Foundations for a Healthy Waters Plan

Summary of Phase 1 Work and Next Steps

January 2023

CITY OF VANCOUVER

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List of Abbreviations

AIWWTP	Annacis Island Wastewater Treatment Plant
BC	British Columbia
City	City of Vancouver
Council	Vancouver City Council
CSO	combined sewer overflow
IIWWTP	Iona Island Wastewater Treatment Plant
IRMP	Integrated Rainwater Management Plan
LWMP	Liquid Waste Management Plan
Park Board	Vancouver Park Board
Province	Province of British Columbia
SSO	sanitary sewer overflow
UNDRIP	United Nations Declaration on the Rights of Indigenous Peoples
VanPlay	Parks and Recreation Services Master Plan
VSA	Vancouver Sewerage Area
WWTP	Wastewater Treatment plant

SECTION 1
Background and Context

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Background and Context

The Healthy Waters Plan provides the unique opportunity to address a range of intersecting challenges facing Vancouver in a holistic and integrated manner. This includes rainfall-induced pollution from combined sewer overflows (“CSOs”) and urban runoff. We are also now at a critical juncture where the impacts of climate change are directly impacting human health and infrastructure, and protecting the community against the associated flooding, heat and drought impacts is paramount. The Healthy Waters Plan also must consider the needs of a growing population and address aging infrastructure. Future investments, policy and regulation must deliver on multiple objectives, and a much higher level of collaboration will be needed between the City, the Musqueam, Squamish and Tsleil-Waututh Nations, Metro Vancouver, senior levels of government, and the community.

This document summarizes the work completed in the first of a 3-phase planning effort to re-envision the City’s sewage and rainwater management systems. This includes the Current State Assessment of the City’s systems, governance and regulatory context, which is critical foundational work for the planning to follow. It also includes the development of the Strategic Framework of Guiding Principles, Goal Areas and Objectives to guide the Plan, and a description of the next steps to be taken in Phase 2.

1.1 Purpose of the Healthy Waters Plan

In May 2020, Vancouver City Council (Council) directed staff to develop the Healthy Waters Plan to identify long-range strategic investments, policy, and partner collaboration needed to address the following key issues:

CSOs and polluted urban runoff impact aquatic ecosystem health and public access to water.
The City has a regulatory requirement to eliminate combined sewer overflows (CSO) by 2050 and implement plans to reduce stormwater pollution. Vancouver City Council and the Vancouver Park Board (Park Board) have made a priority to increase public access to water.

Population growth, housing needs, and land-use recommendations in adopted community plans face uncertainty when it comes to the capacity of the existing sewage and drainage system.
In addition, a comprehensive integrated system planning effort is required to ensure that infrastructure services can sustainably support population growth and land use directions as contemplated in the Vancouver Plan[1].

Climate change impacts, including the increasing intensity and frequency of rainfall events, sea level rise, and drought, adds further strain on sewage and rainwater management services.
The Healthy Waters Plan will help strategically target investments and policies to mitigate risk and maintain affordability.

The Healthy Waters Plan will focus primarily on the City's sewage and drainage services, but will also identify opportunities to align and optimize investments and other interventions with the regional system. A critical need is to align with the pending update to the LWMP, which will serve as a regulatory plan for the regional government and its members.

[1] The Vancouver Plan https://vancouverplan.ca/

Significant and continued investment will be required to renew and adapt the city's aging sewers infrastructure.
Despite substantial planned increases in investment, we anticipate that the rate of asset deterioration will continue to exceed the rate of renewal until the mid 2030s.

Water is a vital resource and life force for communities and ecosystems.
For millennia, the Musqueam, Squamish and Tsleil-Waututh Nations have developed around their relationships with water. Post-contact, through land development, de-forestation, the burying of streams and development of modern sewer and drainage infrastructure, our relationships with water, the land and natural systems have been disrupted. The Healthy Waters Plan will provide the vision for the sewer and drainage system with the foundational principles of Vancouver Plan: Reconciliation, Equity, and Resilience, while strategically target investments and policies to mitigate risk and maintain affordability.

The City and Metro Vancouver Regional District jointly provide sewage and drainage services, with the City providing local infrastructure and Metro Vancouver managing regional conveyance and wastewater treatment. The Healthy Waters Plan should allow investments and outcomes across both systems to be optimized and align with the upcoming update to the Metro Vancouver Liquid Waste Management Plan ("LWMP"), which serves as a regulatory plan for the regional government and its members.

1.2 Project Work Plan and Status Update

Partner, stakeholder, and public engagement are tailored for each phase of the plan development (Appendix B describes the Engagement Framework). The development of the Healthy Waters Plan incorporates a phased process, informed by the successful experiences of other jurisdictions, to develop a comprehensive and integrated plan to address multiple objectives

Figure 1-1. A three-phased approach to Plan development

SECTION 2
The Evolution of Sewage and Rainwater Management

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The Evolution of Sewage and Rainwater Management

Section 2 describes the historical legacy and evolution of policy and decision making that has resulted in the present-day sewage and drainage system. This history is critical context for future planning efforts, including addressing the need for reconciliation with the Musqueam, Squamish and Tsleil-Waututh Nations. It also helps to demonstrate how sewage and rainwater management priorities have changed over time, influencing investment and management decisions along the way.

Before settler colonization, Vancouver was a mixed hemlock forest with marshes that fed more than 50 streams, and the surrounding waters were exceedingly ecologically rich in both resident and migratory marine species (Figure 2-1). Since the 1960s, the City began the practice of installing separated sanitary and storm pipes when new neighbourhoods were developed. Beginning in the 1970s, the City began separating sewage and stormwater flows in targeted areas of the Downtown and West End to address water quality issues (Figure 2-2). Within the 2011 regional LWMP, the City recommitted to separating 1 percent of its sewer inventory on an annual basis, with the target of eliminating CSOs by 2050.

Figure 2-1. Select History of Vancouver Sewerage Area through 1937

Following settler colonization, the first sewers were constructed in 1889, with the primary purpose to convey sanitary waste away from the new city and reduce the frequency of water-borne disease outbreaks. This system was expanded over time to serve new development. Streams were culverted and buried to allow for this widespread development and were connected to the sewer system. This combined sewer system conveyed mixed sanitary and rainwater directly to receiving waters.

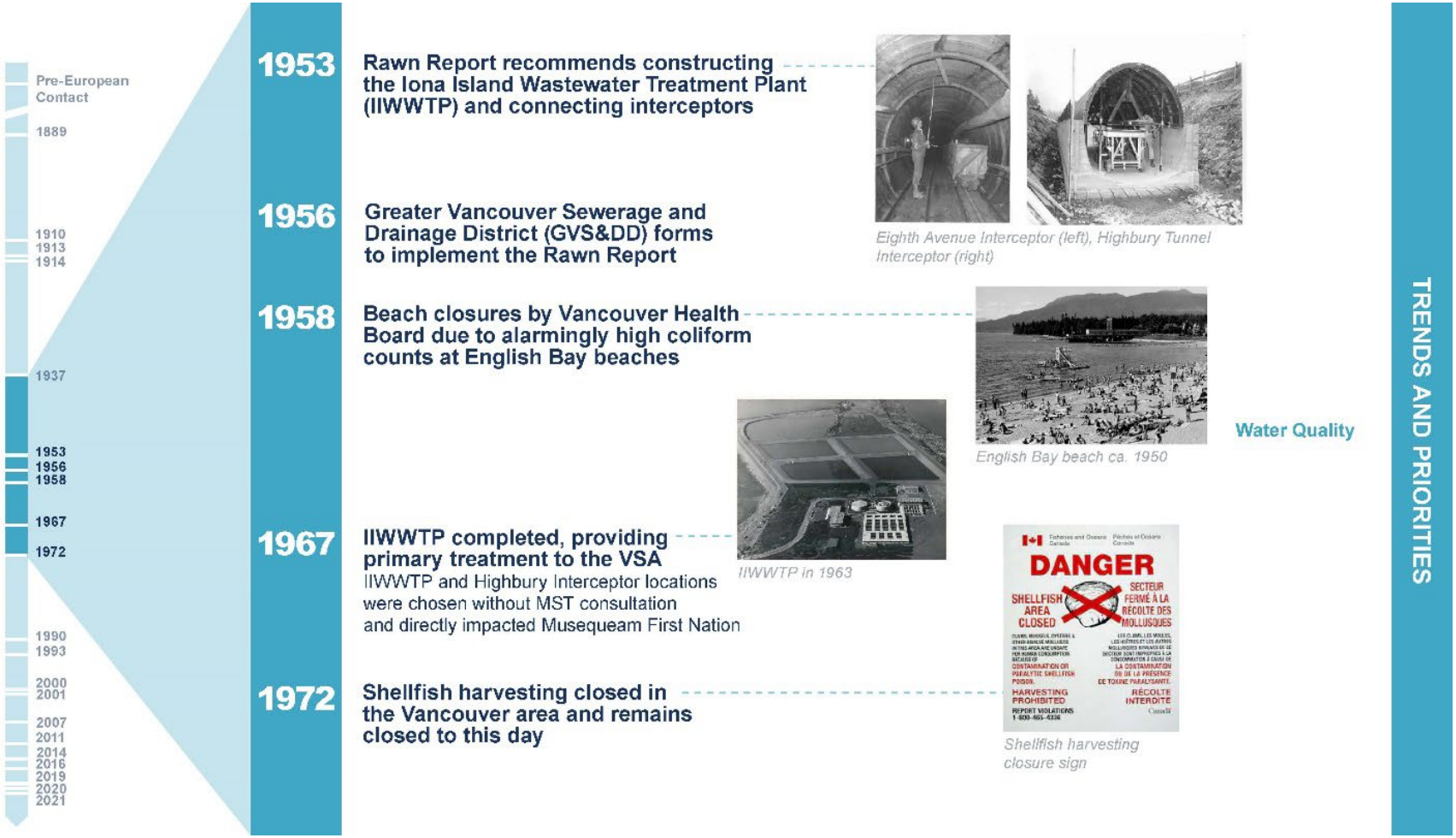

Figure 2-2. Select History of Vancouver Sewerage Area, 1953-1972

Driven by emerging concerns regarding sewage pollution in Vancouver waterways, in 1953, the "Rawn Report" recommended the construction of interceptor pipes to convey sewage from the city to a new wastewater treatment plant at Iona Island wastewater treatment plant (IIWWTP). Following the Rawn Report, the Greater Vancouver Sewerage and Drainage District[1] (referred to in this report as "Metro Vancouver") was established to provide regional conveyance and treatment services (Figure 2-2).

Figure 2-3. Select History of Vancouver Sewerage Area, 1982-2021

Figure 2-4. Select History of Vancouver Sewerage Area, 2007-2021

As shown in Figure 2-4, the local First Nations have long been advancing water quality and environmental restoration efforts, and in late 2018 and 2019, a number of Council imperatives around resilience, climate adaptation, climate emergency, watershed revival, blue green systems and accelerating action on CSOs emerged. The Vancouver Park Board (Park Board) commissioners also passed a number of resolutions urging the City to accelerate efforts to address CSOs and restore the water quality in False Creek and other waters surrounding Vancouver.

In addition to the impacts to coastal biodiversity and resilience, ecosystem services, and Indigenous rights and food security, Vancouver beaches experience occasional advisories when levels of E. coli bacteria exceed recommended guidelines. The causality of these E. coli exceedances is not well understood but is likely the result of multiple sources of pollution, including CSOs and urban runoff.

In response to water quality issues and Council direction, the City and Park Board have also implemented a number of actions to reduce sources of pollution and improve ecological conditions in False Creek. To better coordinate actions and ensure a comprehensive approach in False Creek, the City established an interdepartmental action program, the False Creek Water Quality Improvement Initiative, in 2017 which is ongoing.

In February 2020, Council approved the Aquatic Environments Action plan. This plan set out an integrated approach to improve aquatic environmental health by advancing strategic planning and policy work by the Vancouver Plan and the City's Healthy Waters Plan, as well as the delivery of concrete actions implemented through the City's water quality and environmental improvement programs and initiatives.

Following Council approval, the Park Board endorsed the Rain City Strategy in February 2020. This Strategy builds upon provincial regulatory obligations and nearly two decades of green rainwater infrastructure leadership, pilot and demonstration projects developed by the City, Park Board, community, industry and academia in Vancouver.

In November 2019, Council approved the Rain City Strategy, with direction to accelerate the implementation of green rainwater infrastructure solutions to reduce pollution from urban runoff, adapt to climate change impacts, reduce the volumes of CSOs and ease the burden on infrastructure associated with increased rainwater volumes and urbanization.

The Park Board, through its VanPlay, Parks and Recreation Services Master Plan, has continued to emphasize the importance of natural systems, flow of water connectivity, and urban biodiversity as foundations for thriving cities and ecosystems. VanPlay offers a vision for integrated water multi-functionality: access to nature, rainwater management, ecosystems, recreation etc., and relies on clean water.

In October 2022, Vancouver City Council approved the UNDRIP Strategy, which includes “calls to action” on social, cultural, and economic well-being; ending indigenous-specific racism and discrimination; self-determination and inherent right of self-government; and rights and title of indigenous people. The UNDRIP Strategy was co-authored and endorsed by the Musqueam, Squamish, and Tsleil-Waututh Councils, along with the City of Vancouver. It includes a number of actions that relate to the management of water in the City.

2.1 The Sewer and Drainage System Today

The City is part of the larger Vancouver Sewerage Area (VSA) as shown in Figure 2-5. The VSA also includes areas outside of the City of Vancouver, including the Musqueam Indian Reserve No. 2, the University Endowment Lands, Mitchell Island (Richmond), Sea Island (Richmond) and regions of Burnaby near its border with Vancouver.

Within the VSA and FSA, ownership and operation of infrastructure is structured as follows:

- Metro Vancouver owns and operates the major trunk sewer and interceptor network that conveys sanitary and combined flows, along with the WWTPs (Figure C-1).
- The City owns and operates the network of sanitary, storm, and combined sewer mains, with the sanitary and combined sewers feeding into the Metro Vancouver system.
- Both the City and Metro Vancouver own and operate combined sewer outfalls connecting to their respective sewer systems.
- The majority of stormwater outfalls from the drainage system are owned by the City, as seen in Figure C-2, but also not shown are many private outfalls that discharge to receiving waters.

The City's sewage and drainage system is divided into 19 sewer catchments that make up five basins. The IIWWTP receives flow from 18 of the 19 sewer catchments that convey sanitary flow during dry weather and combined sewage during wet weather. One catchment in the southeast corner of the City is part of the Fraser Sewerage Area (FSA) and conveys sanitary flow to Annacis Island Wastewater Treatment Plant.

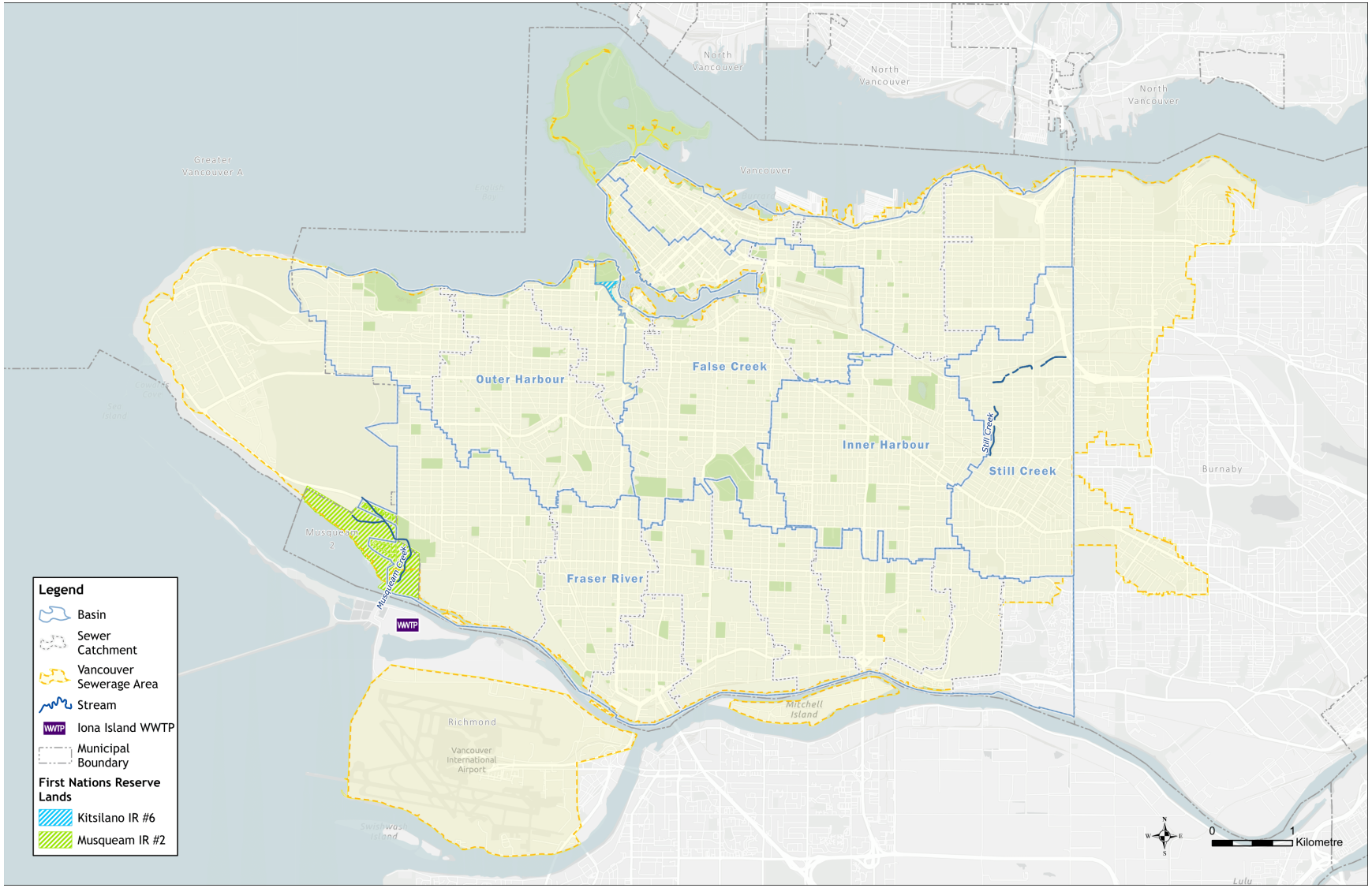

Figure 2-5. Vancouver Sewerage Area (Iona Island WWTP drainage area

CITY'S SEWAGE AND DRAINAGE INFRASTRUCTURE:

In total, the sewage and drainage system consist of more than 2100 km of City sewer mains, approximately 130 km of Metro Vancouver trunk sewer and interceptors, more than 93,000 sewer service connections, 33 active sanitary pump stations (24 owned by the City, 7 owned by Metro Vancouver, and 2 owned by Musqueam), 28 CSO outfalls (13 owned by the City, 15 owned by Metro Vancouver), and approximately 150 storm sewer outfalls. As of 2022, the City also owns over 300 Green Rainwater Infrastructure assets.

SECTION 3
Current Regulatory Context

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Current Regulatory Context

In Canada, the development of laws, regulations, and policies for sewage and drainage management is a shared responsibility of the federal, provincial, regional, and local governments. Indigenous Nations and peoples also have constitutional rights that must be respected.

3.1 Vancouver's Regulatory Obligations

The Provincial Municipal Wastewater Regulation sets limits for CSOs and SSOs. Where the regulatory standards are not being met, an approved LWMP can be put in place that sets the pathway for long-term regulatory compliance. Figure 3-1 illustrates the key environmental regulatory requirements for sewage and rainwater management.

In 1990, following approval by the Province of British Columbia (Province), the "Stage 1" regional LWMP was established, which was necessary to meet the requirements of the Provincial *Environmental Management Act*. Further updates were brought forward in 2000 and 2001, to outline commitments toward sewer separation, eliminating CSOs, and upgrading the IIWWTP.

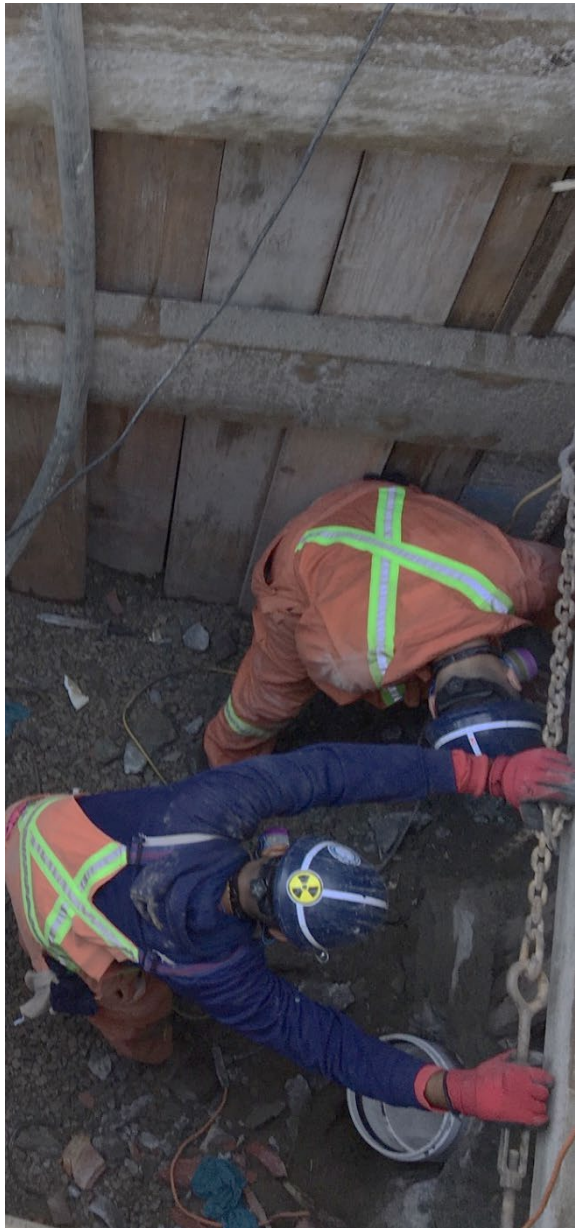
Subject to approval by Metro Vancouver Boards, Vancouver City Council, and the Province, the updated LWMP will establish a new regime of regulatory commitments for Metro Vancouver and its members, including the City of Vancouver.

In 2011, the Province approved the updated LWMP, a 10-year plan which sets regulatory obligations for Vancouver around:

- Eliminating CSOs by 2050
- Replacing 1 percent of mainline sewers with separated sewers on an annual basis
- Developing and implementing an Integrated Rainwater Management Plan (IRMP)
- Monitoring and mitigating water quality impacts from polluted urban runoff

All municipalities in Metro Vancouver must also have Integrated Rainwater Management Plans (IRMPs) and provide reports to the Province, through Metro Vancouver biannually, on their progress and compliance. In 2016, Council adopted the City's IRMP, which focused on runoff water quality and addressing the impacts of the sewer and drainage system on local receiving waters and aquatic ecosystems. The IRMP established a long-term target to capture and remove runoff pollutants from 90 percent of the runoff volume from effective impervious areas for the City's average annual rainfall. The IRMP included a strong emphasis on green rainwater infrastructure approaches that use a combination of engineered and ecosystem service methods to manage rainwater volume and water quality. Further to this, in 2019 Council adopted the Rain City Strategy, which included implementation of rainwater management requirements for new development and development of tools for existing buildings, as well as a range of actions for streets, public spaces, and parks.

Metro Vancouver has initiated the process of updating the LWMP, with the final plan due to be submitted to the Province for review by Q3 2023.



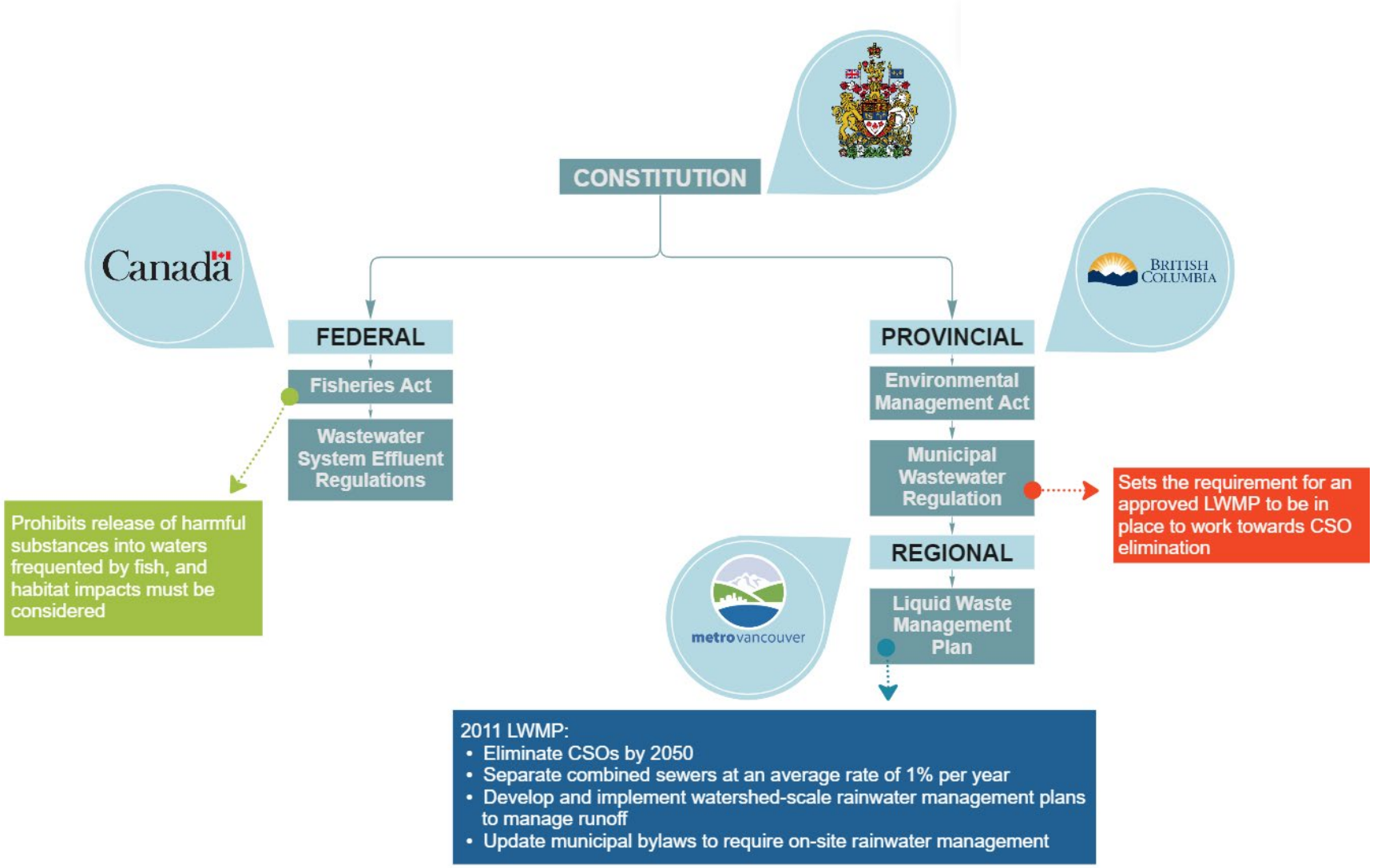


Figure 3-1. Key Environmental Regulations to Guide the Healthy Waters Plan

3.2 First Nations

Vancouver is located on the unceded traditional territory of the xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh (Squamish), and səlilwətaɬ (Tsleil-Waututh) nations who have been stewards of the land, air, and water since time immemorial.

Vancouver was once a mixed hemlock forest with marshes that fed more than 50 streams. As the city developed and densified, these streams were buried and redirected into rainwater and combined sewer pipes without consultation of Indigenous Nations. The early period of sewer infrastructure development took place when significant dispossession, active exclusion, and negative health and environmental impacts to areas stewarded by local Indigenous Nations were not considered.

Today, the Crown in BC is legally obligated to consult and accommodate Musqueam, Squamish and Tsleil-Waututh Nations on certain land and resource decisions that could impact their Indigenous Interests.[2]

In 2019, the First Nations Fisheries Council of British Columbia signed a memorandum of understanding with three provincial ministries[3] that formalized a collaborative working relationship and coordinated approaches to support First Nations involvement in developing and implementing policy and managing fish, fisheries, water, and habitat. The BC government has committed to take all measures necessary to ensure provincial laws are consistent with UNDRIP and will lead to reform of provincial legislation and policies.

The Government of Canada, the Province of BC, and the City of Vancouver have all adopted the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP). In October 2022, Vancouver City Council approved the UNDRIP Strategy, which includes a number of actions that have implications for sewage and rainwater management in the city.

[2] Government of British Columbia. Environmental Protection and Sustainability and Natural Resource Stewardship: Consulting with Musqueam, Squamish and Tsleil-Waututh Nations. Retrieved January 2021 from https://www2.gov.bc.ca/gov/content/environment/natural-resource-stewardship/consulting-with-firstnations

[3] https://www2.gov.bc.ca/assets/gov/environment/plants-animals-and-ecosystems/fish-fish-habitat/fishery-resources/signed_copy_of_fnfc_bc_mou_20nov19.pdf

3.3 Provincial Water Quality Objectives

Provincial ambient Water Quality Objectives include Guidelines for contaminant limits within waterbodies to meet the specific designated uses for different water bodies.

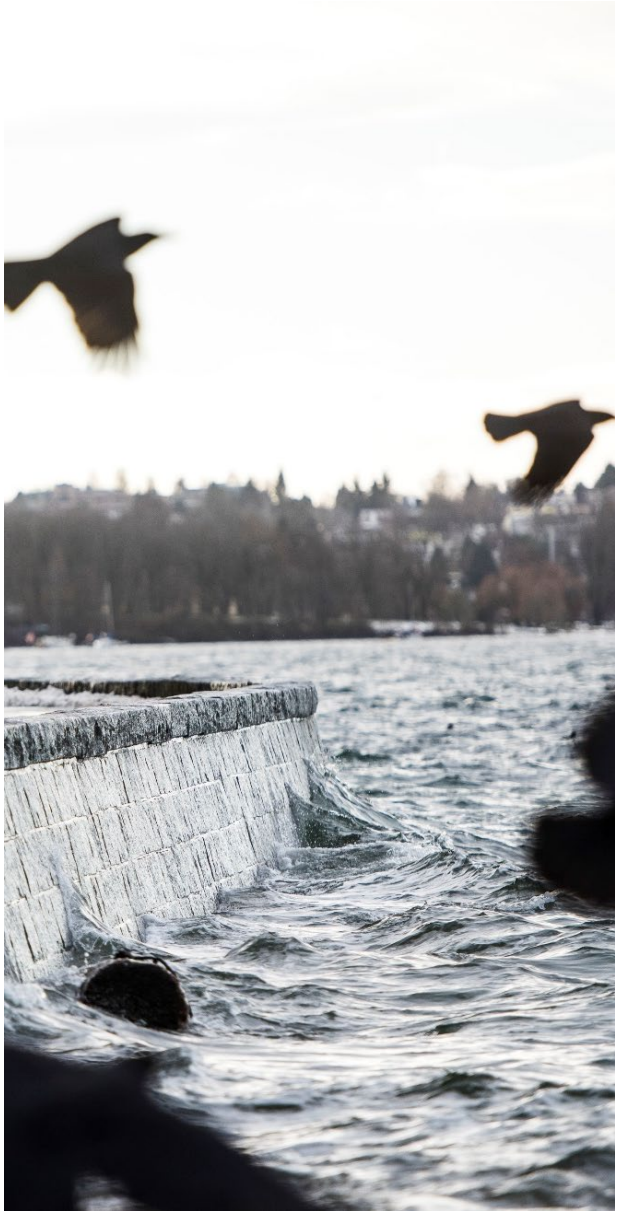
Water Quality objectives have been developed for Burrard Inlet and the Fraser River and are currently under review by the BC Ministry of Environment and Climate Change Strategy. A summary of these objectives is included below.

The Provincial water quality objectives, considering these uses, will need to be considered in development of the Healthy Waters plan, along with key policy directions from the Vancouver Plan, the Aquatic Environments Action Plan and the regional Liquid Waste Management Plan.

3.3.1 Burrard Inlet Water Quality Objectives

Recently, updated ambient water quality objectives have been set for Burrard Inlet. This work was led by the Tsleil-Waututh Nation, in collaboration with the B.C. Ministry of Environment and Climate Change Strategy the B.C. Ministry of Land, Water and Resource Stewardship and the B.C. Ministry of Health. The Burrard Inlet WQOs define conditions that represent levels of low risk to a set of designated water uses. The 'designated water uses' or water 'values' to be protected include:

- **Aquatic life and wildlife:** Water quality supports biodiversity and viable, healthy populations of species in the long-term. Species and habitats are found at multiple locations and represent the range once more broadly present.
- **Human consumption of shellfish and finfish:** Healthy, wild shellfish and finfish can be harvested safely by present and future generations.



- **Cultural practices and recreational uses**: Water and sediment are safe and clean for cultural, spiritual, and recreational activities including primary and secondary contact activities.
- **Institutional or commercial uses**: Water uses meet institutional or commercial needs without negatively affecting water quality at intake sites, outflow sites, or the receiving waters.

3.3.2 Fraser River Water Quality Objectives

Designated water uses within the North Arm of the Fraser River bordering the City on its southern limits include aquatic life, wildlife, livestock watering, irrigation, and recreational uses, including primary and secondary contact. These uses are not dissimilar to the Burrard Inlet Water Quality Objectives, but they have not been updated since 1998 to reflect the new values-based approach.

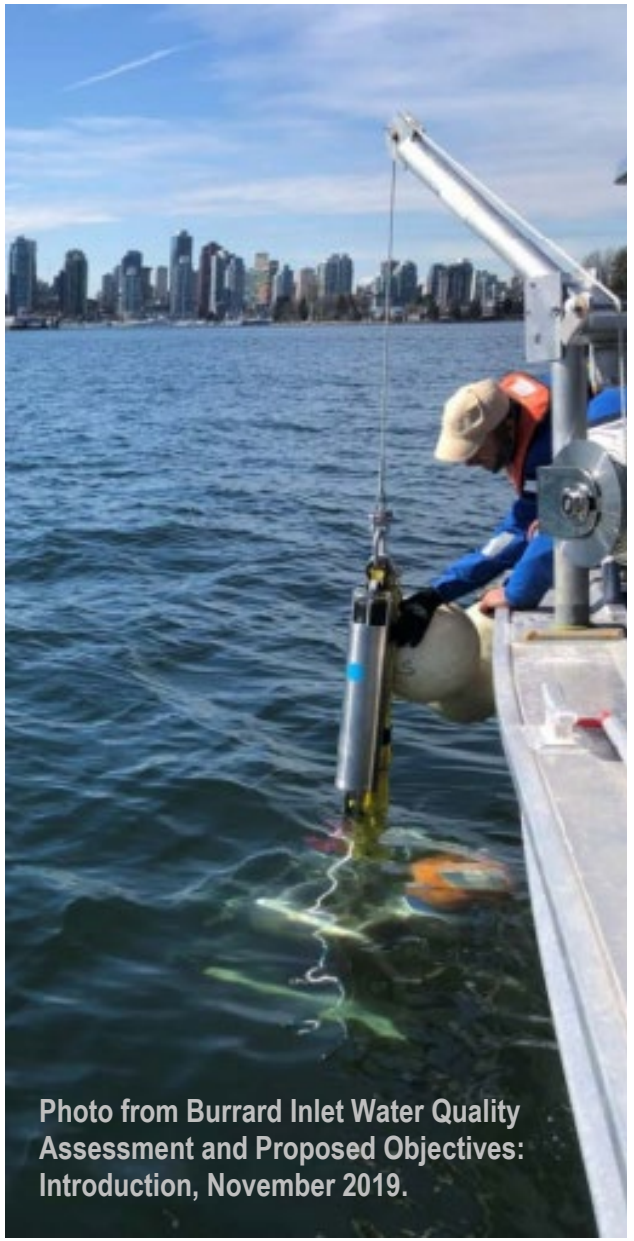


Photo from Burrard Inlet Water Quality Assessment and Proposed Objectives: Introduction, November 2019.

SECTION 4
Current State Assessment – Citywide Overview

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Current State Assessment – Citywide Overview

The purpose of the Current State Assessment is to provide a base level, current state understanding of the City and Metro Vancouver VSA sewage and drainage systems and programs, and associated risks.

4.1 Current Status of Sewer Separation

While newly developed areas of the city were built with separated sanitary and rainwater pipes beginning in the 1960s, the separation of existing combined sewers did not begin until the 1970s when the City began a targeted approach to address sewage pollution in waters adjacent to downtown.

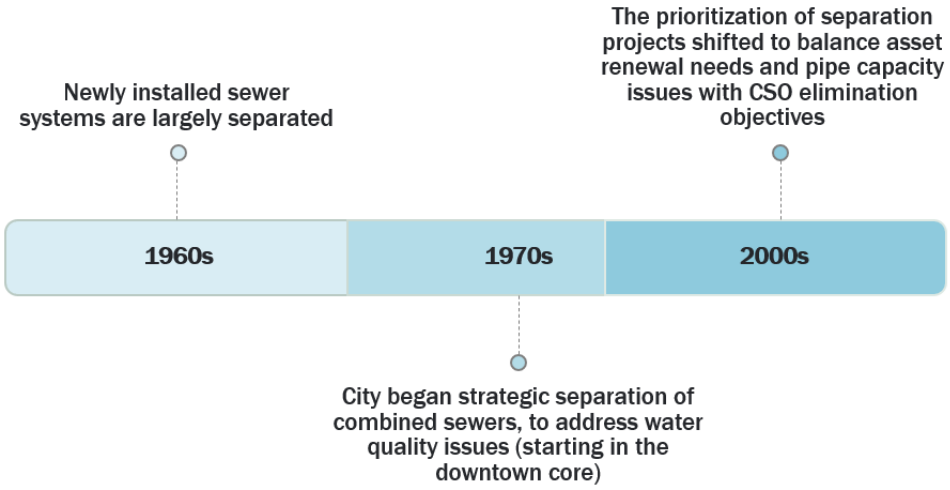


Figure 4-1. Evolution of the City's Sewer Separation Program

While early decision making around which sewers to separate had a focus on water quality, in the 1990s, decision-making factors were broadened to include prioritizing the need to renew aging and failing pipe infrastructure. In the last 20 years, the City expanded its drivers for the sewer separation program to address deteriorating asset condition and system capacity issues in addition to CSO elimination.

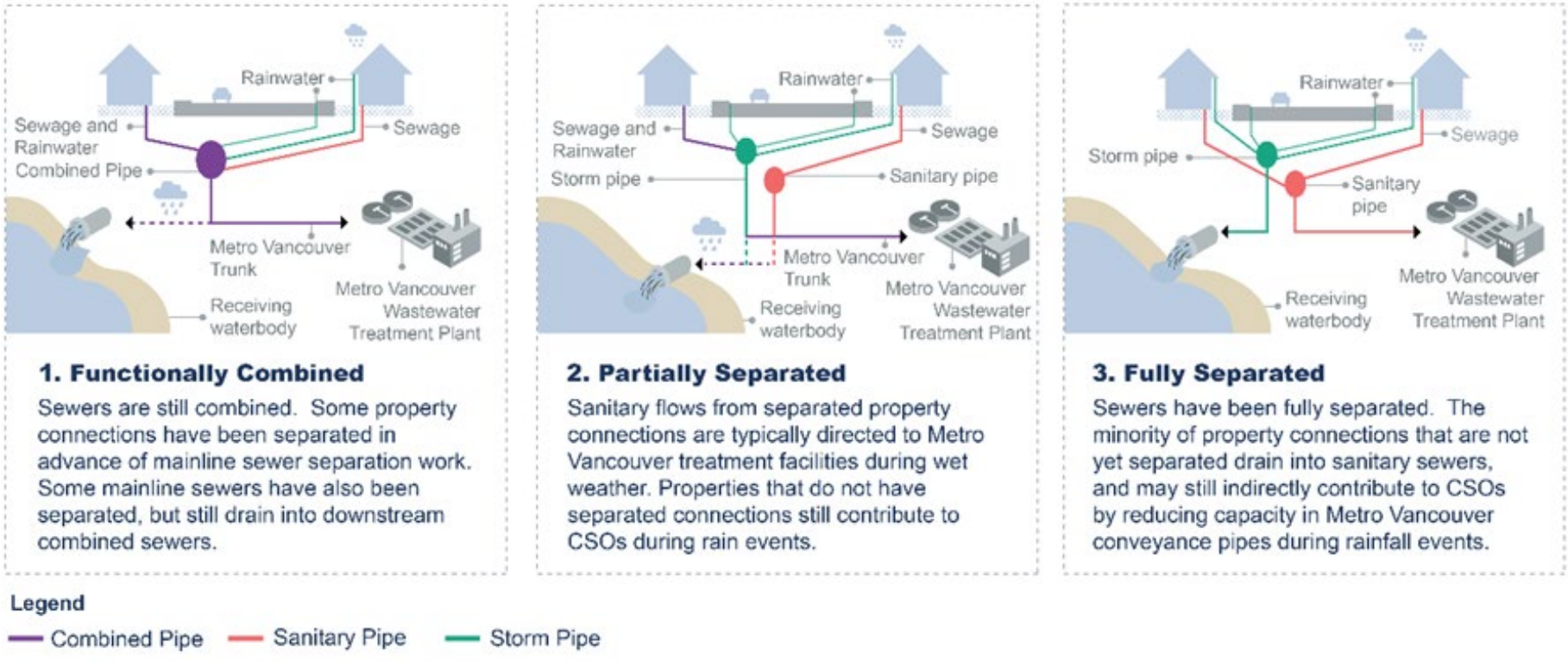


Figure 4-2. Progress achieved on sewer separation

Figure 4-3 shows how the sewer separation work has progressed over the years. This work involves separating mainline sewer pipes in the streets, as well as the connection pipes and associated plumbing of the properties served by the system. Mainline sewer pipes are separated through the City's asset renewal program, and a small portion through upgrades to serve growth. Property connections are separated at the time of property redevelopment or major renovations. Today, 56 percent of City's mainline sewers are separated, and approximately 60 percent of its property connections are separated.

The City has faced capacity and affordability challenges in keeping up with renewing aging sewer system assets and in meeting its target of separating 1 percent of mainline sewers per year.

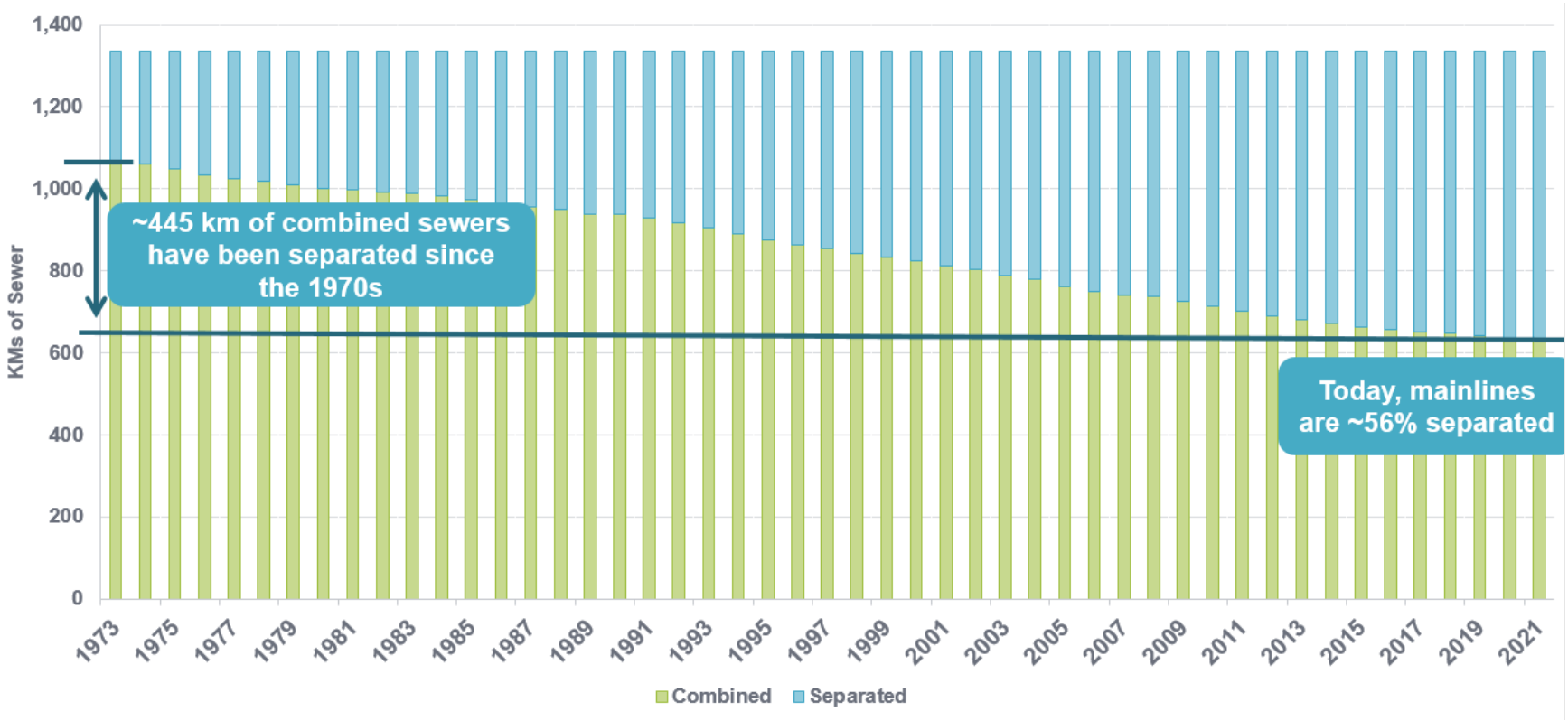


Figure 4-3. Graph of progress achieved on sewer separation

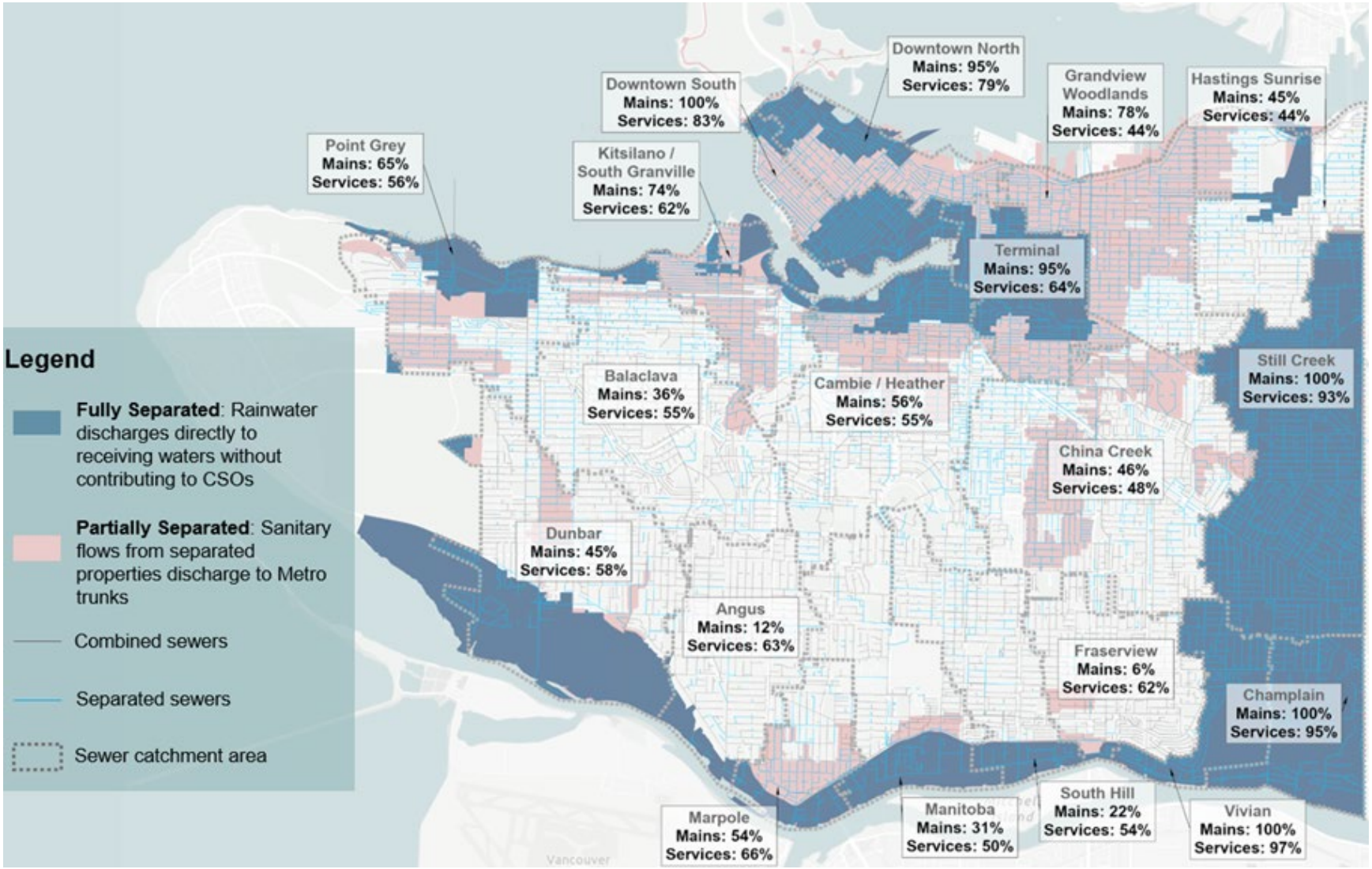


Figure 4-4. Current status of sewer separation

Figure 4-4 shows the current status of sewer separation across the City:

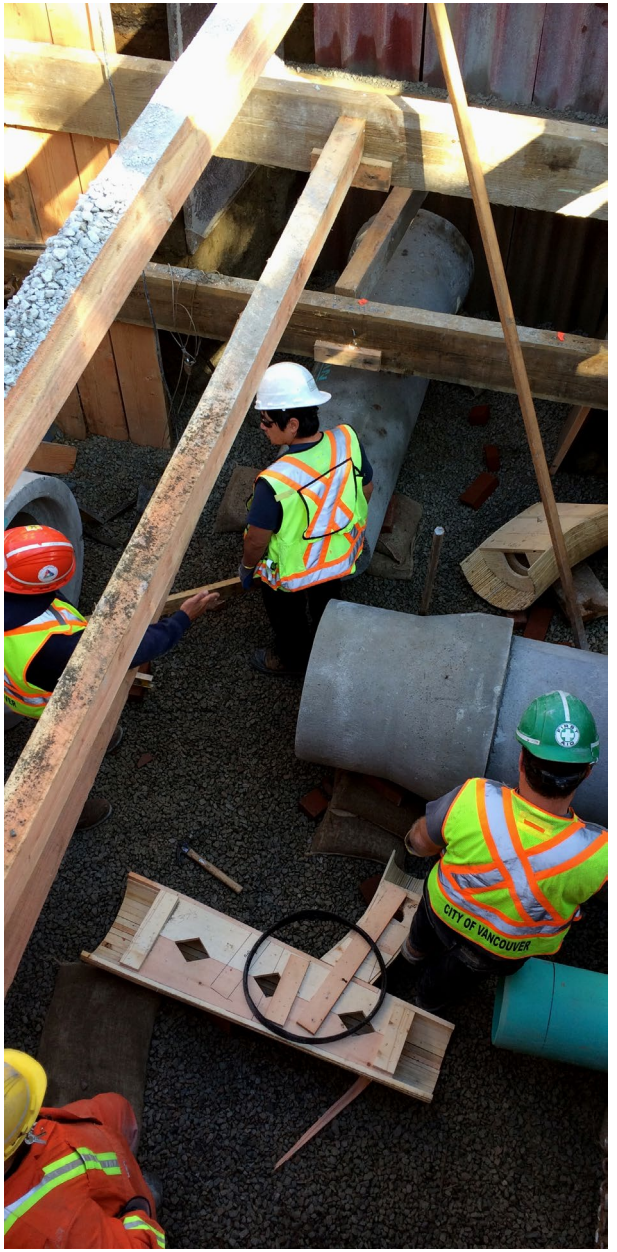
Areas shaded in dark blue are considered fully separated, as rainwater runoff is diverted directly to receiving waters and does not contribute to CSOs during rainfall events.

Areas shaded in pink are partially separated. In these locations, the sanitary flows from private properties that have separated sanitary/rainwater plumbing (i.e., through redevelopment) are directed to Metro Vancouver treatment facilities. The properties that do not have separated sanitary/rainwater plumbing connections still contribute to CSOs.

Areas of the City that are not shaded are considered to be functionally combined. These areas have some mainline sewer pipes that are separated, and private properties that have been redeveloped will have separated sanitary/rainwater plumbing connections. However, these areas still drain into combined sewers downstream and contribute to CSO events.

Barriers to achieving full sewer system separation include:

- The need to address the remaining inventory of combined connections from private properties, which are currently separated through the cycle of property redevelopment
- The need to construct stormwater trunks and outfalls for some areas to create a conduit for the urban rainwater runoff to discharge into the receiving water bodies. Consequently, these areas continue to primarily discharge to Metro Vancouver interceptors and contribute to a higher frequency of CSOs during certain rain events
- The escalation of construction costs and the need to balance CSO elimination objectives with affordability.



4.2 Current Status of CSOs and Urban Runoff Pollution

Municipal sewage includes a range of pollutants from households, businesses, industries, and institutions. In 2020, approximately 32 million cubic metres (32 billion litres) of CSOs were discharged4 in the VSA from Metro Vancouver CSO outfalls, and an additional 6 million cubic metres (6 billion litres) of CSOs was estimated to have been discharged from the City outfalls.

In 2020, approximately 75 percent of CSO volumes were discharged into the Inner Harbour of Burrard Inlet, as per Figure 4-5. The disproportionately high volumes of CSO discharged into Burrard Inlet was raised as a concern by partners and stakeholders in the Healthy Waters Plan engagement process as well.

A smaller but still significant frequency and volume of CSO events also occur in English Bay, False Creek, and the Fraser River. West side beach areas have much lower frequency and volume of CSO events, primarily because the system has been designed and operated over the past decades to prioritize the protection of public health in areas popular for swimming and other recreational activities. While total discharge volumes are a key factor influencing degree of impacts, other important considerations include pollutant types and concentrations.

As the combined system is separated, most CSO outfall structures are intended to serve the rainwater system. Therefore, the total discharge volumes and frequencies may not notably decrease even as the proportion of sanitary sewage discharged by CSO outfalls will continue to decrease.

[4] The Vancouver Sewerage Area includes the joint municipal and regional system that serves Vancouver, parts of Burnaby and the University of BC Endowment Lands. CSO discharges include a mixture of rainwater (estimated at approximately 90% of CSO volume on average) and sanitary sewage (estimated approximately 10% of CSO volume on average).

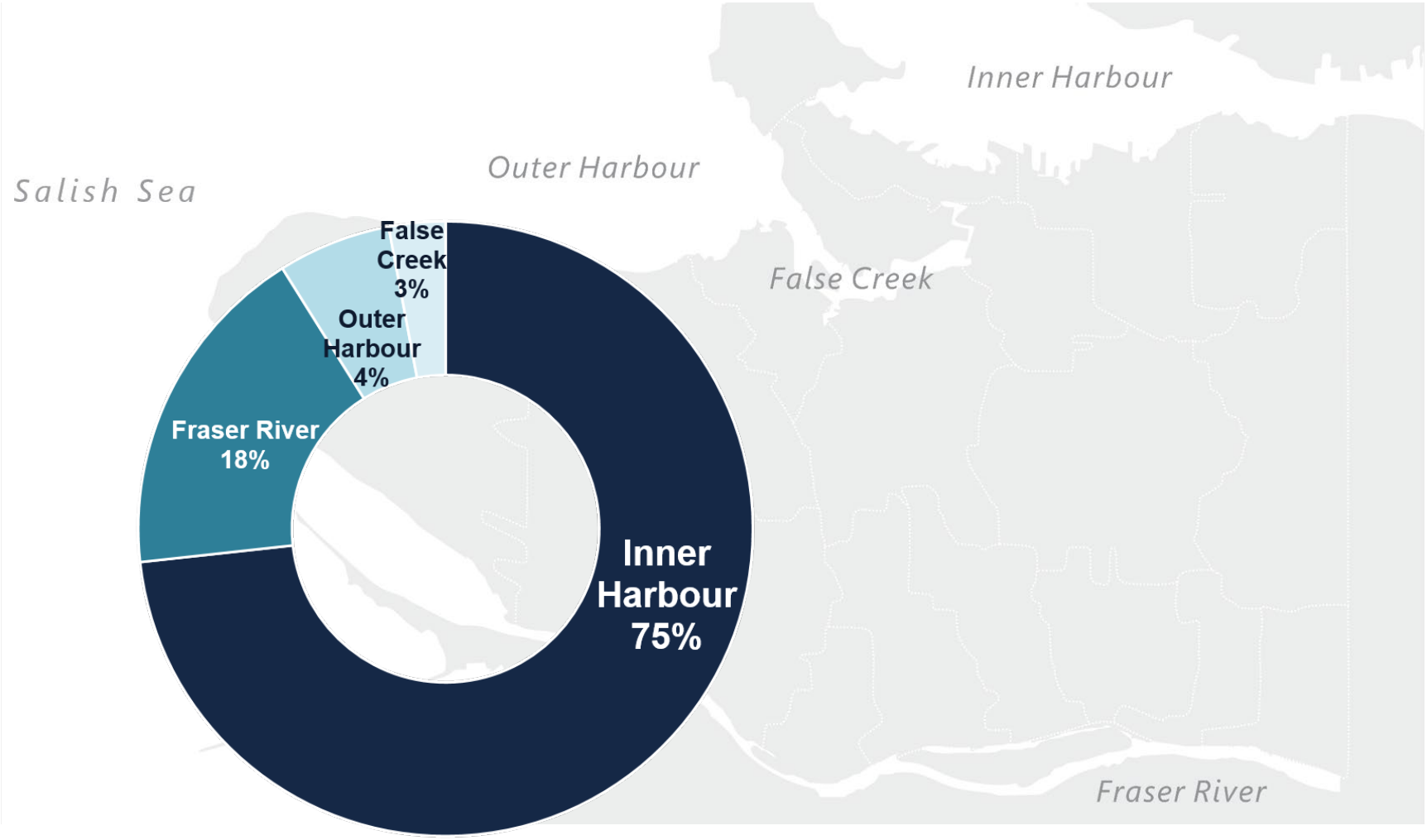


Figure 4-5. Distribution of CSO volumes discharged to Vancouver's receiving waters for 2020

In addition to sanitary sewage constituents, water quality in receiving environments can be adversely impacted by pollutants carried in urban runoff, such as sediment, hydrocarbons, micro-plastics, heavy metals, litter, and biological pollutants.

Stormwater outfalls currently provide minimal to no treatment of runoff pollutants prior to discharge, and as work continues to separate sanitary and storm pipes, the volume of untreated runoff entering receiving waters will increase if source control interventions are inadequate. However, due to the combined nature of much of the system today, a portion of the combined sewage and urban rainwater runoff (first flush) is often directed to the IIWWTP. The City also has erosion and sediment control programs, waste discharge quality control programs and source control measures designed to prevent pollution at the front-end.

The amount of impervious area in a city also has a significant impact on the volume of rainwater runoff, the amount of pollutants that are carried to receiving waters, and flooding risk. This is because rainwater runoff picks up pollutants as it flows across streets and other areas in the urban landscape. Currently, 49% of the city consists of impervious surfaces[1].

The deployment of green rainwater infrastructure helps to remove a portion of pollution picked up in urban runoff and improve receiving water quality.

[1] Approximate. Source: the 2019 Rain City Strategy - https://vancouver.ca/files/cov/rain-city-strategy.pdf

4.2.1 Wet Weather Operations

Both the City and Metro Vancouver own and operate many diversion structures or “sewer separators” within the system that control how low and high flows are managed. Of these, the Yukon Gate along the 8th Avenue Interceptor is the most important control feature of the VSA sewer system for CSO management. It is operated to protect the recreational waters of the Burrard Inlet Outer Harbour and False Creek by directing CSOs to the Inner Harbour. Sewer separators are located along combined sewer systems where they allow lower flows to be conveyed to the treatment plants and higher flows to combined sewer outfalls to prevent flooding of infrastructure and homes. Metro Vancouver also operates eight dynamic radial control gates that open and close based on water levels measured within the interceptors and pump stations.

Metro Vancouver’s interceptor network conveys a finite volume more than the average dry weather flow, meaning that the system will overflow when the wet weather flow (consisting of sanitary flow and urban runoff) exceeds dry weather flow (sanitary flow only) based on the interceptor system’s capacity.

As more of the combined system is separated and sanitary pipes are directly connected into the interceptors, overflows into receiving waters will consist of less sewage.

The wet weather operations and control structures within the City’s and Metro Vancouver’s respective systems can influence when and how much overflow is discharged, depending on the intensity and duration of a rain event.

4.3 Sewage and Urban Rainwater Runoff Impacts on Receiving Waters

For thousands of years, the region was stewarded by Indigenous Peoples. With colonization, the health of Vancouver's receiving waters has been impacted in many areas.

These impacts have been a result of urban and industrial development, culverting and burying streams, infilling coastal areas, hardening of shorelines, losing riparian areas, altering water flow regimes, presence of invasive species, and pollution from various human activities on land and within water bodies (e.g., CSOs and illegal cross-connections of sewers, illegal boat discharges, animal faecal matter, and legacy contamination from historical land uses). Impacts have also occurred from activities outside of the City, including marine shipping and other Vancouver Port activity. This has all combined to significantly alter the health of Vancouver's receiving waters.

In 2020, Council directed staff to proceed with development of the Aquatic Environments Action Plan, with a focus on holistic aquatic environmental health. Whereas the scope of the Healthy Waters Plan covers the sewage and drainage system, the scope of the Aquatic Environments Plan covers the complex and interdependent drivers (sewage and drainage being one of many) that impact water quality as well as broader biodiversity objectives for Vancouver's receiving bodies.

Pollutants behave differently and pose varying risks to human and ecological systems. Some pollutants degrade, while others accumulate in sediments and/or tissues of marine organisms. Some interact with each other and have additive or synergistic effects. Based on studies led by Metro Vancouver, it is understood that microbial pollution can travel a significant distance and persist for several days following a CSO event, while the impacts of non-microbial pollutants are more often observed in areas closer to outfalls.

In addition to pollutant type, the extent of human health and ecological impacts associated sewage and runoff pollution can depend on a variety of factors including the type and concentration of pollutants and the specific characteristics of the receiving waterbody. Differing human uses and ecological considerations are also a major factor, requiring a strategic and tailored approach for each receiving water body.

The Healthy Waters Plan also needs to consider recent work completed by Metro Vancouver to assess human health and ecological risk impacts associated with its CSOs. Sewage and urban stormwater pollutants and their human and environmental impacts are well documented. Monitoring programs that support the Vancouver sewerage and drainage system exist, but without a comprehensive and systematic local monitoring approach, it is challenging to assess the relative impact of Vancouver's wastewater and rainwater runoff discharges. Based on studies led by Metro Vancouver, we know that microbial pollution can travel a significant distance and persist for several days following a CSO event, and the impacts of non-microbial pollutants tend to be most acute in areas near outfalls. The technical report on microbiological indicators produced as part of the Burrard Inlet Water Quality Objectives update presents data from 1973 to 2016, as a first step in understanding trends, priorities, and knowledge gaps.[5]

Even the most advanced wastewater treatment systems cannot remove all sewage and urban runoff pollutants and as such, many communities invest in green rainwater infrastructure and pollution prevention programs to reduce rainwater volume and prevent hazardous substances from entering the municipal sewerage system. Municipalities with fully separated sewer systems also continue to pursue source control strategies including public education and regulation.

[5] LeNoble, J.L., Lilley, P. and A. Rao. 2021. Water Quality Assessment and Proposed Objectives for Burrard Inlet: Microbiological Indicators Technical Report. Prepared for Tsleil-Waututh Nation and the Province of B.C. Main report and appendices available at https://www2.gov.bc.ca/gov/content/environment/air-land-water/water/water-quality/water-quality-objectives/south-coast-region-water-quality-objectives/burrard-inlet-water-quality-objectives

4.4 Current Status of Sewer Backups and Overland Flooding

Sewer backups and overland flooding are caused by a variety of factors and are being exacerbated by climate change.

4.4.1 Sewer Backups

Sewer backups are caused by a variety of factors including blocked, clogged, and damaged pipes; undersized pipes with inadequate capacity; and heavy rainfall events that exceed the design capacity of the sewers. Based on the staff's operational knowledge, the leading causes of sewer backups in the City is tree root intrusion into pipes as well as oil, fat, and grease buildup. Blockages on property service connection pipes are the most common form of backup event. However, backups can also occur in mainline sewers that have exceeded their design capacity due to flows from heavy rainfall, high tide and high groundwater levels; a risk that is increasing with aging infrastructure and climate change.

While back-up prevention devised have been required for all new buildings since 2018, most properties are not protected from sewer backups.

4.4.2 Overland Flooding

Vancouver is exposed to overland flooding hazards from various sources, including high coastal water levels, high river and creek levels, and high rainfall intensity and volume, overwhelming drainage infrastructure. The severity of these hazards is increasing with climate change.

Overland flooding in Vancouver typically results from drainage system limitations during heavy rainfall events, particularly when the soil is already saturated. Operational issues can also result in overland flooding, such as catch basins being plugged by leaves and sediment during the fall. The drainage system capacity is also increasingly being limited by high coastal water levels, which are occurring more frequently due to sea level rise and storm surge events. Under extreme rainfall events, overland flow will occur primarily on the road network along similar paths to historic streams that were buried. Many cities utilize roads for managing overland flow, but in the City of Vancouver overland flow via roads is not at this time considered a part of the rainwater conveyance network due to existing system design limitations. Regardless, when the roads and underlying drainage have insufficient capacity, overland flooding can impact people, properties, and infrastructure.

Overland flooding risk from coastal and Fraser River sources has been assessed through the Coastal Flood Risk Assessment and Coastal Adaptation Plan programs, which are informing on-going planning work. This work has been based on provincial recommendations to plan for 0.5 m of sea level rise by 2050 and 1 metre of sea level rise by 2100. Work is also underway to update an overland flood assessment and related planning for the Still Creek floodplain in the City. For extreme rainfall flood hazard and risk, operational knowledge and on-going overland flow modelling work have been informing utility planning; however, a comprehensive risk assessment is still required as a foundation for policy and investments for managing overland flood risk.

FLOODING IN VANCOUVER:

Under extreme rainfall events, overland flow will occur primarily on the road network and follow topographic lows generally where historic streams were buried. When the roads and underlying drainage have insufficient capacity, overland flooding can impact people, properties, and infrastructure.

SECTION 5
Preliminary Baseline Forecast and Growth

SECTION 5

Preliminary Baseline Forecast and Growth

A Preliminary Baseline Forecast has been developed to better understand our future planning context considering asset management needs, water quality and complying with regulations for CSO elimination, uncertainties related to climate change and population growth, and financial considerations.

5.1 Forecasting Investment Requirements for Asset Renewal and Pollution Control

The 2011 LWMP commits the City to separating 1 percent of its sewers on an annual basis, as well as eliminating CSOs by 2050. The 1 percent separation rate was developed based on a generalized assumption that pipe assets have an average lifecycle of 100 years and, therefore, would require an average 1 percent per year renewal rate.

As such, system separation takes place concurrently as part of system renewal. In recent years, the City has fallen short of achieving the 1 percent renewal rate due to significant cost escalation for sewer construction, project delivery capacity limitations and affordability constraints.

To provide an approximate overview of upcoming costs to achieve full system separation, a hypothetical scenario was created to assess the financial implications associated with achieving 100 percent sewer separation by 2050. This scenario considers how much of the sewer system is separated today but does not consider the amount of separation progress that may be achieved through the growth program to serve new development. It also does not consider the extent to which complementary tools like green rainwater infrastructure requirements and capital projects may contribute to CSO mitigation.

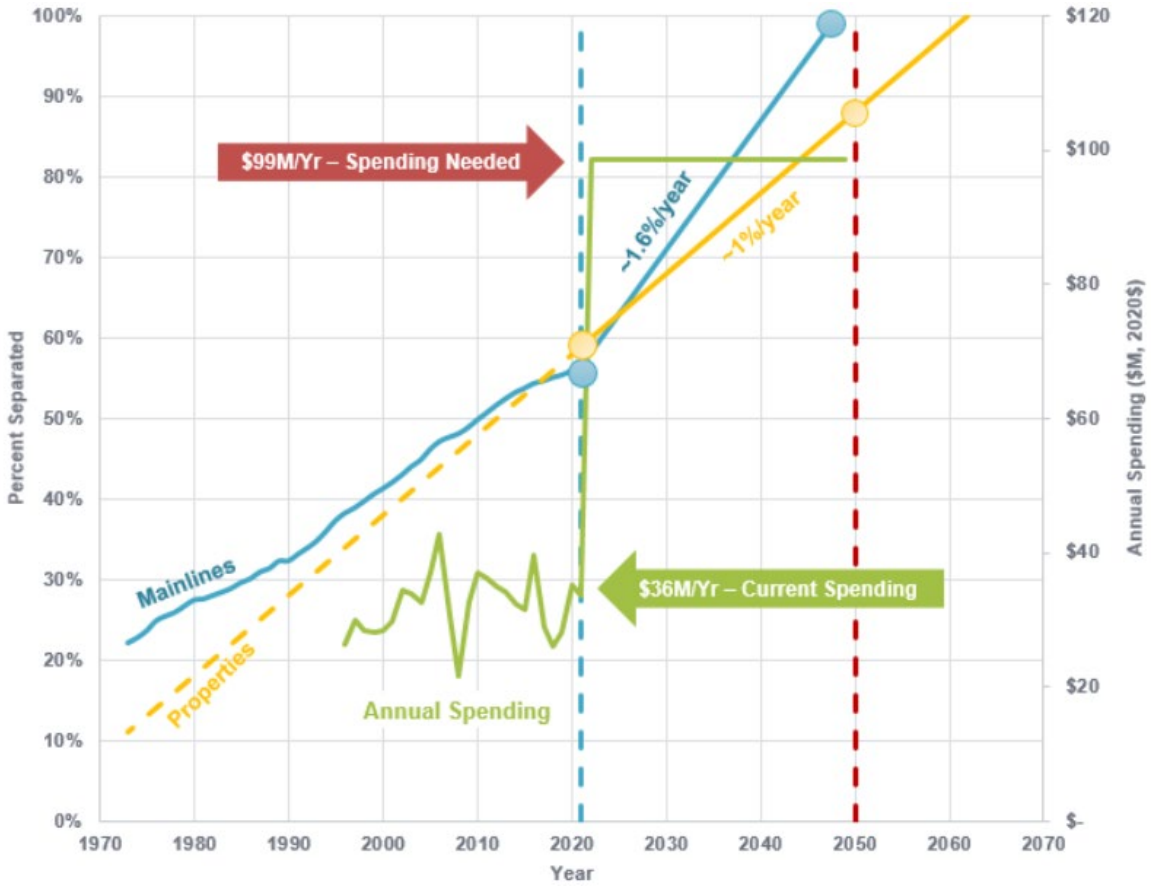


Figure 5-1. Preliminary Baseline Forecast – 100% Sewer Separation by 2050[6]

In summary, this baseline forecast indicates that 100 percent sewer separation by 2050 is not likely affordable nor achievable, and that sewer separation alone will likely exacerbate flood and runoff water quality risks and create significant cascading risks that further exacerbate affordability challenges, particularly around flood-prone areas of the city.

[6] The Key scenario assumptions to achieve 100 percent system separation by 2050 that inform Figure 5 1 include: An average renewal and separation rate of 1.6 percent of the system per year, between 2022 and 2050. A 1.6 percent rate considers previous years where the 1 percent target was not achieved. Private property plumbing and connection pipes are separated at the time of redevelopment (analysis assumes 1 percent of inventory separated per year).

Key conclusions from the preliminary baseline forecast include:

To achieve 100 percent sewer separation by 2050, annual spending would need to be increased by 175 percent above the 2019-2022 Capital Plan Sewer Renewal program (increasing from $36 million per year to $99 million per year)

Based on redevelopment alone, a portion of combined private connections from existing properties will not be separated by 2050 (our analysis forecasts property connection separation is unlikely to be achieved until after 2060). Therefore, additional City spending and/or regulatory measures would need to be advanced to complete separation of private-side combined connections.

Concurrently, concentrating investment on sewer separation alone will increase the amount of urban runoff flowing directly to receiving waters, with implications for water quality. It will also not serve to reduce flood risks in low lying areas where drainage capacity is limited. Mitigating policies and complementary investments will be needed concurrently to address flood risks and runoff water quality.

This baseline scenario may also result in some mainline sewer assets being renewed well ahead of their end of life, which reduces the value achieved from infrastructure investments made in past years.

In 2019, the Rain City Strategy was adopted, which set the target for green rainwater infrastructure to manage 40 percent of impervious areas by 2050. Implementation of green rainwater infrastructure to date has focused on removing contaminants from urban runoff, preserving pipe capacity through rainwater volume reduction, and achieving a range of social and ecological co-benefits. Further analysis is required within the Healthy Waters Planning process to define the role of green rainwater infrastructure for CSO elimination and for the LWMP update.

5.2 Rising Costs

Figure 5-2 shows how the City's sewage and rainwater management costs have changed over the years, normalized to 2020 dollars. It also includes a 5-year forecast, which incorporates Metro Vancouver's most recent 5-year forecast for its costs to be recovered from the Vancouver Sewerage Area, as well as the City's forecast costs, based on the current capital plan and operating spend trajectory. It accounts for construction cost escalation associated with capital programs but does not consider the significant and very recent inflationary pressures experienced in 2022, and future uncertainty.

A key driver for Metro Vancouver's forecasted cost increase is the upgrade of the IIWWTP to secondary or tertiary treatment[7]. To comply with federal regulations, Metro Vancouver must upgrade the facility to significantly reduce pollutant loading from the VSA into the Salish Sea. This project is currently estimated to cost approximately $10 billion, factoring in future inflation and contingencies. While Metro Vancouver has a regulatory requirement to complete the project before 2030, the earliest viable time that the project could be completed is 2034.

It is anticipated that this project will require significant VSA sewer levy increases that will continue beyond the 5-year horizon shown on Figure 5-2. At this time, the cost implications for the City of Vancouver and its sewer utility customers are not known. Other regional liquid waste infrastructure upgrades will also have uncertain cost implications for Vancouver.

[7] Revised Liquid Waste Committee Agenda Package - March 9, 2022 (metrovancouver.org)

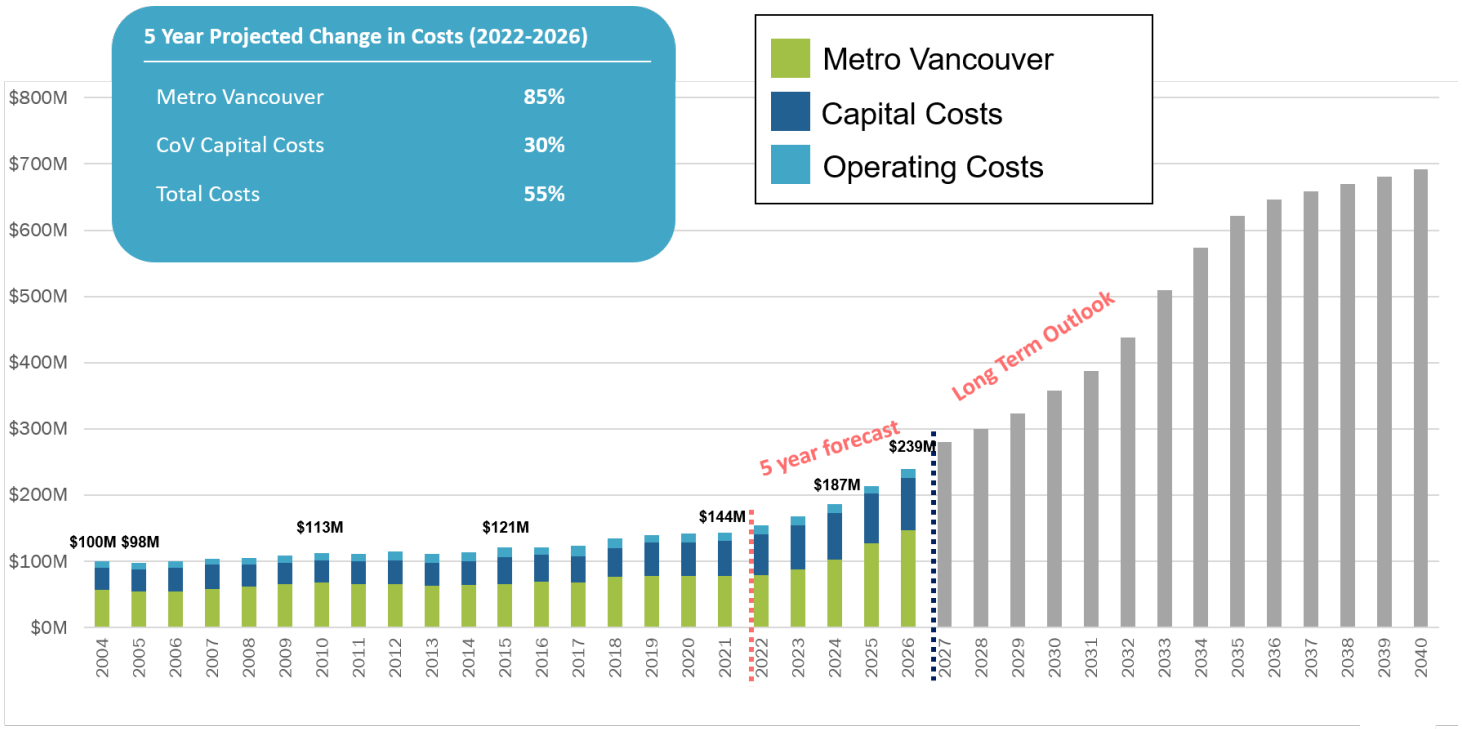


Figure 5-2. Sewage and Rainwater Management Costs (2020$)[8]

[8] The forecasted cost increases from 2022 to 2026 are based on Metro Vancouver's 5-year forecast (presented as part of the Metro Vancouver 2022-26 Financial Plan in October 2021), as well as the forecast presented to Council in the 2022 Sewer Rate Report. For 2027 to 2040, the forecast has a high level of uncertainty around how the IIWWTP project will be funded. Key assumptions regarding the IIWWTP that are factored into the 2027-2040 forecast include: (1) total project cost of $9.9 billion, with Vancouver's share being 65% of the total and no senior government funding allocation; (2) operating cost of $100 million per year, beginning in 2035 when secondary and tertiary treatment plant operations are anticipated to commence; (3) project fully debt funded at current market debt rates; and (4) project substantially complete by 2034, with ongoing capital works at the site completing by 2040.

5.3 Managing Growth

Between 1991 and 2016, Vancouver's population grew by 34 percent and added 160,000 people and more than 100,000 jobs—the largest increase in the region[9]. Currently, 662,000 people reside in Vancouver and is forecasted to add 7,000 new residents per year growing to 920,000 people by 2050[10].

Meeting the needs of population growth and densification requires cost recovery streams to fund growth in system capacity, and appropriate development policy to mitigate the financial and service-level impacts of this growth.

This section outlines the City's approach to funding and managing the impacts of growth on its sewage and rainwater management system:

Funding Growth:
Growth-driven system capacity improvements have historically been funded by developers via the rezoning process, capital improvements with sewer utility rates and property taxes, and beginning in 2019, via the Utilities Development Cost Levy charged to new developments. The 2023-2026 Capital Plan forecasts approximately $282 Million in developer-funded capacity improvements for the sewage and rainwater management system.

Development Policy to Mitigate the Impacts of Growth:
A range of policy tools are already in place to help mitigate increases to sanitary flows and urban rainwater runoff into the system. This includes water conservation policies which reduce the volumes of sanitary flow, as well as application of the Rainwater Management Bulletin requirements which reduces the rainwater loading on the drainage system from larger developments. When low density areas of the City are redeveloped, it typically results in a significant increase in the amount of impervious areas which can significantly increase rainwater runoff loading. The current Rainwater Management Bulletin requires

[9] Vancouver Plan 2050

[10] Population Projections Technical Background, 2022

that new developments manage the first 24mm of rainwater on site, and further evaluation will be done under the Pathways Study in Phase 2 of Healthy Waters Plan to assess the viability of more stringent requirements. This work is critical to mitigate the need for costly investments in the drainage system, manage flooding risk in low-lying areas, and reduce CSOs. In addition, work is underway as part of a groundwater management strategy to evaluate tools to prevent groundwater discharges and better manage discharges when they cannot be avoided (e.g., construction dewatering).

In July 2022, Vancouver City Council approved the Vancouver Plan, which guides density and land use going forward in the city (see Land Use Strategy map. Figure 5-3). The Vancouver Plan also defines a range of other policy directions, including ones that address equity, resiliency, climate protection and restored ecosystems (see Ecological Vision map, Figure 5-4). The Healthy Waters Plan along with subsequent more detailed watershed planning, will need to deliver adequate capacity as well as identify necessary funding and development policies to serve and manage this growth.

In addition, Metro Vancouver is currently designing the IIWWTP to account for future population growth and assumes the continuation of sewer separation work in the VSA. Beyond the initial IIWWTP capacity investment, Metro Vancouver is deferring the need for additional capacity expansions to a later date. **This is important for defining pathways in the Healthy Waters Plan, as it necessitates the reduction of urban rainwater runoff entering the Metro Vancouver system to deliver adequate wastewater treatment capacity to serve future growth.**

Beginning in 2018, the Utilities Development Cost Levy enabled the City to dedicate funds for major neighbourhood-scale system upgrades to serve growth. This levy will need to be calibrated over time to address capital cost escalation and the capacity needs of new development.

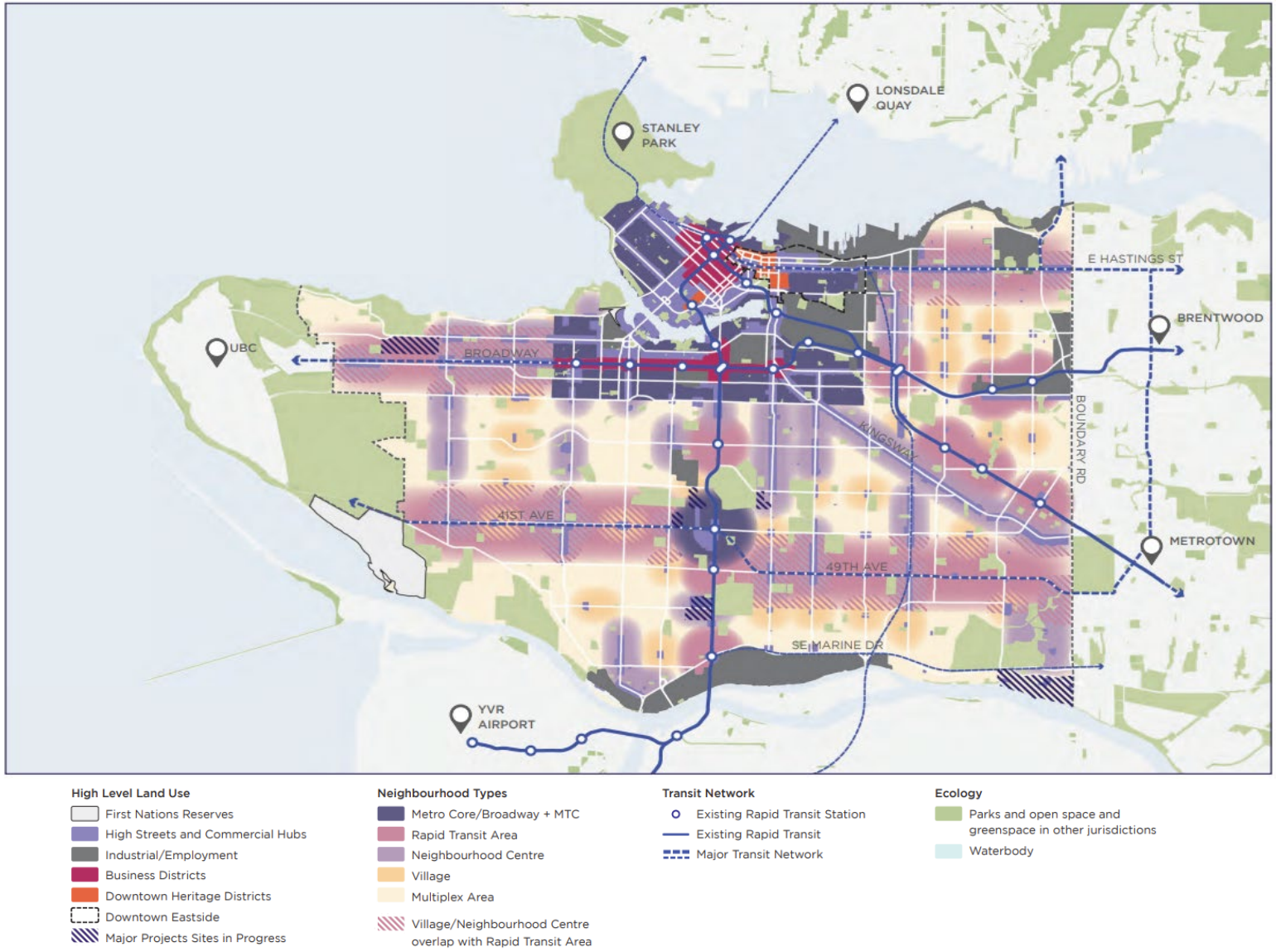


Figure 5-3. Vancouver Plan Land Use Strategy

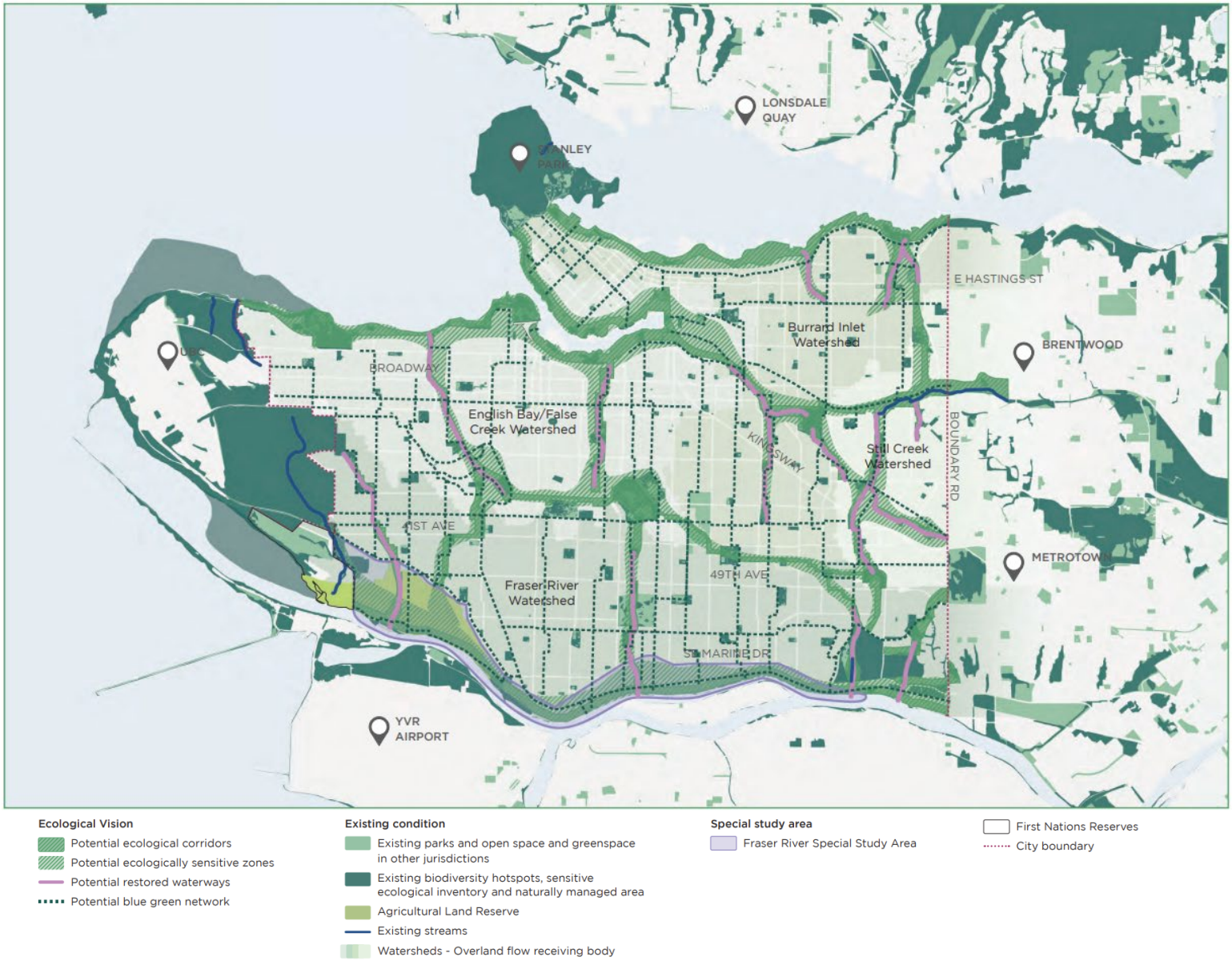


Figure 5-4. Vancouver Plan Long-term Ecological Vision

SECTION 6
Guiding Principles, Goal Areas, and Objectives

SECTION 6

Guiding Principles, Goal Areas, and Objectives

6.1 Engagement Approach

The proposed Strategic Framework of Guiding Principles, Goal Areas, and Objectives were developed in collaboration with the Healthy Waters Plan Project Advisory Group, Leadership Forum, and Technical Working Group. Appendix B provides information regarding the composition and roles of these engagement groups.

The project team would like to acknowledge the contributions of partners and stakeholders in the development of the Strategic Framework of Guiding Principles, Goal Areas, and Objectives. Their advice helps to ensure that this framework is sufficiently comprehensive, addressing core needs of the community and the environment as well as the policy objectives of First Nations and other levels of government.

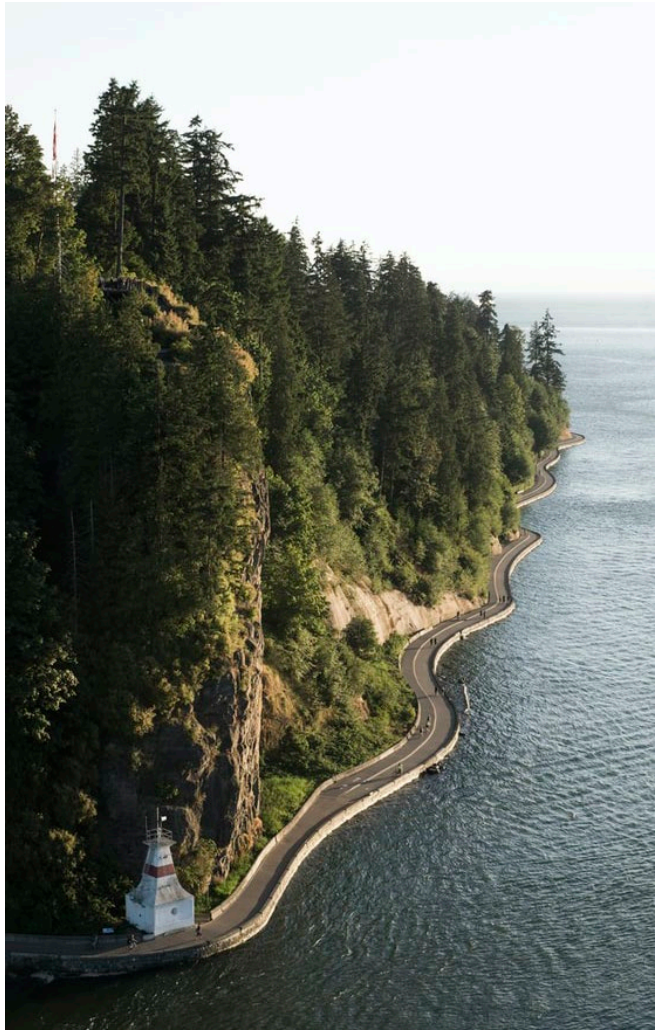
6.2 Guiding Principles

Guiding Principles are critical to all stages of the Healthy Waters Plan development. They will inform how the engagement work is conducted, how various pathway options will be defined in Phase 2, and how the plan is implemented, which includes the prioritization of investments.

Figure 6-1. Proposed Guiding Principles for the Healthy Waters Plan

6.3 Goal Areas and Objectives

Goal Areas describe the high-level vision of what we want to achieve with the Healthy Waters Plan. Each Goal Area has an associated set of specific objectives that describe what matters in achieving a Goal Area.



Goals and objectives will be considered in the evaluation of different pathways in Phase 2 of Healthy Waters Plan. To be useful in this analysis, an objective must be:

- Focused on one particular area (e.g., CSO elimination)
- Measurable (e.g., number of CSO events per year) so that the degree to which an alternative pathway meets the objective can be quantified
- Directional (e.g., increase, decrease, minimize, maximize)

Table 6-1 presents the proposed Goal Areas and Objectives to be considered by Council. These Goal Areas and Objectives will form the basis of evaluation of different investment, policy, and partnership pathways in Phase 2. Not all objectives are of equal importance, and, based on further analysis and engagement, later phases of the Healthy Waters Plan will assign appropriate weightings to the various objectives.

Each objective will have corresponding performance measures that are used for the assessment. For example, in Objective 1, “Work toward eliminating pollution of waterways due to CSOs” could have a corresponding performance measure such as “Number of annual CSO events” or “Total annual volume of CSO discharges in litres.”

Table 6-1. Proposed Goal Areas and Objectives for the Healthy Waters Plan	
Goal Area	**Objectives**
1. Healthy Waterways	• Work toward eliminating pollution of waterways due to CSOs • Work toward eliminating pollution of waterways due to SSOs • Reduce the pollution of waterways due to urban runoff • Minimize rainwater and groundwater conveyed to Metro Vancouver WWTPs • Reduce improper discharges into the sewage and drainage system
2. Healthy and Liveable Watersheds	• Increase the retention and infiltration of rainwater into the ground • Increase the amount of naturalized areas within the rainwater management system • Reduce the impact of drought on street trees and other natural assets • Increase the connectivity of naturalized areas and green rainwater infrastructure
3. Adapt to Risk and Uncertainty	• Minimize sewer back-up risk to people, critical infrastructure, and property • Minimize overland flooding risk to people, critical infrastructure, and property • Minimize flooding risk due to sea level rise, storm surges, and king tides that disrupt drainage services • Minimize seismic risk to sewage and drainage services • Minimize sewer and drainage system capacity risk due to growth, development, and climate change
4. Affordable and Optimal Service Delivery	• Minimize the cost of public infrastructure to taxpayers and ratepayers • Minimize the cost of private infrastructure to property owners and development • Maximize the equity of cost distribution • Maximize the adaptability of investments to manage future uncertainties

In some cases, the performance measures and associated targets will need to consider senior government regulation or the regional LWMP. For example, eliminating waterway pollution caused by CSOs will need to have a performance target that aligns with the regional LWMP. In addition, the Burrard Inlet Water Quality Objectives, which are being updated as led by Tsleil-Waututh Nation, will need to be considered during the planning process, including when performance targets are set and implementation actions are prioritized across the city.

It is also critical that the Healthy Waters Plan objectives are adequately comprehensive to support a holistic evaluation of alternatives. Some of the objectives are not historically considered as core service areas for sewage and rainwater management. For example, the objectives listed in Goal Area 2, “Healthy and Livable Watersheds” are not historically core services to be delivered. Participants in the engagement process affirmed that it is critical that these objectives be considered in the analysis for water management solutions like green rainwater infrastructure.

This proposed Strategic Framework is subject to change, based on outcomes from Phase 2 technical work and engagement.

SECTION 7
Next Steps for Phase 2

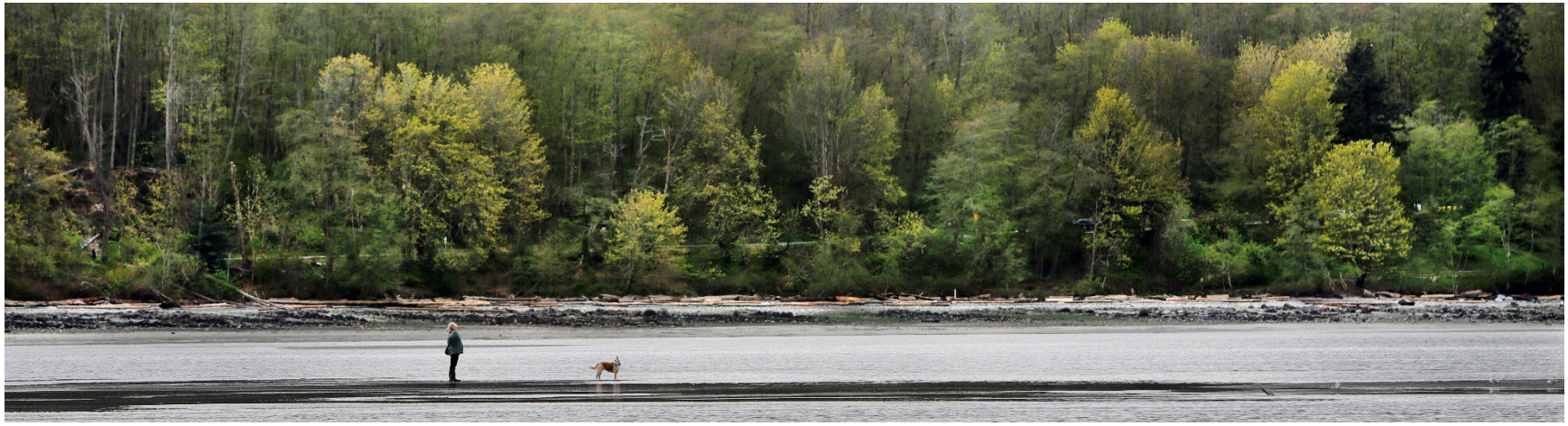
SECTION 7

Next Steps for Phase 2

Phase 2 of the Healthy Waters Plan will follow a structured and collaborative decision-support process that is driven by systems data and engagement group values. The process will be highly facilitated bringing the Project Team and its collaborators through several steps that include the exploration, creation, and evaluation of a wide range of future potential investments, policies, and partnerships.

Working at both the Basin and Citywide scales, this process will assemble Options into themed Pathways and compare their relative performance and costs to the current Baseline Forecast. Each Pathway will be crafted to address the Goals and Objectives that were developed with Project Partners and Stakeholders in Phase 1.

This process will highlight the important differences and trade-offs between potential future Pathways and will inform the development of a Preferred Pathway whose adaptive implementation will be refined in Phase 3.



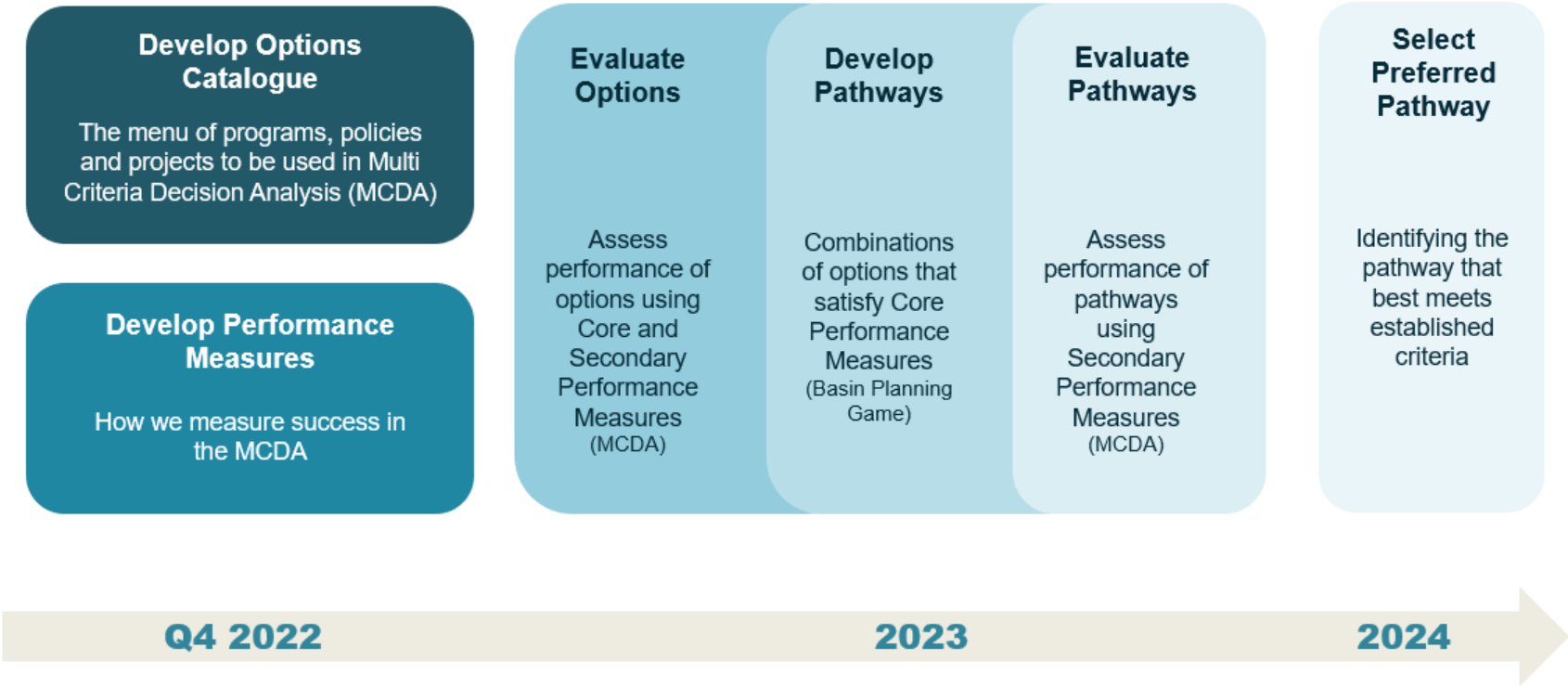


Figure 7-1. Phase 2 Key Planning Activities

1. Develop Options Catalogue:

This step will develop a catalogue of potential solutions to address the goals of the Healthy Waters Plan. Collectively referred to as the Options Catalogue, these programs, policies and projects will make up the pathways to be evaluated in the Phase 2 planning process. The Catalogue will draw heavily upon the City's current options in use, options identified in other City planning processes, and leading practices from other jurisdictions. Each Option will be described and illustrated and accompanied with its unit costs and performance. The Technical Working Group and Project Advisory Group and the Expert Advisory Panel will be the key participants in this activity.

2. Develop Performance Measures:

Each of the Plan's Goal and Objectives will have an associated Performance Measure that describes how we will measure success, which will serve as an input into Multi-Criterial Decision Analysis (MCDA) used to evaluate the Options Catalogue and Pathways. Performance Measures may include numeric and actionable Performance Targets (where appropriate and necessary for Phase 2), and relative weightings will be established according to input from the engagement committees. The Technical Working Group, Expert Advisory Panel and Project Advisory Group will be key participants in this activity.

3. Evaluate Options:

The Multi-Criterial Decision Analysis tool ("MCDA") will be used to assess individual items in the Options Catalogue, prior to Pathways development.

4. Develop Pathways:

The plan will utilize a facilitated, interactive Basin Planning Charrette and a Mass Balance Model to iteratively explore, ideate and evaluate potential basin Pathways. Members of the Technical Working Group will collaboratively assemble Options into Pathways and evaluate their performance against the Performance Measures for Vancouver's five receiving-waters and basins (see maps in Appendix A). Each basin's unique characteristics will inform appropriate solutions. This exercise will include intensive participation by the Technical Working Group, as well as the Expert Advisory Panel and Project Advisory Group.

5. Evaluate Pathways:

The team will evaluate approximately three different Pathways per basin using the Mass Balance model, the Metro Vancouver VSA Mike Urban model, the Financial Model, as well as other potential analytical tools as appropriate for the Performance Measures identified. These inputs will go into the MCDA tool for a comprehensive assessment. The Technical Working Group and Expert Advisory Panel will be the key participants in this activity, with touchpoints as needed with the Project Advisory Group and Leadership Forum.

6. Select Preferred Pathway:

For each of Vancouver's basins, a Preferred Pathway will be developed, drawing from the Options that contributed to highest pathway scores across the different evaluated Pathways. The Technical Working Group will be the key participants in this activity, with check-ins as needed with the Project Advisory Group, Leadership Forum and Expert Advisory Panel. The Preferred Pathway will be further refined in Phase 3 for the final Adaptive Plan.

7.1 Analytical Tools

To support this process, the project team will create and utilize several analytical tools to assist in decision-making. These tools include a Mass Balance Model that will allow the team to forecast the performance of the Options and Pathways on CSOs, flooding and pollutant loadings and a Financial Model that will allow the City to understand the financial implications of the various Pathways.

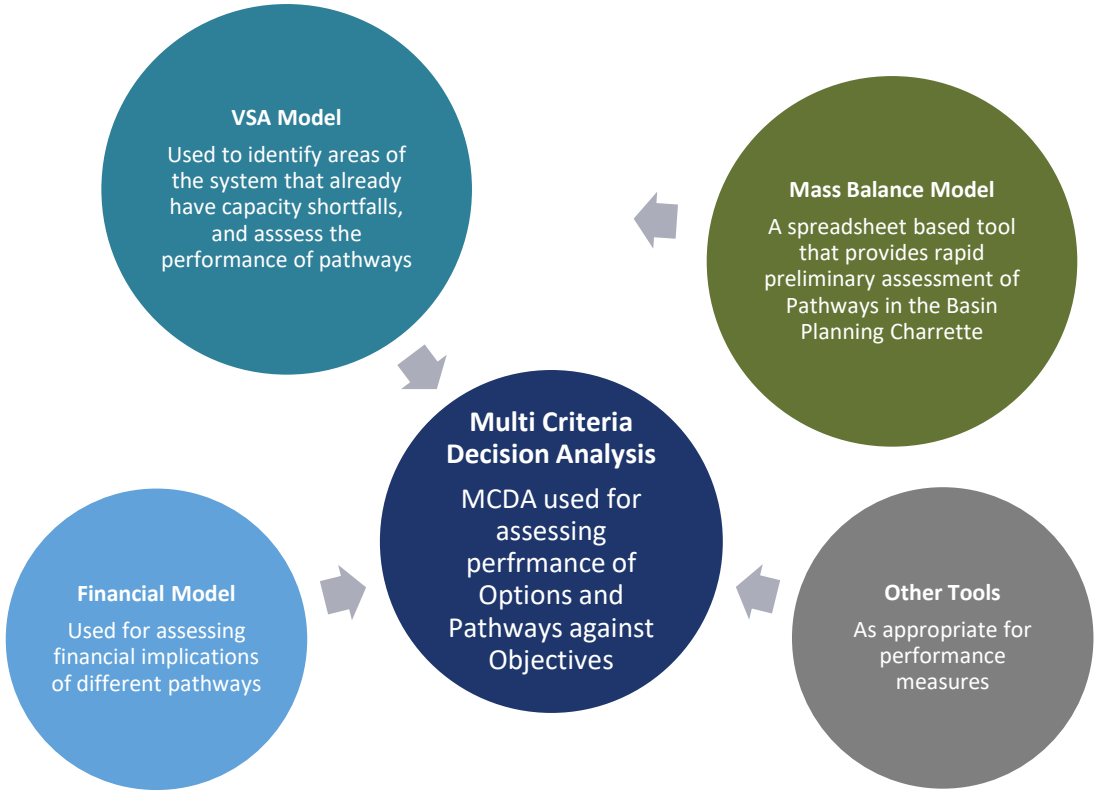


Figure 7-2. Phase 2 Analytical Tools Supporting the MCDA

The Mass Balance Model is a simplified tool that allows for rapid, real-time` assessment of the Options and Pathways being explored in this Plan, narrowing the range of pathways requiring evaluation using the more accurate VSA Mike Urban Model. Outputs from these analytical tools will serve as the inputs into the MCDA which facilitates the comparison of Pathways across a range of quantitative and qualitative Performance Measures as shown in Figure 7 3. Once the final short-listed Pathways are created, the Team will assess their performance against CSO, flooding and water quality performance measures using the VSA model. Other performance measures will be evaluated using other tools identified in Figure 7-3. Table 7-1 describes the tools in further detail.

Table 7-1. Tools that will support Healthy Waters Plan Phase 2 planning process		
	Platform	**Description**
Vancouver Sewerage Area (VSA) Model	Mike Urban	• The VSA Model is Metro Vancouver's existing 1D hydrodynamic model of the Vancouver sewerage area's trunk sewer system and is currently supporting HWP analysis. • The model will be used to understand system performance, evaluate existing system constraints, and identify potential flooding risks. • The VSA model will be used to develop existing flow pathways, boundary conditions, and develop flow time series for sewer systems and inform the mass balance model. • The VSA model will be the primary technical analysis tool to be used to assess the short-listed pathways identified in Phase 2, along with the recommended "Preferred Pathway"
Mass Balance Model	Microsoft Excel	• A new city-wide mass balance model will be developed in Phase 2 of Healthy Waters Plan to explore and short-list pathway scenarios for analysis by VSA model and the Basin Planning Charrette. • The model will build on existing models such as the Broadway Water Balance model, spreadsheet tools developed for the Cambie Corridor, and Metro Vancouver's VSA Model to create a high-level assessment of the inputs and outputs of Vancouver's sewer and drainage system. • This model will be used as preliminary screening tool to evaluate pathways that test the performance targets that represent the Healthy Waters Plan's Core Performance Measures. Selected pathways from this model will be analyzed in the VSA model before finalizing the pathways. • This tool will be critical in facilitating the Basin Planning Charrette to support the City and its engagement partners in co-creating the pathways for Healthy Waters Plan.
Financial Model	Microsoft Excel	• A financial model will be developed to support in assessing financial implications of the pathways evaluated in the Phase 2 of Healthy Waters Plan. The model will be based on City's existing financial model. • The model will include a forecast of risk-cost matrix to effectively compare the financial implications of each pathway by evaluating total cost (capital and operational), ratepayer impact, rate recovery, and affordability.
Multicriteria Decision Analysis (MCDA) Tool	Microsoft Excel	• The MCDA tool represents a framework for organizing the qualitative and quantitative goals and objectives of Healthy Waters Plan to make decisions on the pathway. This decision support tool will evaluate the pathways that include range of with close engagement with various partners and stakeholders of the project. • Risk and uncertainty will also be included as MCDA inputs to test for their impact on outputs. Uncertainties may be comprised of difference in stakeholder values or uncertain future. Where uncertainties prove significant for decision-making, they will be further refined or actions to reduce uncertainty will be identified.

7.2 Basin Planning Charrette

Central to the Healthy Waters Plan's guiding principles are collaboration and transparency. In that spirit, a Basin Planning Charrette process will be used to ensure that project partners are co-creators of the Pathways being explored in this planning. This exercise brings together the Technical Working Group and other engagement partners to ideate and collaboratively contend with the technical, financial, and social trade-offs associated with the use of different solutions identified in the Options Catalogue. This will help to identify pathways to be evaluated and refined.

Following the evaluation of the Preferred Pathways, the project team will identify which components of the evaluated pathways will make up the "Preferred Pathway". This hybrid pathway made up of a collection of programs, policies and projects will be further refined in Phase 3. The Phase 3 Final Plan will include recommendations for prioritizing investments, implementation strategies, financial planning and a timeline that includes the adaptive management approach for updating the plan in future years.

APPENDICES

Appendix A: Basin Characterization Maps

APPENDIX A
Basin Characterization Maps

MAPS AVAILABLE AS SEPARATE PDF DOCUMENT

In Phase 2, the Healthy Waters Plan will organize the planning and Pathway evaluation around the City's five drainage basins and their associated receiving waters. These basins include the lands draining to the Inner Harbour, Outer Harbour, False Creek, the Fraser River and Still Creek.

This approach will focus analysis and dialogue on the relationships between the land use, infrastructure conditions, the regional sewage system context, and the health of the major water bodies. It will also facilitate analysis and exploration of the socio-cultural and environmental conditions that fall into the goals and objectives of the Healthy Waters Plan. The engagement process will collaboratively establish basin-level performance targets which will further inform future watershed scale capital and program planning efforts and aim towards alignment with regional Water Quality Objectives.

The basin characterization infographics summarize the Phase 1 findings at the basin scale and include statistics and information specific to the lands and receiving waters for each basin. Additional characterization of the basins will be completed in Phase 2 to integrate output from the Mass Balance and VSA models, in order to identify system constraints and to support the assessment of the feasibility of different Pathways.

To supplement this basin characterization in Phase 2, Metro Vancouver has been utilizing the VSA Mike Urban model to assess capacity of the system. This capacity analysis will help to identify those areas in the City more exposed to sewer flooding and backup risk, as well as estimating CSO locations and volumes associated with different rainfall events. This work by Metro Vancouver will be a critical input to the basin planning game.

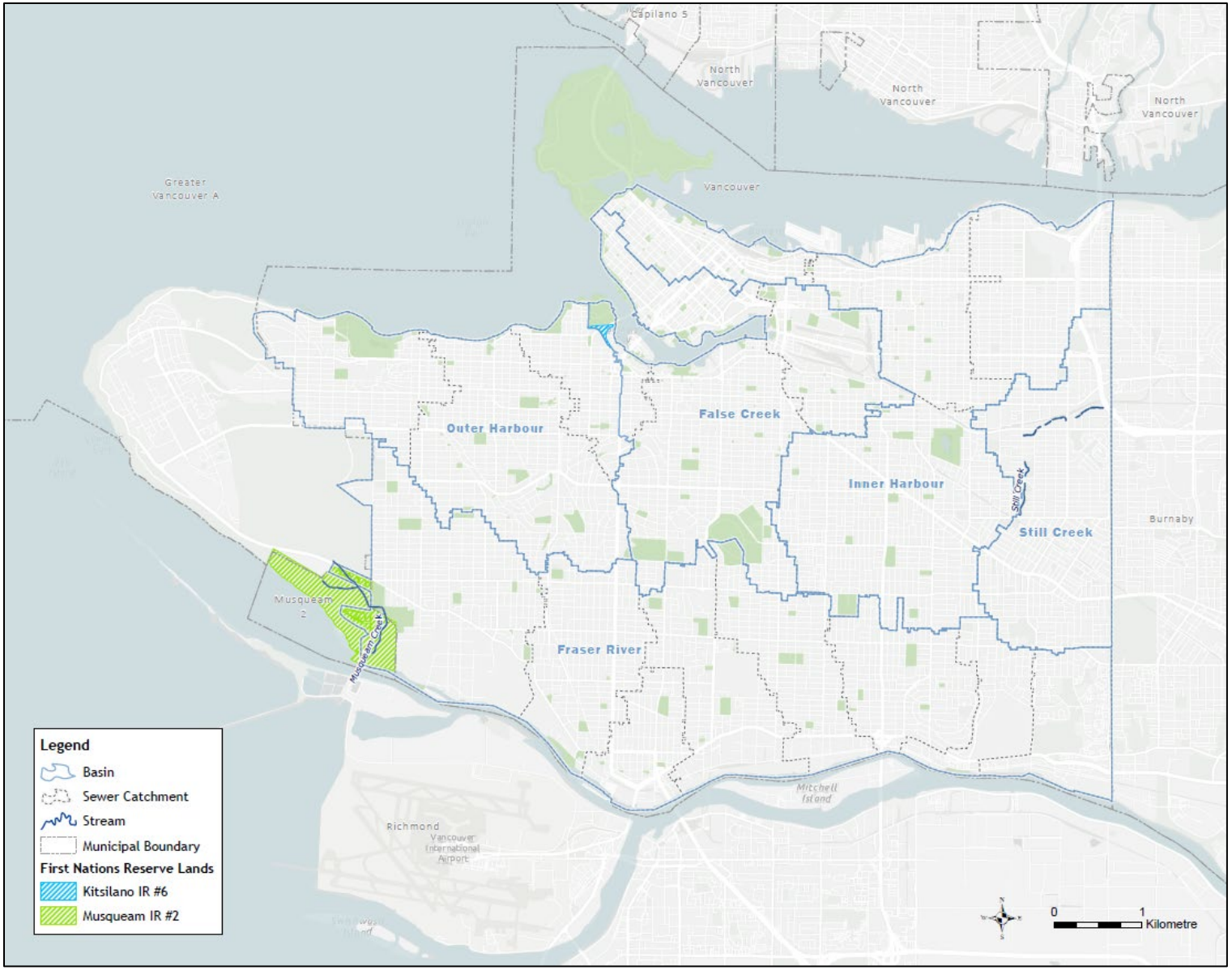


Figure A-1. Five basins of City of Vancouver

Appendix B: Engagement Structure for the Healthy Waters Plan

APPENDIX B

Engagement Structure for the Healthy Waters Plan

Engagement Framework

The Engagement Framework describes who is involved in the Healthy Waters Plan planning process, and in what capacity. The Engagement Framework is guided by the City's core values for public participation, themselves informed by the International Association for Public Participation ("IAP2"). The Healthy Waters Plan commits to an engagement process that: advances reconciliation, is equity-infused, is integrated and coordinated, and that is collaborative. Table B-1 summarizes each engagement committee and level of engagement.

Indigenous Engagement

The project team followed the City of Vancouver Indigenous Engagement Protocol in establishing respectful and reciprocal relationships with Musqueam, Squamish and Tsleil-Waututh Nations. The project team submitted formal referrals to the Musqueam, Squamish and Tsleil-Waututh Nations and to the Metro Vancouver Aboriginal Executive Council (MVAEC) in May 2021 and in August 2021.

Further to the referral process, the project team developed capacity-funding agreements with Musqueam Indian Band and Tsleil-Waututh Nation to support their full participation throughout the development of the Healthy Waters Plan. As of summer 2022, MVAEC has not formally responded to the City's referrals. The Squamish Nation has declined to participate in the Healthy Waters Plan engagement process.

Table B-1. Engagement Framework	
Project Advisory Group ***IAP2 Level: Involve, Collaborate***	**Who:** Staff from the Government of Canada, Province of BC, Metro Vancouver, Musqueam Indian Band, development community, Port of Vancouver, Vancouver Coastal Health, BC Housing, and NGOs and advocacy groups. **What:** The Project Advisory Group represents the interests of those who will be affected by project decisions, and will significantly inform the goals, objectives and performance measure for the Healthy Waters Plan.
Leadership Forum ***IAP2 Level: Collaborate***	**Who:** Senior managers and staff from Metro Vancouver, City of Vancouver, Province of BC, Government of Canada, Musqueam Indian Band, Tsleil-Waututh Nation. **What:** The Leadership Forum is a venue for higher-level discussions around regulatory matters, related financial and investment considerations, and linked decision-making pathways around the Healthy Waters Plan and the Integrated Liquid Waste Resource Management Plan
Technical Working Group ***IAP2 Level: Involve***	**Who:** Technical staff from the City of Vancouver, Metro Vancouver, Musqueam Indian Band and Tsleil-Waututh Nation **What:** The Technical Working Group meets to review technical deliverables from the Current State Assessment, and achieve shared, inter-jurisdictional learning occurs, and support collaboration across jurisdictions
Expert Advisory Panel ***IAP2 Level: Involve, Collaborate***	**Who:** A multi-disciplinary group of experts with no vested interest in the outcomes of the project, from other wet-weather cities, academic expertise, Traditional Ecological Knowledge and experience of environmental justice efforts from the United States and Canada **What**: The Expert Advisory Panel provides independent advisory support to help define and expand the envelope of what is possible within the Healthy Waters Plan. The Expert Advisory Panel helps to fill knowledge gaps and provide best practices.

Appendix C: Additional Maps and Graphics

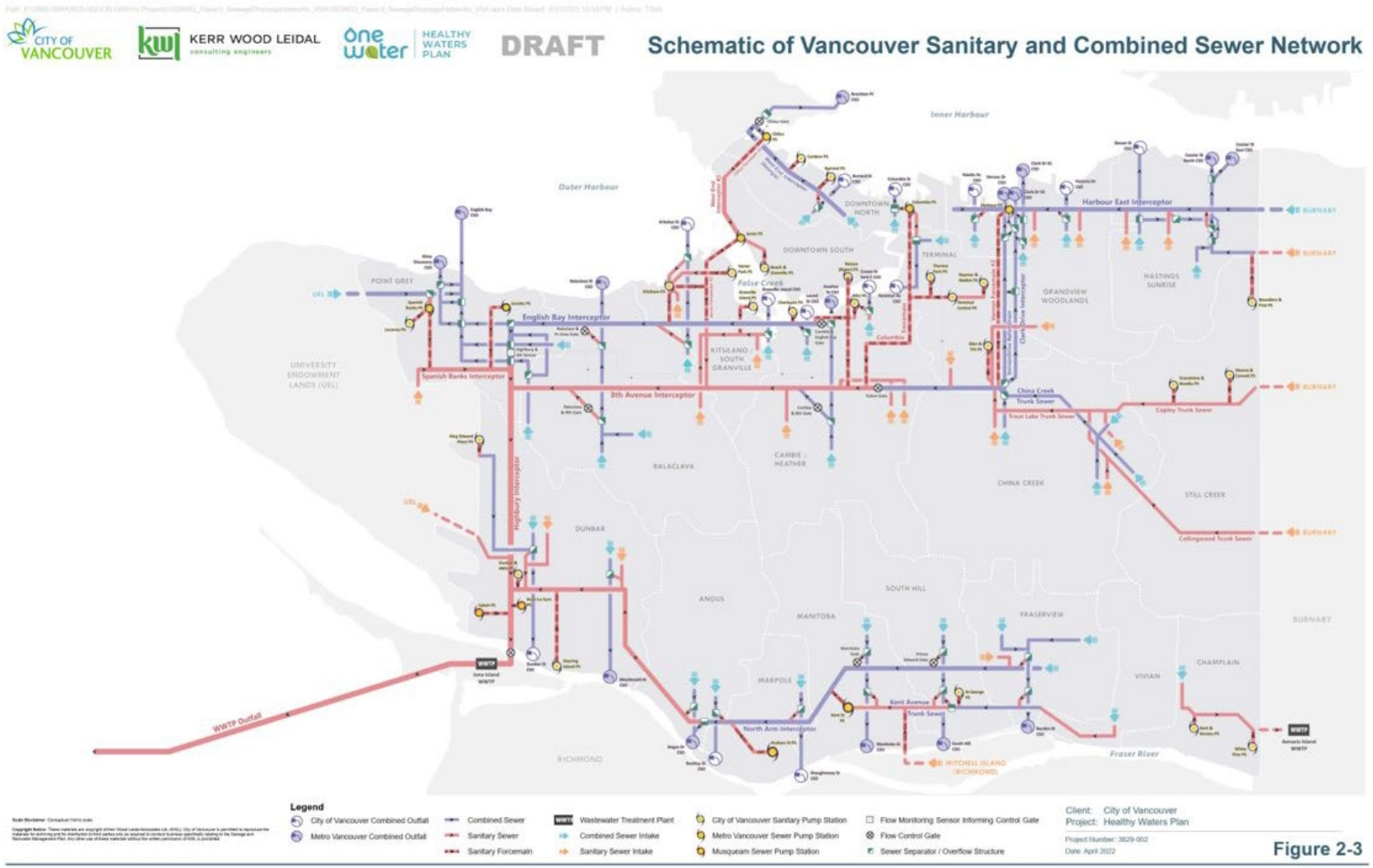
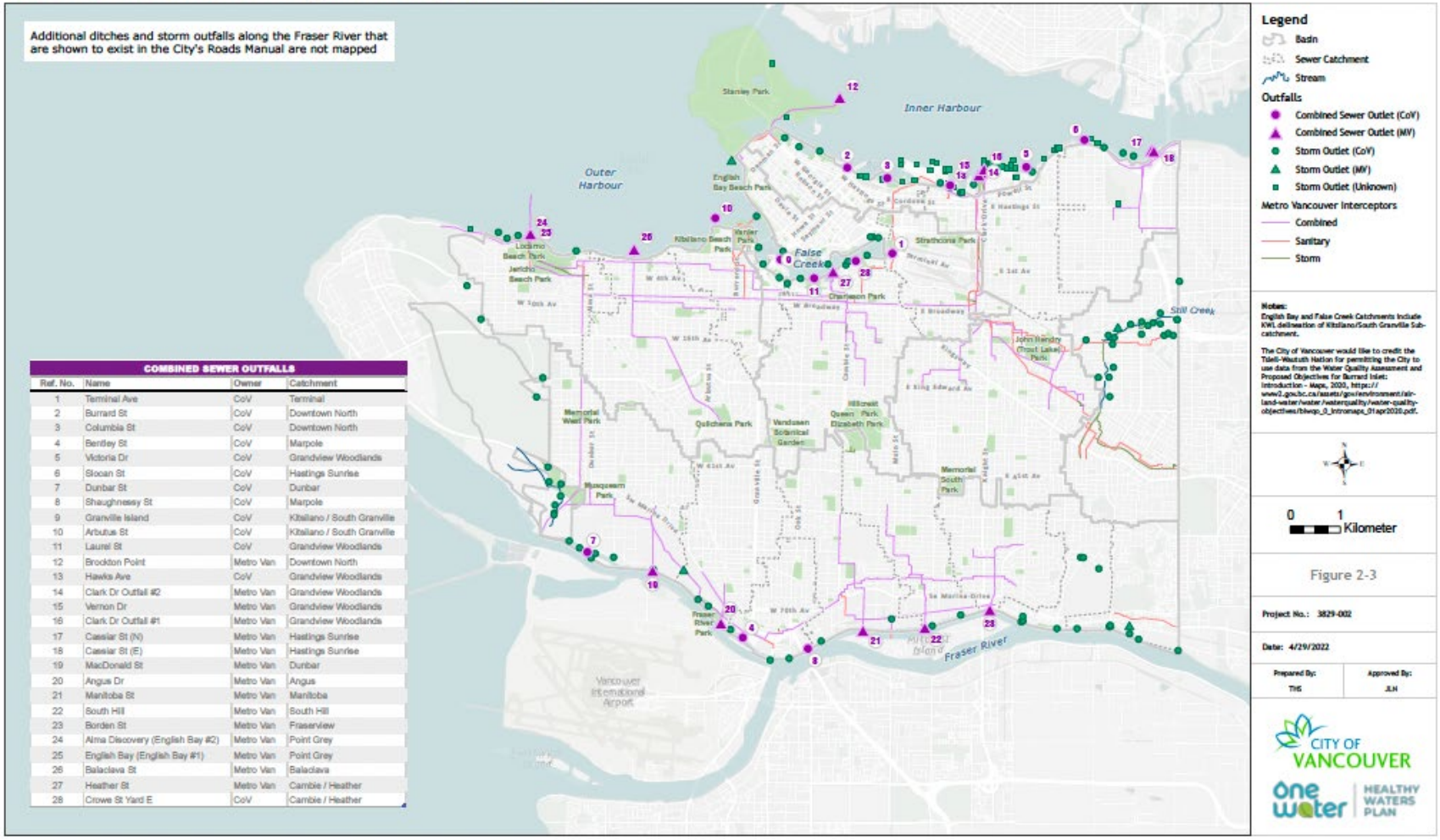


Figure C-1. Vancouver Sewer and Drainage System Network

Vancouver and Metro Vancouver's Stormwater and Combined Sewer Outfalls

Healthy Waters Plan - Paper #2 Aquatic Health



COMBINED SEWER OUTFALLS

Ref. No.	Name	Owner	Catchment
1	Terminal Ave	CoV	Terminal
2	Burrard St	CoV	Downtown North
3	Columbia St	CoV	Downtown North
4	Bentley St	CoV	Marpole
5	Victoria Dr	CoV	Grandview Woodlands
6	Slocan St	CoV	Hastings Sunrise
7	Dunbar St	CoV	Dunbar
8	Shaughnessy St	CoV	Marpole
9	Granville Island	CoV	Kitsilano / South Granville
10	Arbutus St	CoV	Kitsilano / South Granville
11	Laurel St	CoV	Grandview Woodlands
12	Brockton Point	Metro Van	Downtown North
13	Hawks Ave	CoV	Grandview Woodlands
14	Clark Dr Outfall #2	Metro Van	Grandview Woodlands
15	Vernon Dr	Metro Van	Grandview Woodlands
16	Clark Dr Outfall #1	Metro Van	Grandview Woodlands
17	Caesiar St (N)	Metro Van	Hastings Sunrise
18	Caesiar St (E)	Metro Van	Hastings Sunrise
19	MacDonald St	Metro Van	Dunbar
20	Angus Dr	Metro Van	Angus
21	Manitoba St	Metro Van	Manitoba
22	South Hill	Metro Van	South Hill
23	Borden St	Metro Van	Fraserview
24	Alma Discovery (English Bay #2)	Metro Van	Point Grey
25	English Bay (English Bay #1)	Metro Van	Point Grey
26	Balaclava St	Metro Van	Balaclava
27	Heather St	Metro Van	Cambie / Heather
28	Crowe St Yard E	CoV	Cambie / Heather

Figure C-2. Vancouver and Metro Vancouver's Stormwater and Combined Sewer Outfalls

To be added later

Figure C-3. CSO Activation in Various Wet Weather Conditions