Toward natural asset management in the

City of Surrey

British Columbia

Summary of inventory results and implications
June 2021

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Municipal Natural Assets Initiative

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

Inventories provide details on the type 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.

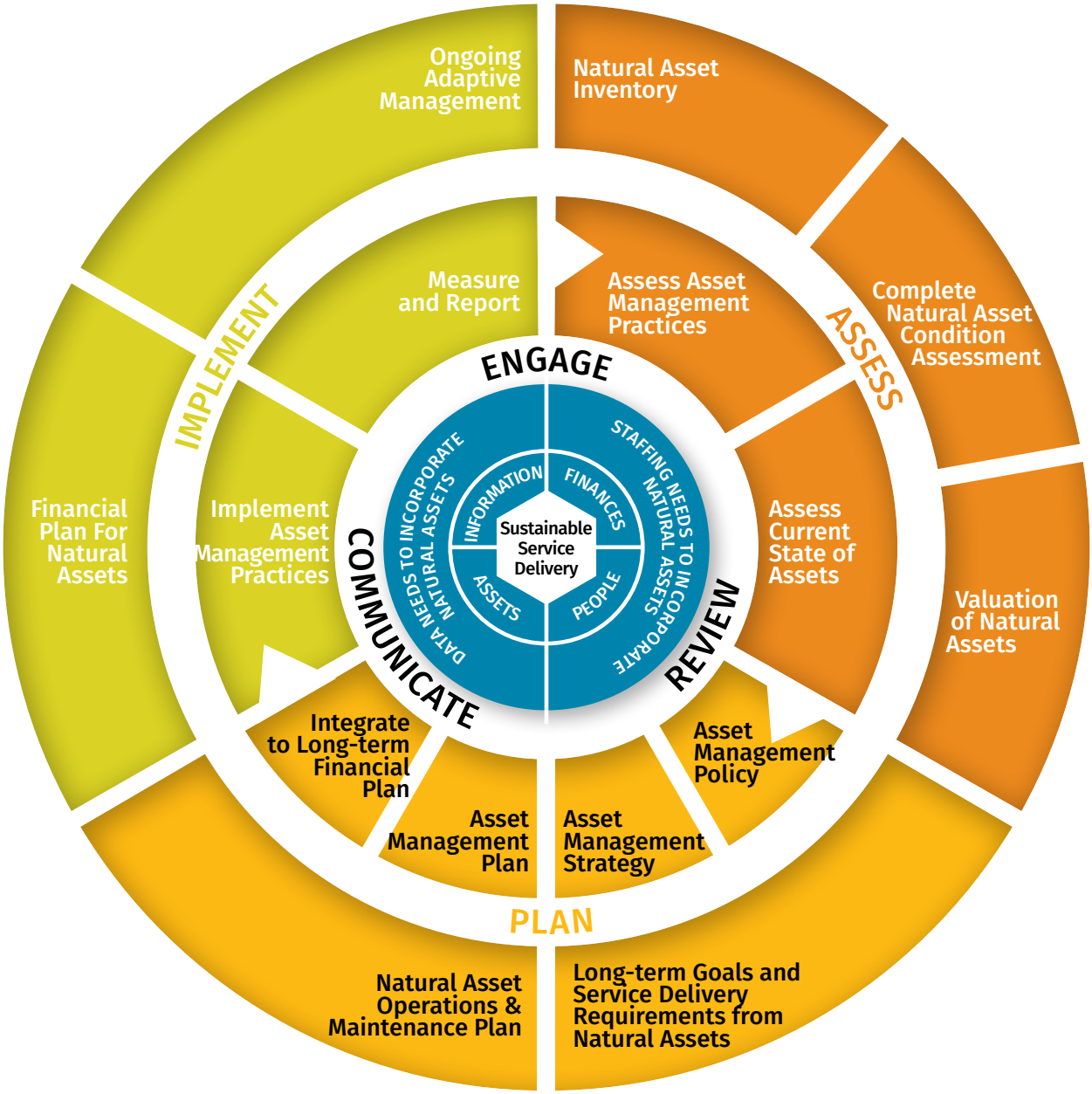

Figure 1: *The Asset Management Process. MNAI has adapted this for use with natural assets.*

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 Surrey[3].

The City of Surrey (population ~580,000) is located in British Columbia south of the Fraser River and north of the Canada–United States border. It is a member municipality of the Metro Vancouver Regional District and metropolitan area and the province's second-largest city by population.

Surrey's interests in natural asset management relate to reducing the impacts of growth, climate change, stemming biodiversity loss, and its 2019 declaration of a climate emergency.

Surrey also wants to link the management of natural and engineered assets within its overall asset management efforts, and support collaboration with adjacent jurisdictions in Metro Vancouver and across the Canada-U.S.A. border in Whatcom County, Washington State.

Surrey states it recognizes natural assets as integral to its livability and long-term resilience and wishes to link natural asset management with land use planning and existing efforts such as its stormwater management and biodiversity conservation efforts.

The Little Campbell River Watershed is the primary focus for this natural asset inventory in Surrey. This watershed is both trans-municipal (Surrey, Township of Langley, City of White Rock) and transboundary (Surrey and Whatcom County). Surrey views the inventory as a first step to determining the role of green infrastructure and natural assets in recognizing, protecting, and managing the ecological components required to buffer against climate change impacts such as flooding, drought, sea level rise, food security, forest cover loss, and aquifer and groundwater protection at a watershed level. The inventory will also increase the understanding of where future initiatives could be focused for other shared watersheds. High priority services from natural assets include:

- Maintaining freshwater quality and groundwater recharge
- Mitigating flooding and sea-level rise
- Enhancing air quality
- Reducing urban heat island effects

3 *Retrieved April 20, 2021 from www.surrey.ca/business-economy/business-data/population-estimates-projections*

- Enhancing pollinator services for agriculture
- Increasing opportunities for recreation and tourism
- Improved mental and physical health and well-being and community livability

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[4] 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 to prioritize actions that increase their effectiveness in managing all assets, including natural ones.

Surrey's completed readiness assessment indicates it is at varying levels of progress in formally adopting asset management as an integrated business process in the four competency areas (policy and governance, people and leadership, data and information, and planning and decision making). Surrey does have a Sustainable Service Delivery Framework that guides Engineering and Public works activities, but the policy does not apply to the whole city and does not include natural asset considerations as it is focused on financial targets. That said, Surrey does have several policies and strategies that prioritize natural assets, such as its Sustainability Charter, Biodiversity Conservation Strategy, Shade Tree Management Plan, Natural Areas Management Plan, and Official Community Plan/Sensitive Ecosystem Development Permit Area Guidelines and others.

Individual operational departments are siloed in that they manage the assets they are responsible for with limited cross-functional collaboration. Also, there is currently no position responsible for asset management city-wide or for championing natural asset management. Asset management planning is done in a structured way but is applied inconsistently across the organization. That said, there is a good foundation for increased cross-functional collaboration by drawing on initiatives such as Surrey Excels, a strategic framework used to guide the City in achieving its vision of a thriving, green, inclusive city; Surrey's Sustainability Office which supports multiple departments; and the Environmental Planner and Biodiversity Conservation Planner positions that provide support and expertise to other departments.

Surrey is relatively advanced in collecting and managing its asset and performance data and connecting it with financial data for engineered assets,

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

with several gaps identified for natural assets that will be improved as a result of this inventory. Surrey is not yet consistently monitoring and measuring the quality of natural assets, how well they are functioning, or for what services they provide, and there is no framework to determine the approach to doing so. They are making progress in some specific areas, for example, Surrey's work on coastal flood adaptation (CFAS) is looking at the value of ecological services. However, this work is focused on specific adaptation and mitigation issues versus looking at natural assets holistically across the City.

Surrey develops five-year capital plans with annual budget requests and adjustments to address natural assets. Financial planning does not yet consider the total value of natural assets or include a longer-term financial plan to manage and sustain the services they provide.

4 Natural asset inventory

4.1. Inventory overview

MNAI gathered a range of data for an area scoped to the Little Campbell River watershed boundary. The inventory has two main components, or ways, to express the information: an asset registry and an online dashboard. MNAI provided the registry to Surrey as Excel data, and the dashboard in a website format. 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 Surrey, GeoBC and Metro Vancouver's open data portal. MNAI combined the spatial data layers to establish a comprehensive depiction of natural assets. Table 1 describes the data sources used to develop the inventory and condition assessment.

TABLE 1: DATA SOURCES SUMMARY

DATA	SOURCE	PURPOSE
Land Cover Classification 2014 – 5m Hybrid (Raster)	MetroVancouver Open Data	Used to create the base inventory
Sensitive Ecosystem Inventory for Metro Vancouver (2014)	MetroVancouver Open Data	Merged with the land cover classification dataset above to obtain a more comprehensive asset inventory
FWA_Wetlands_Polygons	GeoBC	Used to incorporate wetlands into the inventory
Municipal Boundaries	MetroVancouver Open Data	Used to assign natural assets to municipality
Ecological_Significance_of_Hubs	City of Surrey	Used to assign natural asset to ecologically significant hubs

TABLE 1: DATA SOURCES SUMMARY

DATA	SOURCE	PURPOSE
GIN_Hub	City of Surrey	Used to assign natural asset to GIN hubs
ImportantTrees	City of Surrey	A count of trees within each asset
Specimen_Trees	City of Surrey	Asset IDs were assigned to relevant trees that were within the asset
Screen_Trees	City of Surrey	Asset IDs were assigned to relevant trees that were within the asset
Trees	City of Surrey	Asset IDs were assigned to relevant trees that were within the asset
Nest Locations	City of Surrey	Asset IDs were assigned to relevant nest locations that were within the asset
Carbon Biomass 2019 – 2m (Raster)	MetroVancouver Open Data	Used to sum biomass carbon within each asset. Each raster cell represents a 4-metre-squared area and was multiplied by 0.0004 to convert to hectares
Carbon Soil 2019 – 2m (Raster)	MetroVancouver Open Data	Used to sum up the soil carbon within each asset. Each raster cell represents a 4-metre squared area and was multiplied by 0.0004 to convert to hectares
Little Campbell River watershed boundary	City of Surrey	Used to clip other datasets and for computing total area of the study site
Little Campbell River Basin boundary (2006)	City of Surrey	Used to assign assets to their appropriate basin and incorporated into the dynamic map within the final dashboard
Little Campbell River Sub-Basin boundaries (2006)	City of Surrey	Used to assign assets to their appropriate sub-basin and incorporated into the dynamic map within the final dashboard
Digital Road Atlas	GeoBC	Used to perform road density condition assessment on each asset and assign a road density score
ParcelMap BC Parcel Fabric	GeoBC	Used to determine which entity owns/is responsible for the natural assets in the inventory
Biodiversity Management Areas	City of Surrey	Layer incorporated into spatial asset inventory dataset. Assets were given a land use label from the management unit based on which unit comprised the majority of the asset area. The total area of assets with the Biodiversity Conservation Strategy was also added and can be viewed in the asset registry of the dashboard

The inventory project defined a total of 36,558 individual assets, covering 3,620 hectares (ha) of land, as noted in Table 2. The majority of this was forest cover, followed by shrubs and riparian assets.

TABLE 2: SUMMARY OF NATURAL ASSETS BY TYPE

NATURAL ASSET TYPE	NUMBER OF ASSETS	TOTAL AREA (HA)	AVERAGE ASSET AREA (HA)
Forests	24,884	2,806	0.11
Grasslands	595	89	0.15
Riparian	2,891	300	0.10
Shrub	4,559	171	0.04
Water	862	50	0.06
Wetland	2,767	204	0.07
Total	**36,558**	**3,620**	**0.10**

4.3. Asset registry

MNAI gathered the data, then sorted and analyzed it for relevance, and then delineated the type, location and extent of natural assets within the project area. Each asset 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. The information pertaining to each asset was then placed into an asset registry. An excerpt from Surrey's registry showing natural asset characteristics and details is in Table 3.

TABLE 3: EXCERPT FROM THE REGISTRY

Natural Asset Registry

Asset ID	Asset Type	Asset Area (ha)	Sub-Asset Type	Municipality	Primary Catchment	Sub Basin Name	Crown Agency (ha)	Crown Provincial (ha)	Federal (ha)	SEI Data	SEI Grade	Total Carbon (tC)	Biodiversity Conservation Strategy Area (ha)	BCS Majority Land Use	Road Density Score	Relative Size Score	Permeability Score	Total Score
FOR-10009	Forest	0.002	Young Forest (small)	Surrey	Surrey	Mainstem 3				Yes	D	0.87	0.00	Little Campbell River	1	1	10	12
FOR-10010	Forest	0.010	Young Forest (small)	Surrey	Surrey	Mainstem 3				Yes	No Rating	0.92	0.01	Little Campbell River	1	1	10	12
FOR-10013	Forest	0.010	Young Forest	Surrey	Surrey	Kuhn Creek/Theodore Creek				Yes	No Rating	0.00	0.01	Little Campbell River	1	1	10	12
FOR-10014	Forest	0.005	Young Forest	Surrey	Surrey	Kuhn Creek/Theodore Creek				Yes	No Rating	0.00	0.00	Little Campbell River	1	1	10	12
FOR-10015	Forest	0.003	Young Forest (small)	Surrey	Surrey	Mainstem 3				Yes	No Rating	0.00	0.00	Little Campbell River	1	1	10	12
FOR-10016	Forest	0.003	Young Forest	Surrey	Surrey	Kuhn Creek/Theodore Creek				Yes	No Rating	0.11	0.00	Little Campbell River	1	1	10	12
FOR-10019	Forest	0.008	Young Forest	Surrey	Surrey	Mainstem 3				Yes	No Rating	0.00	0.01	Little Campbell River	1	1	10	12
FOR-10020	Forest	0.005	Young Forest	Surrey	Surrey	Mainstem 3				Yes	No Rating	0.00	0.01	Little Campbell River	1	1	10	12
FOR-10021	Forest	0.045	Young Forest (small)	Surrey	Surrey	Mainstem 3				Yes	No Rating	0.15	0.04	Little Campbell River	1	1	10	12
FOR-10022	Forest	0.159	Young Forest	Surrey	Surrey	Mainstem 3				Yes	No Rating	28.36	0.16	Little Campbell River	1	1	10	12
FOR-10023	Forest	0.546	Young Forest (small)	Surrey	Surrey	Mainstem 3				Yes	D	188.96	0.55	Little Campbell River	1	1	10	12
FOR-10024	Forest	0.002	Young Forest	Surrey	Surrey	Mainstem 3				Yes	D	0.28	0.00	Little Campbell	1	1	10	12

4.4. Carbon storage

The availability of detailed carbon storage data from Metro Vancouver[5] made it possible to estimate the amount of carbon stored by the natural assets in the Little Campbell River's inventory, as noted in Table 4.

Carbon storage was estimated using the Carbon Soil and Carbon Biomass raster datasets from the Metro Vancouver Open Data Catalogue. The data resolution is $2m^2$, meaning each pixel represents an area of 4m. The carbon stored in each pixel is measured in tonnes of carbon/hectare (tC/ha). To convert raster cell values into tC, the tC/ha value of each pixel was multiplied by 0.0004. Carbon soil and carbon biomass for all pixels within the asset were then summed to get tC for each asset. Total carbon storage is the sum of soil and biomass.

5 *Metro Vancouver. (2019).*

TABLE 4: NATURAL ASSET CARBON STORAGE			
ASSET TYPE	BIOMASS CARBON (tC)	SOIL CARBON (tC)	TOTAL CARBON STORAGE (tC)
Forest	269,371	227,558	496,929
Grassland	1,041	1,324	2,365
Riparian	36,266	32,142	68,408
Shrub	1,135	2,096	3,231
Water	427	1,640	2,067
Wetland	7,223	25,667	32,890
Total	**315,464**	**290,427**	**605,891**

4.5. 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 3 and Figure 4 are screen shots from the dashboard that MNAI provided to Surrey. The full version can be accessed at *go.greenanalytics.ca/Surrey*.

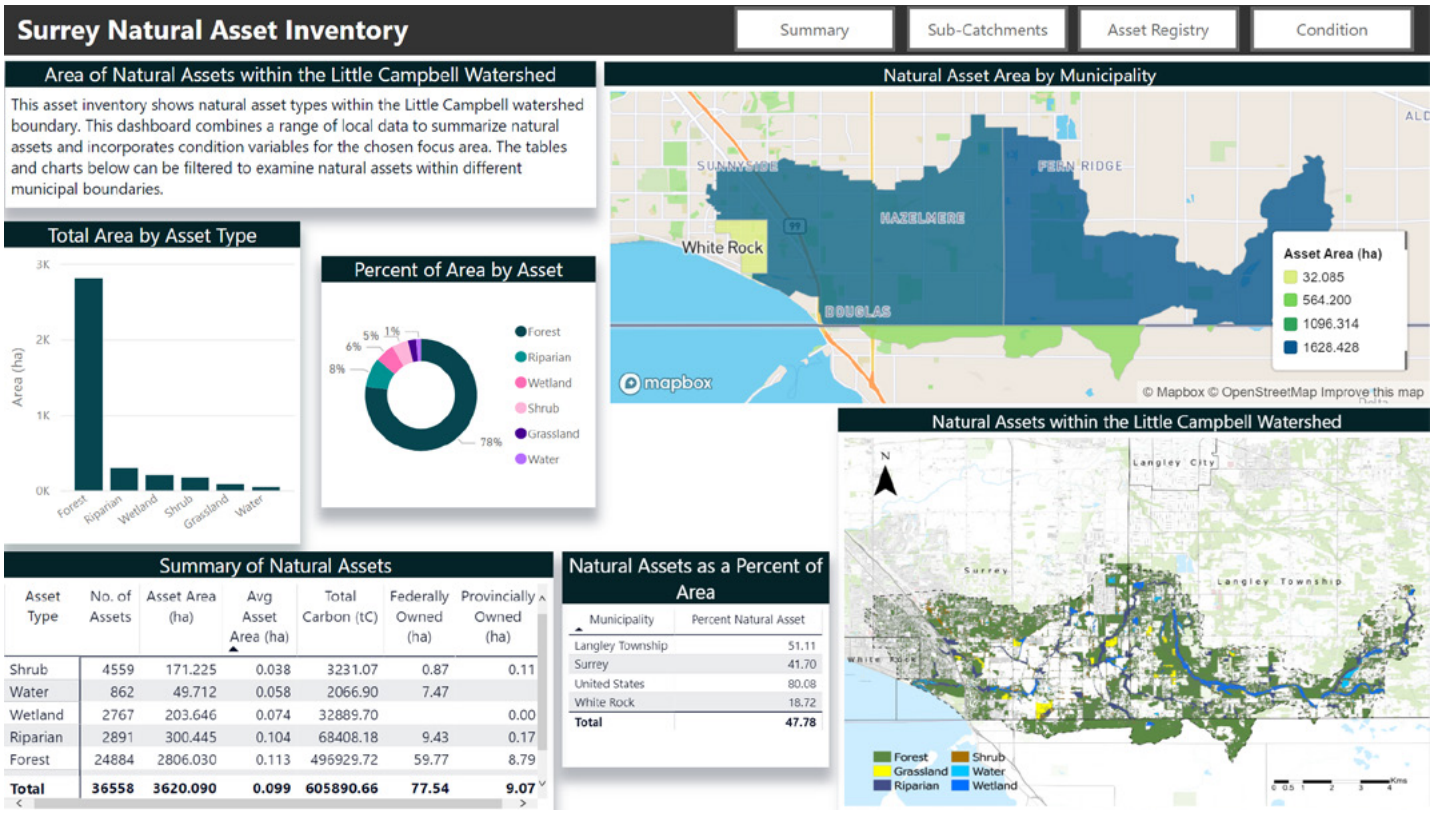

Figure 3: Screenshot of main inventory summary

4.6. 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 the ability of natural assets 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.

A desktop condition assessment was completed and built into the inventory to provide an initial understanding of the status of the natural assets for Surrey. The condition assessment steps and indicators are summarized in Table 5 and depicted graphically in Figure 4. A portion of the Little Campbell River's assets are covered by the Sensitive Ecosystem Inventory (SEI) published by the Metro Vancouver Regional District. For those assets, the SEI rating is provided in the inventory and dashboard.

TABLE 5: 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
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*

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 intensive land use (0 for intense land uses, otherwise 10).
- 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 4 demonstrates the results of the condition assessment as presented in the inventory dashboard.

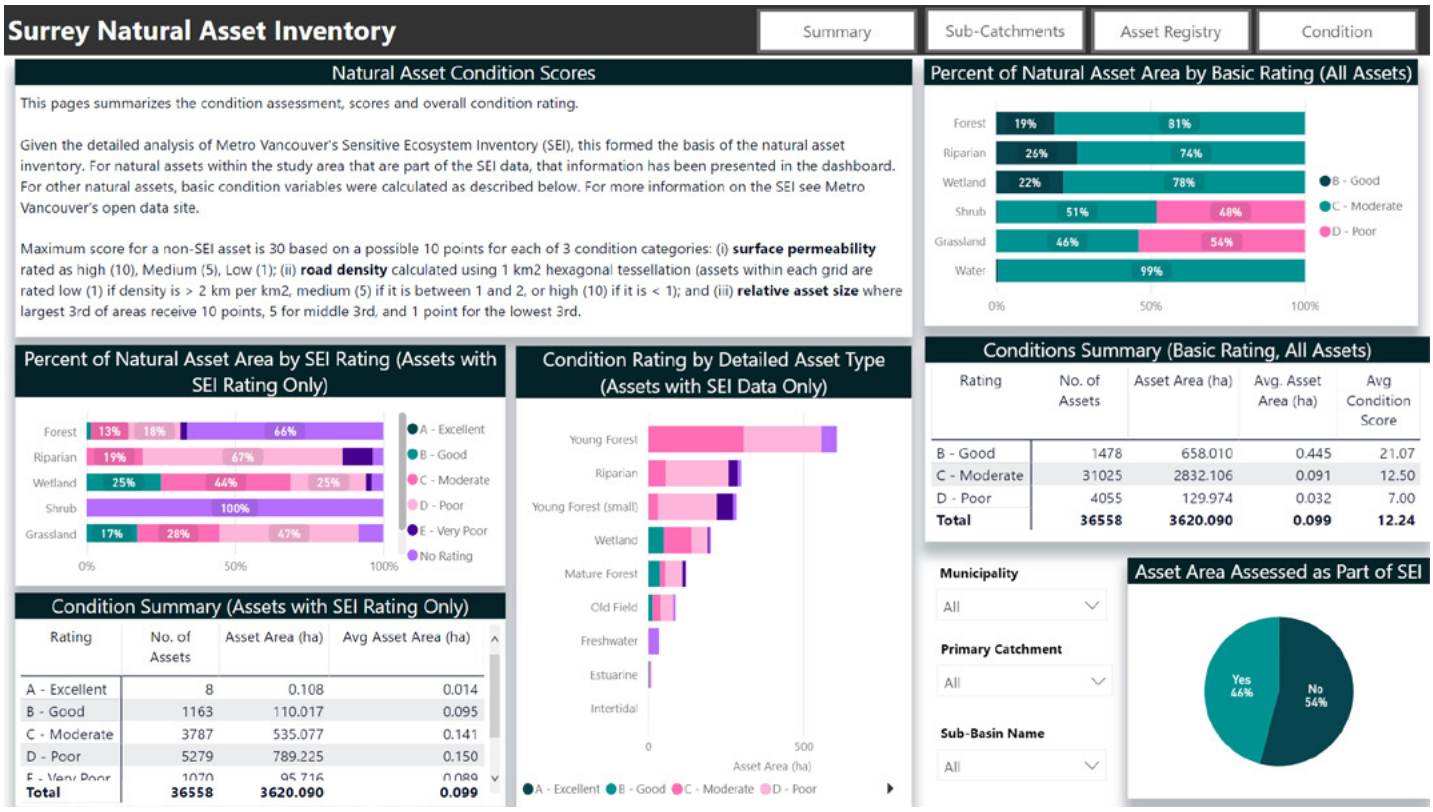

Figure 4: Snapshot of condition assessment results

Of the assets for which SEI data was available (46 per cent of the area), about 110 ha (or 7 per cent of the SEI-rated assets) of natural assets were assessed as being in good condition and 535 ha (or 32 per cent of the SEI-rated assets) in moderate condition. Grasslands and riparian assets were largely rated poor according to the SEI rating.

Using MNAI's desktop condition rating system, 658 ha (18 per cent) of assets were rated good and 2,832 ha (78 per cent) of assets were rated moderate. According to this rating system, forests, riparian and wetland assets all ranked largely good and moderate.

Table 6 summarizes condition ratings according to MNAI's desktop condition assessment approach and Figure 5 summarizes condition by natural asset type.

TABLE 6: SUMMARY OF NATURAL ASSET CONDITION RATINGS
MNAI desktop approach

Condition Rating	Number of Assets	Total Area (ha)	Average Total Score	Average Condition Score
Good	1,478	658	0.45	21.07
Moderate	31,025	2,832	0.09	12.50
Poor	4,055	123	0.03	7.00
Total	**36,558**	**3,620**	**0.10**	**12.24**

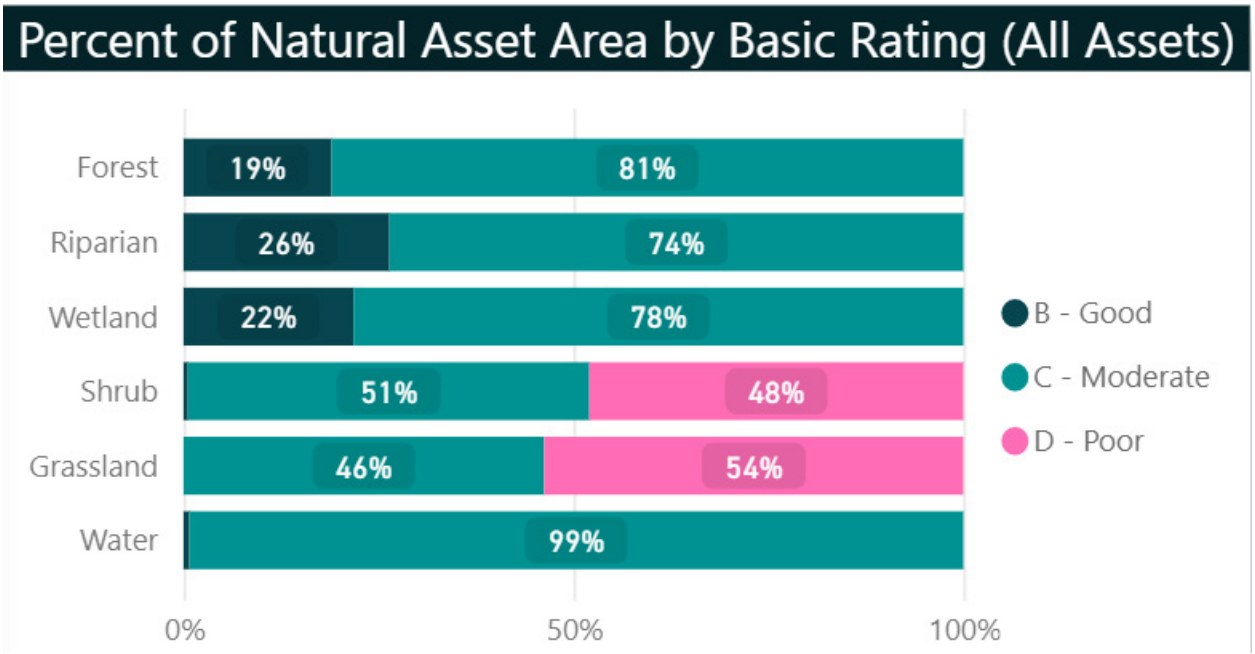

***Figure 5**: Summary of condition rating by natural asset type (MNAI desktop approach)*

4.7. 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 Surrey 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, Surrey 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 (e.g., overuse of salt on roads)
- Drought (current and future)
- Erosion
- Lack of flood hazard mapping
- Lack of land management plans
- Lack of monitoring reports
- Construction activity
- Political policy change
- Groundwater

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, Surrey 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:

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

In terms of scope, the identified risks affect natural assets across all of Surrey, 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.

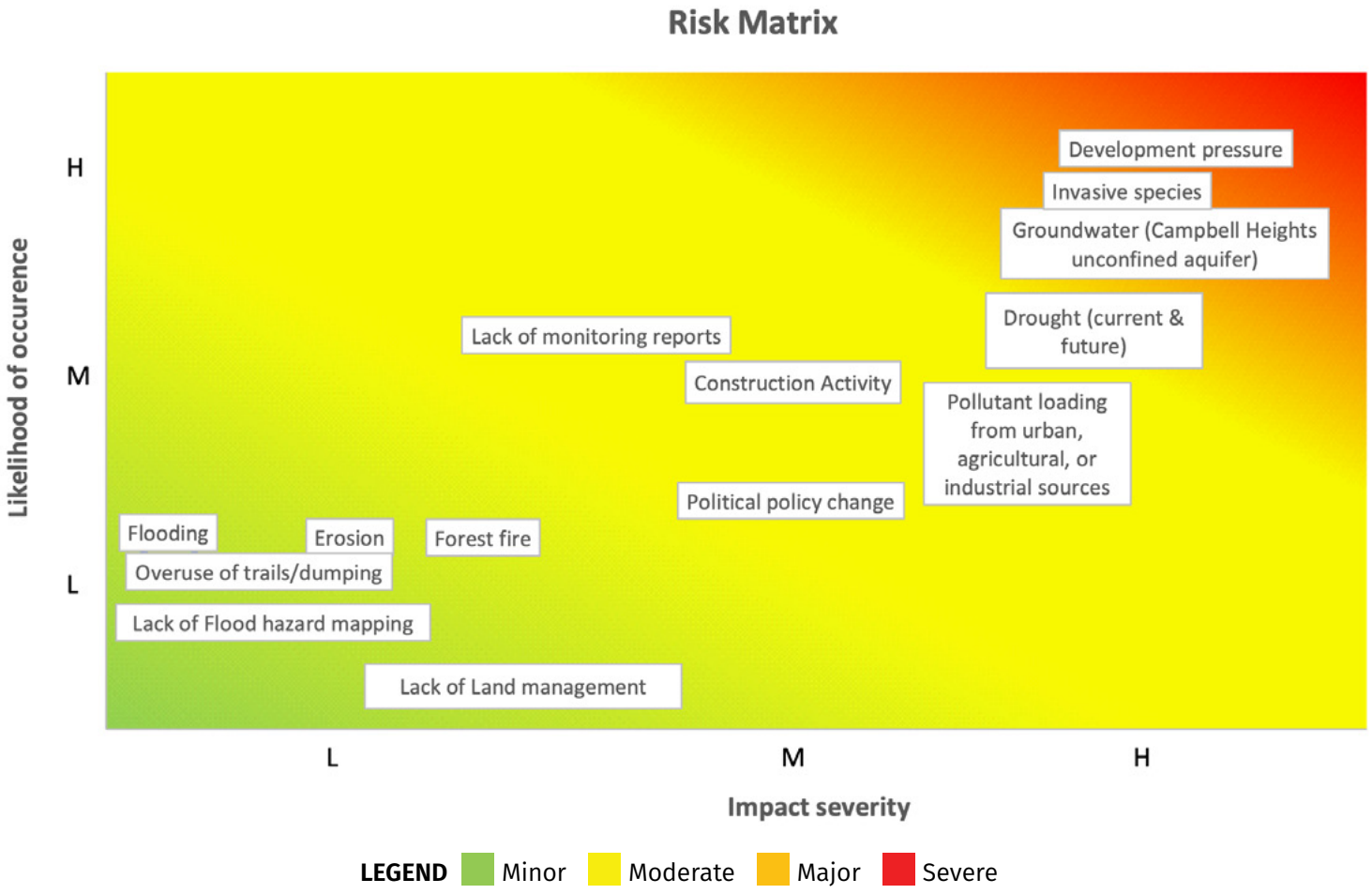

Figure 6: Results of risk management process

6 Implications

This section provides insights that can be gained from considering both the inventory - including the condition and risk assessments - and the asset management readiness assessment. It is divided into (a) potential priorities for Surrey (b) possible actions for the further development of the inventory, and (c) issues Surrey can consider to advance to a full natural asset management initiative.

6.1. Potential priorities for the City of Surrey

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

- **Development pressure:** Surrey is the third fastest-growing city in Canada and faces significant development pressures[6]. Surrey staff participating in the project identified the neighbourhoods of South Campbell Heights, Darts Hill, and Sunnyside Heights as areas of heightened concern for upland forests, wetlands, habitat on private lands, and natural assets adjacent to development on public lands. Within these areas, some agricultural lands have been converted from diverse crop production to industrial agriculture (e.g., greenhouses, berry crop monocultures). Some contiguous upland forests and wetlands have also been fragmented due to technology and business parkland uses, resulting in increased impervious areas, intensive land uses adjacent to undeveloped and rural areas, and increased road densities.
- **Invasive species:** Invasive species can reduce resiliency, increase climate-related risks, negatively impact biodiversity, impair terrestrial and aquatic ecological services, lower property values, and increase municipal costs to maintain, control and eradicate target species. They can also impact engineered assets such as roads. Surrey administers public education campaigns and conducts vegetation maintenance to remove invasives from parks and natural areas. Surrey can also draw upon resources and support from volunteers, the Invasive Species Council of BC, and the Invasive Species Council of Metro Vancouver.

6 *See for example www.peacearchnews.com/news/development-pressures-prompt-need-for-surrey-city-centre-plan-update/*

- **Groundwater:** The Campbell Heights unconfined aquifer is in the upper reaches of the Little Campbell Heights watershed. It provides base flow for several streams, potable water for local residents, and is an important asset for overall watershed health. However, it is highly vulnerable to change, depletion, and contamination. Surrey recognizes the need to protect the recharge and quality of water within the aquifer[7] as an essential part of its management.
- **Drought:** Drought was identified as a medium-high-level risk. While it is not currently a major issue, it is anticipated to become a high priority given local climate change projections. Of particular concern are the natural assets of the upper watershed, including forests and groundwater, which could be subject to pollutant loading and low flows due to water extraction. Engineered assets, such as residential wells and agricultural irrigation systems, may also be negatively impacted. Increasing permeable surfaces and undertaking a Drinking Water Quality and Supply Strategy are recommended next steps for Surrey.

TABLE 7: 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 7 lists and provides brief descriptions of risk mitigation strategies.

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

Improving cross-functional collaboration in asset management planning at a strategic level would help ensure that infrastructure decisions are well integrated across all service areas, and that they incorporate natural asset management considerations.

Building on initiatives such as Surrey Excels and the work of Surrey's Sustainability Office, a cross-functional group could be established to ensure that natural asset considerations are incorporated explicitly into asset management plans across all service areas. The natural asset inventory developed through this project is a good foundation upon which to strengthen natural asset data, build an understanding of the current and expected performance of natural assets in delivering a range of services, and link that with asset management and financial planning. Natural asset management

7 *City of Surrey, 2021b.*

plans could be developed that align with Surrey's existing policies and strategies that protect natural assets, and with other strategic service delivery objectives.

Surrey's Environmental Planner and Biodiversity Conservation Planner already provide support across departments. To further develop staff capacity in natural asset management, a key next step could be to complete a review to identify where staff skillsets could be enhanced to fill gaps for natural asset management.

6.2. Possible actions for the further development of the inventory

Based on the inventory, Surrey 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 Surrey's risk mitigation strategies (see Table 7).
- Further develop the condition assessment and risk assessment using local climate projections, land use modelling, and other data already at their disposal.
- 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.
- Share the inventory with adjacent local governments to stimulate collaboration within the Little Campbell watershed.
- 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 Surrey 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 this, 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**. The natural asset implementation phase is an adaptive management cycle, not a finite journey. It is during this time that actions identified based on the previous steps can begin to be implemented. MNAI can provide ongoing advice / guidance on policy pieces and integration of the above information for 12-18 months. After this point, 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**. Project monitoring is essential 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 Surrey's risk identification

This Annex contains results of Surrey's use of MNAI's risk identification tool, which they self-administered with guidance from MNAI. Table 1 was the main product, developed by Surrey personnel, that resulted 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	L	Natural assets on all public lands (e.g., parks and natural areas)	Redwood Park is a major biodiversity hub in the watershed which may receive increasing pressure as adjacent areas develop and transition from rural acreages to infill and high-density housing	Low now at the watershed level, but development pressures will increase the use and demand on public land = increased trail demand, so likely rise to medium over time, especially if public lands have more active uses implemented
2/ Flooding (current and future)	L	Non-city-engineered asset: Provincial highway (99) which connects to the border and U.S. Implications for adjacent land uses (emergency access, local economy e.g., retail, commercial and industrial lands) if flood events increase over time. City-engineered assets: low-lying municipal roads and City utilities in the lower watershed, similar impact issues	Semiahmoo First Nation community (lower watershed, estuary in White Rock, nearshore inundation issues)	The Little Campbell River watershed is not a dyked system compared to other major watersheds in Surrey (e.g., Nicomekl and Serpentine rivers). Natural floodplain processes are allowed to happen, but the estuary in Semiahmoo Bay may be a hotspot for issues. As well, Surrey may see unmitigated risks in South Campbell Heights area, which could become an issue if it doesn't do proper land management in the watershed or sub-watersheds to address adaptation and mitigation. Risk will escalate over time as sea level rise increases (e.g., the need for expediting the implementation of Surrey's Coastal Flood Adaptation Strategy). Storm surge is included in this risk as opposed to a separate/distinct category, and is part of overall CFAS planning

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
3/ Forest fire	L	Natural assets such as upland and urban forests		The Little Campbell River watershed is part of the Coastal Douglas-fir (CDF) zone, a unique biogeoclimatic zone in southwest B.C. that stretches from Vancouver Island across and down west of the Cascades to California. The CDF zone is naturally a low-moisture ecological community and has evolved with fire, but climate change is exacerbating fire risk; remaining intact forested hubs and corridors may be more prone to fire events. The presence of emergency infrastructure (e.g., fire control, municipal water sources) and adjacent development and land use help reduce the likelihood of unmitigated fire events in most local forested areas, or in forest-developed land interfaces.
4/ Invasive species	H	Natural assets such as public lands (e.g., parks and natural areas), terrestrial and aquatic habitats. Direct competition, displacement, and predation on native flora and fauna. Engineered assets such as roads (e.g., from species like Knotweed) and private land impacts through lowered property values.		Reduced resiliency contributes to increased negative effects from climate change (changes to vegetation community = more fire prone), biodiversity loss, etc., impairing ecological services ability. Increased maintenance costs, control, and eradication costs

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
5/ Development pressure	H	Natural assets on private lands (upland forests, wetlands, old-field habitat), Natural assets on public lands (adjacency effects from degraded natural assets on private land, increased road densities, etc.)	South Campbell Heights, Darts Hill, Sunnyside Heights neighbourhoods	Agricultural lands are subject to conversion from traditional open soil/ diverse crop production to industrial agriculture and intensification of production (e.g., greenhouses, berry crop monocultures), remaining contiguous upland forested areas and wetlands are vulnerable due to conversion of undeveloped and rural land cover to industrial, business and technology park land uses (e.g., residential housing densification, business, technology and light industrial facilities) and associated impervious areas and increased road densities
6/ Pollutant loading from urban, agricultural, or industrial sources	M	Natural assets such as aquatic habitat, aquatic species, groundwater	All	Non-point source pollution and oxygen depletion combine with seasonal low flows (tied to irrigation and groundwater uses) to exacerbate pollution impacts in the Little Campbell River watershed. As well, the upper watershed sits over vulnerable, unconfined aquifers susceptible to contamination. Can trend towards high if present septic field contamination not improved with sanitary infrastructure technology or other infrastructure to help reduce surface and groundwater non-point source pollution (NPSP) e.g., agricultural runoff. Conversely, changes in land use (land cover conversion from rural and forested to commercial and residential) can contribute to intensification of NPSP if left unmitigated. Modes of transportation may parallel increased population and development = higher NPSP from even more diverse sources

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
7/ Drought (current and future)	M–H	Natural assets such as aquatic and terrestrial habitats (e.g., forested components), groundwater. Engineered assets such as residential wells and agricultural irrigation	Upper watershed is more vulnerable due to soil and geology (will be more severely impacted), lower watershed conditions will provide greater resiliency	Not so much an issue now, but with climate change this will likely become a higher priority issue (e.g., incremental risk), ties to other potential risk factors e.g., pollutant loading (lack of dilution) with existing low flow issues due to ground and surface water extraction in the watershed
8/ Erosion	L	Natural assets, mainly aquatic habitat (localized and site-specific)	Some sites in Fergus sub-watershed, upstream areas around Semiahmoo First Nation (estuary and lower floodplain areas)	Will be mitigated and maintained as long as proper low impact development and land use planning is implemented. Maintain proper erosion and sediment control bmps and actions. Surrey does not have control on land use planning decisions in upper watershed that is situated in other municipal jurisdictions. Sediment movement from adjacent land use (e.g., linear infrastructure like railway corridor) having localized effect in the estuary)
9/ Lack of flood hazard mapping	L			Have number of resources to assist in management of this issue, as long as information is updated regularly to allow for deployment and adaptative management

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
10/ Lack of land management plans	L	Natural assets such as aquatic and terrestrial habitats		Surrey is well-positioned to address this risk with ISMPS, NCPs, LAPs, BCS, OCP, green levies, and development cost charges (DCCs) - natural assets are well-considered in land use planning, challenge is pre-emptive processes or demands from private land interests potentially circumventing intended planning approaches, gap between completion and implementation of land management planning processes (tied to gap in regulatory tools). Tied to capacity within the organization – development pressures are diverse and high volume, reflective of Surrey's rapid growth. Pressures to amend existing plans not seen cumulatively, so long-term effects not well visualized. Can end up having decisions inconsistent with intended processes
11/ Lack of monitoring reports	M			Quite varied in respect to level and quality of data and reporting, disjunct between information gathered or provided and what may be happening on the ground, volumes of data available through variable sources and formats, e.g., from QEPs, community science (iNaturalist) etc., but no consistent way to curate, analyze and mesh together to make more easily applied to mitigation or management approaches

TABLE 1: SIMPLIFIED RISK IDENTIFICATION SURVEY

Risk	Ranking (L/M/H)	Assets Affected	Location	Notes
12/ Construction activity	M			Has similar issues as development pressure, but fairly well articulated and managed through regulatory (Development Permits, bylaws, etc.) and policy/guidelines. Challenge is ability to monitor (oversight capacity) so on paper well managed but on the ground, implementation may be more difficult to address (e.g., compliance issues, BMP consistency issues, ESC violations). So low in respect to tools but high in respect to non-compliance impacts
13/ Political policy change	M			Similar to all levels of government, vulnerable to changes through electoral cycles, can have implications for policy and planning (e.g., change every four years), can have significant implications for changes in priorities i.e., asset priorities (engineered assets versus natural assets)
14/ Groundwater (Campbell Heights unconfined aquifer)	H		Especially in the unconfined aquifer area of the upper part of the watershed	Highly vulnerable to change, depletion, contamination, covers large area, also important asset for watershed health and recharge, as well as human use

Municipal Natural Assets Initiative