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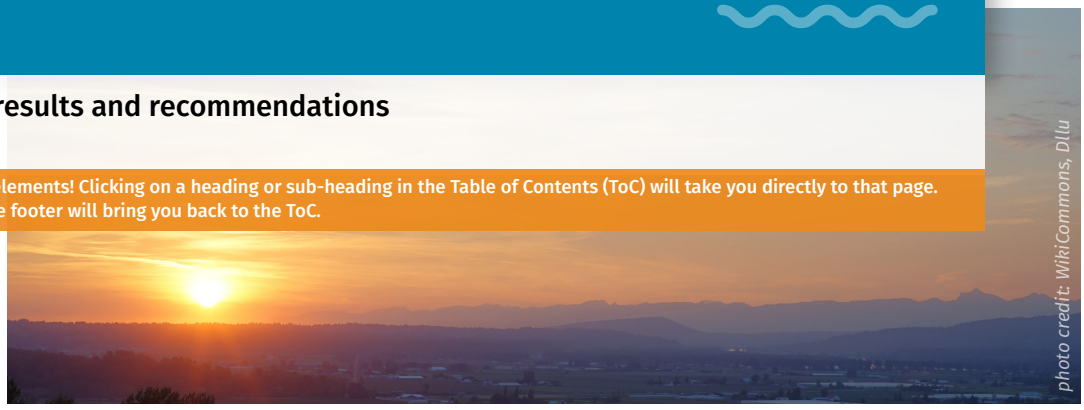
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Toward natural asset management in the

City of Abbotsford

British Columbia

Summary of inventory results and recommendations
September 2021

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Municipal Natural Assets Initiative

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Making Nature Count

Making Nature Count

Invest in Nature

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

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Table of Contents

1 Purpose

This document summarizes the results of a project to develop a natural asset inventory in the City of Abbotsford and documents steps the local government can take to proceed to a full natural asset management initiative.

2 Introduction

What are municipal natural assets

The term *municipal natural assets* refers to the stock of natural resources or ecosystems that a municipality, regional district, or other form of local government could rely upon or manage for the sustainable provision of one or more local government services[1].

Why manage natural assets

A growing number of local governments recognize that it is as important to understand, measure, manage and account for natural assets as it is for engineered ones. Doing so can enable local governments to provide *core* services such as stormwater management, water filtration, and protection from flooding and erosion, as well as *additional* services such as those related to recreation, health and culture. Outcomes of what is becoming known as *municipal natural asset management* can include cost-effective and reliable delivery of services, support for climate change adaptation and mitigation, and enhanced biodiversity.

How to manage natural assets

There are numerous ways for local governments to manage natural assets. The Municipal Natural Assets Initiative (MNAI) uses methodologies and tools rooted in standard asset management and provides a range of advisory services to help local governments implement them. MNAI has developed the methods and tools with significant investments, piloting, refinement, peer review, and documentation of lessons in multiple Canadian provinces. MNAI's mission is to make natural asset management a mainstream practice across Canada, and in support of this, for local governments to accept and use the methodologies and tools in standard ways across the country.

1 *mnai.ca/media/2018/02/finaldesignedsept18mnai.pdf*

What is a natural asset inventory?

Natural asset inventories provide details on the types of natural assets a local government relies upon[2], their condition, and the risks they face. As depicted in Figure 1 and explained in detail in the Annex, a natural asset inventory is the first component of the Assessment phase. The Assessment phase, in turn, is the first of three phases of a full natural asset management project. By itself, an inventory will not give a sense of asset value but is an essential first step in the full natural asset management project.

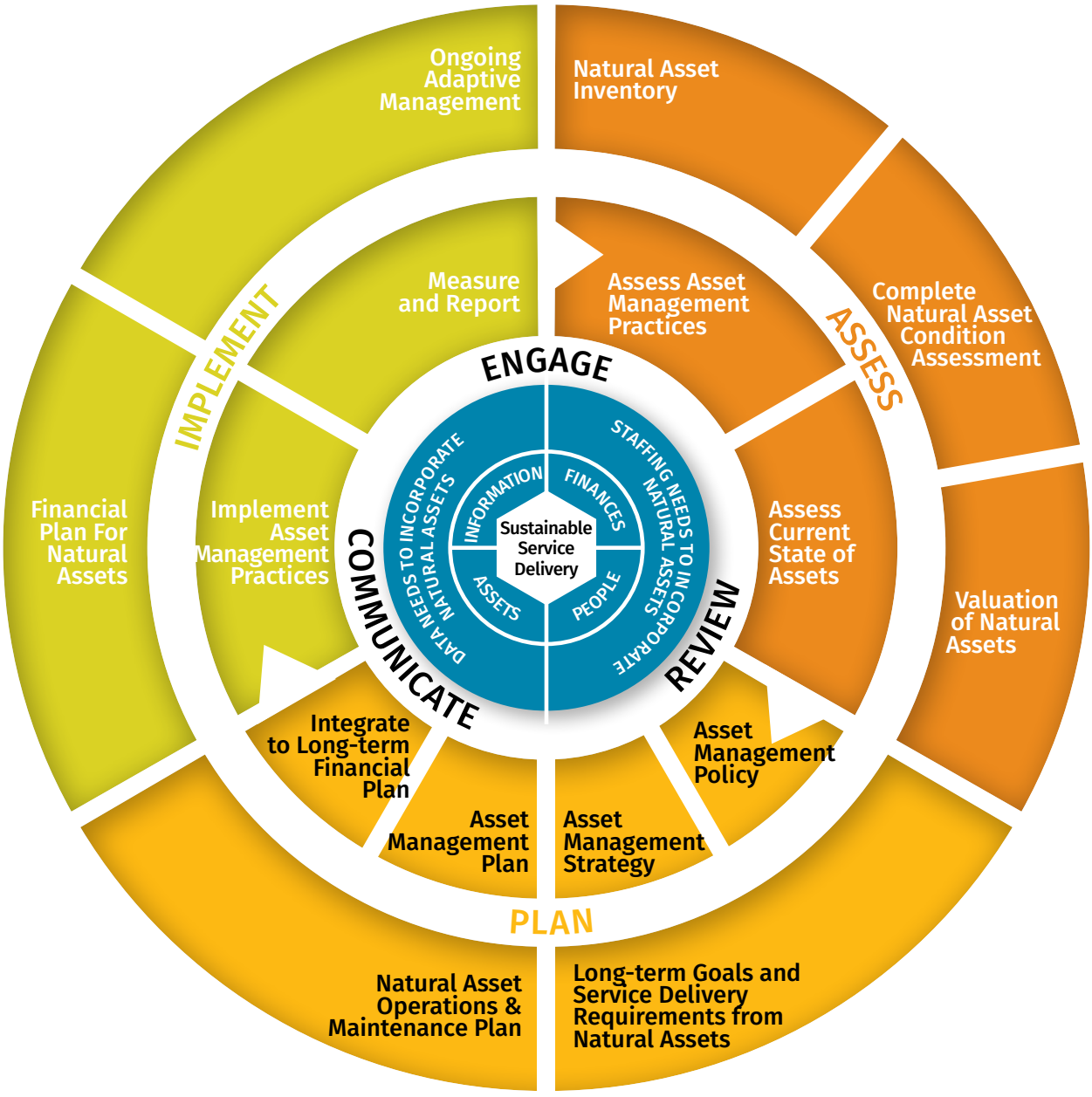


Figure 1: *The Asset Management Process. MNAI has adapted this for use with natural assets.*

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

3 Local government context

3.1. General

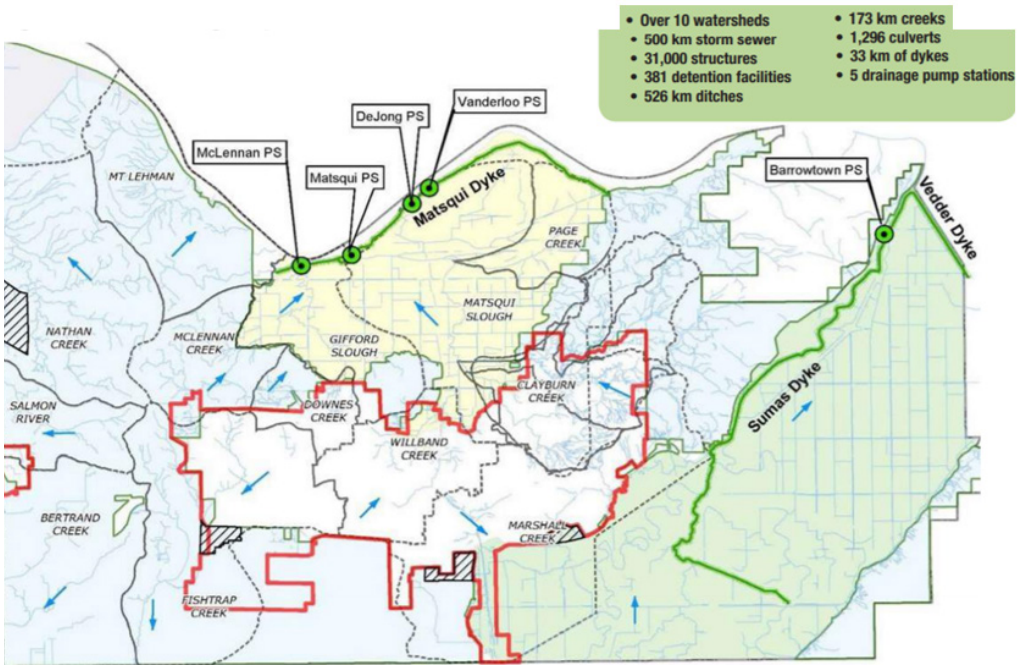


Figure 2: City of Abbotsford[3].

The City of Abbotsford (population ~141,400) in British Columbia is south of the Fraser River and north of the Canada–United States border. It is the largest of the Fraser Valley Regional District cities by population and the largest city by area in the province[4].

The City of Abbotsford relies heavily on its greenways and natural waterways for stormwater management and drinking water and on a river for wastewater management. It also manages and maintains a variety of drainage channels and has a tree retention policy coming into force.

High priority services from natural assets include stormwater, flood and wastewater management. Other services that are of priority for the City of Abbotsford's agricultural community include protection from extreme heat, forest fires and drought.

The City of Abbotsford has three main interests in natural asset management. First is an overall desire to improve decision-making. The City of Abbotsford believes that an enhanced understanding of its natural assets and their service value is crucial to, for example, development decision-making and will help better protect and retain the natural systems that are relied upon for providing services across the municipality.

Second, the City of Abbotsford intends to include natural assets in its Asset Management Strategy and associated long-term financial plans. This will require an understanding of costs to replace natural assets with engineered solutions should a natural asset fail to provide service or be removed.

3 *Wikipedia. Retrieved April 2021 from en.wikipedia.org/wiki/Abbotsford,_British_Columbia*

4 *Engineering and Regional Utilities, Master Plans (June 2018). City of Abbotsford. Retrieved April 2021 from www.abbotsford.ca/sites/default/files/docs/city-hall/2018 Utilities Master Plans - Drainage - Wastewater - Water.pdf*

Third, a natural asset inventory will help the City of Abbotsford achieve 2013 Community Sustainability Strategy outcomes.

3.2. Asset management readiness assessment

As part of inventory development, MNAI helps local governments determine their overall state of asset management maturity. To do this, MNAI has adapted the Federation of Canadian Municipalities (FCM)'s asset management readiness assessment tool[5] to help local governments measure their progress on both asset management and natural asset management in four competency areas, with each area describing outcomes based on five levels of progress or maturity.

The completed readiness assessment helps local governments prioritize actions that increase their effectiveness in managing all assets, including natural ones.

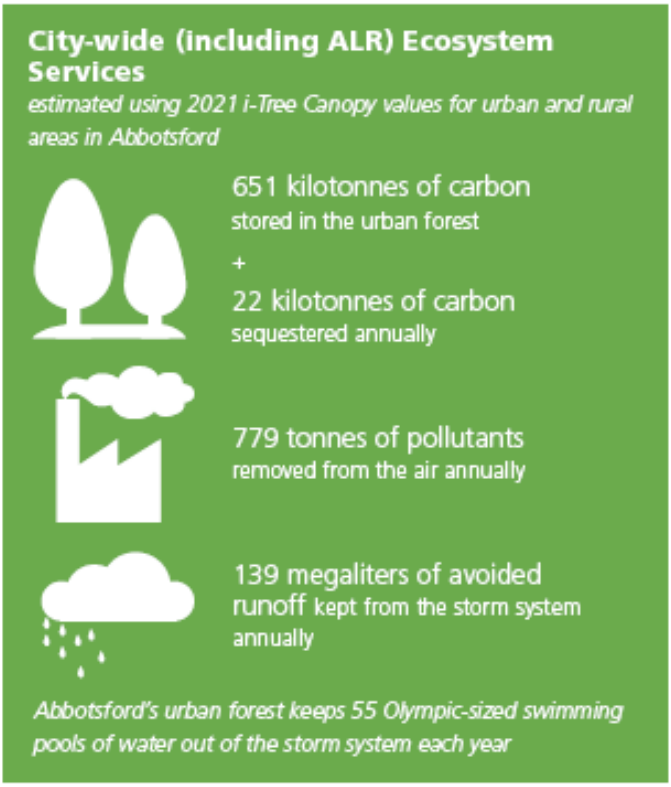
The City of Abbotsford considers itself in the early stages of formalizing asset management and is in its first cycle of the process in relation to the Asset Management BC Framework for Sustainable Service Delivery. In terms of policy and governance, the City of Abbotsford has an asset management strategy that is guiding activities for the next five years, but specific objectives have not yet been included for natural assets. The City of Abbotsford has not yet defined the benefits that natural assets deliver, except for the urban forest where benefits have been identified and quantified to some degree in the draft Urban Forestry Strategy (v4)[6].

City-wide ecosystem services values from Abbotsford's urban forest were estimated using i-Tree Canopy[2]. The economic value of carbon storage is estimated at $119 million, with an additional $4 million of carbon being sequestered yearly. The value of air pollution removal is estimated at $438 thousand per year and avoided runoff at $409 thousand per year.

The replacement value of the City's 11,000 inventoried trees was estimated at nearly 6 million dollars using i-Tree Eco. The inventory represents only a fraction of the City's public trees because many more uninventoried trees are found in forests on City managed lands.

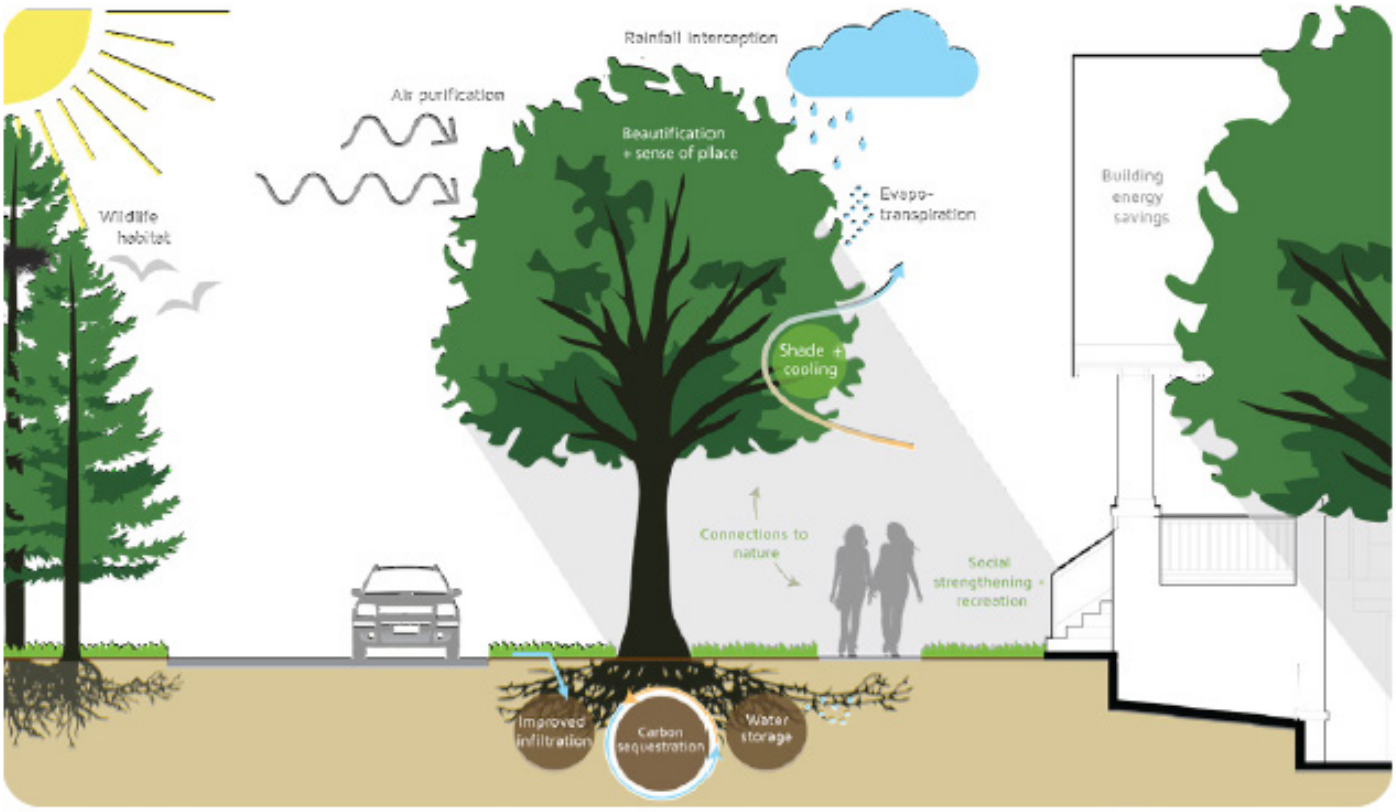
2 USDA I-Tree Canopy 2021 values

Ecosystem Service	Amount per m² of canopy	$ per ha of canopy
Carbon sequestered	.258 kg/yr	$473.43
Carbon stored	7.685 kg	$14,101.61
Avoided runoff	1.637 L/yr	$48.29
PM2.5 removed	0.335 g/yr	$37.47
PM10 removed	1.485 g/yr	$6.36
Carbon monoxide removed	0.089 g/yr	$0.06
Nitrogen dioxide removed	0.799 g/yr	$0.11
Ozone removed	5.618 g/yr	$7.72
Sulfer dioxide removed	0.304 g/yr	$0.02



5 *See fcm.ca/sites/default/files/documents/resources/tool/asset-management-readiness-scale-mamp.pdf for details*

6 *City of Abbotsford, 2021.*



The urban forest provides many important services to our community.

Council has endorsed in principle the draft Urban Forest Strategy. The Strategy identifies the need to develop an asset management policy over the short-term, establish a cross-functional asset management team, and acquire appropriate software.

There is a champion on the senior leadership team responsible for asset management, but a designated full-time lead for asset management is still needed. In terms of accountability, the asset management strategy has only gone to the Committee of the Whole, meaning Council still needs to approve funding for priority improvements in the strategy.

The City of Abbotsford is at a relatively early stage of developing its asset data, with partial information about the condition of critical assets. It has not determined lifecycle investment requirements for all major asset classes and work is still needed to ensure that maintenance leads to updating the condition of the assets in the register. In addition, the City of Abbotsford has not yet developed performance measures or levels of service for engineered or natural assets.

Because the City of Abbotsford is at an early stage of formalizing asset management, it does not have a common, structured approach to asset investment planning across departments, and each department determines its needs separately. There is also not yet a documented approach to investment planning related to natural assets. Budgeting is done based on a combination of historical values and new priorities and the City of Abbotsford has not yet developed long-term financial plans.

4 Natural asset inventory

4.1. Inventory overview

MNAI's natural asset inventories have two main components to express natural asset information: an asset registry (which is a tabular representation of the data) and an online dashboard. MNAI provided the registry to the City of Abbotsford in an Excel file and the dashboard as a website address. Information on the condition of the assets is a subset of the inventory and is depicted in both the registry and dashboard.

4.2. Inventory data

To establish the inventory, MNAI obtained data from the City of Abbotsford, GeoBC and Metro Vancouver's open data portal. MNAI combined the spatial data layers to establish a comprehensive depiction of natural assets. The resulting inventory is, of course, only as current as the data upon which it relies. For example, it is possible that areas that are classified as forest in the current iteration of the inventory may have recently been cleared and converted to agriculture lands. This speaks to the imperative to keep the inventory and hence the data upon which it is based up-to-date. Table 1 describes the data sources used to develop the inventory and condition assessment.

TABLE 1: SUMMARY OF DATA USED

DATASET NAME	SOURCE	PURPOSE
Abbotsford_Boundary	City of Abbotsford Open Data Hub	Used to delineate study area
Land Cover Classification 2014 – 5m Hybrid (Raster)	Metro Vancouver Open Data	Used to create the base natural asset inventory
Annual Crop Inventory 2020	Government of Canada; Agriculture and Agri-Food Canada; Science and Technology Branch	Used to add in agriculture information to the base natural asset inventory
FWA_Wetlands_Poly	GeoBC	Used to add in any missing wetlands data to the natural asset inventory
Lake%2C_Marsh_%26_River_Bank	Abbotsford	Used to add waterbody/wetland assets to natural asset inventory
Airport_Boundary	City of Abbotsford Open Data Hub	Used to insert polygon representing airport into natural asset inventory
FWA_Assessment_Watersheds_Poly	GeoBC	Used to assign assets to appropriate watershed and summarize assets by watershed in dashboard

TABLE 1: SUMMARY OF DATA USED

DATASET NAME	SOURCE	PURPOSE
Digital Road Atlas (DRA) - Demographic Partially-Attributed Roads	GeoBC	Used to perform road density condition assessment
Agricultural_Land_ Reserve	Abbotsford	Used to summarize asset area within the ALR and indicate which assets are within ALR
Aquifers_-_Province	Abbotsford	Each aquifer has its own column in the asset inventory with associated asset area assigned to it
Creeks_and_Streams	Abbotsford	Used to summarize length of features within assets. Name of feature also added where possible
Dykes	Abbotsford	Use to assign name and length of dyke which crossed through an asset to relevant assets using a spatial join
Floodplains	Abbotsford	Used to assign asset area within floodplains and floodplain area name
Major Streams	Abbotsford	Used to summarize length of streams within an asset
Nests	Abbotsford	Count of nests within assets assigned to each asset. Spatial join of asset ID to nests will link nests to assets in dashboard
Official_Community_ Plan_-_Land_Use	Abbotsford	Used to assign majority land use designations to assets
Sensitive_Ecosystems	Abbotsford	Assets were designated as being in a sensitive ecosystem area and asset area with sensitive ecosystem determined
Trails	Abbotsford	Used to summarize length of trails in assets and assign trail name to associated asset
Reserve_Boundary	City of Abbotsford Open Data Hub	Used to indicate assets located on reserve land
Soil__Types_Classification	City of Abbotsford Open Data Hub	Used to assign majority soil type to assets
Steep_Slope	Abbotsford	Used to determine assets within steeply sloped areas and assign the majority slope to those assets
Parks	Abbotsford	Used to determine area of assets within parks and assign park name to assets within that park
Land_Parcels	Abbotsford	Used to assign ownership details to assets (e.g., asset area designated as municipal government type)

The inventory project defined a total of 3,602 individual assets covering 27,483 hectares (ha), as noted in Table 2. The majority of this area was agriculture, followed by forest. Note that the City of Abbotsford has more than 1,000 ha of land designated as City Parkland. This area is captured in a combination of forest assets, grassland assets and shrubland assets (depending on what the dominant landcover is for the given City Parkland). The City Parkland data is contained in the City of Abbotsford canopy cover dataset, which could not be reconciled with the other datasets provided by the City within the time and budget constraints of the current project. The urban park asset type in the table below includes all features from the "Parks" data layer that the City of Abbotsford provided, excluding areas captured in the base landcover data layer. Note also that the asset inventory summary presented in Table 2 captures water and wetland assets as depicted in the base landcover data layer and the lakes, marshes, and rivers dataset that the City of Abbotsford provided. The City of Abbotsford also provided watercourse data as line data, which MNAI incorporated into the inventory as an asset attribute, not as an asset type. These attributes are clearly demonstrated in the asset registry and the inventory dashboard (both of which are described below).

TABLE 2: SUMMARY OF NATURAL ASSETS BY TYPE

NATURAL ASSET TYPE	NUMBER OF ASSETS	TOTAL AREA (HA)	AVERAGE ASSET AREA (HA)
Agriculture	894	16,070	17.97
Flooded Vegetation	6	0.52	0.09
Forest	526	7,998	15.21
Grassland	833	1,762	2.12
Shrubland	274	151	0.55
Urban Park	110	146	1.32
Water	337	1,164	3.45
Wetland	622	193	0.31
Total	**3,602**	**27,483**	**7.63**

Figure 3 shows the spatial distribution of the natural assets.

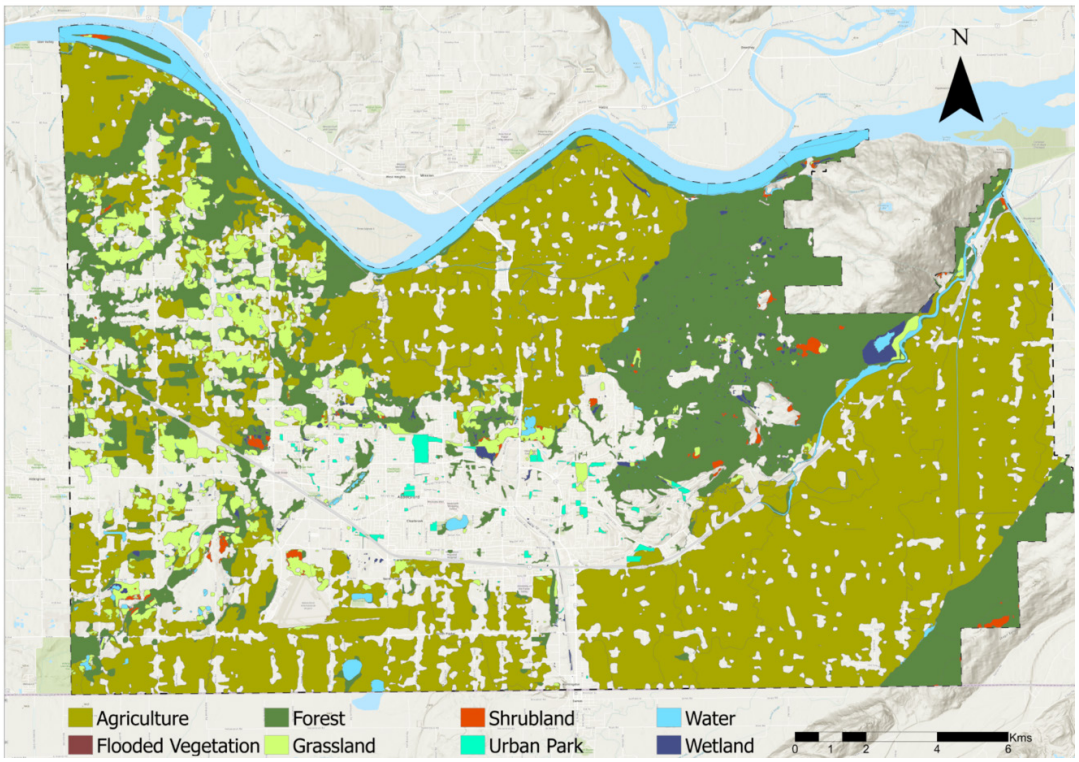


***Figure 3**: Spatial distribution of natural assets.*

4.3. Asset registry

Each asset within the inventory has a unique identification number that allows individual assets to be selected, analyzed, and the corresponding data manipulated as required. For example, changes in condition can be noted for individual assets. Information on each asset is housed in an asset registry. Table 3 is an excerpt from the City of Abbotsford's registry showing natural asset characteristics and details.

TABLE 3: EXCERPT FROM THE REGISTRY

Natural Asset Registry

Asset ID	Sub-Asset ID	Asset Type	Asset Area (ha)	Watershed	Waterbody Name	Sensitive Ecosystem Area (ha)	OCP Land Uses	Floodplain Area (ha)	Floodplain Area	Total Creeks Streams Length (km)	Dykes Length (km)	Dykes Name	Park Area (ha)	Park Name	Reserve Land (ha)	Interior Forest %	Adjacent Land Use Score	Permeability Score	Relative Size Score	Road Density Score	Total Score
AGR100	AGR100-1	Agriculture	0.01	Unknown C		0.00	Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	6	5	1	10	22
AGR101	AGR101-1	Agriculture	0.01	Unknown C		0.00	Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	6	5	1	10	22
AGR1017	AGR1017-1	Agriculture	12.51	Unknown C		7.03	Agriculture	0.00		0.06	0.06		0.00		0.00	0.00	7	5	1	10	23
AGR1017	AGR1017-2	Agriculture	49.58	McLennan Creek		2.17	Agriculture /General Industrial	0.00		2.20	2.20		0.00		0.00	0.00	6	5	1	10	22
AGR1018	AGR1018-1	Agriculture	6.92	Fraser River D		2.70	Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	8	5	1	10	24
AGR1019	AGR1019-1	Agriculture	12.71	Fraser River D		5.35	Agriculture	0.00		0.27	0.27		0.00		0.00	0.00	7	5	1	10	23
AGR1020	AGR1020-1	Agriculture	51.20	Fraser River D		0.29	Agriculture	0.00		0.23	0.23		0.00		0.00	0.00	7	5	1	1	14
AGR105	AGR105-1	Agriculture	0.09	Unknown C		0.00	Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	7	5	1	10	23
AGR106	AGR106-1	Agriculture	0.68	Unknown B		0.00	Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	4	5	1	1	11
AGR106	AGR106-2	Agriculture	0.87	Unknown C		0.00	Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	4	5	1	1	11
AGR107	AGR107-1	Agriculture	0.29	Unknown C		0.00	Agriculture	0.00		0.10	0.10		0.00		0.00	0.00	6	5	1	1	13
AGR108	AGR108-1	Agriculture	1.17	Unknown C		0.00	Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	5	5	1	10	21
AGR109	AGR109-1	Agriculture	0.15	Marshall Creek		0.00	Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	4	5	1	1	11
AGR110	AGR110-1	Agriculture	0.01	Marshall Creek		0.00	Institutional/Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	6	5	1	1	13
AGR112	AGR112-1	Agriculture	0.19	Unknown B		0.00	Agriculture	0.00		0.00	0.00		0.00		0.00	0.00	4	5	1	1	11
AGR113	AGR113-1	Agriculture	0.01	Marshall Creek		0.00	High Impact Industrial	0.01	B	0.00	0.00		0.00		0.00	0.00	7	5	1	1	14
AGR114	AGR114-2	Agriculture	74.18	Unknown B		15.28	Agriculture	0.00		3.11	3.11		0.00		0.00	0.00	6	5	1	1	13
AGR115	AGR115-1	Agriculture	0.03	Marshall Creek		0.00	High Impact Industrial	0.03	B	0.00	0.00		0.00		0.00	0.00	8	5	1	1	15
AGR116	AGR116-1	Agriculture	0.01	Marshall Creek		0.00	High Impact Industrial	0.01	B	0.00	0.00		0.00		0.00	0.00	7	5	1	1	14
AGR117	AGR117-1	Agriculture	0.01	Marshall Creek		0.00	High Impact	0.01	B	0.00	0.00		0.00		0.00	0.00	6	5	1	1	13
Total			**27482.55**			**7,373.59**		**12,606.66**		**1,199.92**	**1,199.92**		**1,894.00**		**271.07**						

4.4. Online dashboard

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

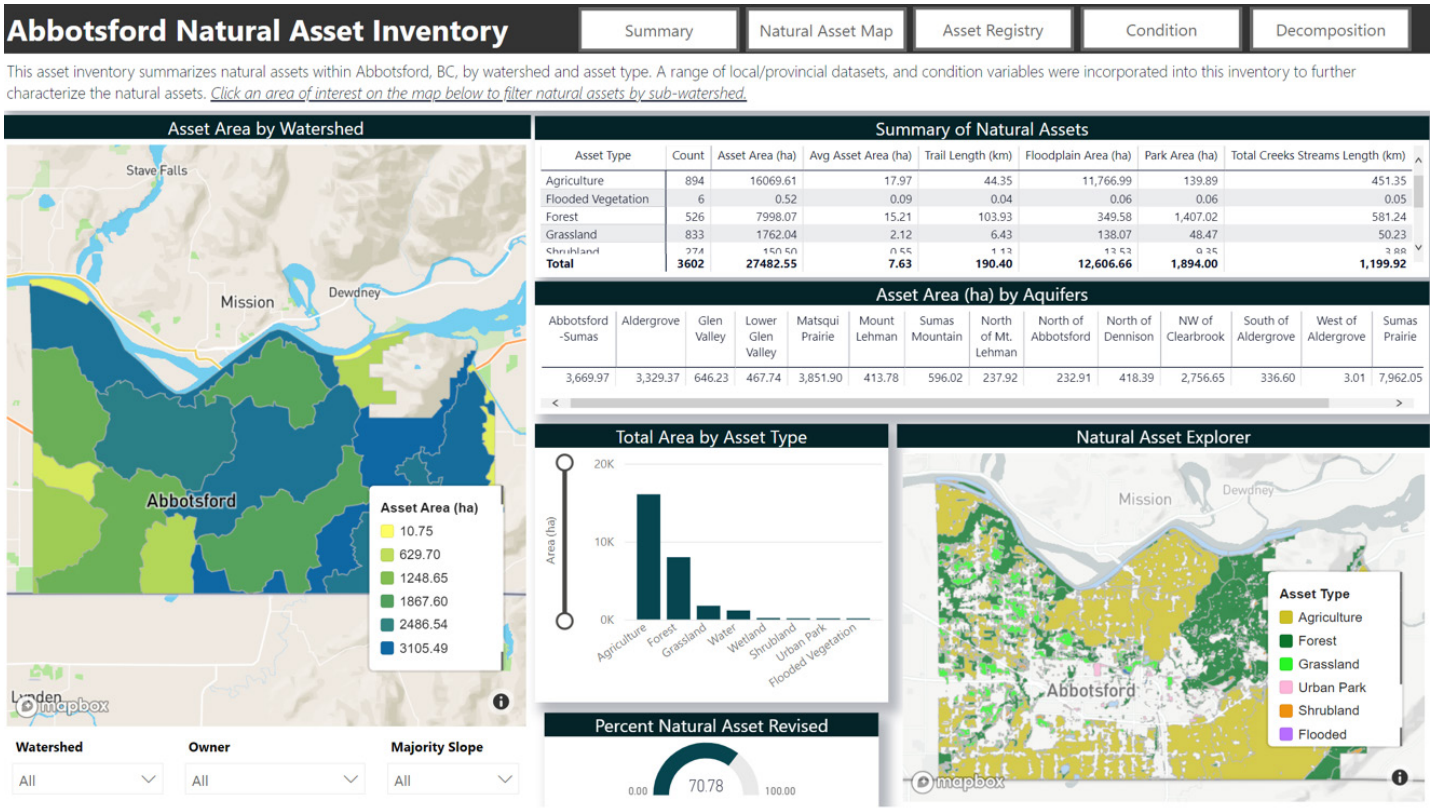


Figure 4: Screenshot of main inventory summary

4.5. Condition of natural assets

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

MNAI completed a desktop-based condition assessment and built it into the inventory to provide an initial understanding of the status of the natural assets for the City of Abbotsford. As part of a full natural asset management project, this assessment would be expanded to include additional metrics related to condition (e.g., relative biodiversity, riparian and wetland health, soil condition,

fragmentation, prevalence of invasive species and pests, and others). Site visits could also be employed to confirm and verify the condition ratings.

The desktop exercise completed as part of this inventory is a reasonable first step in assessing condition and can be used as a foundation for future work in this area. Table 4 summarizes the condition assessment steps and indicators. These indicators were chosen for their relative ease of measurement (given time and budget constraints) and for their relevance to measuring the ecological health and service delivery capabilities of natural assets. They are proxy metrics for these broader condition considerations. For example, larger asset size implies more connectivity of natural areas, higher road density implies more fragmentation and higher hydrologic impairment of water flows, and more permeability implies greater ability to store water which means more effective stormwater management. The adjacent land use metric captures the proximity of natural assets to other types of natural assets. It also distinguishes between those neighbouring natural assets and built infrastructure.

The extent to which natural assets are influenced by drainage in the adjacent landscape varies depending on factors such as the local topography and soils, orientation (e.g., upland versus lowland, position in the watershed) and the size and nature of the feature itself. However, it is well-established that the condition of a natural asset 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 much more or much less drainage than prior to being in an urban context. Urban runoff also typically carries sediments and contaminants; when such runoff is directed to natural areas and not properly treated, it can negatively impact the feature and its functions.

TABLE 4: CONDITION ASSESSMENT APPROACH AND INDICATORS

Indicator	Description & Methods for Quantification	Data used to Quantify Indicator
Relative asset size	For each natural and semi-natural asset type, total area is calculated, and a rank is assigned to the assets within each class based on its percentile score. Natural assets within the top third of the ranking (e.g., the largest assets within a class) received a 3, those within the middle third of the ranking received a 2, and those within the bottom third of the ranking received a 1.	Natural asset inventory
Road density	Measures the density of the roads in and around the assets according to high density (assets with more than 2km of roads per km squared), medium density (assets with between 1km and 2km of roads per km squared) and low density (assets with less than 1km of road per km squared).	Natural asset inventory plus spatial representations of roads

TABLE 4: CONDITION ASSESSMENT APPROACH AND INDICATORS		
Indicator	**Description & Methods for Quantification**	**Data used to Quantify Indicator**
Surface permeability	The permeability of surfaces is ranked on a scale of nil to high depending on the type of landcover present. Urban areas, roads and industrial areas are ranked as nil. Assets within impervious surfaces are assigned as low permeability. Agriculture and shrublands are ranked as medium. Wetlands, waterbodies and forests are ranked as high.	Natural asset inventory, spatial representations of land uses and roads, as well as the Global Man-made Impervious Surfaces Dataset from NASA *data.nasa.gov/dataset/Global-Man-made-Impervious-Surface-GMIS-Dataset-Fr/dkf4-4bi3*
Adjacent land use	Considers the distance to, and the nature of, the area surrounding natural assets. Intense land uses (e.g., airports) in close proximity to natural assets result in a poor rating, while distant land uses that are less intense (e.g., agriculture) result in a good rating. If there are no human land uses within 100 m of the assets, the assets are scored 10. If there are intensive land uses within 100 m of the assets, the score is 0.	Natural asset inventory plus spatial representation of land use as well as intensity rankings of land uses.

Once conditions were allocated to each asset, an overall score was derived for the project area. The maximum possible score for an asset was 40, based on a possible 10 points for each of 4 categories:

- Road density as low (10), medium (5) or high (1).
- Surface permeability rated as high (10), medium (5), low (1), or nil (0).
- Adjacent land use (Extraction sites/airports = 100; Built-up Impervious = 72.5; Barren = 60; Agriculture = 40; Built-up Pervious = 21.25).
- Relative asset size where the largest 3rd areas receive 10, 5 for middle 3rd, and 1 point for the lowest 3rd.

The total condition score was then converted into a rating scale:

- **Good -** assets with a score of 30 or higher
- **Moderate -** assets with a score between 20 to 29
- **Poor -** assets with a score between 10 to 19
- **Very Poor -** assets with a score lower than 10
- **No Rating**

Figure 5 summarizes the natural asset condition assessment results as per the online dashboard.

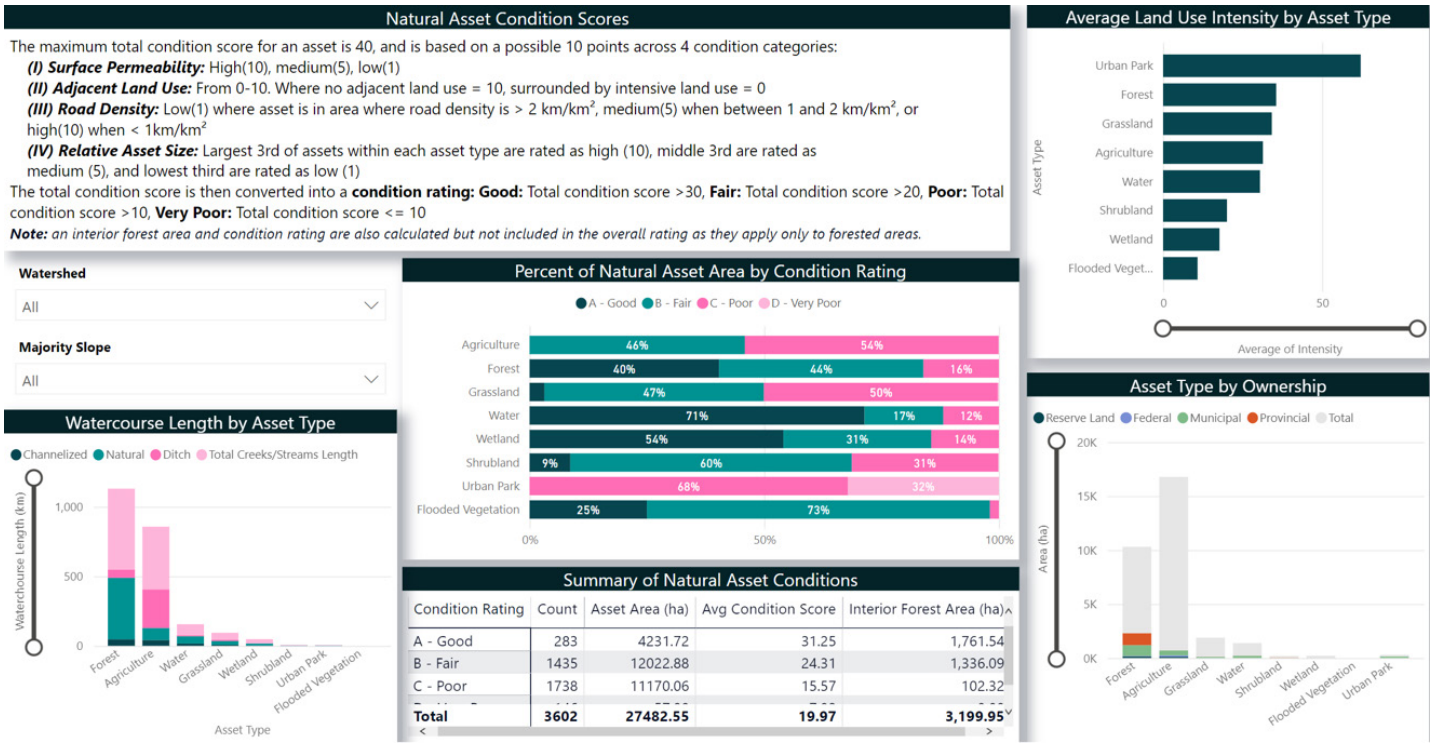


Figure 5: Screenshot of condition assessment details

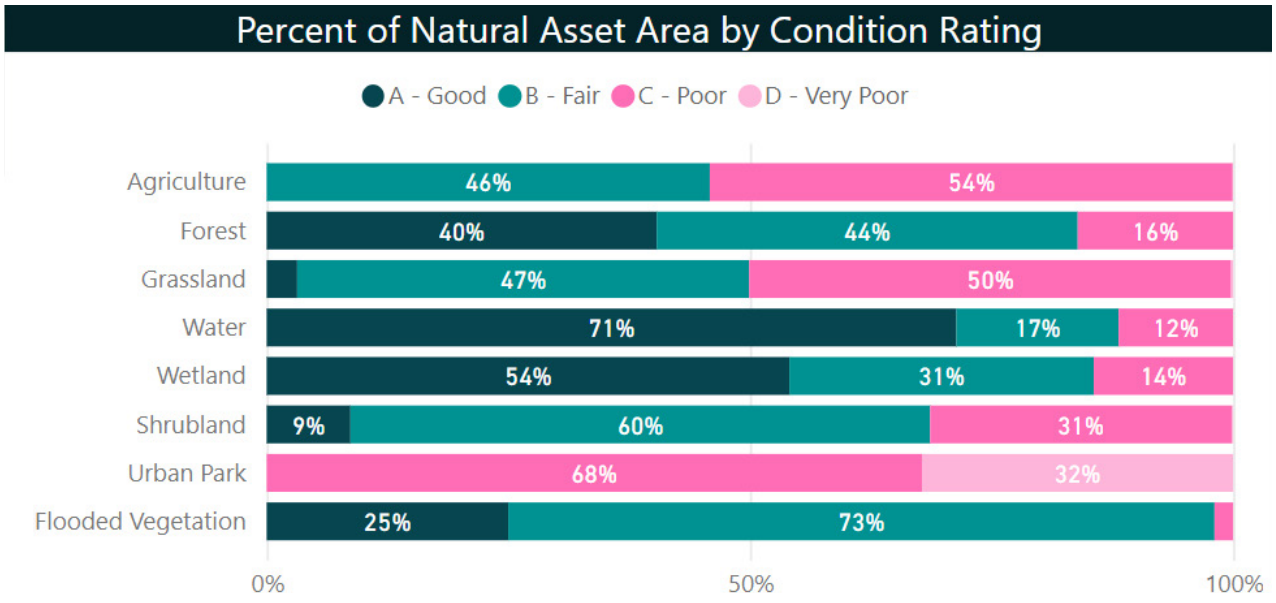
Overall, about 4,232 ha (or 15 per cent) of natural assets were assessed in good condition and 12,023 ha (or 44 per cent) were assessed in fair condition. Forests, water, wetland and flooded vegetation assets all ranked largely good and fair.

Table 5 summarizes condition ratings and Figure 6 summarizes condition by natural asset type.

TABLE 5: SUMMARY OF NATURAL ASSET CONDITION RATINGS
MNAI desktop approach

Condition Rating	Number of Assets	Total Area (ha)	Average Condition Score
Good	283	4,232	31.25
Fair	1,435	12,023	24.31
Poor	1,738	11,170	15.57
Very poor	146	58	7.82
Total	**3,602**	**27,483**	**19.97**

Figure 6: Summary of condition rating by natural asset type (MNAI desktop approach)



4.6. Maintaining the inventory

Inventories are not static. Both the registry and the dashboard can be expanded as new information becomes available. For example, asset condition might improve as a result of restoration efforts, or new studies may add insights on the condition of the assets. New data can be reflected in the asset registry and subsequently in the online dashboard as it becomes available. Furthermore, the level of desired detail may evolve as asset management readiness increases or as areas of natural management focus emerge. However, inventories should grow in detail and sophistication only insofar as they remain aligned with the capacity of the communities to maintain them and the uses to which they will be put. Their evolution and development should be a function of the monitoring, reporting and lessons of the asset management cycle and be driven by the imperative of ensuring sustainable, cost-effective delivery of services to the community, which is the core of asset management.

5 Risk identification

5.1. Risk identification tool overview

Identifying risks facing natural assets can help local governments prioritize their management of natural assets. To this end, MNAI provides local governments with a tool entitled *Risk Identification Process in the Development of Natural Asset Inventories* and guidance in self-administering it.

Risk management is a four-stage process that includes risk identification, analysis of probability and consequence, development of risk mitigation strategies, and control and documentation. The use of the risk identification tool informs the first and second stages of risk management through the identification of top risks to natural assets and their associated services, and a high-level analysis of impacts and consequences.

Risk types relevant to natural asset management typically include:

- **Service risk:** the risk of an asset failure that directly affects service delivery.
- **Strategic risk:** the risk of an event occurring that impacts the ability to achieve organizational goals.
- **Operations and maintenance risk:** risks related to poor asset controls and oversight which can lead to poor record-keeping and poor monitoring of asset.
- **Financial risk:** risks related to the financial capacity of the City of Abbotsford to maintain municipal services.
- **Political risk:** risks related to the nature of municipal politics.

5.2. Using the risk identification tool

Using the risk tool, the City of Abbotsford considered possible risks that the loss of natural asset functions could pose to built infrastructure, personal health and safety, and private property, including:

- Overuse of trails/dumping
- Flooding (current and future)
- Forest fire
- Invasive species
- Development pressure
- Pollutant loading from urban, agricultural, or industrial sources
- Drought (current and future)
- Erosion
- Sedimentation

- Lack of flood hazard mapping
- Lack of land management plans
- Lack of monitoring reports
- Construction activity
- Political policy change
- Lack of legal protection

Each risk was then ranked low, medium or high according to the probability of an impact occurring and the relative magnitude of its negative consequences. To assess impact and consequence, the City of Abbotsford considered four questions:

1/ what impact is likely to happen?

2/ what is the consequence of that impact happening?

3/ what can be done to mitigate the probability of impact and/or consequence?

4/ what cues will signal the need for mitigation?

5.3. Results of the risk identification process

The risk identification process revealed:

- 4 high-level risks (flooding, development pressure, invasive species, and lack of legal protection)
- 10 medium-level risks (overuse of trails/ dumping, forest fire, pollutant loading, drought, erosion, sedimentation, lack of land management plans, lack of monitoring reports, construction activity, and political policy change)
- 1 low-level risk (lack of flood hazard mapping)

In terms of scope, the identified risks affect natural assets across the City of Abbotsford, including those on both public and private lands. The risks also have the potential to negatively impact engineered assets (both city-owned and non-city-owned), personal health, and safety.

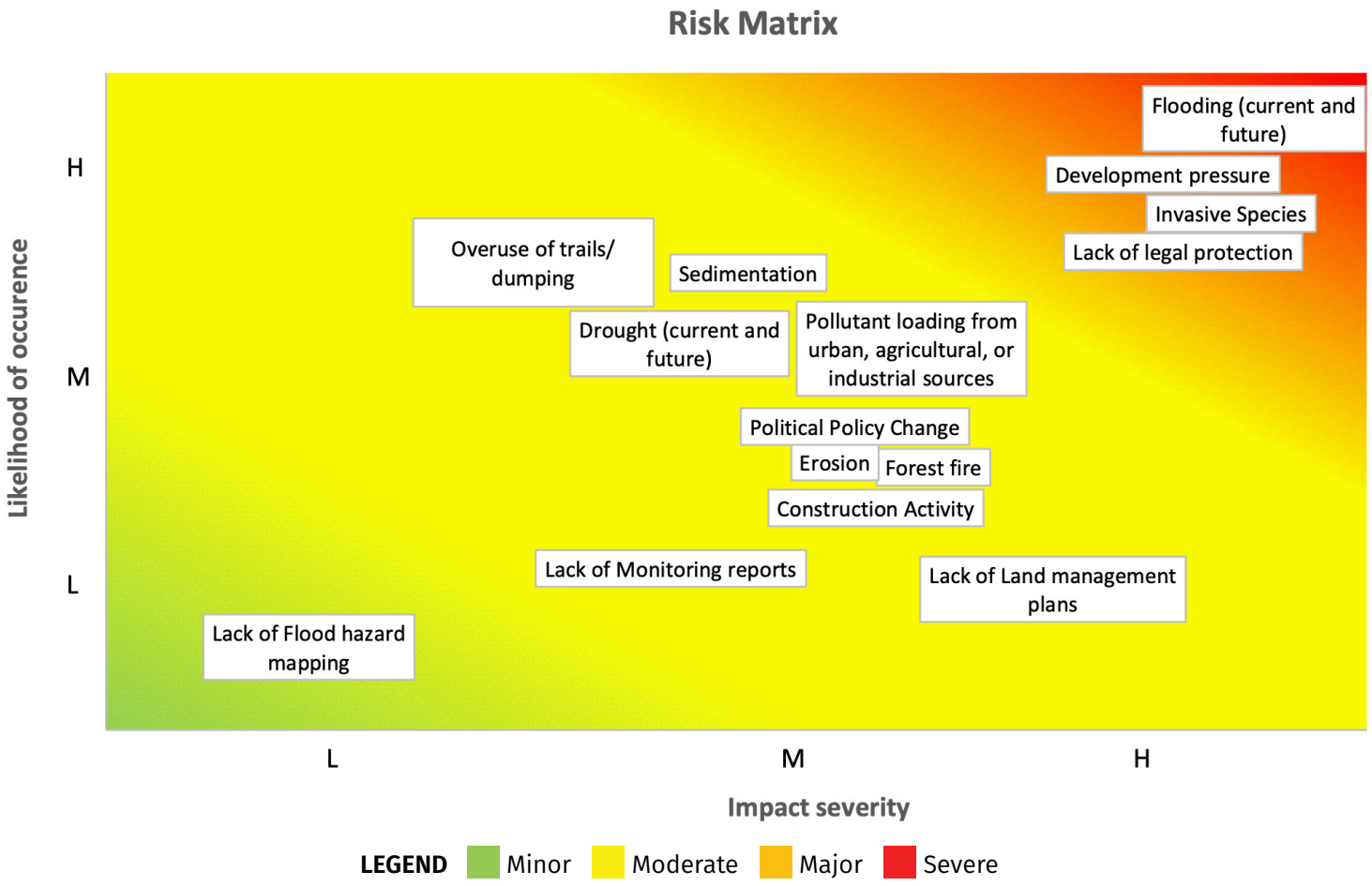


Figure 7: Results of risk management process

6 Recommendations

As much as possible, MNAI considered the inventory (type, extent and location of natural assets), condition (where applicable), risk, and readiness assessments to provide the following insights and recommendations.

This section is divided into (a) potential priorities for the local government (b) possible actions for the further development of the inventory and (c) steps the City of Abbotsford can consider to advance to a full natural asset management initiative.

6.1. Potential priorities for the City of Abbotsford

Combining the results of the condition assessment with the outcomes of the risk identification highlights potential priorities on which the City of Abbotsford could focus their natural asset management efforts. These are:

- **Flooding:** Current and future flooding was identified as a high-level risk (with low likelihood but high consequence) to agricultural lands and parks in Glen Valley, Matsqui Prairie, and Sumas Prairie, as well as the Fraser and Nooksack rivers. Although flooding can occur throughout the year, most severe floods generally occur in the spring and early summer, often coinciding with the freshet. Flooding impacts may include damage to:
  - **natural assets** (e.g., contaminated water in rivers, creeks, wetlands, and waterbodies; destabilized or loss of trees; and sedimentation of trails and shoreline vegetation),
  - **agricultural lands** (damage to crops and livestock; forced evacuation of livestock; and loss of land), and
  - **community** (safety hazards, increased disease and pest vectors, and decreased enjoyment of affected area).

  The City of Abbotsford works with senior levels of government to assess projected impacts to infrastructure and develop management strategies for changing conditions.
- **Development pressure:** Development pressure was ranked as an imminent, yet manageable, high-level risk to forests, shrublands, wetlands, and streams across the City of Abbotsford. Within the urban containment boundary, large forest areas will be converted to residential development. Outside the urban containment boundary, large natural areas are converted to agriculture and built-up areas, both pervious and impervious. Development has also resulted in unauthorized infilling of wetlands and streams. The City of Abbotsford's draft Urban Forest Strategy recognizes the importance of a connected network of trees and natural assets and includes indicators for tracking progress. MNAI encourages further development of the draft Urban Forest Strategy including (a) identifying, measuring, and valuing municipal services provided by the network and incorporating critical

natural assets into long-term financial plans and (b) expanding its natural asset strategies to include wetlands and waterways, which are currently providing stormwater management, drinking water, and waste management services.

- **Invasive species:** Invasive species can reduce resiliency, increase climate-related risks, negatively impact biodiversity, lower property values, and increase municipal costs to maintain, control and eradicate target species. The City of Abbotsford's forests and shrublands, particularly those in dikes, roadsides and parks of urban natural areas, are at imminent risk. Tracking of noxious weeds is underway, which includes tracking of species present in the City of Abbotsford, and species in surrounding areas that pose a risk of spreading. However, some species may be spreading unchecked. MNAI recommends expanding invasive species tracking and drawing upon resources and support from the Invasive Species Council of BC and volunteers to conduct vegetation maintenance to remove invasive species from parks, forests, and shrublands.
- **Lack of legal protection:** The lack of legal protection is a high-level risk to forests, streams, and wetlands in the City of Abbotsford. It is considered an imminent and manageable risk, yet management actions are time constrained as bylaws may not apply to all areas (e.g., Agricultural Land Reserve), lack compliance and enforcement, or come into force too late. To advance the protection of natural assets, the City of Abbotsford could explore, in addition to any bylaw measures: partnerships to increase community support and access specialized skillsets; the creative use of planning tools to ensure natural assets are considered at early development process stages; and develop the business case for natural asset investment by higher levels of government.

TABLE 6: RISK MITIGATION STRATEGIES

Accept	Risk may be acceptable if probability and consequences are small
Minimize	Risk under local government's control that warrants exposure reduction
Share	Partners in a project permit the sharing of larger risks to reduce it for each
Transfer	Insurance, fixed price contracts, and other risk transfer tools

Table 6 lists and provides brief descriptions of risk mitigation strategies.

Opportunities to strengthen natural asset management at an organization-wide level

Overall, staff see the City of Abbotsford's early stage of asset management as an opportunity to incorporate natural asset management considerations from the outset and will make efforts to ensure this integration.

An immediate opportunity is to develop natural asset management objectives that can be achieved within the lifetime of the City of Abbotsford's current asset management strategy. Future asset management strategies would benefit from a fulsome incorporation of natural asset management objectives from the outset to support integration and continuous improvement.

Staff also noted an opportunity to build natural asset management considerations into its asset management policy, which will be developed in the short term. Another short-term action following the completion of this MNAI project is determining resource needs to make progress on natural asset management and securing related support from Council.

The formal asset management team has not yet been established. This creates an opportunity to ensure that, when it does, someone is designated to support incorporation of natural asset management objectives.

The City of Abbotsford has not yet developed levels of service for engineered or natural assets. Short-to-medium-term actions to make progress in natural asset management include developing performance measures or service levels based on the 2020 urban canopy analysis undertaken to support monitoring and maintenance.

As the City of Abbotsford progresses in asset management, it could develop and document an approach to investment planning for natural and built infrastructure assets. This approach should include decision criteria aligned with strategic organizational objectives to support prioritization.

Because the City of Abbotsford does not yet have asset management in place for all major asset classes, there is an important opportunity to incorporate natural asset considerations based on the learnings from this inventory project, or to consider the development of a separate natural asset management plan that complements those being developed for engineered assets. Decisions on whether to develop a separate natural asset management plan will depend on how the organization chooses to organize its asset management plans (e.g., by service area or major asset class).

6.2. Possible actions for the further development of the inventory

Based on the inventory, the City of Abbotsford could consider the following, regardless of whether or not it pursues a full natural asset management process. These are mostly incremental measures.

- Expand the risk identification to include field verification of results.
- Determine acceptable levels of risk to the City of Abbotsford's risk mitigation strategies (see Table 6).
- Identify linkages between services and assets and assess the condition of, and risks to, the assets from the perspective of their ability to deliver services. From a flooding and stormwater management perspective, the wetlands, waterways, and forested areas in the watersheds will be key.
- Share the inventory with adjacent local governments to stimulate collaboration within the watershed.
- Add more condition ratings - for example, canopy cover, which also links to stormwater management services.
- Examine how urban development, flooding, pollutant loading, and lack of legal protection to natural assets interact to increase risk to assets.
- Initiate or enhance monitoring - for example, using gauges, water level sensors, and loggers to improve understanding of trends, feed into condition ratings of assets, and gather information for modelling.
- Schedule regular updates (e.g., every 3-5 years) of the inventory, condition assessment and risk identification to understand trends.
- Maintain interest and momentum in natural asset management to move towards a full natural asset management project.

6.3. Steps to a full natural asset management project

If the City of Abbotsford wishes to proceed with a full natural asset management project, including implementation, it will need to consider the following steps:

1/ **Confirm scope, roles and responsibilities**. Undertake a meeting or workshop to confirm (a) assumptions [for example, that water management and development pressure are the primary services of concern] (b) roles, responsibilities, and capacities (c) community capacity to undertake a larger project.

2/ **Fill essential knowledge gaps**. If discussions on scope and certainty and related data needs for modelling indicate the need for additional data, these could be filled.

3/ **Modelling**. Modelling the levels of service that natural assets currently provide and the levels of service under different potential management, local climate change projections, and rehabilitation or restoration scenarios, is central to natural asset management as it gives communities the ability to explore how different actions will affect the health and corresponding performance of natural assets.

4/ **Economic assessment**. The economic assessment component provides a market-based indication of (a) the current value of the services from natural assets if they had to be provided by an engineered means, and (b) the costs and values of different interventions in terms of service delivery.

5/ **Planning**. This step allows local governments to explore different scenarios such as "what happens to the services provided by the wetland if there is significant building upstream?" or "what happens to the services if the forest is restored?" Using modelling, changes in service levels can be understood and quantified. Corresponding values can also be determined through continued economic assessment. Based on the foregoing, local governments can begin to consider and prioritize actions ranging from status quo to planning, regulatory, financial operations, maintenance, acquisition, and monitoring interventions.

6/ **Implementation**. MNAI can provide ongoing advice / guidance on policy pieces and integration of the above information for 12-18 months. After that, the local government, together with local partners and service providers, would ideally have the capacity to continue these efforts on their own.

7/ **Ongoing monitoring**. It is essential to continue monitoring the project to learn whether interventions are working and to share lessons and learnings from other communities undertaking natural asset management. MNAI would typically stay involved with the community for three years through a monitoring arrangement to be established with the communities.

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Annex: Results of the City of Abbotsford's risk identification

This Annex contains the results of the City of Abbotsford's use of MNAI's risk identification tool which they self-administered with guidance from MNAI. Table 1 was the main product that personnel developed from the exercise.

Step 1: Identification of risks

Common Risks to Natural Assets:

- Overuse of trails/dumping
- Flooding (current and future)
- Forest fire
- Invasive species
- Development pressure
- Pollutant loading from urban, agricultural, or industrial sources (e.g., overuse of salt on roads)
- Drought (current and future)
- Erosion
- Ice jams
- Storm surge
- Lack of flood hazard mapping
- Lack of land management plans
- Lack of monitoring reports
- Construction activity
- Political policy change

Step 2: Complete survey

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
1. Overuse of trails/ dumping	M	Roadsides, trails, parks	everywhere	Dumping often concentrated along backyards and road ends. Dumping has increased in the past when reductions in service occur with our public solid waste management programs. Major contributor to invasive plant spread. Trails that are not actively managed by the City (mtn bike trails, private "convenience" trails) can cause fragmentation of sensitive ecosystems and may be prone to erosion and degradation.
2. Flooding (current and future)	H	Ag land and some parks (e.g., Matsqui Trail)	Glen Valley, Matsqui Prairie and Sumas Prairie, Fraser and Nooksack rivers	The Fraser River freshet can cover our trails and shoreline vegetation in deep sediments. Flooding can destabilize trees. Associated land and tree loss in Parkland is significant. There is a low risk of the Fraser flooding but if it does the impacts would be quite severe.
3. Forest fire	M	Forests, shrubland	Sumas Mtn, Vedder Mtn, Upland areas, Parks and trails	We manage fuel loads in public natural areas. Interface fires could happen in many areas of the City.
4. Invasive species	H	Forests, shrubland	Everywhere, including dikes, parks, roadsides.	Invasive species management is an ongoing concern within the City.

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
5. Development pressure	H	Forests, shrubland, wetland, streams	Everywhere	Imminent Risk – Manageable: ■ Large areas of forest in the Urban Development Boundary will be converted to residential use ■ Large areas throughout the rest of the City are also converted from forest to agriculture/built pervious/built impervious ■ Wetlands and streams are infilled without authorization
6. Pollutant loading from urban, agricultural, or industrial sources	M	Ag land, aquifer, streams	Lowlands streams and ditches in Sumas and Matsqui Prairies, Roadside ditches and streams	All streams fronting roads are at risk of pollutants from vehicles.
7. Drought (current and future)	M	Forests	Uplands affected more than lowlands.	Mature conifers already showing signs of stress, Paper birch, western hemlock and western red cedar are currently the most obvious native tree species being affected. Insufficient soil volumes and quality in streetscapes will exacerbate drought symptoms and watering/irrigation needs. Increases in impermeable surfaces will exacerbate drought conditions.
8. Erosion	M	Streams in ravines	Fraser River erosion arcs, Horn Creek Park, Clayburn Creek Trail	Associated with larger storm events. Fraser river erosion arcs have caused trails to be closed and has resulted in many large shoreline trees being lost. Horn Creek Park has lost large areas of streambank which has led to ongoing destabilization and removal of large native trees and other vegetation in a sensitive ecosystem.
9. Sedimentation	M	Streams, wetlands	Lower Enns brook, Stoney Creek, Horn Willband Creek	

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
10. Lack of flood hazard mapping	L			
11. Lack of land management plans	M		Outside of UDB, on Sumas Mountain and Vedder Mountain. Lack of internal plans for management of public natural lands.	
12. Lack of monitoring reports (could be lack of monitoring and enforcement – e.g., of drug use debris, illegal dumping, improper use of trails)	M	Forests, greenspaces, natural areas, tree planting	Lack of monitoring of invasive species, point source pollution, erosion, canopy loss, permeable surface loss.	Without monitoring reports, we do not have baseline of data. We don't have a clear picture of what would be lost to development without proper reports and background data. Drug usage and shanty towns are becoming a challenge for City staff who have to maintain drainage channels in the urban degraded stream corridors where homeless congregate. Lack of awareness = poor stewardship.
13. Construction activity	M	Trees/urban tree canopy, streams	Development, building and demolition sites.	Poor implementation of BMPs (including tree protection, ESC, etc.). Large need for increased education and enforcement.
14. Political policy change	M	Forests, trees, natural areas,	Lacking strong natural asset protection policies currently.	Risk should reduce within the next 2 years. Pending policies and current Council directions seem to indicate positive change.
15. Lack of legal protection	H	Forests, streams, wetlands	Lacking enforcement abilities in Streamside Protection bylaw, NEDP areas.	Imminent Risk – Manageable but time constrained: Tree Protection Bylaw (TPB) is really a tree cutting bylaw. Streamside Protection Bylaw (SPB) and TPB don't apply to ALR. SSDP/NEDP have no way of compelling compliance or penalizing for NC.

Municipal Natural Assets Initiative