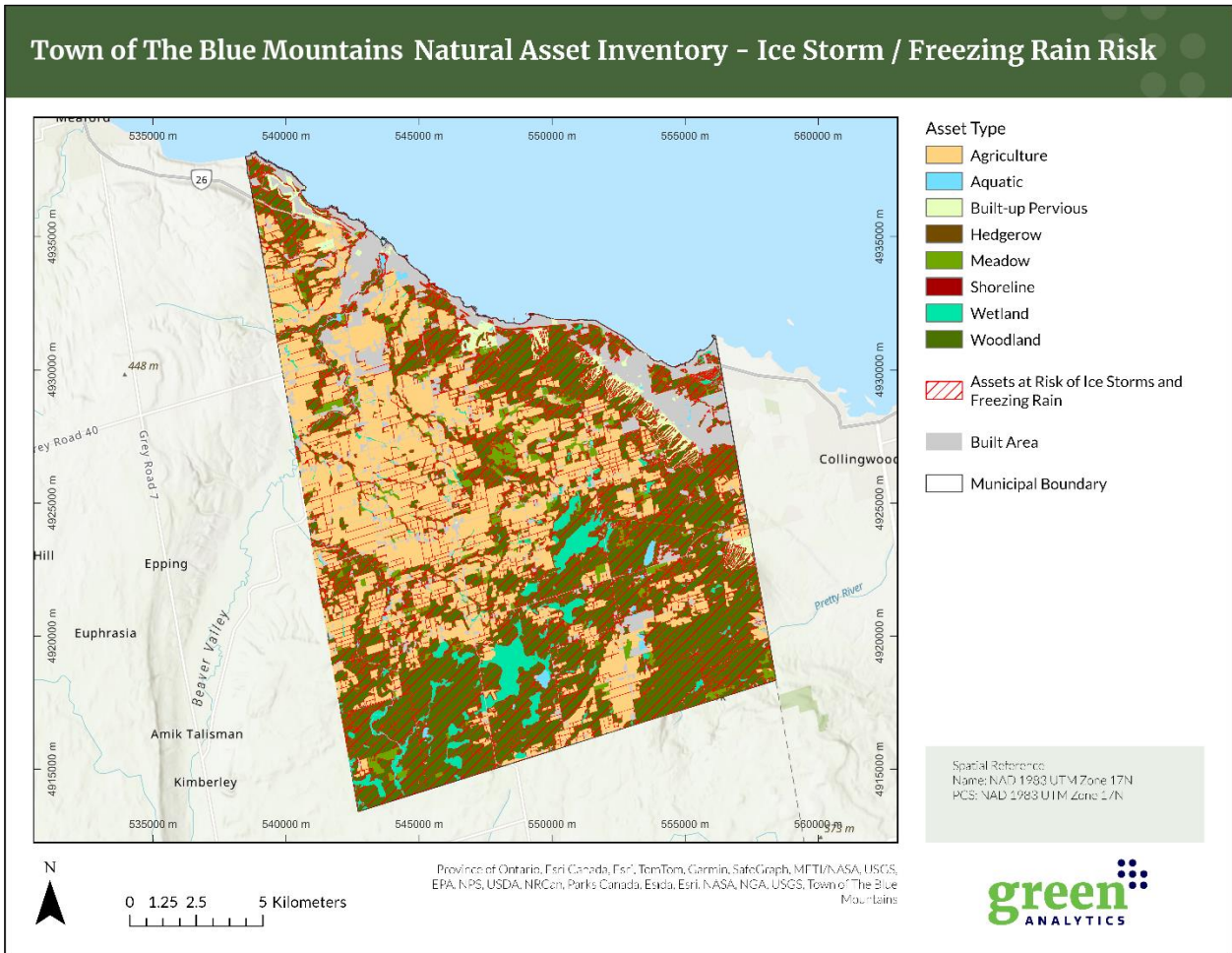


Figure 14-8. Map of assets in Town of The Blue Mountains vulnerable to ice storms / freezing rain risks.

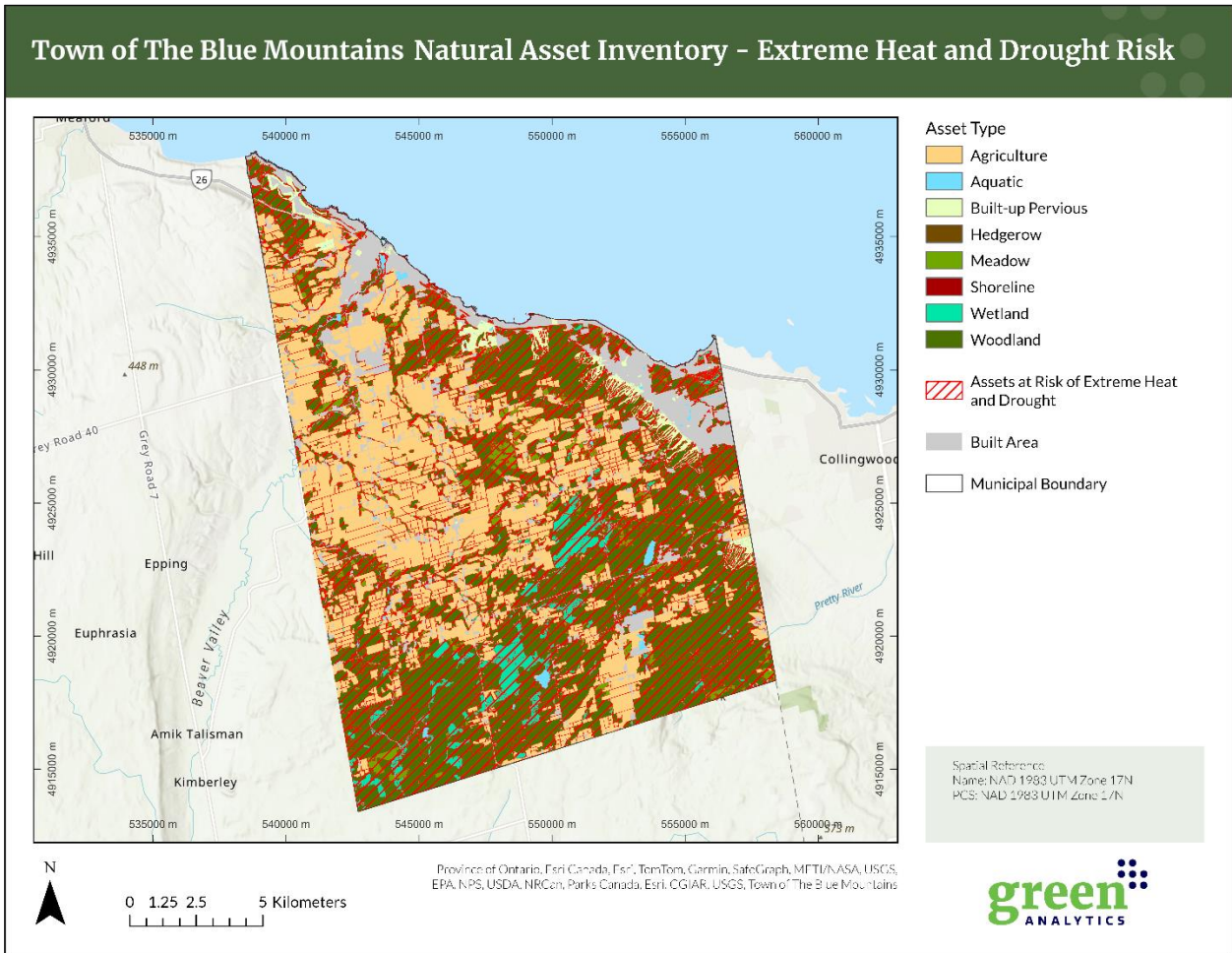


Figure 14-9. Map of assets in Town of The Blue Mountains vulnerable to extreme heat and drought.

Town of The Blue Mountains Natural Asset Inventory - Contamination and Pollution Risk

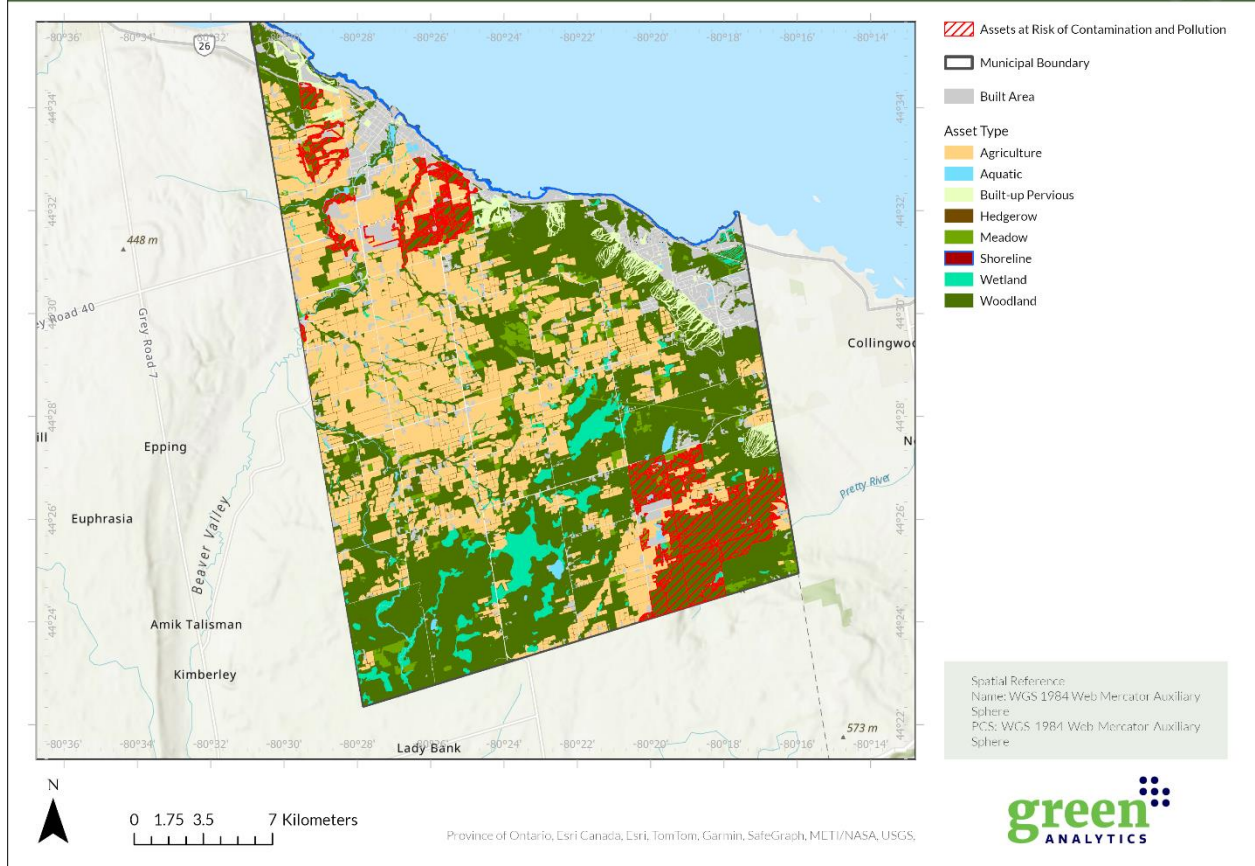


Figure 14-10. Map of assets in Town of The Blue Mountains vulnerable to contamination / pollution risks.

Town of The Blue Mountains Natural Asset Inventory - Land Use Change Risk

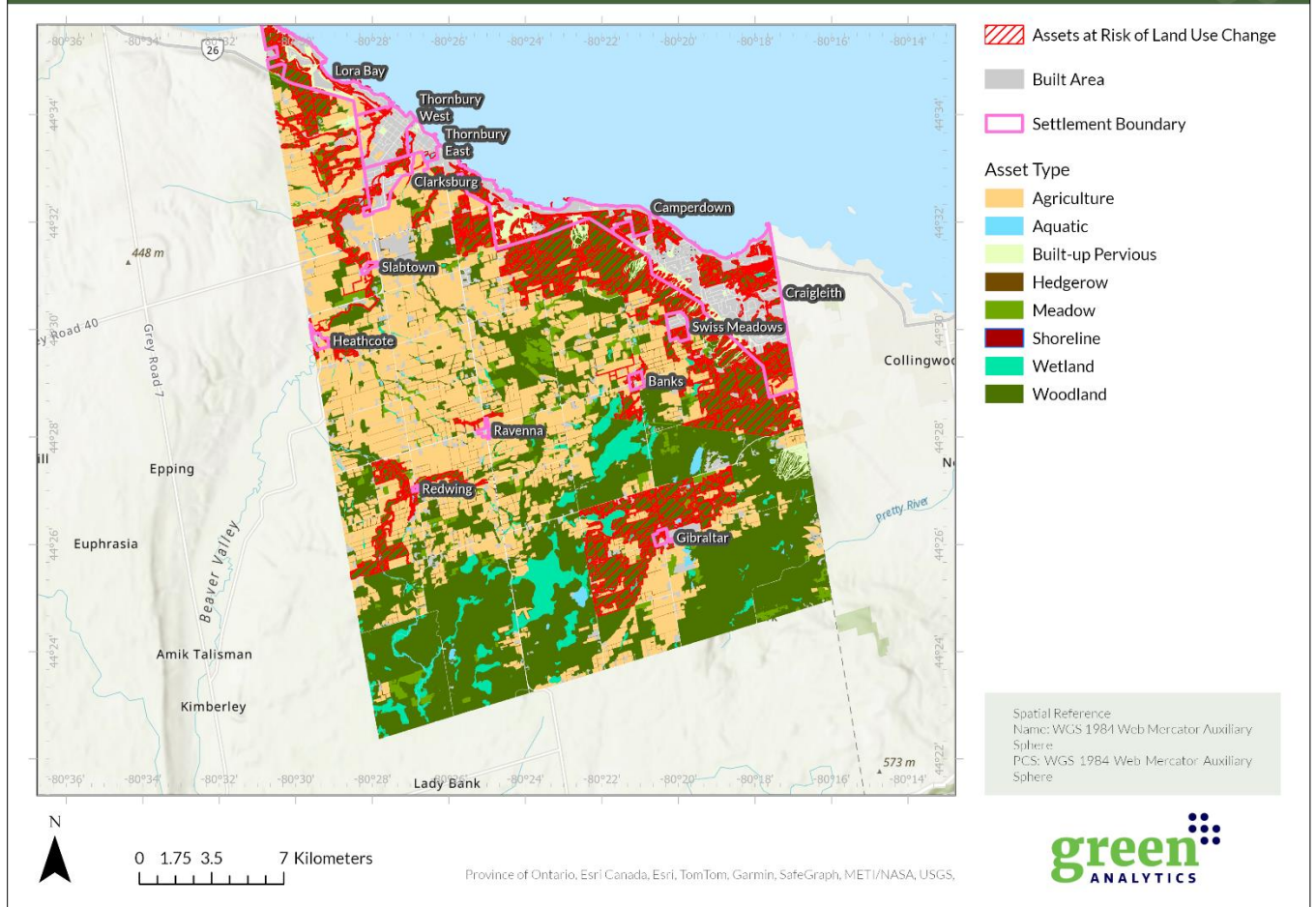


Figure 14-11. Map of assets in Town of The Blue Mountains vulnerable to land use changes.

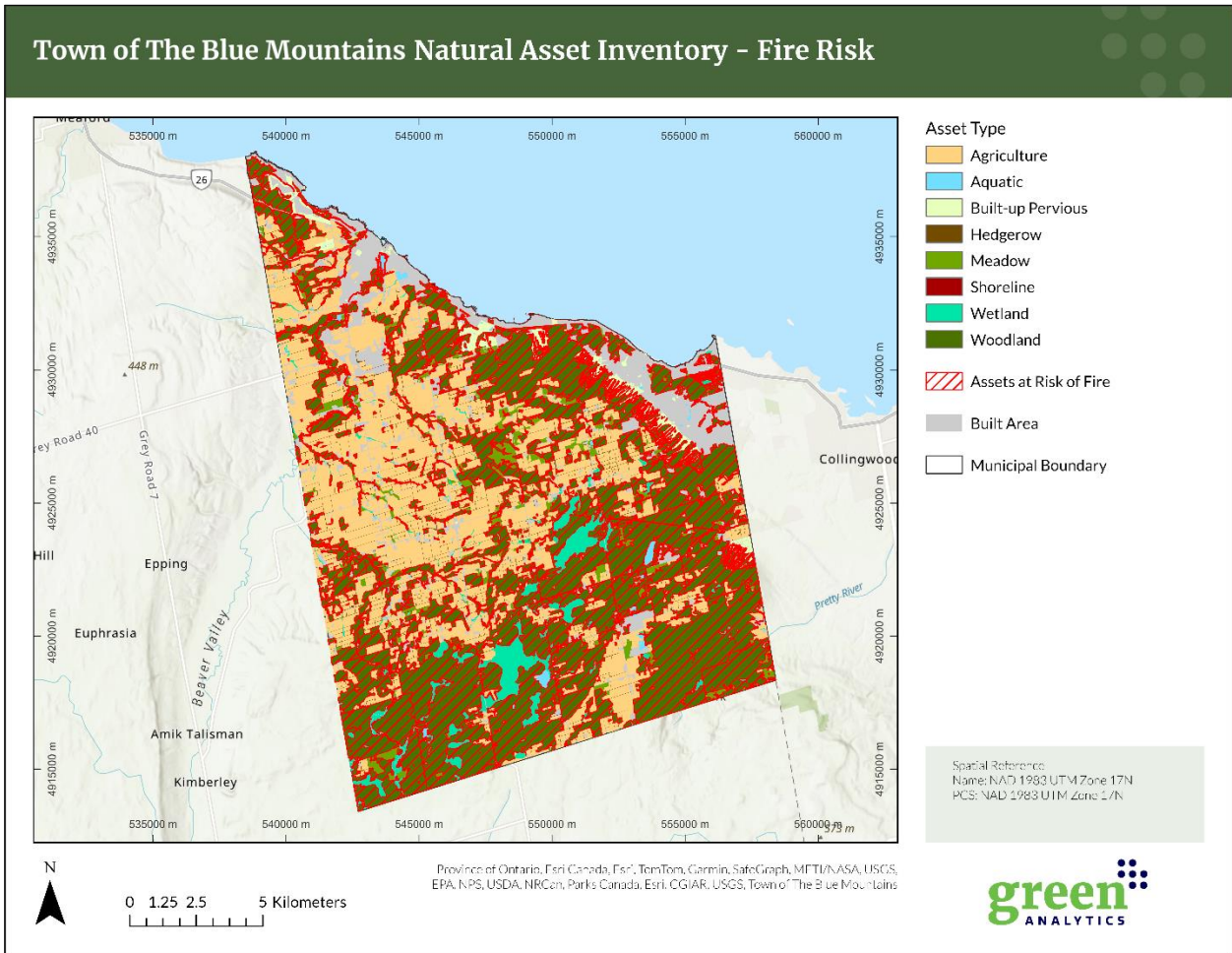


Figure 14-12. Map of assets in Town of The Blue Mountains vulnerable to fire.

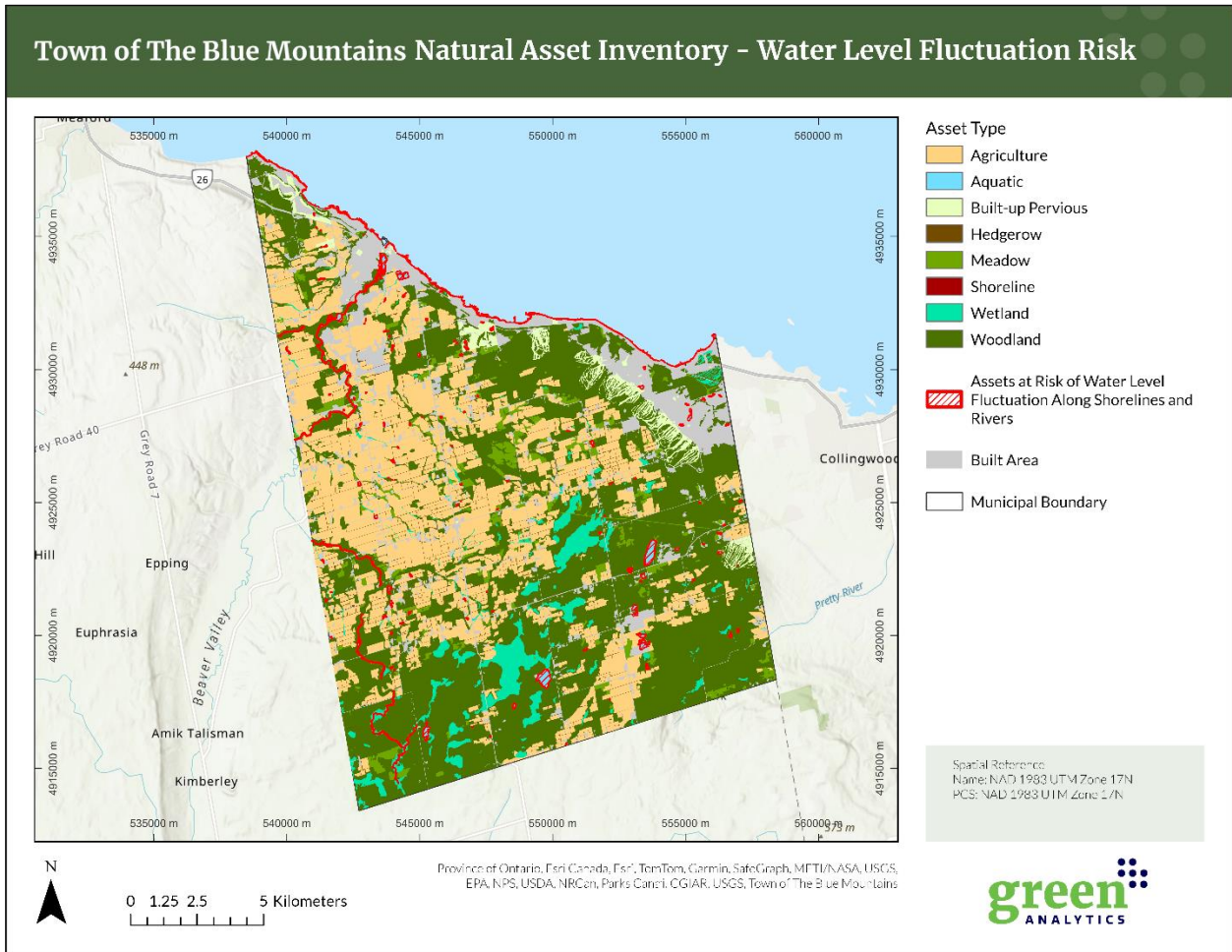


Figure 14-13. Map of assets in Town of The Blue Mountains vulnerable to water level fluctuation along shorelines and rivers.

15 Appendix E: Carbon Sequestration Rates by Land Cover Class

The table below displays the carbon sequestration rates that were used for the natural asset classes within Town of The Blue Mountains. Woodlands and hedgerows have their mean sequestration rates displayed as the values varied by age of the assets.

Table 15-1. Carbon sequestration rates for different natural asset classes within Town of The Blue Mountains.

Ecological Land Classification (ELC) Class	Asset Type	Tonnes C / ha / yr
Deciduous Swamp	Wetland	4.73
Mixed Swamp	Wetland	4.73
Floating-leaved Shallow Aquatic	Wetland	2.14
Thicket Swamp	Wetland	2.02
Deciduous Forest	Woodland	1.93
Deciduous Hedgerows	Hedgerow	1.90
Golf	Golf	1.73
Marsh (Unknown Type)	Wetland	1.59
Meadow Marsh	Wetland	1.59
Shallow Marsh	Wetland	1.59
Submerged Shallow Aquatic	Wetland	1.58
Coniferous Forest	Woodland	1.41
Coniferous Forest	Woodland	1.33
Coniferous Hedgerows	Hedgerow	1.31
Deciduous Forest	Woodland	1.17
Treed Shoreline	Shoreline	1.08
Mixed Forest	Woodland	1.00
Mixed Forest	Woodland	0.78
Deciduous Thicket	Woodland	0.78
Mixed Thicket	Woodland	0.78
Mixed Hedgerows	Hedgerow	0.78
Treed Agriculture	Woodland	0.78
Mixed Meadow	Meadow	0.48
Mixed Pervious	Built-up Pervious	0.48
Park	Built-up Pervious	0.48
Graminoid Meadow	Meadow	0.48
Mixed Grasses	Built-up Pervious	0.48
Agriculture Crop Defined	Agriculture Crop Defined	0.31
Open Agriculture	Agriculture	0.31
Mixed Pervious Surfaces (UAD)	Built-up Pervious	0.31
Agriculture and Undifferentiated Rural Land Use	Agriculture and Undifferentiated Rural Land Use	0.31
Cemetery	Built-up Pervious	0.30
Open Shoreline	Shoreline	0.00

Ecological Land Classification (ELC) Class	Asset Type	Tonnes C / ha / yr
Open Water	Aquatic	0.00
Open Water (Varied Type)	Aquatic	0.00
Open Aquatic	Aquatic	0.00
SWM Pond	Aquatic	0.00
Mixed Ponds	Aquatic	0.00
Water (ESRI)	Aquatic	0.00