Toward natural asset management at the

Port of Vancouver

British Columbia

PORT of vancouver

Natural Assets Initiative
MAKING NATURE COUNT

Summary of inventory results and recommendations

December 2023

Natural Assets Initiative
MAKING NATURE COUNT

Invest in Nature

The Natural Assets Initiative (NAI) is a Canadian not-for-profit that is changing the way local governments deliver everyday services — increasing the quality and resilience of infrastructure at lower costs and reduced risk. The NAI team provides scientific, economic and government 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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1 Purpose

This document summarizes the results of a project to develop a natural asset inventory for the Vancouver Fraser Port Authority (hereafter "the Port Authority"), and documents steps it can take to proceed to a full natural asset management initiative.

2 Introduction

What are municipal natural assets

The term *natural assets* refers to the stock of natural resources or ecosystems that a municipality, regional district, port or other watershed stakeholder could rely on or manage for the sustainable provision of one or more services[1].

Why manage natural assets

A growing number of local governments, watershed agencies and other entities such as the Port Authority recognize that it is as important to understand, measure, manage and account for natural assets as it is for engineered assets. Doing so can enable better provision of 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 and others to manage natural assets. The Natural Assets Initiative (NAI), a Canadian national not-for-profit, develops and uses methodologies and tools rooted in standard asset management, and provides a range of advisory services to help local governments implement them. NAI has developed methods and tools with significant investments, piloting, refinement, peer review, and documentation of lessons in multiple Canadian provinces. NAI's mission is to make natural asset management a mainstream practice across Canada and, in support of this, for local governments and other watershed stakeholders to accept and use the methodologies and tools in standard ways across the country.

1 See *Developing Levels of Service for Natural Assets (2018)*

What is a natural asset inventory?

Natural asset inventories provide details on the types of natural assets local governments or other watershed stakeholders and rightsholders rely upon[2], their condition, and the risks they face. As depicted in Figure 1, a natural asset inventory is the first component of the assessment phase. The assessment phase, in turn, is the first of three phases of comprehensive natural asset management efforts. By itself, an inventory will not give a sense of asset capacity or service values but is a logical and essential first step towards more comprehensive natural asset management efforts.

Figure 1: *The Asset Management Process.*
NAI has adapted this cycle from Asset Management BC for use with natural assets.

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

3 Port Authority Context

3.1. General

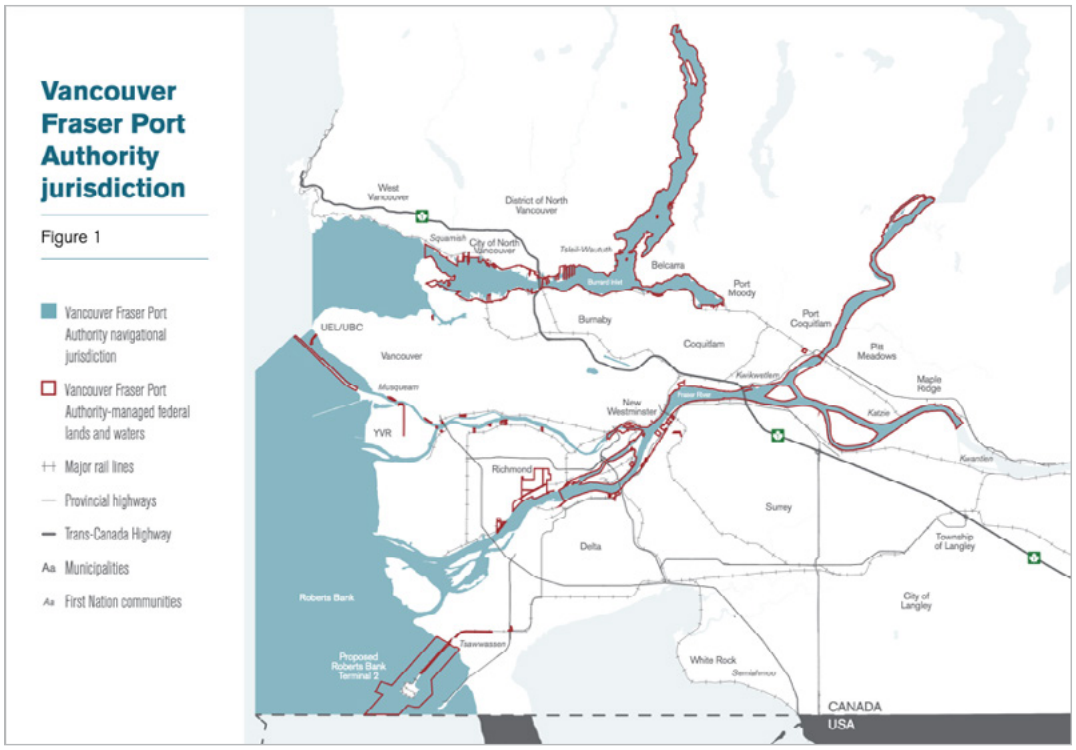

Figure 2: The Port Authority's jurisdiction covers a large swathe of the Lower Mainland, borders on 16 municipalities and intersects traditional territories and treaty lands of several Coast Salish First Nations (Map: Port Authority 2020).

The Port Authority is the federal agency responsible for the stewardship of the lands and waters that make up the Port of Vancouver, Canada's largest port. The Port of Vancouver handles more volume than the next five ports in Canada combined, with more than 140 million tonnes of cargo moving through the Port of Vancouver per year. Geographically, the Port of Vancouver includes more than 16,000 hectares of water, over 1,500 hectares of land, and approximately 350 kilometers of shoreline. It borders 16 municipalities and intersects the traditional territories and treaty lands of several Coast Salish First Nations[3].

From a governance perspective, the Port Authority is accountable to the federal Minister of Transport. Canada Port Authorities are non-share corporations and, by law, must be financially self-sufficient; they manage federal lands and waters in support of national trade objectives for the benefit of all Canadians. The Port Authority operates pursuant to the Canada Marine Act[4], which outlines the legal framework for the governance and operations of Canada Port Authorities. The Port Authority leases federal lands to the 29 terminal operators and other tenants[5] who handle trade through the Port of Vancouver.

3 See https://www.portvancouver.com/about-us

4 Canada Marine Act (S.C. 1998, c. 10).

5 See Footnote 3

The Port Authority has several interests in natural asset management. At an overarching level, the Port Authority's vision is for the Port of Vancouver to be the world's most sustainable port[6], and has defined "a sustainable port" as one which delivers economic prosperity through trade, maintains a healthy environment, and enables thriving communities. The Port Authority's definition of a sustainable port encompasses many facets of natural asset management (See Text Box 1). This vision has an inherent connection to the long-term health of natural assets.

Text Box 1: Areas of focus to maintain a healthy environment within the port authority's definition of a sustainable port

HEALTHY ECOSYSTEMS

- Takes a holistic approach to protecting and improving air, land and water quality to promote biodiversity and human health
- Champions coordinated management programs to protect habitats and species

CLIMATE ACTION

- Is a leader among ports in energy conservation and alternative energy to minimize greenhouse gas emissions
- Protects its assets against potential impacts of climate change

RESPONSIBLE PRACTICES

- Improves the environmental, social and economic performance of infrastructure through design, construction and operational practices
- Supports responsible practices throughout the global supply chain

INDIGENOUS RELATIONSHIPS

- Respects First Nations' traditional territories and value traditional knowledge
- Embraces and celebrates Indigenous culture and history
- Understands and considers contemporary interests and aspirations

More specifically, the Port Authority wants to better understand what natural assets they are responsible for, the services these provide, and to whom. This will allow them to:

- Track changes to natural asset condition and services over time;
- Understand the relationship between natural assets and services such as flood risk reduction in a changing climate;
- Support better and more holistic planning and decision-making which, at present, does not account for natural asset gains and losses;
- Align with global and federal biodiversity targets, which is of particular importance given that the Port Authority operates in an ecologically rich region with one of the highest levels of biodiversity in North America. The Port Authority's jurisdiction includes two national wildlife areas, five provincial wildlife management areas, three designated rockfish conservation areas, and designated critical habitat for southern resident killer whales[7];
- Support and strengthen relationships with neighboring communities, including Indigenous peoples, and help to advance common interests[8];
- Conduct operations and make decisions in a manner that meets obligations under the *Species at Risk Act* — there are over 30 federally listed at-risk species with a probability of being present and interacting with port-related activities or development, including the southern resident killer whale, great blue heron, and little brown bat[9].

6 *From Vancouver Fraser Port Authority Land Use Plan 2020.*

7 *See VFPA Health Ecosystems webpage*

8 *Launch meeting summary notes. (December 2022).*

9 *See footnote 7*

3.2. Asset management readiness assessment

As part of natural asset inventory development, NAI helps local governments and other partners determine their overall state of asset management maturity. To do this, NAI has adapted the Federation of Canadian Municipalities' (FCM) asset management readiness assessment scale.[10] This tool helps 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 tool is appropriate for use by the Port Authority and many other watershed stakeholders.

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

Competency 1: Policy & Governance

The Port Authority has an asset management policy called the Infrastructure Asset Management Directive. This includes principles around which infrastructure assets are to be managed. The Directive does not explicitly refer to the role of natural assets in service delivery, but neither does it exclude them. It may be desirable to either create a new policy or directive applicable to environmental management and natural assets; or, update the existing directive to include natural assets explicitly.

The Port Authority does not have an overarching asset management strategy with objectives for improving asset management systems. There are some strategic objectives related to habitat that focus primarily on how to support growth and development such that habitat-related management actions have been identified to offset the impact of development. Strategic objectives have not yet been defined to manage natural assets for the services they deliver.

The Port Authority's Sustainability Policy identifies healthy ecosystems as priority to accelerate progress towards their vision and enhance long-term value. The policy includes commitments to: establish sustainability goals and targets and develop strategies and action plans to achieve these; lead by example in Port Authority operations and practices; facilitate collaboration with stakeholders to advance shared sustainability objectives; and, support innovation, including facilitating the demonstration, and adoption of innovative practices and technologies.

Ecosystem health is identified within one of the Port Authority's six strategic priorities, which are issues central to their mission and vision. The language within this priority (SP-5) establishes a long-term goal of reversing biodiversity loss by restoring habitat and protecting species at risk. Related to this, there are strategic priority goals and medium-term targets that help measure progress towards this priority; one is to develop a biodiversity strategy by the end of 2026 that outlines how the Port Authority will help reverse biodiversity loss.

10 *FCM Asset Management Readiness Scale*

The Port Authority's 3-to-5-year strategic initiatives include: developing both a biodiversity strategy and a sustainability leadership roadmap; clarifying commitments; and, identifying medium-term strategic actions to accelerate progress towards its vision. **There is an opportunity to include natural asset management objectives in the upcoming biodiversity strategy and roadmap.**

In terms of measurement and monitoring progress on asset management, the Port Authority has standard approaches to developing condition ratings and taking management actions based on condition. However, these do not include measuring progress on natural asset management. Staff noted the opportunity to measure and report on progress on natural asset management in the Port Authority's most recent biennial sustainability report.

Competency 2: People & Leadership

The Port Authority's engineering department has a formal asset management group that follows the Infrastructure Asset Management Directive (noted above), and has roles and responsibilities imbedded in job descriptions. The group is well-integrated in the organization; however, natural asset management is not part the group's mandate, and natural assets are not considered as delivering services in the same way as built infrastructure assets. As such, the group does not currently include a staff person involved in natural asset management planning or activities. The Port Authority has staff responsible for managing environmental issues, lands, waters, and climate, both in the in the ecosystem management and environmental programs department, and in the climate action and sustainability leadership department. Activities include management of habitat and natural areas, including areas administered under the Port Authority's habitat bank (see Text Box 2). These staff collaborate with departments responsible for developing land use plans and designating conservation areas.

Text Box 2: PORT AUTHORITY HABITAT BANK

The port authority manages a Habitat Enhancement Program which has, since 2012, created, enhanced or restored approximately 15 hectares of fish and wildlife habitat, including intertidal salt, brackish, and freshwater marshes, as well as eelgrass beds. The program has also completed feasibility work on over 100 hectares of potential habitat enhancement. In relation to this, the port authority administers a habitat bank that is formalized through a 15-year agreement with Fisheries and Oceans Canada. The Program is intended to provide a balance between a healthy environment and future development projects that may be required for port operations.

Sourced from *www.portvancouver.com/projects/habitat-restoration/*

The Port Authority has assigned resources and funding to develop a biodiversity strategy, with the intent of exploring natural asset management-related work. The Board and executive leadership team have endorsed the development of the biodiversity strategy and committed to develop an internal framework to implement the strategy, through which it will be determined how natural asset management will be integrated.

Competency 3: Data & Information

The Port Authority has comprehensive asset data for built infrastructure and is updating its registry. The Port Authority is in early stages of developing a basic natural assets inventory through the project that is the subject of this report. This effort will allow the Port Authority to increase the scope of assets included in the inventory.

The Port Authority is at an early stage of documenting performance data for natural assets. It has collected natural assets data for the performance requirements for sites *directly* managed by the Port Authority, such as the habitat bank sites, but recognizes that this area is relatively small in relation to its entire jurisdiction containing natural assets. Objectives for these natural assets relate to: restoring eelgrass beds, salt marshes, and natural assets for the sites they manage through a range of programs and operations, including the Habitat Enhancement Program[11].

The Port Authority gathers information about the form and function of sites managed through the Habitat Enhancement Program, the Species at Risk Program, and conducts ecosystem monitoring through its ecosystem health pilot program (e.g., water and sediment quality, benthic and plankton community assessment). They have also conducted studies on white sturgeon and forage fish. However, the Port Authority has not yet set biodiversity-related performance objectives for either natural areas within their jurisdiction, or specific habitat sites or assets. It may wish to define specific levels of service for biodiversity in its forthcoming biodiversity strategy to ensure natural asset management needs are accounted for and managed to meet desired levels of service. Good asset management practice includes executive and board approval of performance objectives.

Competency 4: Planning & Decision-making

The Port Authority has a moderately well-structured asset management system to manage built infrastructure assets over their lifecycle. Planning is typically carried out using a risk-based approach that largely follows regulatory requirements (e.g., for bridges, dock structures, and critical infrastructure). Utilities appear to be managed based on desired performance, less so based on risk. Multiple departments and processes play a role in managing natural assets including ecosystem and environmental programs, land use planning, and project and environmental reviews. However, these activities have not been incorporated formally into natural asset investment planning; as such, there is an opportunity to develop a standardized approach to management of natural assets.

The Port Authority has formal asset management plans for built infrastructure including forecasting lifecycle management needs and risk management strategies for critical assets.

11 *VFPA Habitat Enhancement Program details*

For the habitat bank, the Port Authority has multi-year projections of costs needed for adaptive management. However, as noted in Text Box 2, the habitat bank accounts for 13 sites or 10 hectares, a small geographic area in relation to the over 17,500 hecatres of land and water in the Port Authority's jurisdiction. For other natural areas, natural assets are not yet formally incorporated into asset management plans.

The Port Authority undertakes long-term capital planning for their large, self-led infrastructure projects. This includes planning for some natural assets, such as the 13 sites in the habitat bank. The Port Authority does not currently take responsibility for natural assets on leased lands; tenants are responsible for environmental management on leased lands. Under the Port Authority's Capital Asset Directive, once constructed, capital assets transition to an operating budget. The engineering department is responsible for ongoing maintenance of infrastructure. Capital plans are refreshed every five years to meet lifecycle management costs and utilities management budget decisions are more ad hoc. The real estate department has a budgeting process to manage lifecycle management costs for buildings that are leased to other tenants.

Competency 5: Asset Management Training and Development, Communications

The Port Authority encourages asset management staff to undertake professional development by attending conferences and sharing knowledge. Regular awareness-building and communications with the Board may be helpful to build support for asset management generally, and for natural asset management specifically. In 2022, Board members received information related to biodiversity which included reference to natural assets.

The Port Authority is at an early stage of discussing natural assets in terms of services they deliver. Thus, there has been little internal communications or knowledge sharing about natural assets. Likewise, the Port Authority has not yet begun external or public communications specifically about natural asset management, but does undertake extensive public, stakeholder and Indigenous engagement on a broad range of sustainability related programs and activities, including for the ECHO Program and the Habitat Enhancement Program.

4 Natural asset inventory

4.1. Inventory overview

NAI's natural asset inventories have two main components to express natural asset information: an *asset registry* (which is a tabular representation of the data) and an *online dashboard*. NAI completed the registry and provided it to the Port Authority in an Excel file; the dashboard was provided as a web address. Information on the condition of the natural assets is a subset of the inventory and is depicted in both the registry and dashboard.

4.2. Inventory Data

To establish the inventory, NAI obtained data from the Vancouver Fraser Port Authority, the Metro Vancouver website, the Province of British Columbia's online GIS database, the Federal Government of Canada, Environmental Systems Research Institute (ESRI) and Open Street Map (OSM). NAI combined these spatial data layers to establish a comprehensive depiction of natural assets and to assign relevant attributes to the data (e.g., watershed and municipality).

Table 1 describes the data sources used to develop the inventory and classify its land cover. Table 2 lists the data used to assign attributes to the inventory.

Table 1: **Summary of data Sources Used to Delineate Natural Assets**

FILE NAME	SOURCE	PURPOSE
Vegetation Resource Inventory	Province of BC	Used as the baseline file for the inventory. This provided universal coverage for the study area, was recently updated and is maintained.
Sensitive Ecosystem Inventory	Metro Vancouver Region	Used to better delineate natural areas within the urban core of the Metro Vancouver area and to provide classification of water and oceanic assets.
National Road Network (BC dataset)	Federal Government of Canada	Used to delineate road bridge locations and extents in the natural asset inventory.
National Rail Network (BC dataset)	Federal Government of Canada	Used to delineate railway locations and extents in the natural asset inventory.
Land use in the Metro Vancouver Area	Metro Vancouver Region	Used to classify agriculture areas and better breakdown and identify types of urban areas and roads.
Golf Courses (OSM POIS Dataset)	© OpenStreetMap	Used to classify areas as golf courses.
OSM Land Use	© OpenStreetMap	Used to verify final changes to land cover to account for limitations in SEI and Land Use Data; used as source of park polygons.
OSM Building Footprints	© OpenStreetMap	Used to remove building footprints from inventory.
Eelgrass Boundary Files	Vancouver Fraser Port Authority	Used to delineate the location and extent of eelgrass assets.
ESRI World Imagery Basemap	ESRI	Used to confirm final changes done with OSM land use data and to test condition assessment workflow.

Table 2: Summary of Data Sources Used to Assign Additional Attributes to Assets

FILE NAME	SOURCE	PURPOSE
Provincial Parks	Province of BC	Used to divide areas of interest by provincial park boundaries.
Vancouver Fraser Port Authority Boundary	Vancouver Fraser Port Authority	Used as the basis for the study area.
BC Parcels	Government of Canada	Used to determine which natural assets are associated with which parcels.
Vancouver Fraser Port Authority Land Use Plan	Vancouver Fraser Port Authority	Used to divide areas by land use boundaries.
Regional Park Boundaries	Metro Vancouver Region	Used to divide assets by regional park boundaries.
Habitat Compensation Areas	Vancouver Fraser Port Authority	Used to divide assets by habitat areas.
Habitat Enhancement Areas	Vancouver Fraser Port Authority	Used to divide assets by habitat areas.
Watershed Boundaries	Province of BC	Used to divide assets by watershed boundaries.
Administrative Areas	Metro Vancouver Region	Used to divide assets by administrative boundaries.
Indigenous Reserves	Province of BC	Used to divide assets by reserve boundaries.
Sturgeon Habitat Boundaries	Vancouver Fraser Port Authority	Used to divide areas by zones important to sturgeon (spawning, juvenile holding, closure area, adult holding).
Land Cover Classification - 5 m Hybrid (Raster)	Metro Vancouver Region	Used to estimate canopy extent of coniferous, deciduous and shrubs for each asset.
Invasive Species Points	Vancouver Fraser Port Authority	Used to assign count of invasive species points within each asset, along with a supplementary table used to identify which species relate to which natural assets.
Freshwater Water Assessment (FWA) Watercourse Lines	Province of BC	Used to assess watercourse connectivity of assets.
Freshwater Water Assessment (FWA) Polygons	Province of BC	Used to assess watercourse connectivity of assets.
NBAC Fire Files	Government of Canada	Used to determine which assets were exposed to fire from 2003 to 2021.
Forestry Cut blocks	Province of BC	Used to determine which assets were impacted by forestry.

Including a 2,000 m buffer around the Port Authority's boundary, the inventory defined a total of 35,653 individual natural assets covering 87,350 hectares, as noted in Table 3. A natural asset is defined in the inventory as a continuous area of the same land cover type. For example, an intact forested area would be defined as one asset, but a forested area that is bisected by a road would constitute two assets. See Appendix A for definitions of the various asset types. Barring ocean water assets, the most prevalent type of land cover was forest, followed by agriculture, freshwater, and wetland.

Table 3: **Summary of natural assets within 2000 m of the Port Authority boundary**

ASSET	ASSET AREA (HA)	AVERAGE ASSET AREA (HA)	NO. OF ASSETS
Agriculture	963	11,248.82	11.68
Avalanche Track	16	128.77	8.05
Beach/Shoreline	604	108.32	0.18
Built-up Pervious	3,557	2,131.56	0.60
Eelgrass	289	25.26	0.09
Forest		13,932.24	1.89
Freshwater	3,479	8,484.63	2.44
Golf Course	144	1,050.89	7.30
Herb	1,948	382.17	0.20
Meadow	18	20.46	1.14
Mudflat	1,104	1,399.44	1.27
Natural Bare	335	183.95	0.55
Ocean	1,632	35,909.95	22.00
Old Field	94	433.95	4.62
Riparian	5,907	3,351.74	0.57
Shrub	819	424.10	0.52
Tidal Flat	675	2,378.44	3.52
Unknown	227	162.67	0.72
Wetland	6,453	5,591.82	0.87
Total	**35,653**	**87,349.89**	**2.45**

Figure 3 shows the spatial distribution of the natural assets that intersect a 2000 m buffer around the Port Authority boundary.

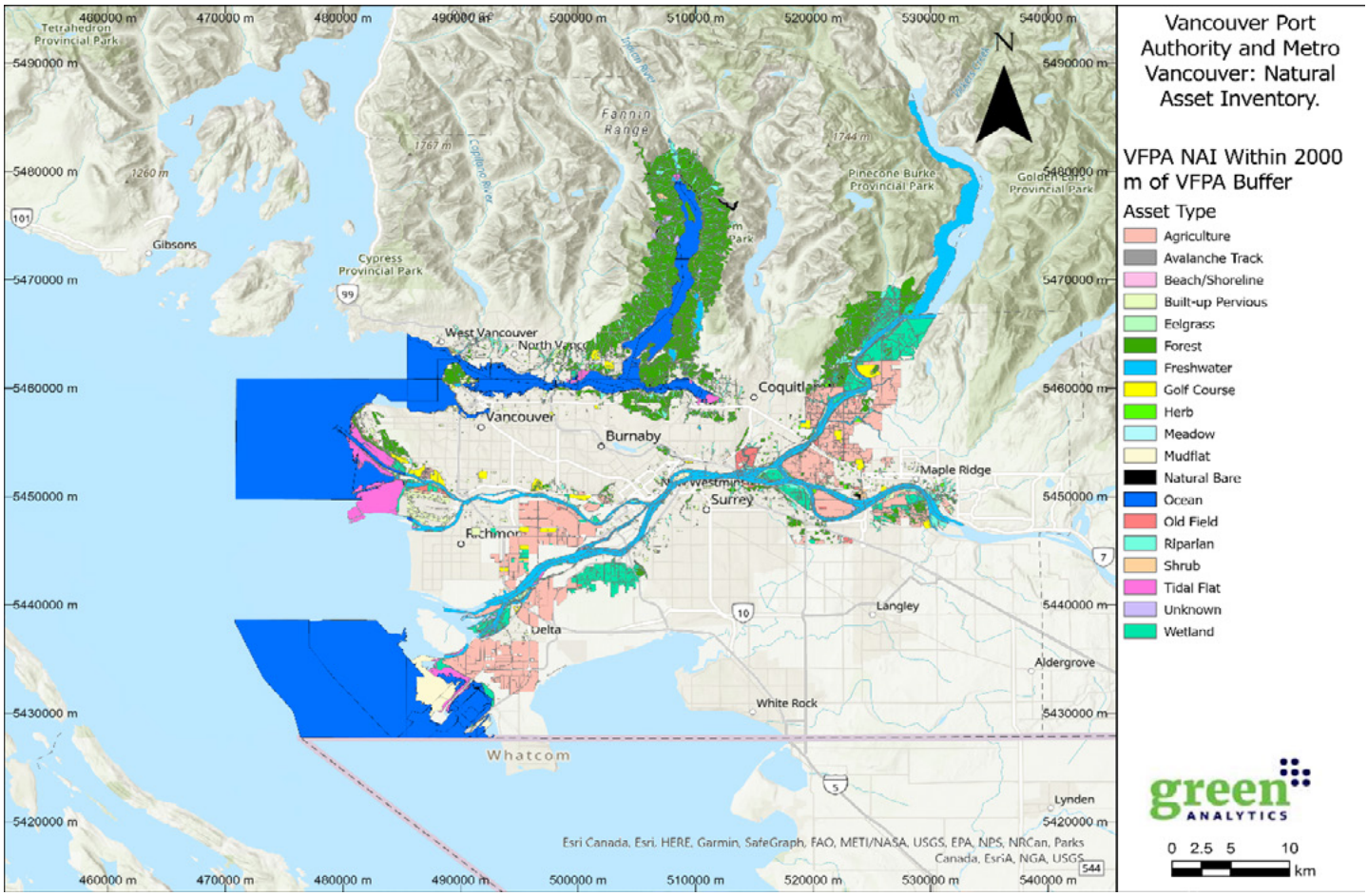

***Figure 3**: Spatial distribution of natural assets within the Port Authority's jurisdictional boundaries plus a 2000 m buffer*

Excluding the 2000 m buffer, Table 4 shows the breakdown of assets within the Port Authority boundary by type.

Table 4: **Summary of natural assets within the Port Authority boundary**

NATURAL ASSET TYPE	NUMBER OF ASSETS	TOTAL AREA (HA)	AVERAGE ASSET AREA (HA)
Agriculture	22	106.29	4.83
Beach/Shoreline	269	39.91	0.15
Built-up Pervious*	224	20.68	0.09
Eelgrass	258	24.01	0.09
Forest	1,028	60.58	0.06
Freshwater	1,583	3,633.64	2.30
Herb	220	16.00	0.07
Meadow	3	2.53	0.84
Mudflat	732	490.18	0.67
Natural Bare	69	2.34	0.03
Ocean	1,040	6,536.31	6.28
Riparian	1,347	89.18	0.07
Shrub	150	6.53	0.04
Tidal Flat	292	417.53	1.43
Unknown	67	4.65	0.07
Wetland	1,615	282.38	0.17
Total	**8,919**	**11,732.76**	**1.32**

Figure 4 shows the location and extent of the assets captured within the natural asset inventory.

***Figure 4**: Spatial distribution of natural assets within the Port Authority's jurisdictional boundaries plus a 2,000 m buffer*

4.3. Asset registry

The asset registry is a tabular depiction of the asset inventory. It contains detailed information on all assets and their attributes. As noted, a natural asset is defined as a continuous area of the same land cover type. Each continuous stretch of the same type of land cover (e.g., a forest) will have a unique Asset ID. After these continuous stretches have been identified and assigned an Asset ID, other criteria are used to further categorize the assets, including: the composition of the land cover type (e.g. marsh versus swamp for distinguishing boundaries within larger wetlands, or coniferous versus deciduous trees for distinguishing forest cover assets); the adjacent municipality; protected area designations; watershed boundaries; and, other land attributes. This could divide a forest asset into several smaller sub-assets, each with a unique Sub-Asset ID, depending on the number of attributes associated with the specific forest asset.

For example, an intact forested area that covers two watershed boundaries will have one Asset ID and two Sub-Asset IDs. Each asset in the asset registry thus has two alphanumeric codes associated with it; first is an "Asset ID", which identifies stretches of the same type of land cover and the second is a "Sub-Asset ID", which reflects attributes of the asset.

Table 5 is an excerpt from the Port Authority's online registry. Each asset within the inventory is a row in the asset registry; the columns contain attribute data. The asset registry is housed in the online dashboard.

Table 5: **Excerpt from the registry**

PORT of vancouver — Vancouver Fraser Port Authority | Natural Asset Inventory

Summary | Asset Registry

The inventory was constructed based on the natural asset classes of each polygon. The polygons that shared broad types of land cover were given a common classification and were grouped together based on similar properties. Details of these areas and related ecological properties are provided in the table below.

Filter by VFPA Jurisdiction: Completely Within Jurisdiction | Within Jurisdiction + Outside Jurisdiction (to 2000m)

Sub: All

Natural Feature Inventory

Sub-Asset ID	Asset ID	Asset Type	Landcover	Asset Area (ha)	Watershed	Municipality	
EEL27-1	EEL27	Eelgrass	Eelgrass	0.72		District of North Vancouver	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL27-2	EEL27	Eelgrass	Eelgrass	0.29		District of North Vancouver	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL28-1	EEL28	Eelgrass	Eelgrass	0.10		District of North Vancouver	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL28-2	EEL28	Eelgrass	Eelgrass	0.71		District of North Vancouver	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL29-1	EEL29	Eelgrass	Eelgrass	0.09		City of Port Moody	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL30-1	EEL30	Eelgrass	Eelgrass	0.19		City of Port Moody	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL30-2	EEL30	Eelgrass	Eelgrass	0.49		Village of Belcarra	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL30-3	EEL30	Eelgrass	Eelgrass	0.19		Village of Belcarra	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL30-4	EEL30	Eelgrass	Eelgrass	0.00		Village of Belcarra	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL3-1	EEL3	Eelgrass	Eelgrass	0.71		City of Burnaby	Recreation areas are primarily designated for public recreational use such as parks and viewing areas.
EEL31-1	EEL31	Eelgrass	Eelgrass	0.10		Village of Belcarra	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL31-2	EEL31	Eelgrass	Eelgrass	0.00		Village of Belcarra	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL31-3	EEL31	Eelgrass	Eelgrass	0.00		Village of Belcarra	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL31-4	EEL31	Eelgrass	Eelgrass	0.01		Village of Belcarra	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL3-2	EEL3	Eelgrass	Eelgrass	0.02		City of Burnaby	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL32-1	EEL32	Eelgrass	Eelgrass	0.11		Village of Belcarra	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate
EEL3-3	EEL3	Eelgrass	Eelgrass	0.00		City of Burnaby	Port water areas are primarily designated for shipping, navigation, moorage, and anchorage in open wate

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, through the online dashboard, natural asset information can be quickly summarized by watershed area, or, if users want to dive into the specifics of forest assets, they can filter the data to focus on that particular asset. Figure 5 is a screenshot from the dashboard that NAI provided to the Port Authority.

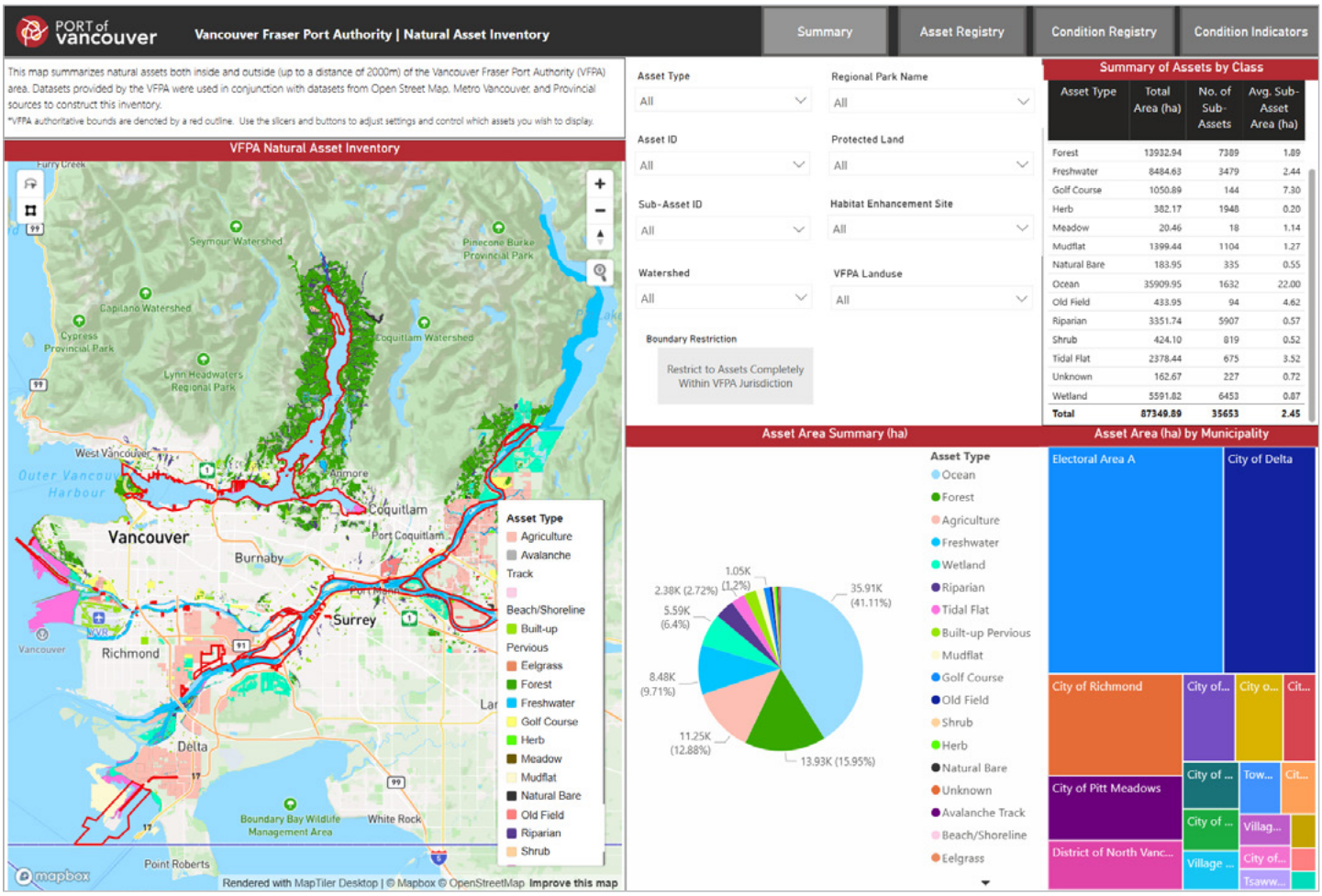

Figure 5: Screenshot of main inventory summary.

4.5. Condition of natural assets

Documenting the condition of natural assets is a key component of natural asset management. 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 can support the effective management of natural assets, be reflected in the registry and the dashboard, and be updated over time.

NAI completed a desktop condition assessment which was integrated into the inventory to provide an initial understanding of the condition of the natural assets within and around the Port of Vancouver. As part of a full natural asset management project, NAI would expand this assessment to include additional metrics related to condition (e.g., relative biodiversity, riparian and wetland health, and soil condition) and could conduct site visits to verify condition. The desktop exercise completed as part of this inventory is a reasonable first step in assessing condition and a foundation for future work.

Table 6 lists the asset types that were included and excluded from the condition assessment. The condition assessment was scoped to the assets noted in Table 6 as these are amenable to the condition indicators included in the assessment. The indicators are described in detail in Table 7. A separate set of condition

indicators would be needed for excluded land cover types. For example, indicators to assess the condition of agricultural areas (which are intended to provide food services) should be different from the condition metrics employed to assess built-up pervious areas (which provide recreation services). Similarly, water-related assets (eelgrass, ocean, beach/shoreline, mudflat, tidal flat) should be assessed with condition indicators suited to such assets.

Table 6: List of assets included/excluded from condition assessment

Asset Types Included in Condition Assessment	Asset Types Excluded from Condition Assessment
■ Forest ■ Freshwater ■ Herb ■ Meadow ■ Old Field ■ Riparian ■ Shrub ■ Wetland	■ Agriculture ■ Avalanche Track ■ Beach / Shoreline ■ Built-up Pervious ■ Eelgrass ■ Golf Course ■ Mudflat ■ Natural Bare ■ Ocean ■ Tidal Flat ■ Unknown

Three indicator sets were used for the condition assessment. Ranked indicators, listed in Table 7, are indicators that have hierarchical results that assess condition on a scale from “very good” to “very poor”. An example of a ranked indicator is road density. For this indicator, different levels of road density correspond to condition categories such that the higher the road density, the lower the condition and vice versa.

The second set of indicators, listed in Table 8, are threshold indicators. Here, assets are assessed for whether they meet, exceed, or fail to reach a specified threshold. Water connectivity is an example of a threshold indicator; in this case, assets are assessed for whether they intersect a watercourse or not. The third set of condition indicators, listed in Table 9, are biophysical indicators whose value reflects the condition of an asset. An example is the extent of natural area within 100 m of an asset; this indicates how much natural, undeveloped area surrounds a natural asset.

NAI chose these indicators 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 broader condition considerations. For example, more natural areas surrounding an asset indicates less pressure from human development and use, and higher road density implies more fragmentation and higher hydrologic impairment of water flow.

Table 7:
Condition assessment approach and indicators – Ranked Indicators

Indicator	Description & Methods for Quantification	Data used to Quantify Indicator*
Road/Rail Density	Measures the density of the roads and rail tracks in and around the assets in km/km2. A 100 m buffer was generated for each asset and the length of all roads and railway tracks within that area was measured. An estimate of road density was calculated by taking the combined length of railways and roads in the buffered area and dividing by the area of each asset's buffer in km2. Then, a rating was applied based on the road density for each asset, with the value linked back to each asset. Categories were derived from histograms generated from the rail/road density measures for the assets of the inventory. The following rating system was used: ■ Assets with 0-2 km/km2 road density= Very Good ■ Assets with 2-5 km/km2 road density = Good ■ Assets with 5-8 km/km2 road density = Fair ■ Assets with 8-10 km/km2 road density = Poor ■ Assets with >10 km/km2 road density = Very Poor	Natural asset inventory and road and rail datasets (applied to all assets included in condition assessment).
Presence of Interior Habitat	A measure used to assess which assets are suitable for wildlife habitat, indicated by how much interior area an asset has within it. Assets of the same type were merged into continuous areas. Then, the area within these merged zones measured a specific distance from the outer edge was generated as a separate polygon representing these interior natural areas. The amount of overlap of these interior areas within each asset was then measured for each asset, and the following rating was applied: ■ Assets with an interior area measured 100 m from the feature edge = Very Good ■ Assets with an interior area measured 75 m from the feature edge and not already captured as Very Good = Good ■ Assets with an interior area measured 50 m from the feature edge and not already captured as Very Good or Good = Fair ■ Assets with an interior area measured 25 m from the feature edge and not already captured as Very Good, Good, or Fair = Poor ■ Assets with no interior area measured at 25 m from the feature edge that does not fall into Very Good, Good, Fair, or Poor = Very Poor	Natural asset inventory (applied to all assets included in condition assessment).

Table 8:
Condition assessment approach and indicators – Threshold Indicators

Indicator	Description & Methods for Quantification	Data used to Quantify Indicator*
Interior Forest Area	Measures area of forest cover 100 m from the interior edge of forest assets[1]. Estimated by merging all forest assets together and buffering the merged area by -100 m. The area within each forest asset was measured in hectares. Forests with greater interior area are better insulated from impacts of adjacent land uses and provide more habitat. Any forest asset that has an interior area measured at this distance from the forest edge was classified as "Meets Interior Forest Criteria", else it was classified as "Does Not Meet Interior Forest Criteria".	Natural asset inventory (applied to forest assets).
Watershed Forest Area	Watersheds that have 30-50% or more of their area covered in forest have a higher ecological condition than those with less than 30% coverage.[2] If an asset is within a watershed that has 30-50% or more of its area covered by forest, it was classified as "Asset Meets Watershed Forest Area". Forest assets in watersheds with less than 30% forest cover, were identified as "Asset Does Not Meet Watershed Forest Area".	Natural asset inventory and FWA watershed datasets (only applied to forest assets).
Watershed Wetland Area	Watersheds with at least 10% of their area classified as wetland have better overall condition.[3] For this indicator, the percentage area of wetland occupying each watershed was estimated. Assets within a watershed that have 10% or more of its area composed of wetlands were classified as "Asset Meets Watershed Wetland Area". Wetland assets in watersheds with less than 10% wetland area were identified as "Asset Does Not Meet Watershed Wetland Area".	Natural asset inventory and FWA watershed datasets (only applied to wetland assets).
Wetland Proximity to Other Wetlands	Wetlands within 750 m of each other provide easier migration for species that utilize these environments.[4] Wetland assets were rated as "Asset Meets Wetland Proximity Criteria" if they are within 750 m of another wetland. Otherwise, they were identified as "Asset Does Not Meet Wetland Proximity Criteria."	Natural asset inventory (only applied to wetland assets).

(cont'd) Table 8:
Condition assessment approach and indicators – Threshold Indicators

Indicator	Description & Methods for Quantification	Data used to Quantify Indicator*
Forest Proximity to Other Forests	Forest patches (continuous areas of forest large enough to have interior forest area 100 m from the outer extent of undivided forests) that are within 2 km of other forest patches have higher ecological condition and value as habitat.[5] Forest assets that are part of a continuous forest area large enough to be considered a patch where the patch is within 2 km of one or more other forest patches were rated "Asset Meets Forest Proximity Criteria", otherwise they were considered "Asset Does Not Meet Forest Proximity Criteria".	Natural asset inventory (only applied to forest assets).
Watercourse Connectivity/ Watercourse and Asset Connectivity	This metric is to identify assets connected to watercourses. There are two versions of this indicator. The first Watercourse Connectivity indicator assesses whether assets intersect a FWA watercourse line or polygon, or a Riparian asset. Assets that meet this criterion were flagged as "Asset Meets Watercourse Connectivity Criteria." Otherwise, they were classified as "Asset Does Not Meet Watercourse Connectivity Criteria". The second Watercourse and Asset Connectivity indicator assesses whether assets intersect other water assets including mudflats, wetlands and freshwater bodies. Assets that meet this criterion were flagged as "Asset Meets Watercourse and Asset Connectivity Criteria", else they were classified as "Asset Does Not Meet Watercourse and Asset Connectivity Criteria".	Natural Asset Inventory and FWA watercourse line and polygon file (applied to all assets included in condition assessment).

** Data sources provided in Table 1 unless noted here.*

1 *Environment Canada. (2013). How Much Habitat is enough? Third Edition. (p. 69).*
2 *bid, p. 61*
3 *bid, p. 20*
4 *bid, p. 37*
5 *bid, p. 73*

Table 9:
Condition assessment approach and indicators – Biophysical Indicators

Indicator	Description & Methods for Quantification	Data used to Quantify Indicator*
Natural Area within 100 m of Each Asset	A measure of the amount of natural area within 100 m around each natural asset, to indicate how much of the surrounding area is natural. Estimated by applying a 100 m buffer around each asset and measuring the extent and number of all other assets except for Agriculture, Built-up Pervious, and Golf Course to exclude areas with heavy human influence. The area (in ha) of natural assets within this distance, and the percentage of the 100 m buffer occupied by them around each asset, was assigned to each asset.	Natural asset inventory (applied to all assets included in condition assessment).
Fire History	The extent (in ha) of assets that overlap with areas of known fire occurrence in the last 20 years was estimated for each year.	NBAC fire files (applied only to forest, meadow, herb, shrub, and old field assets).
History of Forestry Impact	To account for history and impacts of forestry, the Harvest Date information from the VRI was used in conjunction with Cut Block data from the Province of BC to identify areas of harvesting for forestry. The percentage of an asset's area that overlapped with a known cut block was also estimated.	Natural asset inventory, VRI dataset, and Province of BC Cut Block dataset (applied only to forest assets).

** Data sources provided in Table 1 unless noted here.*

Condition assessment results are presented in the online dashboard and summarized here. For the purposes of this report, condition assessment results are presented for assets within 2000 m of the Port Authority's jurisdiction. The online dashboard, by contrast, allows users to filter results to just those areas within jurisdictional boundaries.

Tables 10 and 11 summarize the results of the ranked condition indicators, presenting the area of each asset type within each ranking. As is shown in Table 10, most of the assets have significant interior habitat area. Exceptions to this are herb, riparian, and shrub assets. Similarly, as Table 11 demonstrates, the vast majority of assets have low road density. The only exception to this are herb assets.

Table 10: Breakdown of the extent (in hectares) of all assets in hectares of each type according to their Interior Habitat Ranking

Asset Type	Very Good	Good	Fair	Poor	Very Poor	Total Area (ha)
Forest	11,232.49	1,023.38	845.46	621.62	218.99	13,932.94
Freshwater	7,670.73	251.90	229.95	177.36	154.69	8,484.63
Herb	58.54	23.43	61.47	103.01	135.73	382.17
Meadow	0	0	16.07	2.55	1.84	20.46
Old Field	361.97	37.44	18.08	11.98	4.48	433.95
Riparian	651.96	282.50	388.99	1,174.21	854.06	3,351.74
Shrub	77.30	35.97	76.03	157.82	76.99	424.10
Wetland	4,528.26	246.45	305.43	331.44	180.24	5,591.82
Total Area	**24,572.26**	**1,901.07**	**1,941.47**	**2,579.99**	**1,627.02**	**32,621.81**

Table 11: Breakdown of the extent (in hectares) of all assets in hectares of each type according to their Road/Rail Density Ranking

Asset Type	Very Good	Good	Fair	Poor	Very Poor	Total Area (ha)
Forest	10,706.12	1,870.36	730.19	148.56	477.71	13,932.94
Freshwater	6,627.70	1,240.55	315.66	71.18	229.54	8,484.63
Herb	58.84	68.98	82.64	37.29	134.43	382.17
Meadow	17.93	0	0.13	0	2.40	20.46
Old Field	154.65	132.19	83.25	59.88	3.98	433.95
Riparian	2,038.76	500.75	299.10	226.18	286.95	3,351.74
Shrub	171.98	59.40	56.80	34.57	101.36	424.10
Wetland	4,610.73	596.73	219.03	72.05	93.28	5,591.82
Total Area	**24,386.72**	**4,468.96**	**1,786.79**	**649.70**	**1,329.65**	**32,621.81**

Tables 12 through 18 summarize threshold indicator results. Table 12 shows administrative areas that meet the threshold for interior forest area (i.e., the administrative areas listed all have interior forest area greater than zero). Interior forest areas are greatest in Electoral Area A, with over 1,800 ha, followed by the District of North Vancouver with more than 700 ha and the City of Coquitlam with over 500 ha.

Table 12: Breakdown of the amount of interior forest area within each Administrative Area in all assets within 2000 m of the Port Authority's boundary

Administrative Area	Interior Forest Area (ha)
Electoral Area A	1843.63
District of North Vancouver	726.25
City of Coquitlam	529.68
City of Port Moody	506.81
Village of Anmore	428.71
Village of Belcarra	225.47
City of Burnaby	129.16
City of Vancouver	98.19
Township of Langley	21.02
City of Pitt Meadows	17.51
City of Delta	10.04
City of Surrey	8.76
City of Port Coquitlam	0.56
District of West Vancouver	0
City of Maple Ridge	0
City of New Westminster	0
City of North Vancouver	0
City of Richmond	0
Tsawwassen First Nation	0

Table 13: **Extent of wetland assets according to the watershed wetland area criterion**	
Watershed Wetland Patch Condition Rating	**Area (ha)**
Asset Meets Watershed Wetland Area Criterion	3,190.62
Asset Does Not Meet Watershed Wetland Area Criterion	2,401.19
Total Area	**5,591.82**

Table 14: **Extent of forest assets according to the watershed forest area criterion**	
Watershed Forest Patch Condition Rating	**Area (ha)**
Asset Meets Watershed Forest Area Criterion	9,565.54
Asset Does Not Meet Watershed Forest Area Criterion	4,367.40
Total Area	**13,932.94**

Tables 15 and 16 present the area of assets that meet the forest and wetland proximity criteria. The results demonstrate that over 90% of the forest assets that were captured in the condition assessment are within 2000 m of other forest assets. In the case of wetland proximity, almost all (99%) wetland assets met the proximity criteria, which means that almost all of the wetland assets are within 750 m of other wetland assets.

Table 15: **Forest proximity conditions for forest assets**	
Forest Proximity Condition Rating	**Area (ha)**
Asset Meets Forest Proximity Criterion	12,675.30
Asset Does Not Meet Forest Proximity Criterion	1,257.64
Total Area	**13,932.94**

Table 16: **Wetland proximity conditions for wetland assets**	
Wetland Proximity Condition Rating	**Area (ha)**
Asset Meets Wetland Proximity Criterion	5,539.29
Asset Does Not Meet Wetland Proximity Criterion	52.52
Total Area	**5,591.81**

Results for the final threshold-related indicator are presented in Table 17. Here, the area of assets that meet the watercourse connectivity criterion are compared with those that do not meet this criterion. Over 90% of the assets meet the watercourse and asset connectivity criterion, which means that the vast majority of the assets within 2000 m of the Port Authority's boundary are connected to some type of watercourse.

Table 17: **Assets area (in hectares) by asset type according to their watercourse and asset connectivity criterion**

ASSET TYPE	ASSET MEETS WATERCOURSE AND ASSET CONNECTIVITY CRITERION	ASSET DOES NOT MEET WATERCOURSE AND ASSET CONNECTIVITY CRITERION	TOTAL AREA (HA)
Forest	12,645.91	1,287.03	13,932.94
Freshwater	8,474.24	10.39	8,484.63
Herb	213.71	168.46	382.17
Meadow	17.93	2.53	20.46
Old Field	383.85	50.09	433.95
Riparian	3,351.74	0	3,351.74
Shrub	263.62	160.49	424.10
Wetland	5,380.14	211.68	5,591.82
Total	**30,731.15**	**1,890.66**	**32,621.81**

Table 18 summarizes the amount of area in and surrounding (within 100 m) natural assets that is comprised of natural land covers. With the exception of herb and old field assets, the assets within 2000 m of the Port Authority's boundary are largely surrounded by other natural assets.

Table 18: **Average percentage of 100 m buffer around assets (including asset itself) that is composed of natural area for each asset type**

ASSET TYPE	AVERAGE % OF AREA IN AND SURROUNDING (100 M BUFFER) ASSETS THAT IS NATURAL
Forest	75.71
Freshwater	72.82
Herb	37.67
Meadow	86.89
Old Field	58.04
Riparian	72.24
Shrub	62.17
Wetland	86.15

The final two condition indicators relate to fire and harvest history. No forest, old field, shrub, herb, or meadow assets within 2000 m of the Port Authority's boundary were significantly exposed to fire and forestry activity in the last 20 years.

Overall, for the assessed condition indicators, natural assets within 2000 m of the Port Authority's boundary fare well in that they rank as fair, good or very good across ranked indicators, threshold indicators and biophysical indicators. Results of the assets just within the Port Authority's boundary (not including those located within a 2000 m buffer of the boundary) are available through the online dashboard.

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, and new studies may add insights into asset condition. New data can be reflected in the asset registry and subsequently in the online dashboard. Furthermore, the level of desired detail may evolve as asset management readiness increases or as areas of natural asset management focus emerge. That said, inventories should grow in detail and sophistication only insofar as they remain aligned with the capacity of the Port Authority 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 Port Authority and adjacent local governments and other entities.

5 Risk identification

5.1. Risk identification tool overview

Identifying risks facing natural assets can help the Port Authority prioritize natural asset management efforts. To this end, NAI provided the Port Authority with a tool titled *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 by identifying the 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 organization to maintain services
- **Political risk:** risks related to the nature of politics

5.2. Using the Risk Identification Tool

Using the risk tool, NAI facilitated a discussion with Port Authority staff to identify hazards to natural assets that could pose risks to them or to the Port Authority's built infrastructure, shipping operations, health and safety, or property in their jurisdiction. Port Authority participants included representatives from ecosystem management and environmental programs, climate actions and sustainability leadership, engineering, and real estate departments. Potential hazards to biodiversity are listed in Table 19. Hazards are broken down into those related specifically to potential impact from shipping operations, and potential impacts from port-related upland activities.

Table 19: Potential hazards to biodiversity

POTENTIAL IMPACTS TO BIODIVERSITY OR NATURAL AREAS FROM SHIPPING/ON-WATER OPERATIONS	POTENTIAL IMPACTS TO BIODIVERSITY OR NATURAL AREAS FROM UPLAND OPERATIONS	POTENTIAL IMPACTS TO BIODIVERSITY OR NATURAL AREAS FROM INCLEMENT WEATHER OR CLIMATE CHANGE
■ Shoreline erosion from wave activity ■ Discharges from ships ■ Scouring ■ Underwater noise ■ Air pollution and emissions ■ Ambient noise and light ■ Invasive species ■ Accidents and malfunctions (e.g., fires, spills, loss of cargo) ■ Dredging ■ Abandoned vessels ■ Transiting vessels	■ Land development ■ Stormwater runoff ■ Contaminated sites ■ Accidents and malfunctions (e.g., fires, spills) ■ Invasive species ■ Ambient noise and light ■ Air pollution and emissions ■ Land encroachment	■ Sea level rise/storm surge ■ Flooding (e.g., freshet, atmospheric river) ■ Drought or extreme heat

Port Authority staff assessed the likelihood and consequence of each risk on a five-point scale. This was then used to create a risk score by multiplying the likelihood score by the consequence score. Existing management plans and mitigations were considered when scoring. The scales used to estimate likelihood and consequence are shown below.

The results of the risk identification can form the basis of a more comprehensive risk assessment. An important next step for the Port Authority could be to identify specific assets at risk and specific locations to be prioritized for management actions.

The matrix in Figure 6 shows risks ranging from low to high based on their risk score. Lowest risks appear in the green shaded background and highest risks appear in red shaded background. See Appendix B for list of risk rankings.

***Figure 6**: Risks along spectrums of likelihood of occurrence and impact severity*

Risks in blue text are those categorized as shipping related; those in green text relate to upland risks; and those in brown are climate related risks.

5.3. Potential Priorities for the Port Authority

This sub-section summarizes activity areas where risks to natural assets were identified as medium to high. It includes a description of potential impacts to biodiversity, existing management actions, and initial opportunities.

Land development: Land development was identified as a **high risk**. It can result in direct loss to habitat and biodiversity, fragment habitat or natural areas, and include infilling of waterways or intertidal natural assets. In some cases, land development projects require habitat offsetting. However, this practice is not without risks and controversy. The Port Authority has in place the Project and Environmental Review (PER) process to assess the environmental impact of proposed projects within port jurisdiction. The Port Authority would benefit from not only better understanding the natural assets present in its jurisdiction but also the cumulative impacts to natural areas from land development.[12] In most instances, undisturbed habitats and natural areas function better and provide more ecosystem services than human engineered or constructed

12 *See for example, the Province of British Columbia's Cumulative Effects Framework: Cumulative Effects Framework Overview - Province of British Columbia (gov.bc.ca).*

habitats. There is opportunity for the Port Authority to link natural asset mapping and the inventory to land use planning tools and biodiversity targets in order to improve management of habitat and natural areas/assets, with an overall goal to understanding trade-offs and maximising the maintenance of services from nature.

Climate change-related impacts: These include sea level rise, storm surge, flooding, drought, and extreme heat related to climate change and were considered **medium-high to high risk** based on uncertainty of potential impacts. Rising global average temperature is associated with widespread changes in weather patterns, sea level rise, and storm surge. Warming of oceans and extreme atmospheric heat can have ecosystem impacts related to changes in migration, introduction of disease, and mass die-off events. Sea level rise is caused by the ocean expanding as it heats up due to global warming and melting stores of ice from glaciers and ice sheets. Storm surges occur in coastal areas when strong onshore winds and low atmospheric pressure during passing storms raise water levels above predicted levels. Flood and freshet risk is predicted to evolve with climate change. Annual freshet has impacts along the Fraser River. Changes in the climate are shifting traditional freshet windows from late spring to any time of year and inclement weather, such as atmospheric rivers, may cause more frequent flooding events. These impacts may interact in different ways.

Failure to mitigate climate change, failure of climate change adaption, natural disasters and extreme weather events, and biodiversity loss and ecosystem collapse are identified as the top four most severe global risks over the next 10 years by the World Economic Forum (2023). Climate projections from Metro Vancouver show that, by 2050, the Lower Mainland region will experience more frequent and severe extreme weather events (2016). Current modelling from the Province of British Columbia suggests the region's sea level will rise by 1 metre by the year 2100, with Vancouver ranked as one of the most at-risk cities in the world for losses due to flooding (2014, p. 9).

The Port Authority has programs and initiatives aimed at reducing emissions that affect air quality and climate change. These include shore power, EcoAction program (a vessel incentive program), Non-Road Diesel Emissions Program, drayage truck[13] emission requirements, Low Emission Technology Initiative and the Pacific Northwest to Alaska Green Corridor. The programs support the collaborative Northwest Ports Clear Air Strategy goal of phasing out all port-related emissions by 2050, and the Port Authority's strategic priority to achieve net zero emissions by 2050.

The Port Authority has established an internal climate adaptation team comprised of representatives from planning, engineering, ecosystem management, emergency management, and sustainability departments to better understand climate change-related risks and increase port resiliency to

13 *A truck used for short-distance transport of cargo.*

climate change impacts. The Port Authority is undertaking climate adaptation planning to identify key actions to improve port resiliency, focusing on flooding from sea level rise and severe weather events. The goal is to develop flood risk mapping for the Port Authority's jurisdiction that models scenarios of sea level rise and river flooding from heavy rains and freshet. This includes a flood risk mapping tool for the Fraser River. These maps show areas likely to flood. Together with this inventory, they will suggest which assets, both engineered and natural, are most at risk; understanding the vulnerability of these assets from these impacts will help define priority areas for action (e.g., rehabilitation) to reduce risk and increase climate resilience.

Stormwater runoff: Stormwater is water that originates from precipitation events such as rainfall and snow and ice-melt. In developed areas, impervious surfaces such as pavement and roofs prevent precipitation from naturally infiltrating into the ground. Instead, it flows rapidly into storm drains, sewer systems, and drainage ditches and may cause flooding, erosion, turbidity, or storm and sanitary sewer system overflow. As the stormwater flows over land it can accumulate debris, soils, sediments and pollutants that can be discharged into marine and freshwater environments, impacting water quality and ecosystems. The Port Authority requires stormwater to be managed effectively by all tenants occupying Port Authority lands and waters, and has guidelines that include information on stormwater sampling requirements and proper treatment. There are opportunities to: update stormwater management plans and guidance documents with best available information, including on natural assets; provide related education to tenants on requirements; and, develop a holistic approach to green infrastructure, of which natural assets are a subset of. The Port Authority should monitor implementation of stormwater management plans to increase their effectiveness.

Invasive species: Invasive species can threaten local biodiversity. The Port Authority monitors and removes invasive species within its jurisdiction and more regionally through collaboration and support for regional initiatives. Management and removal efforts include: supporting annual efforts through a Ducks Unlimited program to eradicate Spartina (an invasive cord grass that modifies natural tidal mudflats); treating upland invasive species annually (e.g., knotweed and hogweed); and, supporting Fisheries and Oceans Canada and local aquatic invasive species programs (e.g., green crab monitoring).

Aquatic invasive species introduced through shipping activities were considered a **medium risk**. The Vancouver Fraser Port Authority was the first port in North America to prohibit in-port ballast water exchange without prior mid-ocean exchange. This practice has now become the basis of Canada's Ballast Water Regulations, and many other countries have similar practices. Ballast exchange is recognized as one of the best available options to reduce the risk of introducing invasive species. All vessels calling on the Port Authority must meet the requirements set out in the International Maritime Organization (IMO) Ballast Water convention, which requires vessels to have an approved ballast water treatment system onboard and conduct mid-ocean ballast water

exchange. Note that the Department of Fisheries and Oceans and Transport Canada have mandates to manage recreational boating.

Anti-fouling coatings applied to vessels can help reduce attachment of marine organisms and may reduce the spread of some aquatic invasive species, but they can also negatively impact water quality and aquatic life. The IMO has guidance documents for control and management of ships' biofouling systems to minimize the transfer of invasive aquatic species. The Port Authority encourages vessels to voluntarily follow the IMO's biofouling guidelines as best practices for aquatic invasive species management. Additionally, it prohibits in-water hull cleaning activities as these can contribute to agitation of anti-fouling coatings and dislodgement of marine organisms from ship surfaces.

The Port Authority should monitor implementation of its invasive species management plan on lands for which they are directly responsible, as well as on parcels they lease to tenants.

Underwater Noise: Underwater noise from shipping activities is considered a **medium risk**. Underwater noise can interfere with marine life including the southern resident killer whales' ability to hunt, navigate, and communicate using echolocation. The Port Authority launched the Enhancing Cetacean Habitat and Observation (ECHO) Program[14] in 2014 to better understand and reduce the cumulative effects of commercial shipping on at-risk whales, with a particular focus on reducing underwater noise . Since the program's launch nearly a decade ago, the ECHO Program has become a world leader in underwater noise reduction research and mitigation. As part of mitigation efforts, the ECHO Program encourages large commercial ships to voluntarily slow down or stay distanced in order to reduce underwater noise while transiting through key areas of southern resident killer whale critical habitat. Since the first slowdown in 2017, more than 15,000 vessel transits have participated in the ECHO Program's voluntary underwater noise reduction initiatives, which now span nearly 80 nautical miles of the Salish Sea. In 2022, these initiatives helped achieve a nearly 50% reduction in underwater sound intensity in key foraging and transiting areas for southern resident killer whales. In future years, the ECHO Program will continue to coordinate voluntary on-water initiatives, continue research on quiet vessel design and technology, and work with partners in government to investigate potential for regional underwater noise targets.

14 *See ECHO Program page for details*

6 Recommendations

This section provides insights gained from considering both the inventory — including the condition and risk assessments — and the asset management readiness assessment. It is divided into:

- **6.1/ Opportunities to strengthen natural asset management at an organization-wide level**
- **6.2/ Possible actions for the further development of the inventory, and**
- **6.3/ Steps the Port Authority can consider to advance to a full natural asset management initiative**.

6.1. Opportunities to Strengthen Natural Asset Management at an Organization-wide Level

1. UPDATE THE INFRASTRUCTURE ASSET MANAGEMENT DIRECTIVE TO INCLUDE NATURAL ASSETS

The Port Authority has not yet begun to formally treat natural assets as valuable infrastructure to the same degree that it treats other infrastructure assets. As noted, the Infrastructure Asset Management Directive does not explicitly refer to the role of natural assets in delivering services. The high-level principles in the policy likely apply to how natural assets should be managed. The Port Authority should consider explicitly including natural assets in an update to the policy.

2. INCLUDE A EMEP REPRESENTATIVE IN THE PORT AUTHORITY'S ASSET MANAGEMENT GROUP

To support integration of natural asset management with overall infrastructure management at the Port Authority, the asset management group should consider including a representative from the Ecosystem Management and Environmental Programs team. Broadening group representation can support coordination of efforts and ensure that natural asset management considerations become part of an integrated approach to manage all valuable infrastructure services.

3. REVIEW APPROACH TO RESOURCE ALLOCATION TO BETTER ACCOUNT FOR NATURAL ASSETS

This assessment indicates that some natural assets, particularly the 13 sites in the habitat bank and contaminated sites, are accounted for in capital plans and operating budgets. However, the vast majority of land is not yet accounted for in this way. The Port Authority should review its approach to budgeting and financial management to determine whether there are ways to better account for natural assets that are not yet actively managed.

4. DEVELOP GUIDANCE FOR NATURAL ASSET MANAGEMENT FOR TENANTS

The Port Authority should define a rigorous approach for tenants regarding natural asset management requirements on leased sites. This could include: establishing the principle, and related policy, that natural assets on leased lands must be identified and managed to the same standard as those on directly managed land; imbedding related requirements into lease agreements; determining how natural assets on leased lands specifically contribute to desired levels of service; supporting capacity and competence development as required; and monitoring compliance against metrics. Such action will be essential to the Port Authority's natural asset management efforts given the high proportion of leased lands in its jurisdiction.

5. IDENTIFY NATURAL ASSET GOALS AND OBJECTIVES

As noted, the Port Authority's vision is to be the world's most sustainable port, defined as one that delivers economic prosperity through trade, maintains a healthy environment and enables thriving communities. Natural assets are therefore central to why the Port Authority exists. Through effective management, they are also a means to achieve environmentally sustainable service delivery. Currently, the Port Authority has goals related to maintaining a healthy ecosystem but does not yet proactively manage natural assets as a part of their service delivery approach.

An important next step, therefore, is to determine and articulate specific objectives related to natural assets to achieve broader sustainability goals. Some objectives could be included in the biodiversity strategy and the sustainability leadership roadmap. The biodiversity strategy is under development and will consider a nature-positive approach, which should lend itself to developing a more standardized approach to the management of natural assets.

6.2. Possible Actions for the Further Development of the Inventory

Based on the inventory, the Port Authority should consider the following, regardless of whether or not it pursues more comprehensive natural asset management efforts.

- Share and discuss the inventory, and potential implications and actions, with adjacent local governments and First Nations. As noted, the Port Authority borders 16 municipalities and intersects the traditional territories and treaty lands of several Coast Salish First Nations. The success of its natural asset management efforts are inherently linked to those of these other entities, and vice versa. Thus, it will be vital to stimulate collaboration within the watershed from the outset.

- Identify links between services and assets, and assess the condition of, and risks to, the assets based on their ability to deliver natural services. From a water supply and stormwater management perspective, watercourses, wetlands, and forested areas in the watersheds will be key.
- Schedule regular updates (e.g., every 3-5 years) of the inventory, condition assessment and risk identification to understand trends.
- Note the location and extent of major land cover changes and ensure they are reflected in the inventory as part of the updates.
- Should the Port Authority produce polygon representation of Shorezone data (salt marsh, eelgrass, etc.), it would be worth adding these layers to the inventory. Vector line data (as currently included in the inventory) is less suited to use in an inventory as lines will often be close to, but not directly within, a defined natural asset.
- The Port Authority's land use spatial data was incorporated into the inventory. This complex, but valuable dataset provides an accurate delineation of how a natural area is purposed (e.g., conservation, recreation, port water and terminal areas). While a natural asset represents a continuous area of natural space, these assets are subdivided based on various datasets (such as Port Authority land use), which can create somewhat jarring polygons for a user who is not familiar with how their land use is delineated. Careful communication of how assets were subdivided should be provided to users of the dashboard and/or GIS technicians utilizing the data.
- Additional (or alternative) condition metrics can be considered in future iterations of the inventory along with site visits to verify findings.

6.3. Steps to a Full Natural Asset Management Project

If the Port Authority wishes to proceed with more comprehensive natural asset management efforts, it will need to consider the following steps. For the reasons stated above, these actions should, where possible and relevant, be undertaken in dialogue with representatives from adjacent local governments and First Nations.

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; and (c) community capacity to undertake a larger project. Given the large size and scope of Port Authority jurisdiction, as well as the opportunity for synergistic activities, the organization should consider very deliberately how to engage adjacent local governments and First Nations on treaty and unceded land.

2/ **Fill essential knowledge gaps**. If discussions on scope, 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 entities 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 environmental management 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, the Port Authority can understand and quantify changes in service levels. They can also determine corresponding values through continued economic assessment. Based on the foregoing, the Port Authority could consider and prioritize actions ranging from status quo to planning, regulatory, financial operations, maintenance, acquisition, and monitoring interventions.

6/ **Implementation**. NAI can provide ongoing advice / guidance on policy pieces and integration of the above information for 12-18 months. After that, the Port Authority, together with local partners and service providers, would ideally have the capacity to continue 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. NAI would typically stay involved with the Port Authority for three years through a monitoring arrangement.

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Appendix A: Asset Type Definitions

Asset Type	Definition
Agriculture	Areas currently or with the potential to grow crops or various cultivated vegetation. Derived from using land use data to identify areas outside of SEI boundaries.
Avalanche Track	Category directly derived from SEI 2014 category of the same name; “subalpine ecosystems influenced by repeated snow avalanches; shrub or herb dominated” (Meidinger et al, 2014).
Beach / Shoreline	Category derived from the SEI 2014 dataset “beaches and rocky shoreline” category; “well- to sparsely-vegetated or non-vegetated beaches and shorelines” (Meidinger et al, 2014).
Built-up Pervious	Composite asset type used to define areas composed of vegetated, permeable areas in an urban setting that are not wholly natural. This can include municipal parks with significant grass cover, grassy cemeteries, or strips of grass next to airports taken from OSM data, among other similar examples. Defined using Park datasets.
Eelgrass	Area defined by provided eelgrass data. Refers to areas with heavy presence of eelgrass indicated by data provided by VFPA.
Forest	Category derived from various SEI and VRI categories, used to define areas with heavy tree cover without any dividing features such as creeks, streams, or roads, and not referring to more wet forested environments like swamps.
Freshwater	Category derived from several VRI and SEI categories used to define areas with confirmed presence and prominence of fresh water. Including, lakes, rivers streams, and other such features (does not include wetlands such as marshes or fens).
Golf Course	Areas derived from OSM data. Refers to extent and locations of golf course greens with more natural features such as confirmed SEI forest or other categories removed.
Herb	A type of natural asset derived from the provincial VRI. It refers to areas made up of with a combination of graminoid and forb plants (Province of BC, 2019).
Meadow	Category derived from SEI data and an OSM area. The SEI category “estuary meadow”, is defined as “found in the high intertidal zone of estuaries where tidal flooding occurs less frequently than daily and is tempered by freshwater mixing. Species composition is relatively diverse, typically with a mix of graminoids and forbs” (Meidinger et al, 2014). Differentiated from wetlands based on definition, as other Meadows in the SEI are specified as wetlands while this one wasn’t. Grouped with OSM Meadow to represent areas that are largely vegetated with low lying plants. Differentiated from VRI “Herb” category on account of closeness to estuaries with SEI source and from varied origins of OSM data.

Asset Type	Definition
Mudflat	Derived from various SEI and significant conservation areas. Refers to areas with large build-up of mud and similar sediments.
Natural Bare	Composite land cover category taken from a variety of SEI and VRI sources. Used to refer to rocky, bare areas with little vegetation. VRI beach category was added to this grouping instead of Beaches / Shoreline category to differentiate it from SEI, which showed beaches in different locations.
Ocean	Category derived from VRI data; "A naturally occurring body of water containing salt or generally considered to be salty" (Province of BC, 2019).
Old Field	Category derived from SEI data category of the same name; "Lands formerly cultivated or grazed but later abandoned. Old-field sites can provide important habitat for wildlife species in human-influenced landscapes. As an intermediate stage in succession, without management they will eventually become forest – some may have been wetlands where the drainage has been altered in order to farm. A minimum size of 2.5 ha was used" (Meidinger et al, 2014). Due to unknown succession stage and little insights into plant composition, these were given their own category.
Riparian	Category derived from SEI data category of the same name "ecosystems associated with and influenced by freshwater" (Meidinger et al, 2014). It was noted that some areas of this category were heavily forested but due to prevalence of channels cutting through them, and for the different properties of the area itself, it was not classified as forest or treated as such for condition metrics.
Shrub	Composite category derived from VRI, SEI, and OSM data. Used to refer to areas classified with high prevalence of shrubbery.
Tidal Flat	Composite Category derived from SEI and significant conservation areas. Defined in SEI dataset as "large flats of silts, sands or pebbles, flooded and exposed in most tidal cycles; macroalgae common" (Meidinger et al, 2014), and this definition was assumed to be applicable to areas represented in significant conservation areas dataset.
Unknown	Category from VRI and SEI, but also used as a means to classify areas where the type of land cover is unknown.
Wetland	Category derived from SEI, VRI, and significant conservation areas datasets. Used to represent, swamps, marshes, wet meadows, fens, bogs, and other similar features representing a mix of a large presence of water along with significant vegetation.

Appendix B: Risk Scores and Rankings for Hazards

Potential impacts to biodiversity or natural areas from shipping/on-water operations	Likelihood	Severity of Impact	Ranking
Shoreline Erosion from Wave Activity	2	2	low
Discharge from Ships	4	2	low-medium
Scouring	4	2	low-medium
Underwater Noise	5	3	medium
Shipping	5	2	low-medium
Ambient Noise and Light	5	1	low
Invasive Species Shipping	3	3	medium
Accidents and Malfunctions	3	3	low-medium
Dredging	5	2	low-medium
Abandoned Vessels	3	2	low-medium
Vessel Traffic	2	2	low

Potential impacts to biodiversity or natural areas from upland operations	Likelihood	Severity of Impact	Ranking
Land Development	5	5	high
Stormwater Runoff	5	3	medium
Contaminated Sites	5	2	low-medium
Accidents and Malfunctions	4	2	low-medium
Invasive Species	4	3	medium
Ambient Noise and Light	5	2	low-medium
Air Pollution and Emissions	5	2	low-medium
Land Encroachment	3	3	low-medium

Potential impacts to biodiversity or natural areas from incidental weather or climate change	Likelihood	Severity of Impact	Ranking
Sea Level Rise/Storm Surge	5	4	high
Flooding	4	4	medium-high
Drought or Extreme Heat	4	4	medium-high


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