Key Directions for the Healthy Waters Plan

Acknowledgements

February 3, 2025

We extend our heartfelt gratitude for the unwavering dedication and thoughtful contributions of those who participated in the development of the Healthy Waters Plan. Your expertise, collaboration, and leadership have been instrumental in advancing our mission to ensure sustainable and healthy water management for our community.

PROJECT TEAM

CITY OF VANCOUVER

- Chris Baber
- Jeremy Boyd
- Tim Douglas
- Lauren Foote
- Zoe Greenberg
- Jamie Huang
- Cathy Pasion
- Rory Teiffel
- Junlin Wang
- Dave Young

BROWN & CALDWELL

- Rosey Jencks
- Sam Cohen
- Topher Jones
- Pratistha Kansakar
- Brent Robinson
- Annaliese Sytsma

ECOPLAN

LOTUS WATER

KERR WOOD LEIDAL

- Jessica LeNoble
- Hua Bai
- Chris Johnston
- Yuquan Li
- Jeffrey Marvin
- Sara Pour

RAFTELIS

SPACE2PLACE

PARTNERS & STAKEHOLDERS

PROJECT PARTNERS

- Musqueam Indian Band
- Squamish Nation
- Tsleil-Waututh Nation
- Metro Vancouver

EXTERNAL PROJECT STAKEHOLDERS

- BC Housing
- Georgia Straight Alliance
- Ministry of Environment and Climate Change Strategy
- Ocean Wise
- Port of Vancouver
- Raincoast Conservation Foundation
- Still Moon Arts Society
- Swim Drink Fish
- Urban Development Institute
- Vancouver Coastal Health
- West Coast Environmental Law

CITY OF VANCOUVER

- Development Services, Buildings & Licensing
- Development Water Resources Management
- Environmental Services
- Engineering Financial Planning & Analysis
- Green Infrastructure Implementation
- Integrated Sewer & Drainage Planning
- Long Term Financial Strategy & Treasury
- Parks Planning, Policy & Environment
- Risk Management
- Sanitation Operations
- Sewers & Drainage Design
- Sewers Operations
- Strategy & Project Support Office
- Streets Design
- Planning, Urban Design & Sustainability
- Transportation Planning
- Waterworks Design

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List of Acronyms and Definitions

CSO: Combined sewer overflow

CREF: Human Health and Ecological Comparative Risk Evaluation Framework

EAP: Expert Advisory Panel

GRI: Green Rainwater infrastructure

GVS&DD: Greater Vancouver Sewerage & Drainage District

LWMP: (Metro Vancouver's) Liquid Waste Management Plan

MBM: Mass Balance Model

MCDA: Multi-Criteria Decision Analysis

Metro Vancouver: Metro Vancouver Regional District

NGO: Non-Governmental Organization

ODP: Official Development Plan

Options: various grey and green infrastructure, policy, and program choices

PAG: Project Advisory Group

Pathway: A combination of various Options

SSO: Separated Sewer Overflow

TWG: Technical Working Group

TSS: Total Suspend Solids

VSA: (Metro Vancouver's) Vancouver Sewerage Area Model

WWTP: Wastewater Treatment Plant

Executive Summary

In May 2020, Vancouver City Council directed staff to develop a comprehensive plan for sewage and rainwater management, now known as the "Healthy Waters Plan". This initiative will guide long-range investments, policies, and programs to address pollution from combined sewer overflows (CSOs) and impacted urban rainwater runoff while meeting the growth needs of the city and addressing key risks related to climate change and aging infrastructure.

A phased approach has been taken for Healthy Waters Plan development, with the engagement process including participation from the xʷməθkʷəy̓əm (Musqueam Indian Band), Sḵwx̱wú7mesh Úxwumixw (Squamish Nation), and səlilwətaɬ (Tsleil-Waututh Nation), Metro Vancouver, senior government representatives and relevant environmental and community groups. The process included steps to ensure alignment with the Vancouver UNDRIP Strategy, the Vancouver Plan, the Metro Vancouver Liquid Waste Management Plan, the Burrard Inlet Action Plan, and other policies.

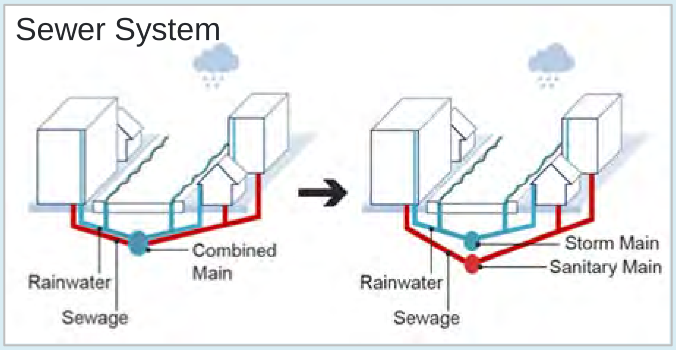
Phased approach for development of the Healthy Waters Plan

Phase 1 included a comprehensive current state assessment of sewage and rainwater management, along with development of a Strategic Framework of Guiding Principles, Goal Areas and Objectives. This framework, adopted by Vancouver City Council in February 2023, was foundational to the structured planning process used in Phase 2. This included use of a Multi-Criteria Decision Analysis (MCDA) framework to evaluate different combinations of infrastructure, programs, and policy options, which led to the Key Directions recommended in this report.

Key Directions for Immediate Adaptation

1 **Adopt an enhanced approach to sewer separation to more rapidly remove rainwater, groundwater and buried creeks from City and regional sewers:**

- Advance critical investments in stormwater trunk pipes and adopt a "bottom-up" approach to prioritize sewer separation in areas adjacent to receiving water bodies to divert non-sanitary flows away from City and regional sanitary sewer infrastructure.
- Develop a proactive program for separating combined sewer connections to private properties, which is essential for addressing a major barrier to CSO elimination; and
- Prioritize investments to maximize value-for-money outcomes, considering ecosystem and public health drivers, along with addressing aging infrastructure, sewer back-ups, flooding, and growth needs.



2 **Expand the use of Green Rainwater Infrastructure on City land to manage and clean rainwater runoff, reduce the volume of rainwater entering the sewer system and expand the use of natural assets to support watershed health.** This will also support improved ecosystem health, climate change adaptation, and livability. Over the next fifty years, this includes the following investments:

43 kilometres of Blue Green Systems to provide a network of green infrastructure typologies contributing to water management, ecological health and active transportation.

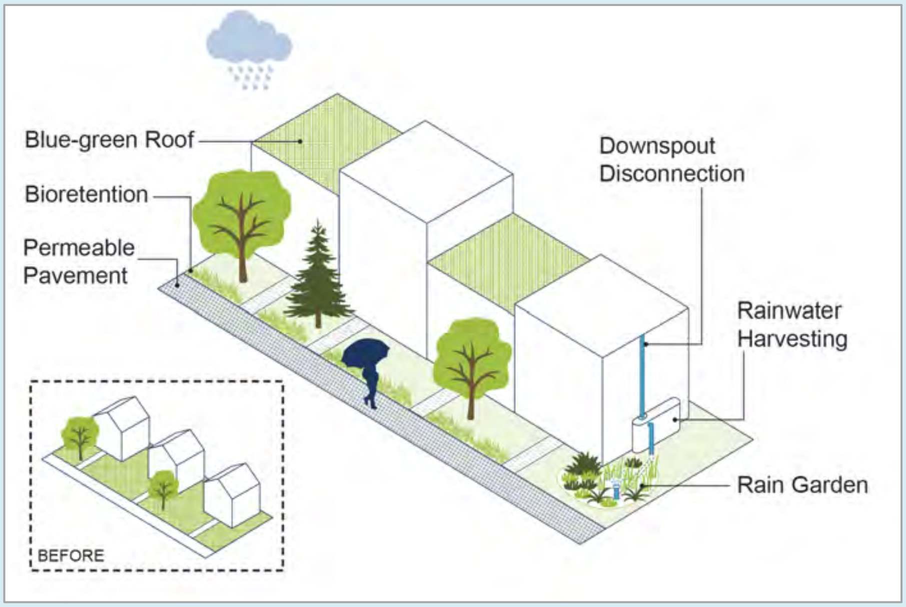
42 kilometres of Green Streets to remove rainwater runoff pollutants and contribute to climate adaptation and livability objectives

18 hectares of Floodable Wetlands and Public Spaces to manage large volumes of rainwater runoff and reduced the burden of rainwater entering the system

4 kilometres of Waterway Restoration to contribute to creek daylighting objectives and improve drainage

30 Rainwater Treatment Devices to remove urban runoff pollutants after they enter the stormwater sewer network

3 **Optimize the use of rainwater management policy for redevelopment**, to minimize costs of growth-driven system capacity upgrades as well as flooding and CSO risks. This includes:



Example of rainwater management practices

- Completing an evaluation of staged detention tank-based approaches for larger building developments, considering opportunities for non-potable reuse of rainwater
- Exploring cost-effective opportunities for retention or hybrid retention-detention based solutions considering appropriate building typologies and geographical factors
- Development industry consultation to support adoption of practical and affordable solutions

Recommendations for Phase 3 Work

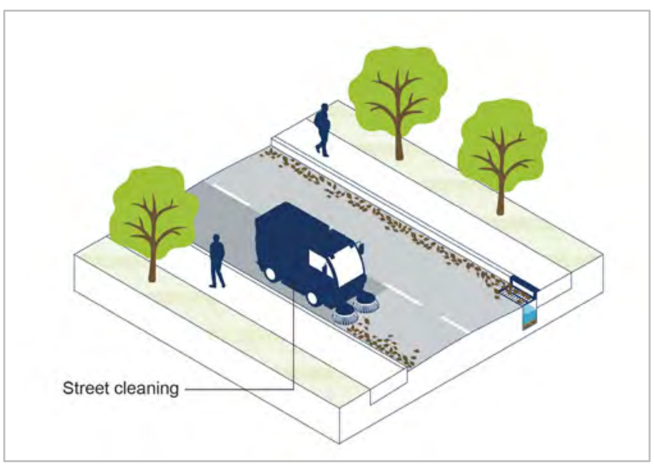
1. **Define the Healthy Waters Implementation Plan** to target investments, policies and programs to maximize the pace of improvements to water quality while addressing flooding, sewer back-ups, aging infrastructure and other critical risks to be managed. Maximizing value-for-money outcomes will be critical for the implementation plan, recognizing the need to stay within the City's financial capacity and preserve affordability for residents, businesses, and housing.

2. **Define flood-proofing policy for redevelopment and critical flood protection investments** at the conclusion of a city-wide Extreme Rainfall Risk Assessment.

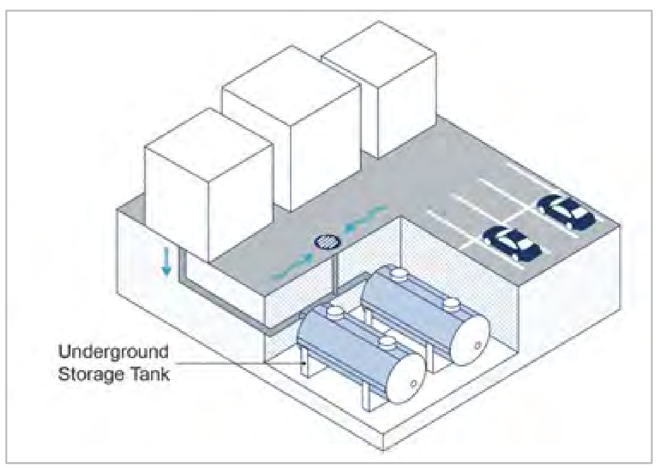
3. **Strengthen existing pollution prevention measures**, including land use planning opportunities and source control measures to prevent harmful substances from entering the sewers and drainage system including targeted street sweeping, improved discharge controls, public education and regulations.

4. **Tailor the Groundwater Strategy** to ensure that it addresses the significant capacity burden on the sewers and drainage system resulting from groundwater leaking into pipes and discharged by the foundation drainage systems of larger buildings.

5. **Complete a feasibility study for CSO rapid treatment and storage solutions** to evaluate options supplemental to sewer separation which could further accelerate CSO elimination.



Example of pollution source control measure (street cleaning)



Example of CSO rapid treatment and storage solution

Performance of the Healthy Waters Plan has been compared to historical practices, where sewer separation work was driven by the need to prevent pipes from failing or address capacity shortfalls, as well as reliance on redevelopment to achieve separation of combined property connections. It has also been compared to a scenario that assumes 100% separation of the sewer system by 2050 to meet current LWMP targets.

In summary, the Healthy Waters Plan:

has the potential to **eliminate an equivalent amount of fecal coliforms** (the primary public health performance measure) as separating the entire sewer network by 2050

will **reduce the impacts of urban rainwater runoff pollution by integrating investments** in sewer separation with GRI and stormwater treatment

will **deliver on a broader range of objectives** including flood protection, healthier watersheds, reducing urban heat, improving biodiversity and livability

Phase 3 work will focus on refining and defining the implementation of the Healthy Waters Plan. This includes:

- Completing actions highlighted as "Recommendations for Phase 3 Work" (described above)
- Defining an Adaptive Implementation Plan which responds to uncertainties including climate change, population growth and other factors and prioritizes investments to maximize the pace of improvements to water quality and responds to other critical drivers
- Defining a monitoring program and performance targets to assess performance over time
- Developing a financial strategy to support the Adaptive Implementation Plan
- Defining requirements for possible future changes to the LWMP

1. BACKGROUND AND CONTEXT

In May 2020, Vancouver City Council directed staff to proceed with development of a comprehensive plan for sewage and rainwater management, now known as the **Healthy Waters Plan**. This initiative will guide long-range investments, policies, and programs to address pollution from combined sewer overflows (CSOs) and impacted urban rainwater runoff. It aims to meet the growth needs of the city while managing key risks related to climate change and aging infrastructure in a holistic and integrated manner. Adopting a "One Water" approach[1] is essential for addressing affordability challenges and maximizing benefits through investment planning, policies and programs. A phased approach has been utilized to plan development (Figure 1).

Figure 1: Phased approach for development of the Healthy Waters Plan

A summary of outcomes from Phase 1 is available in the Foundations for a Healthy Waters Plan report. Vancouver City Council approved the Strategic Framework of Guiding Principles, Goal Areas, and Objectives on February 2nd, 2023.

The **Guiding Principles** (Figure 2) are critical to all stages of the Healthy Waters Plan. They inform how the engagement work is conducted, how various Options are defined, and how the Plan will be implemented, including the prioritization of investments. Guiding Principles include Equity, Reconciliation, Resilience, Collaboration, and Stewardship.

Figure 2: Guiding Principles

[1] The City of Vancouver's "One Water" approach is a holistic water management strategy that recognizes the interconnected nature of all water types: drinking water, rainwater, wastewater, groundwater, and waterbodies. It aims to manage these resources in an integrated manner that supports the community, economy, and environment. This approach includes initiatives like green rainwater infrastructure to reduce flooding and pollution, and the reuse of heat from sewage to warm buildings. It will address the challenges of urban water management in the face of climate change and urban growth.

Goal Areas and Objectives (Figure 3) outline the overarching vision for the Healthy Waters Plan. Each Goal Area includes a set of specific Objectives that identify the key factors necessary to achieve that Goal Area. The Goal Areas and Objectives were identified in Phase 1 and further refined in Phase 2.

Goal Areas	Objectives
Healthy Waterways	• Work towards elimination of pollution of waterways due to combined sewer overflows • Work towards elimination of pollution of waterways due to sanitary sewer overflows • Reduce the pollution of waterways due to urban runoff • Minimize rainwater and groundwater conveyed to Metro Vancouver Wastewater Treatment Plants • Reduce improper discharges into the sewage & drainage system
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
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 disrupting drainage services • Minimize seismic risk to sewage and drainage services • Minimize system capacity risk due to growth, development and climate change
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

Figure 3: Goal Areas and Objectives

Building on the foundational work of Phase 1, Phase 2 focused on defining the Key Directions (referred to during the planning process as the “Preferred Pathway”) for the Healthy Waters Plan. The Key Directions include a range of grey and green infrastructure investments as well as Citywide policies and programs extending to 2075. Phase 3 work will establish an implementation and investment plan utilizing an adaptive approach to address uncertainties, prioritizing action where it is needed most.

1.1 Participants in the Planning Process

Sewer and rainwater management in Vancouver is complex and inter-jurisdictional, with the City of Vancouver and Metro Vancouver jointly providing infrastructure services, and the Province of British Columbia and the Government of Canada acting in regulatory positions. xʷməθkʷəy̓əm (Musqueam Indian Band), Sḵwx̱wú7mesh Úxwumixw (Squamish Nation), and səlilwətaɬ (Tsleil-Waututh Nation) play an important role, and efforts to advance reconciliation are being pursued within the UNDRIP Action Plan (see Section 1.2.1). Additionally, various environmental and community groups are active in this field and their perspectives must be considered in the Plan’s development.

Figure 4 lists the key groups that have been engaged with in the work. In addition to informing the development of the Healthy Waters Plan, the engagement process has aimed to break down silos in the sewers and rainwater management sectors. This relationship building is essential for fostering stronger cross-jurisdictional cooperation in the future.

Project Advisory Group (PAG) is a diverse group of external partners and stakeholders with a vested interest in the outcomes of the Healthy Waters Plan. This group provides input on areas of strategic alignment and plan development.

Technical Working Group (TWG) is made up of SMEs from City of Vancouver, Metro Vancouver, Musqueam Indian Band, Squamish Nation, and Tsleil-Waututh Nation.

Expert Advisory Panel (EAP) includes experts from other wet-weather and leading jurisdictions to provide advice and help guide plan development.

Figure 4: Groups involved in development of the Healthy Waters Plan

PAG and TWG members collaborating at the Basin Planning Charrette engagement event

1.2 Policy Context

The Healthy Waters Plan must align with other plans and policies that are either completed or under development (see details in Appendix A: Policy Framework). Alignment is necessary to ensure a comprehensive and integrated approach to water management that protects public health, supports a thriving ecosystem, and facilitates sustainable urban development.

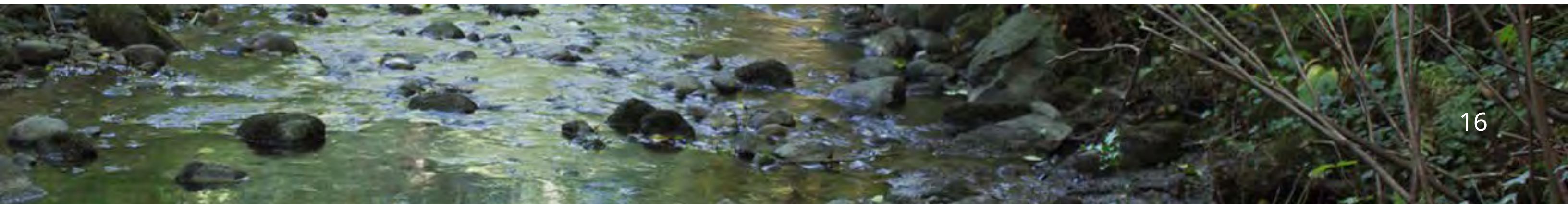
1.2.1 The UNDRIP Action Plan

Vancouver is located on the unceded and traditional territories of the xʷməθkʷəy̓əm (Musqueam Indian Band), Sḵwx̱wú7mesh Úxwumixw (Squamish Nation), and səlilwətaɬ (Tsleil-Waututh Nation), collectively referred to as local Nations. The Healthy Waters Plan is a critical step forward in advancing Vancouver's United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) Action Plan, which aims to foster reconciliation through the integration of Indigenous knowledge into water management strategies. In recent UNDRIP Action Plan discussions with the local Nations, water quality has emerged as a critical issue that needs to be addressed.

The City is surrounded on three sides by the Salish Sea and the Fraser River. Local Nations have historically been, and continue to be, impacted by Vancouver's urban development. Water quality is negatively impacted by rainwater runoff pollution and sewer overflows. These ongoing water quality issues diminish the ability of the local Nations to harvest traditional foods, including fish and shellfish.

Urbanization has also resulted in the burying of creeks across the City and adverse ecosystem health impacts to Musqueam Creek and Still Creek. Negative impacts include sewage spills on Reserve Land and other areas important to local Nations, the development of wastewater treatment facilities adjacent to Reserve Land, and a limitation in the ability to facilitate traditional cultural activities. These negative outcomes stemmed from historical decisions that lacked consultation with and respect for the inherent rights of the local Nations.

The Healthy Waters Plan aims to maximize the pace of water quality improvements and is committed to collaborating with local Nations on a continual basis to ensure that future improvements can be made respectfully and effectively.



1.2.2 The Burrard Inlet Action Plan

The Burrard Inlet Action Plan, led by səlilwətaɬ, aims to improve water quality and ecosystem health in Burrard Inlet through targeted pollution reduction and habitat restoration initiatives. The Healthy Waters Plan seeks to complement these efforts by prioritizing rapid reduction of CSOs while addressing pollution from rainwater runoff. By integrating green and grey infrastructure and prioritizing water quality, the Healthy Waters Plan supports the Burrard Inlet Action Plan's goals of reducing contaminants and protecting aquatic habitats.

1.2.3 Metro Vancouver Liquid Waste Management Plan

Typical of older cities worldwide, much of Vancouver is serviced by combined sewers, which carry mixed sanitary flows and rainwater (Figure 5a). CSOs occur when rainfall events overwhelm the system's capacity to convey sewage to wastewater treatment plants, releasing untreated sewage to waterways. To mitigate CSOs, the City is actively renewing and replacing legacy combined sewer infrastructure with separate sanitary and storm pipes (Figure 5b). The Metro Vancouver Liquid Waste Management Plan (LWMP) (2011) commits Vancouver to separating one percent of its sewer network annually, with the goal of fully preventing CSOs by 2050.

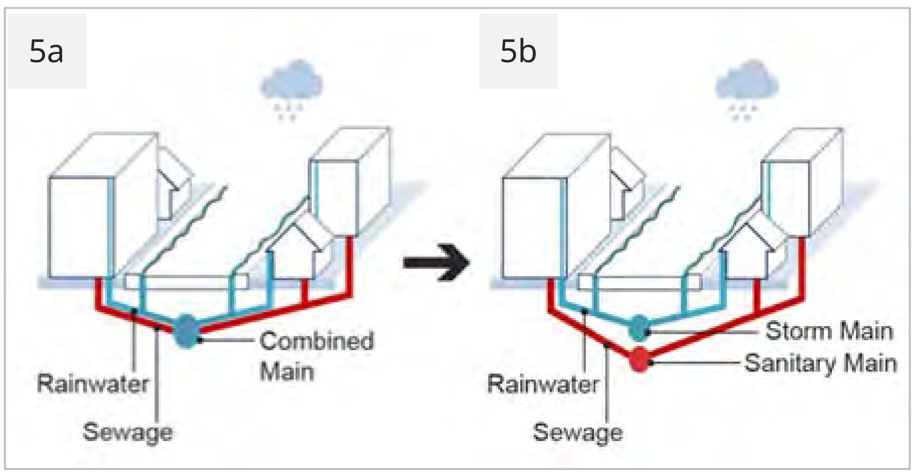


Figure 5a & 5b: (5a) combined rainwater and sewer pipes and (5b) separated sewer and rainwater pipes.

The LWMP is currently undergoing updates which are expected to be complete by 2025. At the time of this report, no changes are being proposed to the existing one per cent separation rate or 2050 CSO prevention target. Work completed within the Healthy Waters Plan has identified barriers to achieving these targets, as well as the need to address critical risks such as those relating to climate change and pollution from rainwater runoff. In accordance with direction received from the BC Ministry of Environment and Climate Strategy, the City will need to complete a comprehensive analysis and engagement process within the Healthy Waters Plan to support a possible future mid-term amendment to the LWMP (Section 3.5.1).

1.2.4 The Rain City Strategy

In 2018, Vancouver City Council approved the Rain City Strategy, which initiated higher levels of investment in Green Rainwater Infrastructure (GRI). Increased investments in GRI will reduce the burden of rainwater on pipe networks and enhance climate adaptation, ecosystem health, and livability (Figures 6a, 6b, and 6c).

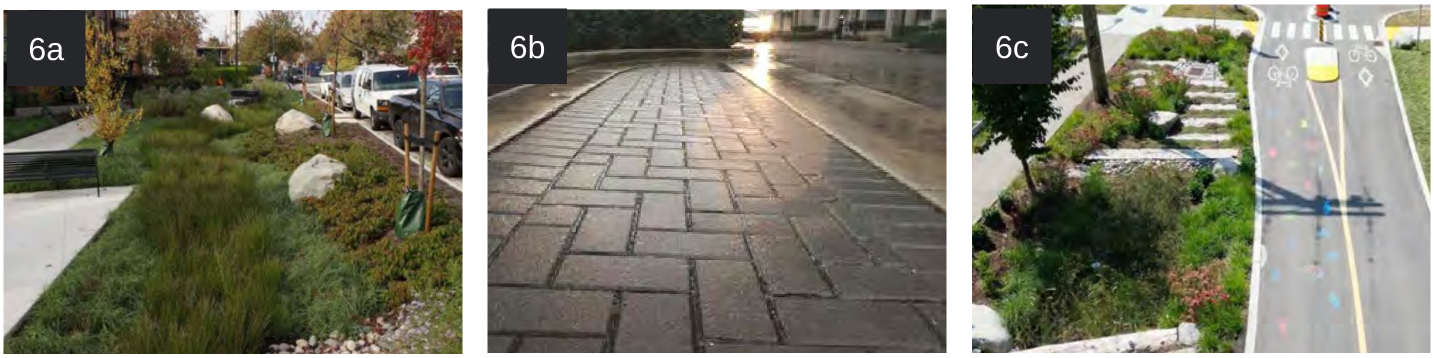


Figure 6a, 6b, 6c: Examples of GRI implementation across the City of Vancouver. (6a) Raingarden and bioswale at Yukon and 63rd. (6b) Permeable concrete throughout Olympic Village. (6c) Raingarden at Woodland Drive and 2nd Ave.

1.2.5 Climate Change Adaptation Strategy

First adopted in 2012, the Climate Change Adaptation Strategy aims to reduce Vancouver's risk to climate impacts. The 2024 to 2025 Climate Change Adaptation Strategy Update and Action Plan is structured around five major climate-related hazards facing Vancouver, including extreme heat, poor air quality, drought, extreme rainfall, and sea level rise. The Healthy Waters Plan must address these hazards using an adaptive approach to respond to uncertainty.

1.2.6 The Vancouver Plan

In 2022, Vancouver City Council approved the Vancouver Plan, which is a unified land-use framework that guides the City's growth and development. It seeks to create a more livable, affordable, and sustainable city for everyone, and clarifies where growth and change will occur over the next 30 years and beyond. The Vancouver Plan emphasizes the integration of land use, equitable housing, complete neighbourhoods, and transportation while also fostering a green economy through policy, demand, and innovation. Additionally, it prioritizes ecological health through improved knowledge, tools, and practices. The aim is to create a city that not only grows responsibly but also preserves and enhances its natural environment.

The City is now in the process of implementing the Vancouver Plan through a range of initiatives; the most relevant to the Healthy Waters Plan include:

- **Vancouver Official Development Plan:** Efforts are in progress to transform the Vancouver Plan into a Vancouver ODP. The ODP will be a policy document adopted by by-law. It will be implemented over time through area plans, rezoning policies, and the Zoning & Development By-law. All subsequent by-laws enacted or works undertaken must be consistent with the ODP.
- **Ecology and Land Use Planning Project:** The Vancouver Plan includes a 100-year Ecological Vision to protect and restore greenspace and ensure a thriving ecosystem. Work is underway to refine this vision and identify an ecological network of natural areas, corridors, and land use practices that support ecosystem health, which will be responsive to water management needs and align with the Healthy Waters Plan.

1.2.7 The Groundwater Strategy

The Groundwater Strategy will be a plan to manage groundwater risks and opportunities across Vancouver. It will identify actions to address issues like reduced sewer capacity, considering the groundwater that enters the system via pipe leaks and the foundation drainage systems of larger buildings. This includes impacts to Iona Island WWTP, which currently has per capita dry weather flows which double that of other regional WWTPs. It will also consider pollutants that are sometimes present in groundwater

The Groundwater Strategy will also address risks related to artesian groundwater conditions as well as rising groundwater tables due to sea-level rise. It will incorporate a focus on protecting ecosystems that depend on groundwater, such as streams and urban trees. It will also ways to use groundwater to improve the City’s water security and emergency preparedness. The Strategy Council Report is expected to be submitted by 2026.

2. THE PHASE 2 PLANNING PROCESS

The purpose of Phase 2 was to define the Key Directions for the Healthy Waters Plan (referred to in this section and during the planning process as the Preferred Pathway). The Preferred Pathway consists of various green and grey infrastructure, policies, and programs (referred to as "Options"). Different combinations of Options were tailored to each of the City's five drainage basins (Figure 7)

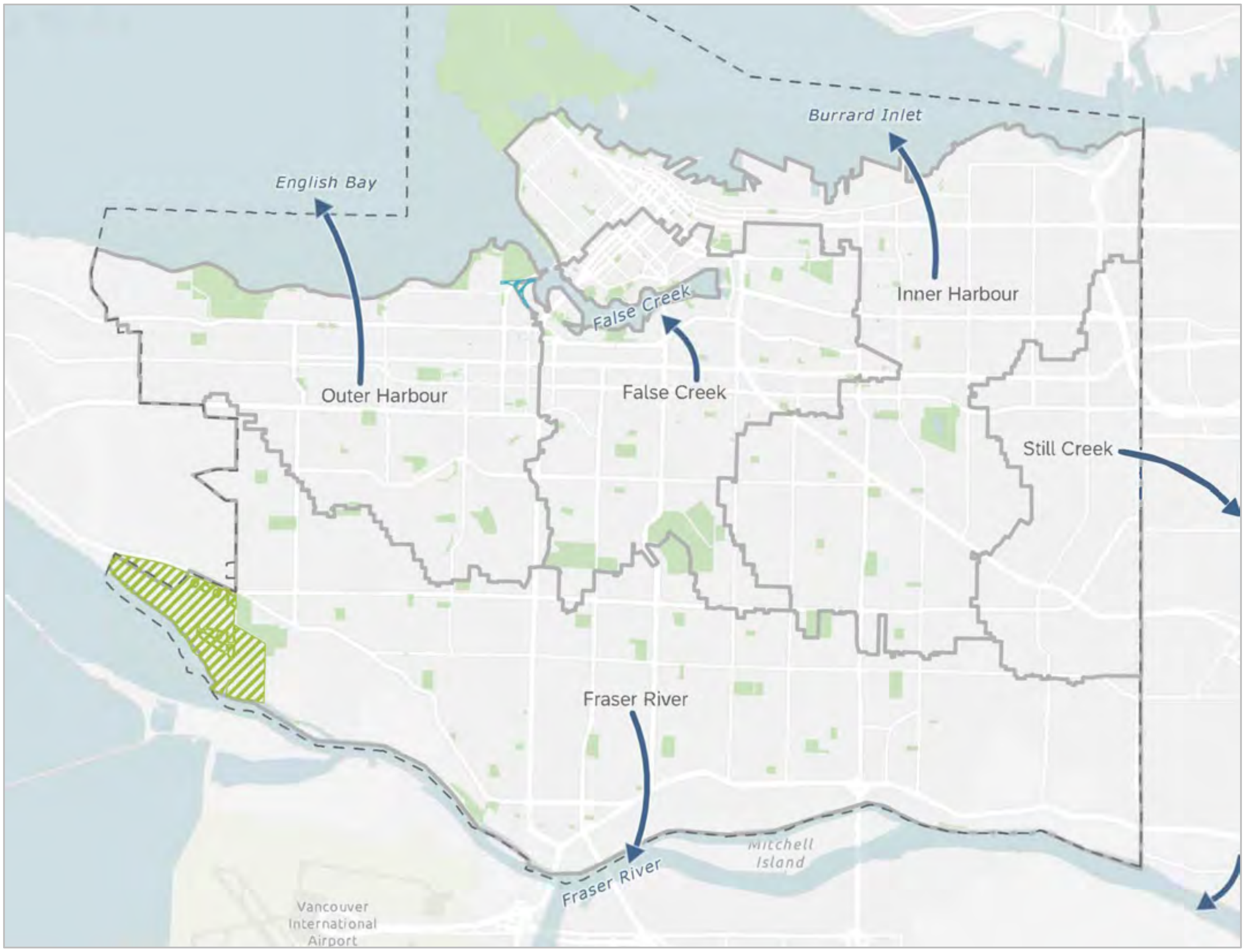


Figure 7: Vancouver's five drainage basins, which are defined by the water bodies they drain into (as detailed by the figure arrows)

The year 2075 was utilized as the planning horizon for the Preferred Pathway. This timeframe allows for the long-term renewal needs of existing sewer system assets to be addressed and the impacts of climate change and population growth to be adequately considered. The Key Directions defined in Phase 2 will serve as the foundation for the implementation plan to be developed in Phase 3.

2.1 Performance Measures, Options Catalogue, and Basin Characterization

Phase 2 commenced with the development of Performance Measures and an Options Catalogue. Simultaneously, each of the City's five drainage basins underwent a characterization process.

Performance Measures were defined based on the Strategic Framework of Guiding Principles, Goal Areas, and Objectives that was established in Phase 1. They were used to create a comprehensive Multi-Criteria Decision Analysis (MCDA) framework, which was used to evaluate the performance of alternative Pathways.

The Options Catalogue details various green and grey infrastructure, policy, and program Options. Various Options were selected from the Options Catalogue when developing alternative pathways to be evaluated, and ultimately the Preferred Pathway for the Healthy Waters Plan.

Basin Characterization for Vancouver's five drainage basins included land use and growth forecasts, existing infrastructure inventories, environmental conditions, and socio-economic factors. Participants in the Healthy Waters Plan engagement process contributed through a basin-characterization workshop and targeted outreach. This work identified unique challenges and opportunities across each basin that were considered when developing the Preferred Pathway

2.2 Analytical Tool Development

To enable a comprehensive comparison of alternative Pathways, an MCDA framework was created using the previously established Performance Measures (Section 2.1) (Figure 8). A Mass and Water Balance Model (MBM), Financial Model, Overland Flooding Risk Assessment Tool, and a Human Health and Ecological Comparative Risk Assessment Framework (CREF) were developed to serve as inputs to the MCDA. A Tally Sheet tool was also developed to allow for real-time and simplified analysis of various Pathways to support the ideation process.

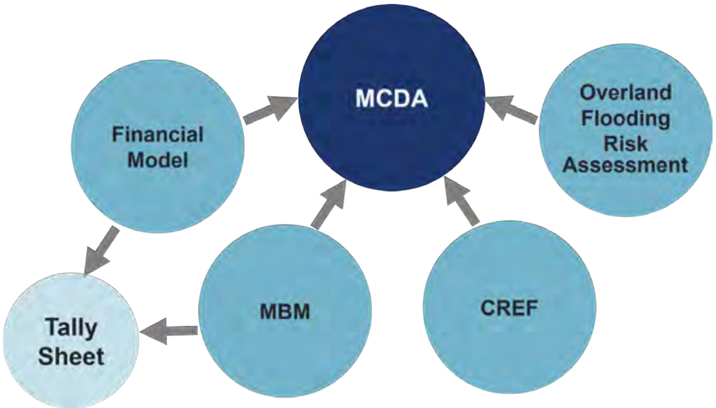


Figure 8: The analytical tools that served as inputs to MCDA during Phase 2 of the Healthy Waters Plan

The **MBM** was used to assess fecal coliform and Total Suspended Solid (TSS) loadings, as well as the frequency and volume of CSOs for alternative pathways.

The **Financial Model** forecasts the available funding for sewage and rainwater costs and public and private costs associated with alternative Pathways.

The **Overland Flooding Risk Assessment Tool** forecasts flood risks associated with extreme rainfall events and quantifies how alternative Pathways can reduce flood risk.

The **CREF** establishes comparative risk factors used in Phase 2 to assess fecal coliform and TSS pollution from sanitary and rainwater runoff sources. It builds on information from Metro Vancouver's risk assessment of combined sewer outfalls[2] and includes outreach with local Nations to identify key aspects related to aquatic ecosystems and human uses. The primary purpose of the CREF will be to support the prioritization of investments in Phase 3, to maximize the pace of improvements to water quality considering ecosystem and public health objectives.

The **Tally Sheet** allowed for simplified real-time analysis to take place during the Basin Planning Charrette workshop (Section 2.5.1).

[2] Metro Vancouver's risk assessment is detailed in the following report: Combined Sewer Overflow Hydrodynamic Modelling and Human Health and Ecological Screening Level Risk Assessment – Burrard Inlet and Fraser River. Sept 22, 2022. Prepared by Tetra Tech Canada Inc.

2.3 Planning Constraints

In the early stages of the Pathway development process, minimum environmental performance requirements, referred to here as "constraints," were established. These constraints were calibrated based on forecast pollutant levels associated with a future fully-separated sewer system, without any new investments in GRI. Additionally, a funding envelope constraint (Section 2.3.2) was defined to cap the long-term costs of alternative Pathways. For a Pathway to be considered in the evaluation process, it must comply with all of these constraints.

2.3.1 Environmental Performance Constraints

Fecal coliform was utilized as an indicator to represent pathogens which are a potential risk to human health. TSS was utilized as an indicator for a broad range of pollutants which potentially impact ecosystem health.

Fecal Coliform from sanitary sewage is considered to have a higher risk factor (2:1) compared to fecal coliform from rainwater runoff. Sanitary sewage has a higher pathogen risk compared to rainwater runoff because it contains higher volumes of human-sourced fecal waste.

TSS is an indicator of a wide range of contaminants in sanitary sewage and rainwater runoff but was assessed to represent an equivalent risk factor in both waste streams for modelling purposes.

2.3.2 Funding Envelope Constraint

A funding envelope was defined to guide expenditures over time based on a long-term forecast of sewer and drainage utility fees, tax-based revenues, and Utility Development Cost Levy (UDCL) revenues to 2075. The forecast was based on the sewer utility's existing capacity supported primarily by utility fees, property tax and the UDCL, excluding amounts for Metro Vancouver levies, with annual increases for inflation and population growth and projected additional funding from a portion of the City's infrastructure levy. For an alternative pathway to be considered feasible, the total capital and operating costs to 2075 must not exceed the total revenues available within the funding envelope.

2.4 Benchmark Pathways

To assess the relative performance of alternative Pathways, two benchmark Pathways were established: (1) a Current Trajectory Pathway, and (2) a 100% Sewer Separation by 2050 Pathway. These Pathways were referred to as the Baseline Pathway and LWMP Pathway in the engagement process.

2.4.1 The Current Trajectory Pathway

The Current Trajectory Pathway follows the City's approach to sewer separation used in recent years, which has targeted limited resources to renewing and separating end-of-life mainline sewers, with private property connections separated through redevelopment. The Current Trajectory Pathway incorporates the following assumptions:

- Significant increase in mainline sewer renewal work to address a backlog of aging sewers which are at risk of failure
- All mainline sewer and property connections[3] will be separated by 2075 through redevelopment
- New storm trunk sewers will be constructed to complete sewer separation work
- 388 hectares of impervious area will be managed by green streets
- Major streets will be swept every 8.5 days
- Use of the current detention-tank based policy for managing rainwater on new development sites, which is intended to preserve capacity in local pipe networks to prevent flooding
- Compulsory costs associated with operations and maintenance, drainage system investments to address sea level rise, etc.

The Current Trajectory, like other Pathways evaluated in Phase 2, included compulsory costs such as core investments in Operations and Maintenance programs, drainage pump stations, and tide gates for sea level rise. The Current Trajectory Pathway also conforms to the funding envelope constraint.

[3] For the Baseline Pathway, there is a high level of uncertainty regarding whether all property connections will be separated by 2075 through redevelopment alone. At current rates of redevelopment, separation of all connections will not be achieved on this timeline, and it is likely that a proactive connection separation program would be required towards the end of the 2075 plan horizon year to achieve CSO elimination.

2.4.2 The 100% Sewer Separation by 2050 Pathway

To align with the 2011 LWMP commitment, the 100% Sewer Separation by 2050 Pathway assumes that mainline sewer separation, including all storm trunks, will be complete by 2050. It also assumes significant investment in the proactive separation of approximately 20,000 combined property connections that are unlikely to be separated through redevelopment activities within this timeframe.

The 100% Sewer Separation by 2050 Pathway is not feasible when viewed through a financial lens, as it exceeds available revenues by ~$2 billion. As described in Figure 9, it would require prolonged increases in funding that would require a doubling of funding from utility rates and property based. The Pathway development process has focused on developing a Pathway that balances financial feasibility with the urgent need to reduce pollution.

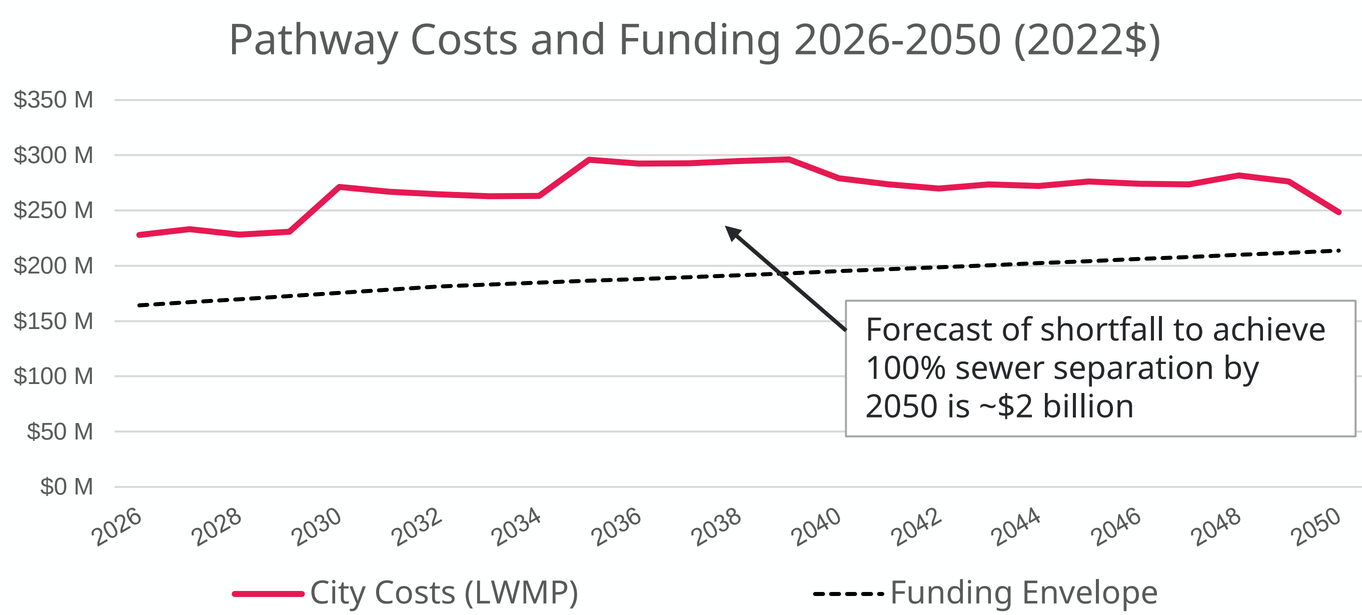


Figure 9: Funding envelope considerations for achieving complete sewer separation by 2050. Achieving complete sewer separation by 2050 would be very challenging to finance

Due to this funding shortfall, this pathway assumes no further investments are available for expanding GRI. Assumptions related to street sweeping, rainwater management policy for redevelopment, and core compulsory investments remain consistent with the Current Trajectory Pathway.

Other issues associated with this benchmark Pathway include:

- Approximately 30% of the combined sewer system with remaining life would need to be renewed prematurely. In the context of affordability challenges, this is an undesirable investment strategy.
- This pathway would require immediate ramp-up of construction programs to renew 1.8% of the mainline sewer assets annually to 2050. This is challenged from a project delivery capacity perspective, and the associated construction would result in significant disruptions to neighbourhoods, businesses, and transportation networks.

2.5 An Iterative Pathway Development Process

Following the Basin Characterization process and the development of an Options Catalogue, an iterative Pathway development approach was utilized to define the Preferred Pathway (Figure 10).

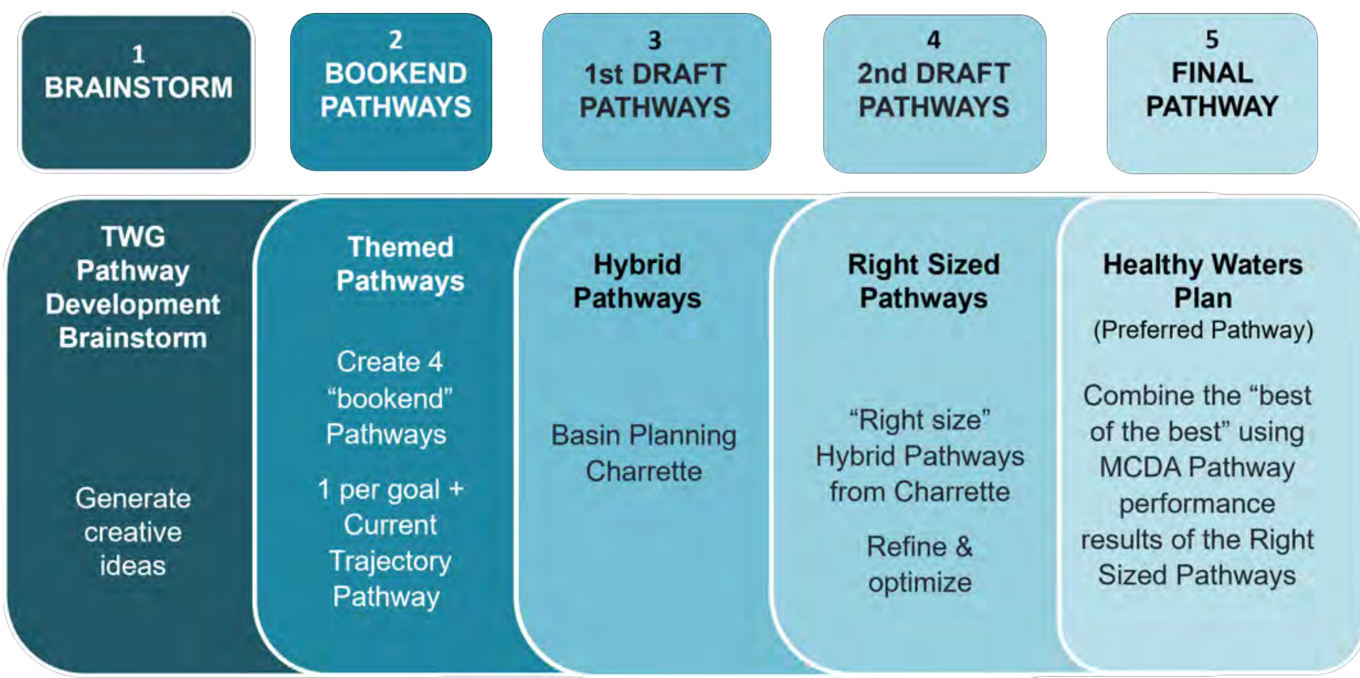


Figure 10: Iterative pathway approach to developing the Healthy Waters Plan

The engagement process involved workshops that brought together the Technical Working Group and Project Advisory Group. This approach facilitated shared learning among partners, stakeholder representatives, and technical staff of different disciplines. The planning process also utilized targeted outreach with subject matter experts to address specific technical aspects of the work, ensuring that the pathway development process was informed by specialized knowledge and expertise.

2.5.1 The Basin Planning Charrette

A Basin Planning Charrette workshop took place on March 12th and 13th, 2024. The purpose of this workshop was to develop a range of alternative Hybrid Pathways for each of the five drainage basins. This included a gamified approach to ideation, where break-out groups were each tasked with defining two different Hybrid Pathways, using the Tally Sheet tool for simplified real-time analysis of pollutant loadings, costs and other factors included in the MCDA:

100% Sewer Separation: Groups developed a Pathway in which the sewer system is fully separated across all drainage basins by 2075.

Selective Sewer Separation: Groups had the flexibility to decide which catchments would achieve full sewer separation by 2075 and which would not. This approach allowed participants to allocate more funding to other Options, provided all constraints were met.

The Charrette was designed to foster discussions around the different trade-offs of various Options, to invite open listening to a range of divergent perspectives, and to encourage collaboration to find the best solutions (Figure 11). This discussion was aided by use of the Tally Sheet tool so that participants could understand how different Options performed. Following the Basin Planning Charrette, Hybrid Pathways developed by participants were reviewed by the project team as inputs to development of three different Right-Sized Pathways for each basin.

Figure 11: Charrette participants utilize Tally Sheet and reference materials to help make informed decisions on which Options to play.

2.5.2 Defining Right Sized Pathways

Utilizing the Hybrid Pathways developed in the Basin Planning Charrette, the Healthy Waters Planning project team developed three different Right-Sized Pathways to undergo more rigorous assessment using the MBM, Financial Model, and MCDA. These Pathways were organized according to different core sewer separation strategies, and used a range of various Options that were prioritized by participants in the Basin Planning Charrette:

A — **Right-Sized Pathway A assumed completion of sewer separation,** with small residual envelope dedicated to investments in GRI. It also included a 24 mm rainwater retention policy for redevelopment and other Options.

B — **Right-Sized Pathway B assumed that sewer separation work was continued to the point of "diminishing returns",** beyond which further investments were not achieving a proportional amount of fecal and TSS loading reductions. This allowed for funding to be redirected to CSO rapid treatment and storage and GRI.

C — **Right-Sized Pathway C assumed that separation work was only completed on catchments where separation work is approaching completion or where assets are in critical condition**. This allowed for funding to be directed to larger investments in CSO rapid treatment and storage and other Options.

HWP Partners and Stakeholders helping to define the Hybrid Pathways at the Basin Planning Charrette

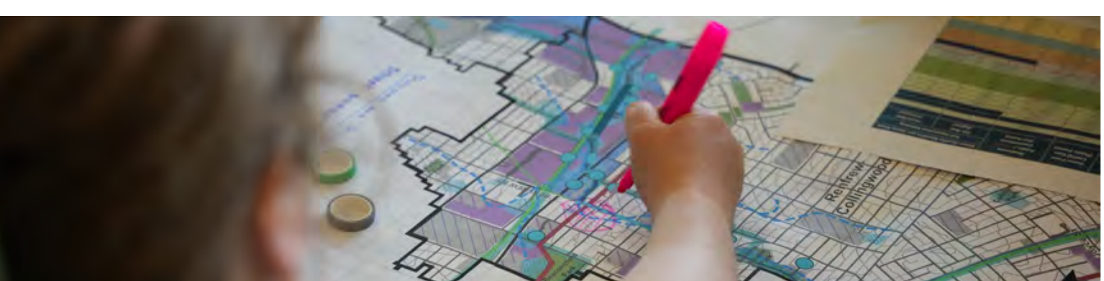
2.5.3 Refinement of Right-Sized Pathways into a Preferred Pathway

A follow-up workshop with the same engagement participants was held on June 25, 2024, to present the results of the Right-Sized Pathways analysis. Participants collectively reviewed the results and made recommendations for which CSO elimination strategy (Right-Sized Pathway A, B or C) should be selected as the basis for the Preferred Pathway development for each basin. Further to this, discussions were held around identifying opportunities for improvement to these base Pathways for subsequent refinement into a Preferred Pathway.

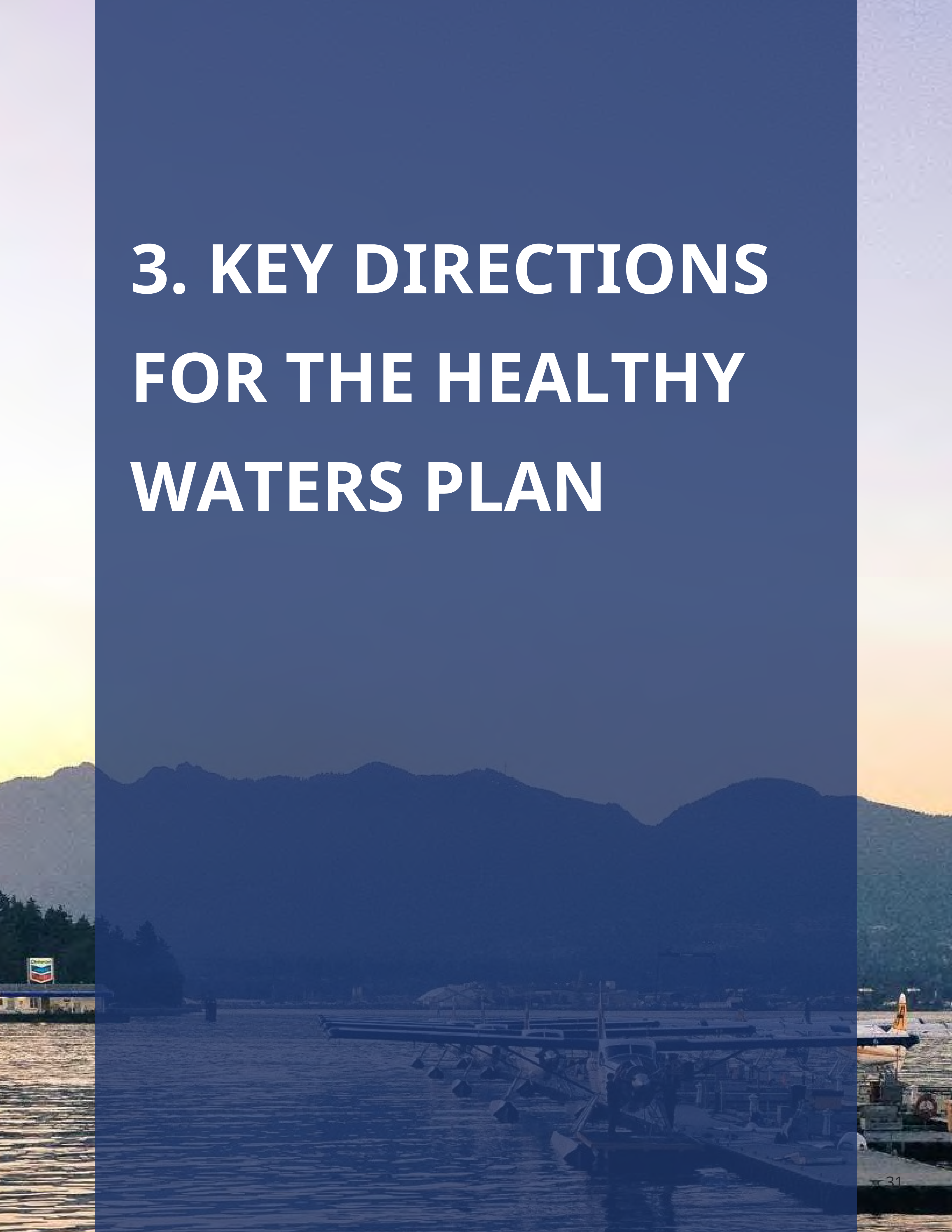
A final workshop was held on September 24, 2024, where the draft Preferred Pathway was reviewed, with discussions focused on finding opportunities for improvement. This Preferred Pathway informs the Key Directions described in the sections to follow.

Appendix C provides detailed information regarding the overall Pathway development process, including the performance outcomes of different Right-Sized Pathways.

HWP Partners and Stakeholders helping to define the Hybrid Pathways at the Basin Planning Charrette



3. KEY DIRECTIONS FOR THE HEALTHY WATERS PLAN



This section describes Key Directions for the Healthy Waters Plan[4] at a citywide scale, which will serve as the basis for the implementation plan to be developed in Phase 3. It also includes anticipated performance outcomes, recognizing that certain Options require feasibility analysis to confirm viability. This section includes Key Directions for immediate adoption and also identifies opportunities which require more exploration prior to adoption. Section 4 provides details for each of the five drainage basins.

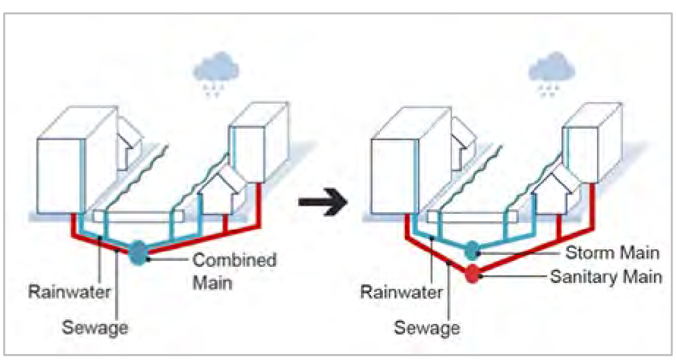
The Healthy Waters Plan offers a financially realistic alternative to the 100% Sewer Separation by 2050 Pathway, while potentially achieving a higher level of pollution reduction when considering both CSOs and urban runoff. The Healthy Waters Plan also aligns more strongly with a broader range of objectives around ecosystem health, livability, climate adaptation and risk mitigation.

Without interventions, the risks associated with CSOs, runoff pollution, and flooding are expected to worsen over time, driven by factors such as population growth, increased impervious surfaces from redevelopment, and more intense rainfall events caused by climate change. Addressing these escalating challenges while maintaining affordability is the central focus of the Healthy Waters Plan.

Key Directions for Immediate Adoption

1 **Adopt an enhanced approach to sewer separation to accelerate efforts to reduce pollution and divert rainwater, groundwater and buried creeks away from City and regional sanitary sewer infrastructure:**

Advance investments in stormwater trunk pipes and adopt a “bottom-up” approach to sewer separation that diverts non-sanitary flows more rapidly away from the sewer system.	Proceed with a proactive program for separating combined sewer connections to private properties, which is essential to addressing a major barrier to achieving CSO elimination.	Prioritize investments to maximize value-for-money outcomes considering to ecosystem and public health drivers, along with addressing aging infrastructure, sewer back-ups, flooding and growth needs.



[4] The engagement process used the terminology “Preferred Pathway” to describe the Key Directions described in this section.

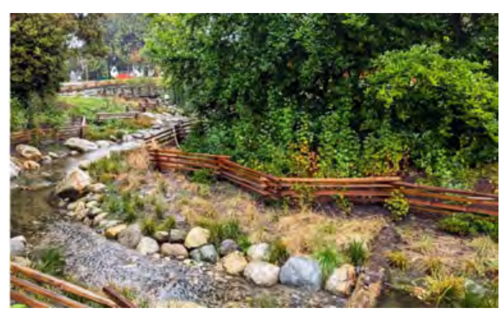
2 **Expand the use of Green Rainwater Infrastructure on streets and public properties to manage and clean rainwater runoff and reduce the volume of rainwater entering the sewer system.** This will also support improved ecosystem health, climate change adaptation, and complement investments in sewer separation. Over the next fifty years, this includes:

43 kilometres of Blue Green Systems to provide a network of green infrastructure typologies contributing to water management, ecological health and active transportation

42 kilometres of Green Streets to remove rainwater runoff pollutants and contribute to climate adaptation and livability objectives

18 hectares of Floodable Wetlands and Public Spaces to manage large volumes of rainwater runoff and reduced the burden of rainwater entering the system

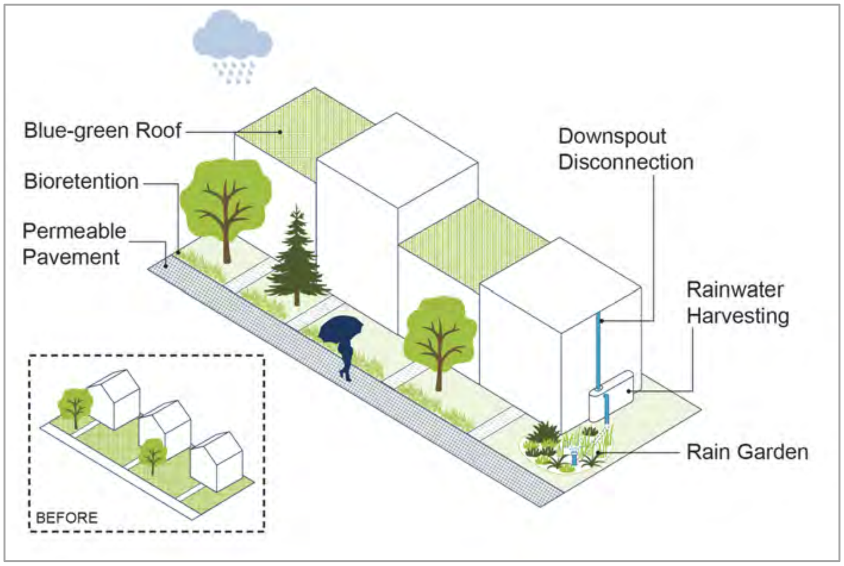
4 kilometres of Waterway Restoration to contribute to creek daylighting objectives



30 Rainwater Treatment Devices to remove urban runoff pollutants after they enter the stormwater pipe network

3 **Optimize the use of rainwater management policy for redevelopment**, to minimize costs of growth-driven system capacity upgrades as well as flooding and CSO risks. This includes:

- Completing an evaluation of staged detention tank-based approaches for larger building developments, considering opportunities for non-potable reuse of rainwater
- Exploring cost-effective opportunities for retention or hybrid retention-detention based solutions considering appropriate building typologies and geographical factors
- Development industry consultation to support adoption of practical and affordable solutions



Example of rainwater management practices

Recommendations for Phase 3 Work

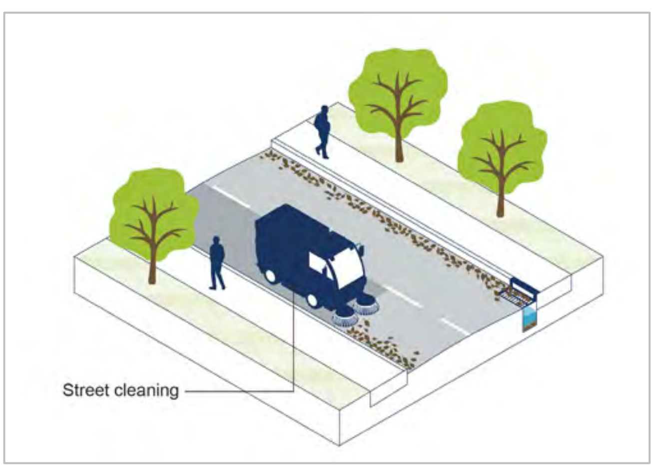
1 **Define the Healthy Waters Implementation Plan** to target investments, policies and programs to accelerate efforts to reduce pollution while addressing flooding, sewer back-ups, aging infrastructure and other critical risks to be managed. Maximizing value-for-money outcomes will be critical for the implementation plan, recognizing the need to stay within the City's financial capacity and preserve affordability for residents, businesses, and housing.

2 **Define flood-proofing policy for redevelopment** and critical flood protection investments at the conclusion of a citywide Extreme Rainfall Risk Assessment.

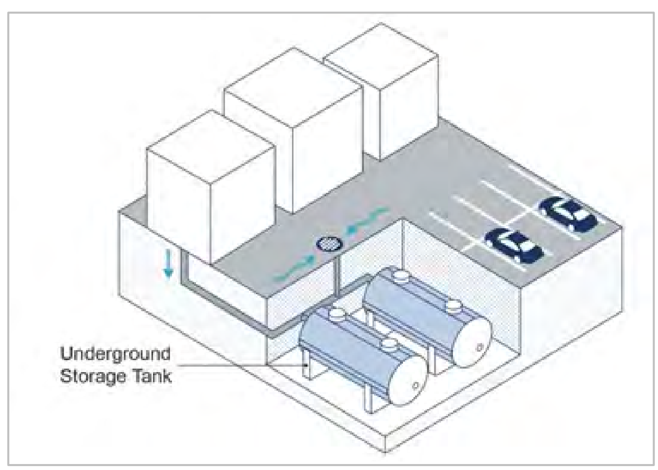
3 **Define a pollution prevention program** including targeted street sweeping, public education, and regulations necessary to prevent harmful substances from entering the sewers and drainage system.

4 **Tailor the Groundwater Strategy** scope to ensure that it addresses the significant capacity burden on the sewers and drainage system resulting from groundwater leaking into pipes and discharged by private properties.

5 **Complete a feasibility study for CSO rapid treatment and storage solutions** to evaluate options supplemental to sewer separation which could further accelerate CSO elimination.



Example of pollution source control measure



Example of CSO rapid treatment and storage solution

3.1 Key Directions Recommended for Immediate Adoption

At the conclusion of Phase 2, the Healthy Waters Plan includes several key directions which are recommended to be adopted for the development of the Public Infrastructure Investment Framework and future capital plans.

3.1.1 An Enhanced Approach to Sewer Separation

Redirecting rainwater away from the sewer system is essential for eliminating CSOs, fulfilling commitments outlined in the LWMP, and aligning with Metro Vancouver's wet weather pricing policy. Diverting groundwater and historical creeks from regional facilities is another critical need.

In recent years, Vancouver has been challenged in keeping pace with aging infrastructure. Limited resources have been focused on renewing and separating sewers at the highest risk of failure and addressing capacity needs driven by population growth. Over the 2023-26 Capital Plan, funding levels and project delivery capacity have been increased to reduce the infrastructure deficit and fulfil sewer separation objectives.

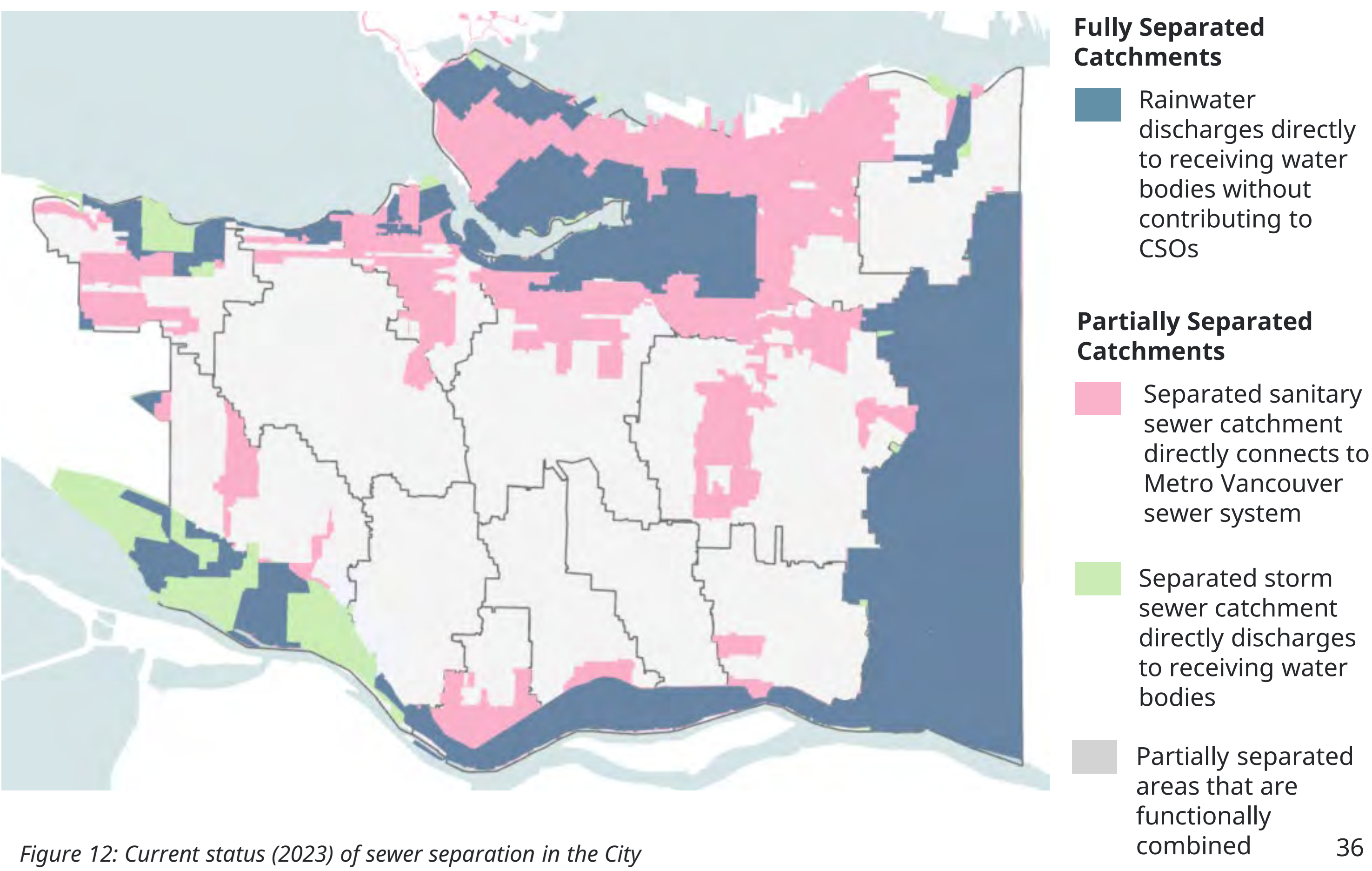


Figure 12: Current status (2023) of sewer separation in the City

As of December 31, 2023, 57.8% of Vancouver's mainline sewer pipes were separated, with 536 kilometres of combined sewer pipes remaining. Figure 12 shows the varying status of sewer separation for different areas of the city, including areas defined by dark blue, light green and pink shading[5]. Areas shaded in light grey have many pipes that have been already been separated, but function as combined systems because those pipes flow into downstream combined pipes. More information on this is available in Section 4.1 of the report titled The Foundations of Healthy Waters Plan.

The benefits of sewer separation are not limited to wet weather conditions; sewer separation is also critical for diverting non-sanitary flows present during dry weather conditions. This includes a significant number of historic urban creeks (see Figure 25 on Page 51) which continue to flow into the sewer system today. It also includes groundwater entering the system through leaking pipes and the foundation drainage systems of larger buildings with basements that intersect the groundwater table.

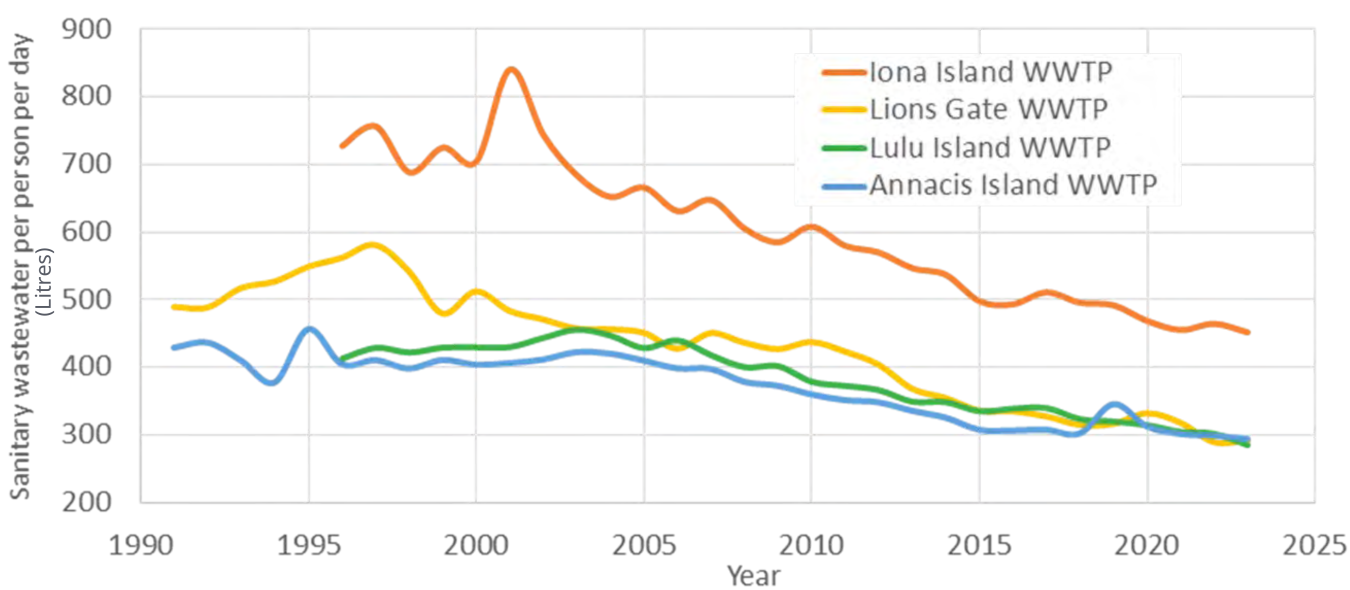


Figure 13: Per capita dry weather flows entering Metro Vancouver Wastewater Treatment Plants (source: Metro Vancouver)

The scale of these non-sanitary flows is evidenced by Figure 13, which shows per-capita flows entering regional wastewater treatment facilities. The VSA, serviced by Iona Island, has dry weather flows which are approximately 50% higher than other sewerage areas. This is likely due to the significant number of historic creeks and groundwater entering combined sewers. These non-sanitary flows have significant capacity and cost implications for the Iona Island WWTP and other critical infrastructure.

[5] Most of the sewers and drainage network still functions as a combined system due to combined connections to private properties, the lack of stormwater trunk pipes and outfalls, and areas with mainline sewers which are separated but drain to downstream combined infrastructure.

New stormwater trunk pipes and outfalls are essential for diverting rainwater, groundwater and historical creeks. However, these investments remain ineffective without the separation of combined sewer connections and private property plumbing, as rainwater contaminated by sewage cannot otherwise be safely diverted to receiving water bodies. 40% of properties in Vancouver have combined sewer connections, which under existing practices are generally only separated through redevelopment or at the time of major building renovations.

Addressing these combined service connections is crucial to achieving progress on CSO elimination. The Healthy Waters Pan recommends further feasibility analysis to define a proactive separation program for connections. This will evaluate a range of solutions ranging from full separation of connections and private property plumbing to solutions that retain the existing combined connection, directing flows to the sanitary system while using other tools[6] for diverting rainwater from properties.

The Healthy Waters Plan recommends adoption of an enhanced approach to sewer separation to accelerate the elimination of pollution and divert rainwater, groundwater, and buried creeks from the system. This includes:

1. Targeting separation investments to areas adjacent to downstream waterbodies and moving upstream (a “bottom-up” approach), advancing investments in new stormwater trunk pipes and outfalls, taking action on combined connections and working upstream to incrementally divert rainwater and non-sanitary flows from the system.
2. Defining new approaches to address combined sewer connections to private properties, which are the single largest barrier to achieving progress on sewer separation.
3. Prioritizing investments to maximize value-for-money outcomes considering public health and ecosystem needs, along with addressing aging infrastructure, sewer back-ups, flooding and growth needs.

[6] Other tools to be evaluated for diverting rainwater from private properties with combined connections includes the disconnection of roof downspouts and modifications to mainline sewer pipes to mitigate the risk of surcharging.

A proactive approach to separating combined property connections, particularly in the pink shaded "partially separated" areas identified in Figure 13, could accelerate progress on CSO elimination by leveraging investments already made in mainline sewer separation. Separating combined property connections is expensive, so proactive investments need to be strategically targeted to areas where the greatest benefit may be achieved (leaving the combined connections in lower priority areas of the city to continue to be separated through redevelopment).

In addition to conventional approaches to sewer separation, innovative solutions like Tight Pipes and Waterway Restoration should be considered as part of watershed planning.

Tight Pipes can be used to direct rainwater from higher elevation areas of the city, bypassing lowland areas. This is a solution that has synergies with future dikes and other shoreline protections, as rainwater can drain by gravity to receiving waters. This can reduce the investment costs and capacity needs for drainage pumping stations, which will be needed to drain lowland areas in the future. This solution also helps to reduce flooding risk (Figure 14).

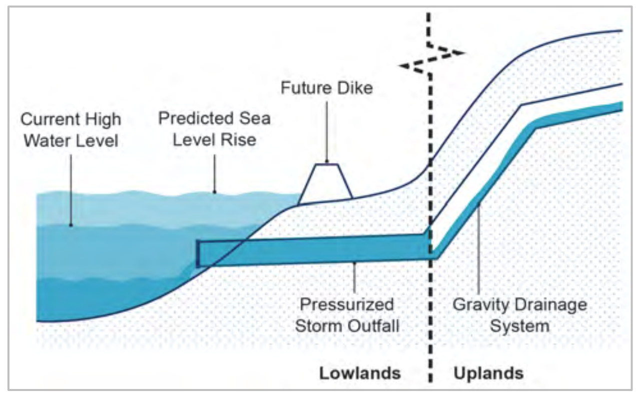


Figure 14: Tight Pipes

Waterway Restoration (e.g. creek daylighting): As part of detailed watershed planning, areas requiring storm infrastructure should also be considered for historical creek daylighting, or vegetated rainwater channels. Opportunities may exist in some locations to offset the cost of expensive storm trunk infrastructure in favour of solutions that provide enhanced ecological and livability benefits (Figure 15).

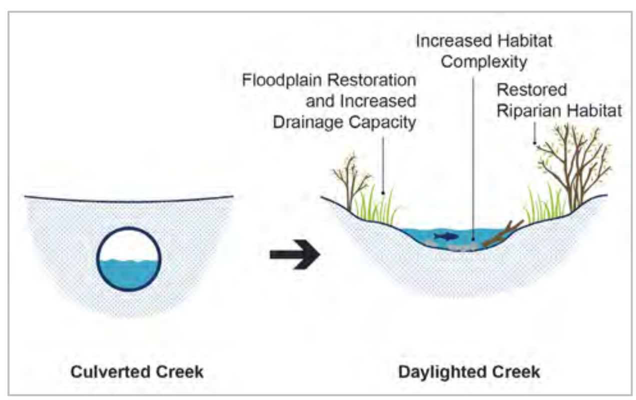


Figure 15: Waterway Restoration

Watershed planning must take a holistic approach to integrate investments in sewer separation with investments in GRI and stormwater treatment. This is necessary to ensure that pollutants from roadways and other land uses do not harm the health of aquatic ecosystems. Figure 16 provides an illustrative example.

Integrating grey and green infrastructure solutions

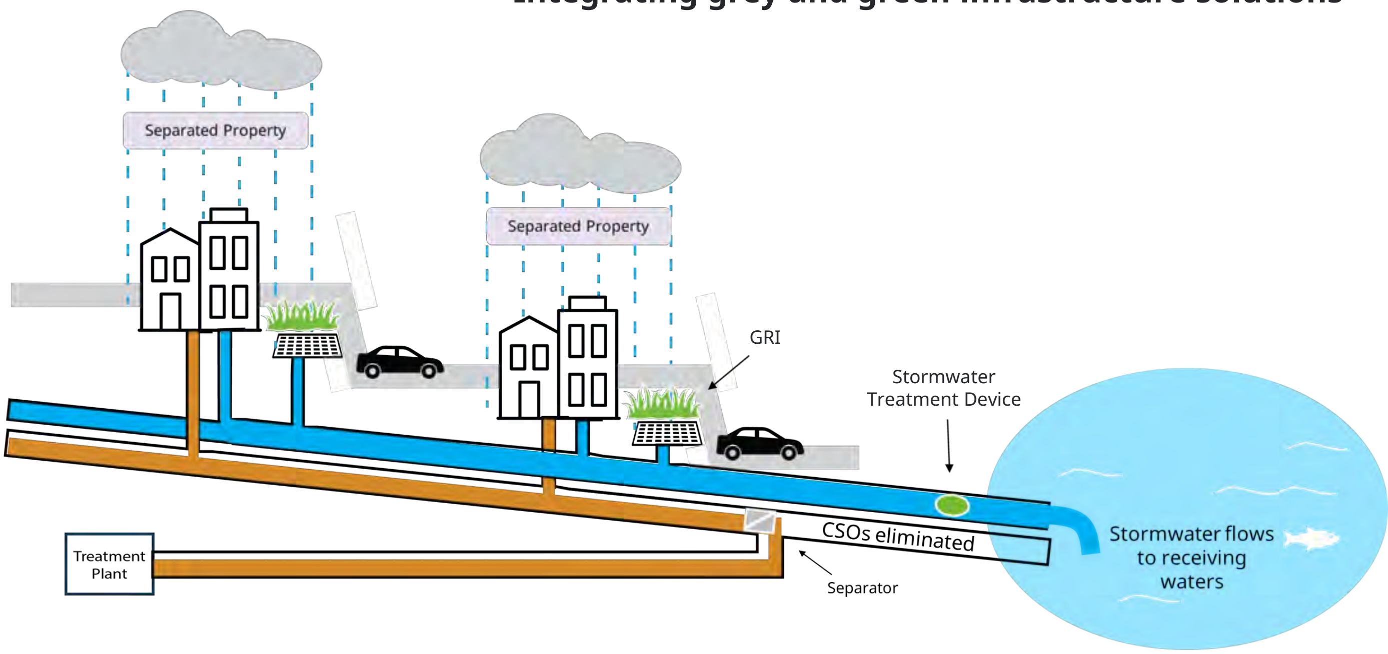
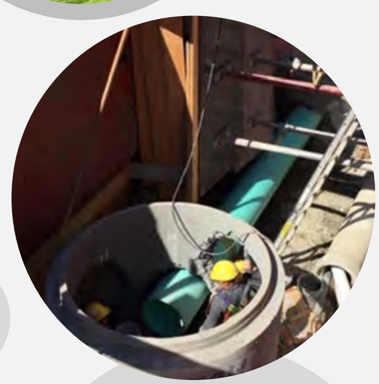


Figure 16: End state of a fully separated sewers catchment. Elements include separated property connections, new storm trunk, separated mainline sewers, increased GRI, and stormwater treatment devices.

An enhanced sewer separation approach is already being contemplated in work underway:

The Charleson Catchment of the False Creek Basin has approximately 30 combined connections remaining, with the majority of sewer mains already separated. Planning is underway to separate or switchover the remaining combined connections to isolate the stormwater network from domestic sewage. Once complete, CSOs at Laurel Street outfall will be eliminated, and stormwater will be diverted to False Creek. Engineering and Parks are also planning for a constructed wetland within Charleson Park to improve water quality prior to discharge to False Creek.

The Hastings-Sunrise West sewer renewal project is in an upper-watershed catchment of the Inner Harbour Basin that will become a fully separated catchment over the next few capital plans. The design prioritizes clean storm water by connecting legacy combined services to the new sanitary system. When completed, the drainage system will be suitable to connect directly with Burrard inlet through a downstream stormwater trunk investment.



Work is also underway using bottom-up separation further to the east, which will divert stormwater away from a Metro Vancouver interceptor and enable other watershed goals including the daylighting of Renfrew Creek.

Bottom-up sewer separation plans are also under development for the Balaclava (Outer Harbour Basin), Fraser-Angus (Fraser River Basin), and Cambie/Heather (False Creek Basin) catchments, with the objectives of diverting rainwater and groundwater from Metro Vancouver interceptors and accelerating reductions in CSOs. This work is also considering the need to address pollution from impacted rainwater runoff.

Recommendations for Phase 3 work include:

Prioritization of sewer separation work between basins will need to consider ecosystem and human health implications

Utilizing the CREF tool, it is recommended that this prioritization effort strongly weight the input provided by local Nations, given the historical impacts associated with sewage pollution.

Evaluate the anticipated cost and pollutant loading reductions for each of the sewer catchments in the City

This cost assessment, along with the CREF framework that compares ecological and human health risks across basins, will help to prioritize and target sewer separation investments to ensure optimal value-for-money outcomes and maximize the pace of improvements to water quality.

Defining a proactive program for separating combined property connections

The primary purpose of this work is to identify a path forward for removing combined sewer connections from the storm system, as well as diverting rainwater from the sanitary system. There are several options that will need to be considered in tandem, including full separation of private property plumbing and connections, and reconnecting of combined properties to sanitary pipes with diversion of rainwater from roofs road drainage (e.g. downspout disconnection Section 3.2.2).

Consider the use of new tools as part of watershed planning and associated sewer separation studies:

- **Tight pipe solutions** to reduce future costs related to drainage pump stations and flooding risks to lowland areas adjacent to waterfronts.

- **Creek daylighting and vegetated rainwater channels be evaluated** to reduce storm trunk pipe costs and achieve enhanced ecosystem and livability outcomes.

Develop two scenarios within an adaptive planning framework:

(1) Use of CSO rapid treatment and storage solutions in limited areas of the city to reduce CSO pollution more rapidly, in conjunction with sewer separation (subject to feasibility analysis and engagement)

(2) Full reliance on sewer separation without CSO rapid treatment and storage solutions.

Forecast investments through 2075 under the Plan include:

- **$2.5 billion** of capital and operating costs for "bottom-up" separation projects targeting rapid CSO elimination and groundwater diversion; and
- **$1.4 billion** for capacity upgrades, repairs, renewals, and rehabilitation of other sewer system assets. Much of this work will result in the separation of sewers as well.

3.1.2 Blue Green Systems

Blue Green Systems are park-like corridors which serve as major drainage networks, reducing flood risk using GRI designed to manage larger storm events (see Figure 17 for example). The "blue" in Blue Green Systems refers to integrated water management and GRI, which includes nature-based solutions like rain gardens and wetlands, as well as functions for climate adaptation and flood management. The "green" refers to the value and services provided by terrestrial vegetation and biodiversity, including trees, urban forests, and other plant, and soil within the system (Figure 18).

Figure 17: Green Rainwater Infrastructure located on the St George Rainway

Blue Green Systems can also incorporate floodable spaces, which feature depressions which collect water during heavy rainfall, draining slowly through vegetation and subsurface storage. Blue Green Systems have the potential to transform the City's water management approach while providing climate-resilient active transportation networks and enhancing livability for a growing population. In support of the Healthy Waters Plan, ongoing efforts aim to define the role of Blue Green Systems, including a Typology Study led by the Integrated Sewers and Drainage Planning branch. In addition, work is underway to align Blue Green Systems with development of the Vancouver Plan - Ecology and Land Use Plan development (see Ecological Network and Figure 19).

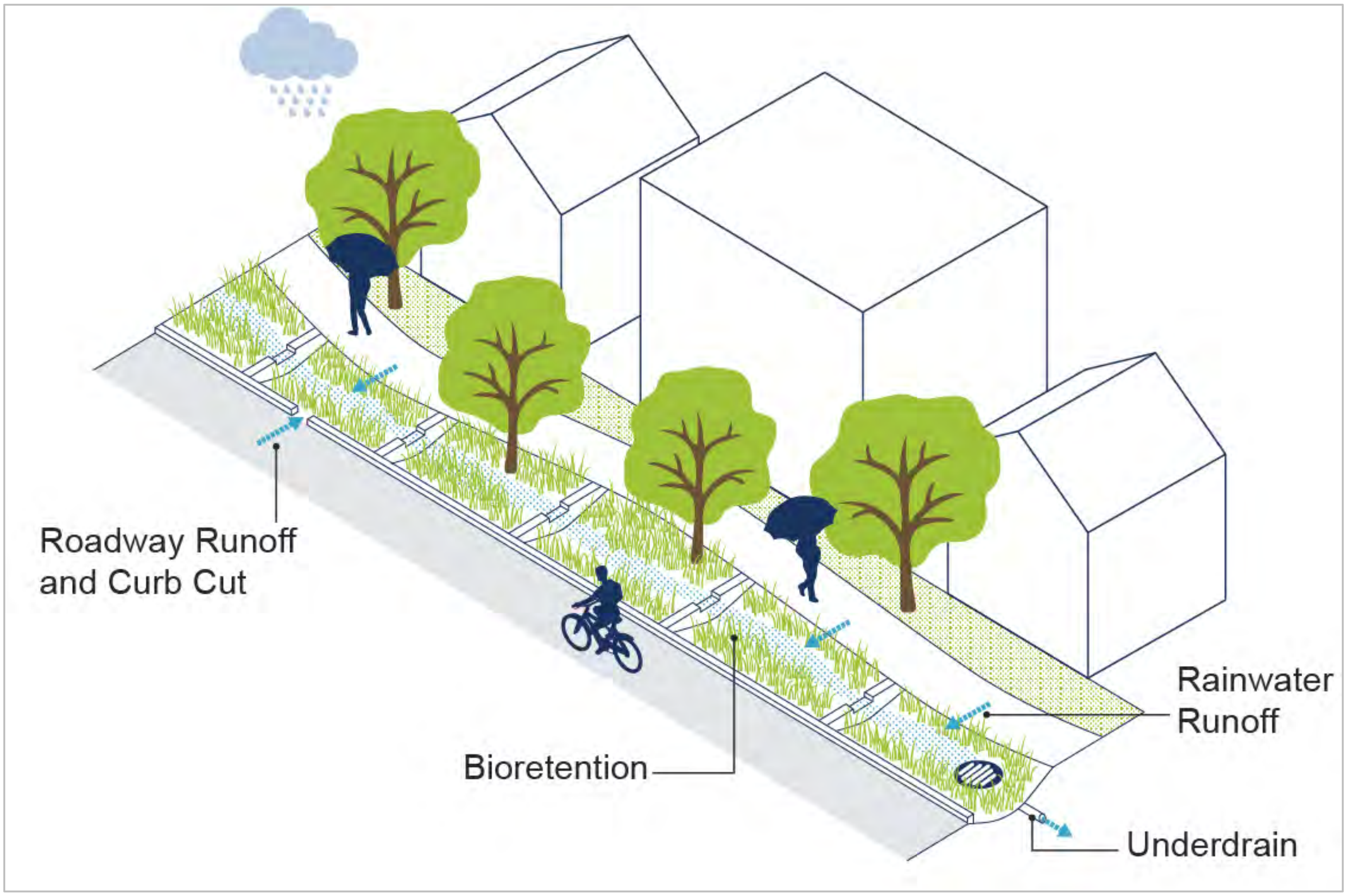


Figure 18: Features of a Blue Green System

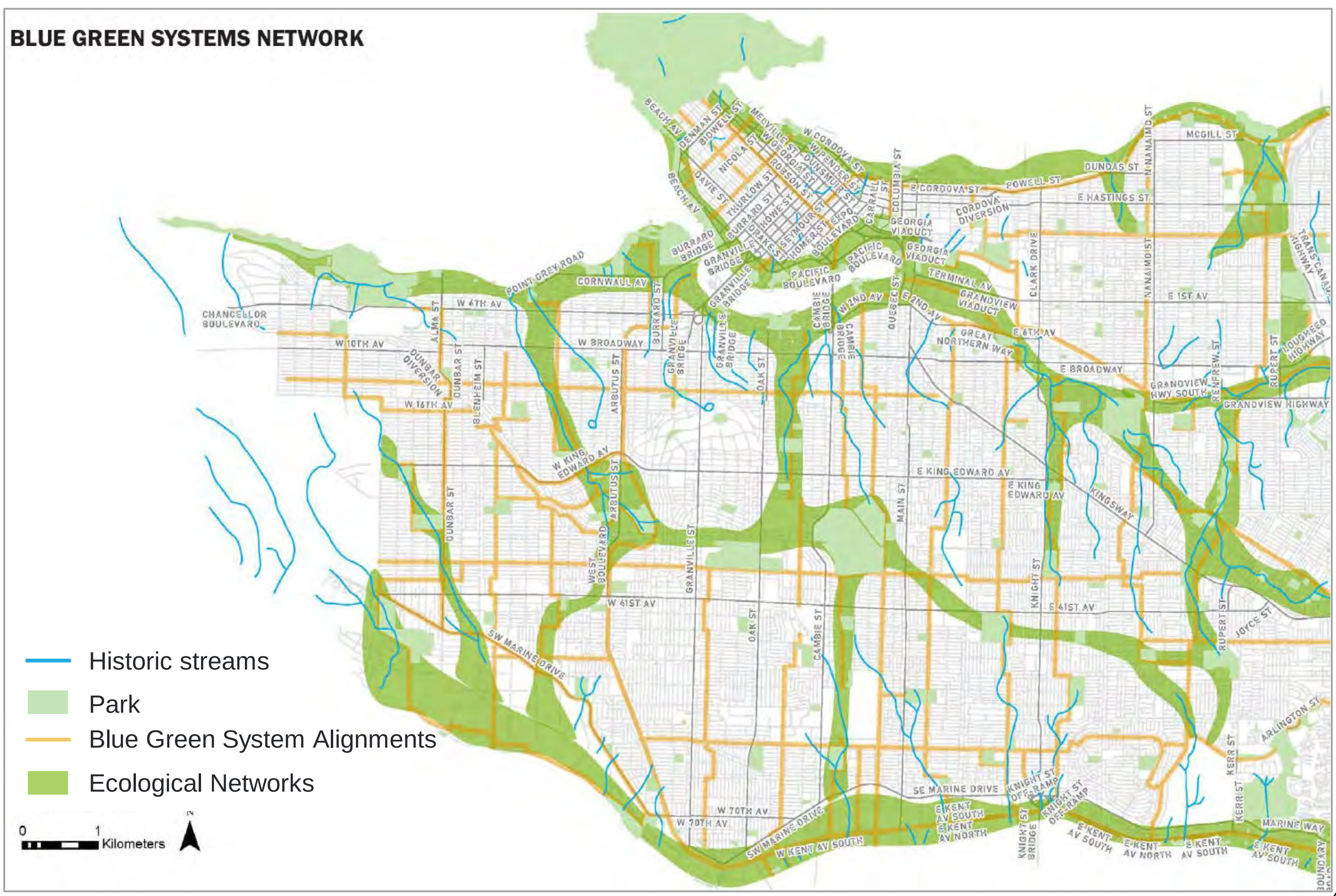


Figure 19: Blue Green Systems alignment with the Ecological Network and Historical Streams

While the benefits of Blue Green Systems are extensive, there are challenges that will require careful consideration as part of detailed watershed planning and design. Since Blue Green systems are used for stormwater conveyance, they require long and continuously connected stretches of municipal right-of-way. Existing grading, surface and sub-surface infrastructure can complicate the continuity and implementation of these systems

The Healthy Waters Plan includes **$420 million** of capital and operating costs for approximately **43 kilometres** of Blue Green Systems managing 109 ha of impervious area citywide.

The financial capacity forecast for sewers and drainage is not able to fund establishment of the full ecological network envisioned in the Vancouver Plan. However, there are broad climate adaptation, ecosystem and livability benefits which extend greatly beyond core sewage and drainage service objectives. Those benefits may support drawing upon sources of funds outside of the sewers and drainage funding envelope, including senior government programs, to gradually build out the network over time.

3.1.3 Green Streets

Green Streets are dispersed rainwater management systems integrated into roadways. They feature a range of vegetated GRI typologies including bioretention areas, tree trenches, and bioswales (Figure 20), as well as non-vegetated systems such as permeable pavements to retain and filter urban runoff (Figure 21). These elements provide multiple benefits, including traffic calming, neighborhood greening, urban heat island reduction, increased biodiversity, reduced localized flooding, and improved rainwater quality. Green Streets support tree growth, canopy development, and urban forestry targets, contributing to the overall resilience and livability of urban environments.

How do Green Streets differ from Blue Green Systems?

Compared to Blue Green Systems, Green Streets capture street drainage and support tree growth while offering more opportunities for parking, pedestrian areas, and surface utilities in constrained urban spaces. Green Streets are also typically designed to manage smaller rainfall events.

Figure 20: Bioretention bulge (a Green Street feature) at 14th and Woodland, Vancouver

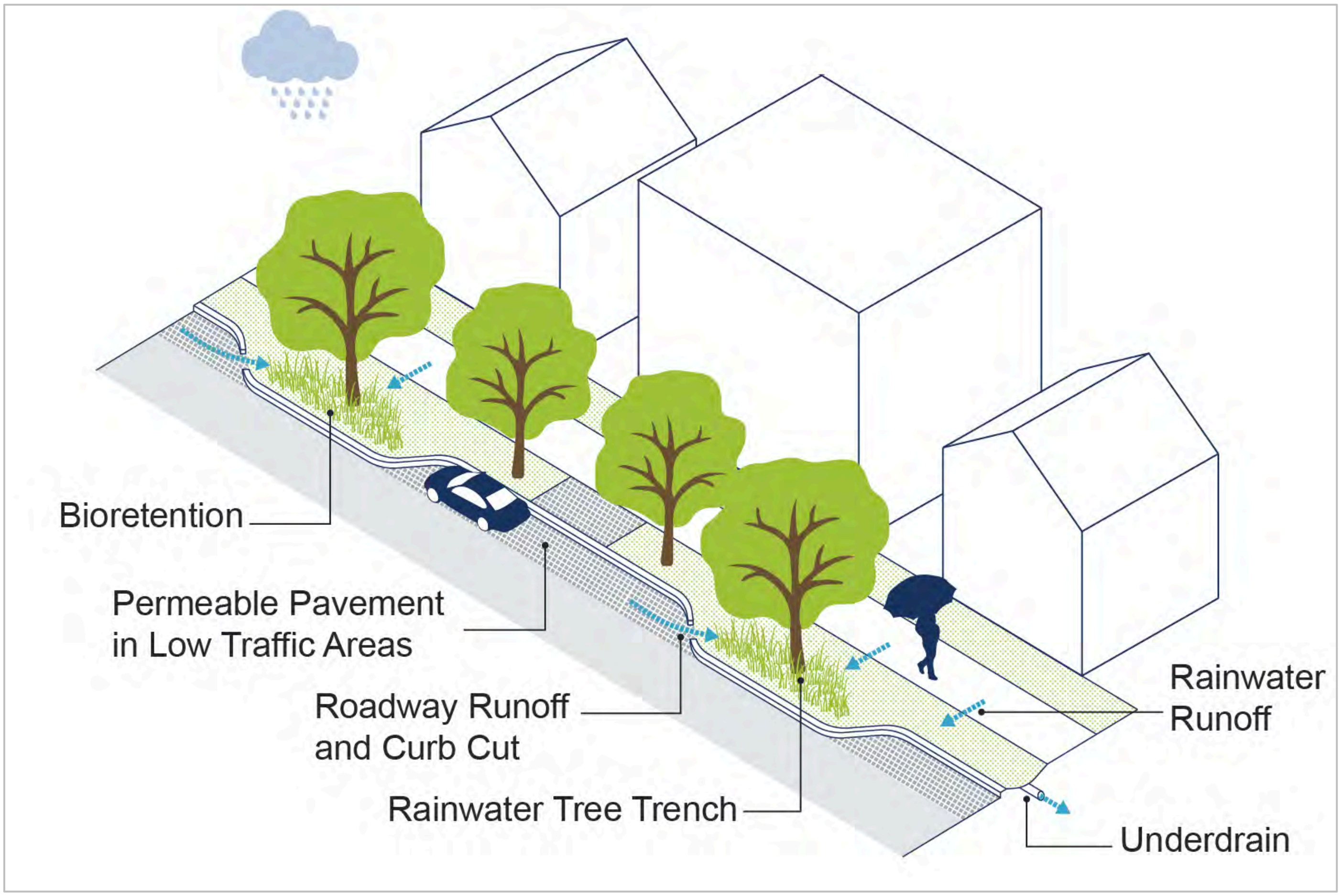


Figure 21: Elements of a Green Street

The Healthy Waters Plan includes **$282 million** of capital and operating costs for approximately **42 kilometres** of Green Streets citywide.

The implementation of Green Streets is limited by the available funding envelope. However, given the extensive benefits of GRI which go well beyond core sewers and drainage service objectives, there may be opportunities to secure additional funding sources. Coordinating Green Street development with other infrastructure projects and standardizing designs can also help reduce costs.

3.1.4 Floodable Wetlands and Public Spaces

Floodable Wetlands and Public Spaces, referred to as “Large-Scale Green Facilities” in the engagement process, manage rainwater and runoff at a neighborhood scale. They use vegetation, soil, and permeable surfaces to slow down, retain, detain, and clean rainwater. This GRI typology can also be designed to store or redirect floodwater to protect vulnerable areas. They may include bioretention areas, engineered wetlands, subsurface infiltration systems, infiltration ponds, and riparian restoration projects (Figure 22).

Figure 22: Hinge Park Wetland, a floodable wetland and public space, that includes a constructed wetland with riparian restoration that manages two-thirds of the rainwater that runs off roadways, plazas, and other public spaces in Olympic Village.

Floodable Wetlands and Public Spaces offer multiple benefits beyond improving water quality and reducing flood risk. This includes contributing to urban greening, boosting biodiversity, and supporting habitat restoration. They can be integrated into parks and underutilized open spaces, enhancing park user experience, and contributing to livability goals. Economies of scale achieved through treating larger drainage areas can also make them more cost-effective compared to dispersed GRI (Figure 23).

Floodable Wetlands and Public Spaces are one of the most cost-effective opportunities available for addressing rainwater pollution. The Healthy Waters Plan recommends that they be considered in all five of Vancouver’s drainage basins. This GRI typology also requires a significant amount of space, typically at the bottom of drainage catchments. Strategic land acquisition may be warranted, particularly in high flood-risk areas or where additional parkland is needed to support population growth. Acquisition may be more feasible in areas exposed to higher flood risk where property owners may be interested in voluntary buyouts.

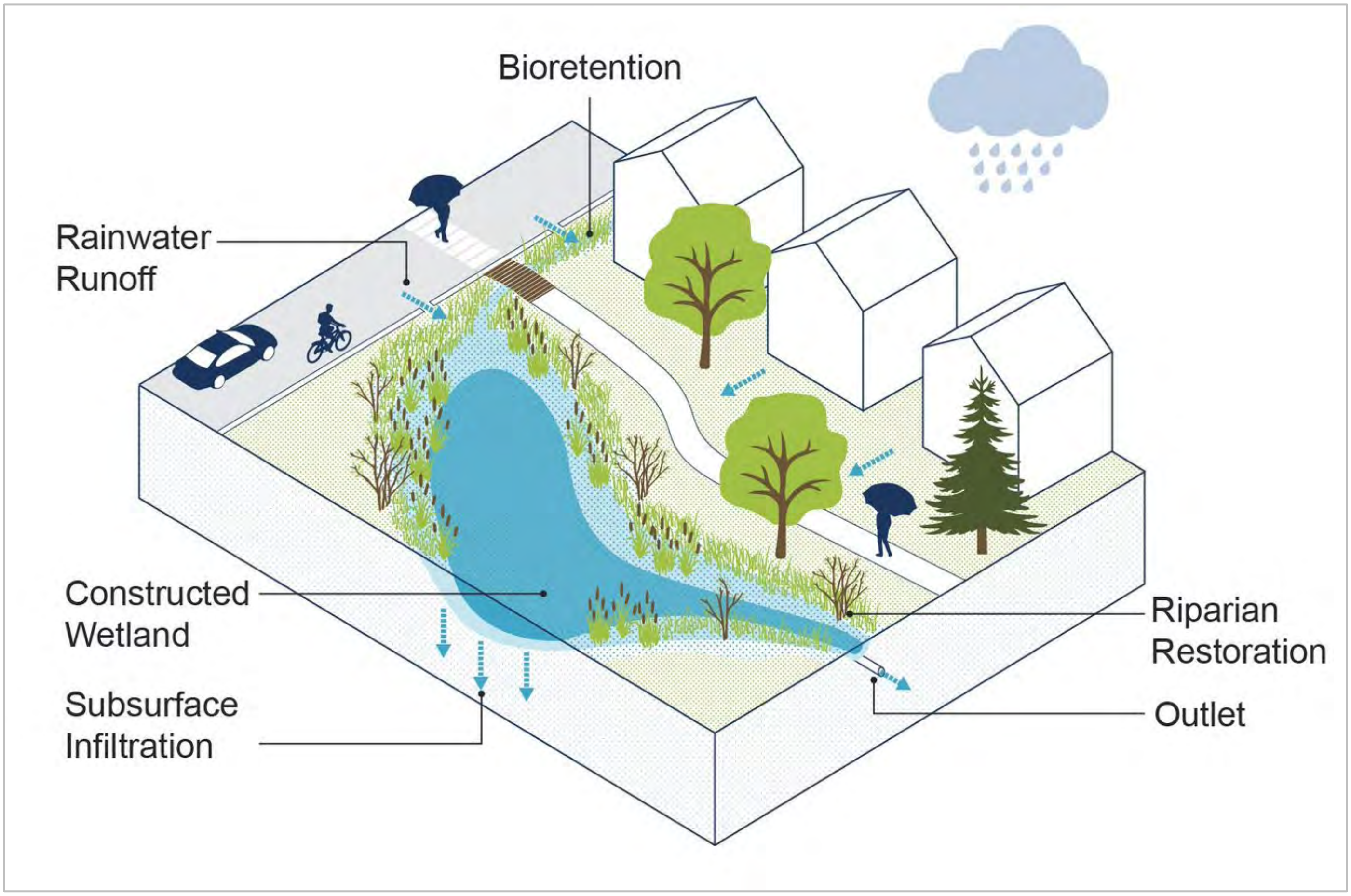


Figure 23: Elements of a Floodable Wetland and Public Space

The Healthy Waters Plan includes **$480 million** of capital and operating costs for approximately **18 hectares** of Floodable Wetlands and Public Spaces managing 286 ha of impervious area citywide.

This estimate does not include land acquisition costs, assuming that portions of existing parks and public spaces may be enhanced through the establishment of these facilities. Given the high demand for public spaces, land costs will need to be assessed as part of detailed watershed planning activities when this GRI typology is considered. If land acquisition is required, alternative rainwater management practices will need to be evaluated in tandem to ensure optimal value-for-money outcomes. The public amenity benefits of Floodable Wetlands and Public Spaces will also need to be assessed.

Given the multiple benefits of this infrastructure, including climate adaptation and support for urban growth, there may be opportunities to secure additional funding sources (for example, from senior government climate adaptation funding programs). Coordinating the development of this Option with park and public space capital projects would be desirable to achieve synergies. (Figure 24).

Figure 24: Example of Floodable Public Space in Rotterdam

3.1.5 Waterway Restoration and Vegetated Rainwater Channels

Waterway restoration and vegetated rainwater channels commemorate historic streams at the surface level, and in some cases include uncovering and restoring waterways that have been replaced with pipes through urbanization. Sewer separation is a critical prerequisite for this Option. The flows from these buried creeks also enter the sewer system and have capacity implications for regional infrastructure (see Figure 13 on page 37).

Vegetated rainwater channels create naturalized waterways in urban environments, and do not necessarily need to follow historic creek paths. Creek daylighting can reintegrate a portion of a historical waterway into the natural drainage system (see Figure 25 for Vancouver's historic streams). These projects may also include the restoration of riparian areas and floodplains along the watercourse.

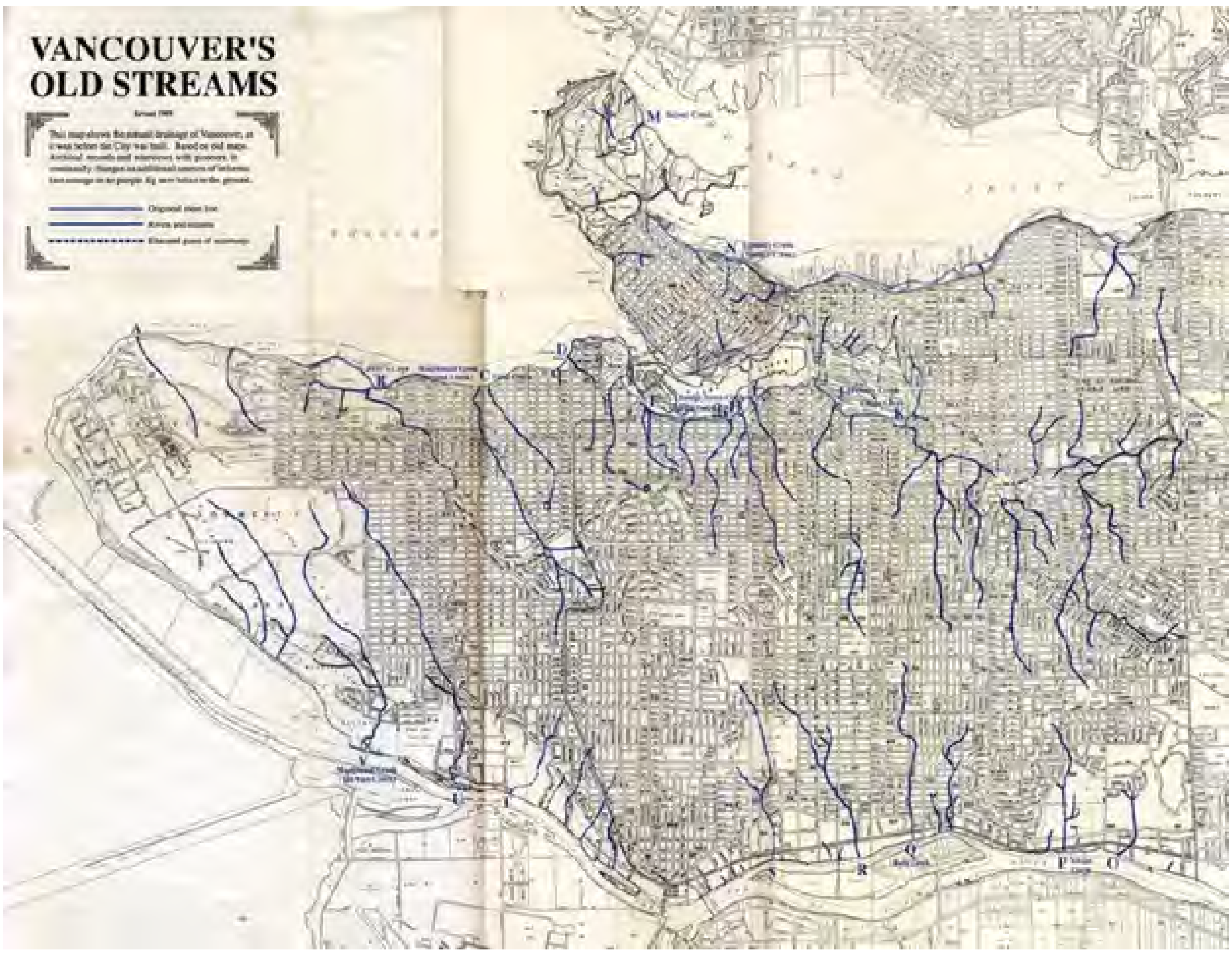


Figure 25: Vancouver's historic streams

Vancouver's streams were once vital spawning habitats for salmon and other species. The daylighting of creeks is a step towards restoring these habitats and supporting the return of spawning fish. This effort benefits the environment while also helping to address the impacts of urbanization on local Nations, advancing reconciliation objectives.

Restoration projects help repair the natural water cycle, increase drainage capacity in areas with undersized pipes, slow down peak flow rates, create recreational opportunities, and provide environmental awareness and education. These projects can also reduce the urban heat island effect, improve water quality, reduce rainwater runoff, and increase biodiversity while enhancing aesthetics and livability. Additionally, this GRI typology can potentially provide an alternative to buried stormwater trunk pipes in certain locations, contributing to sewer separation efforts (see Figure 26 for recent local examples).


Figure 26: Recent examples of creek daylighting restoration projects at Tatlow Creek (left) and Still Creek (right)

The Healthy Waters Plan includes **$93 million** of capital and operating costs for **3,900 meters** of Creek Daylighting and Vegetated Rainwater Channels. Additional funding may be possible if these projects offset costs in grey infrastructure or contribute to livability and ecosystem objectives beyond traditional sewage and rainwater management services.

3.1.6 Stormwater Treatment Devices

Stormwater treatment devices are designed to filter rainwater runoff, removing contaminants such as trash, oils, and solids depending on their design and configuration. Often referred to as hydrodynamic separators or oil-and-grit separators, these devices can be installed with stormwater pipes to remove pollutants before discharge to receiving waters (Figure 27).

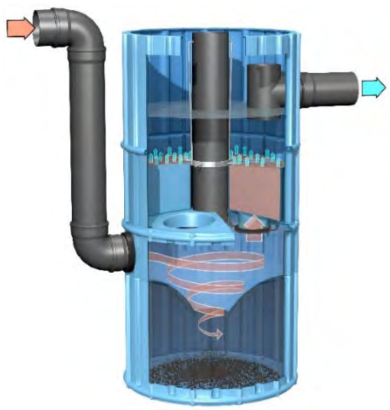



Figure 27: Stormwater treatment device installed as part of the storm sewer conveyance (Source: Wilson Contrete (left) and Sustainable Technologies (right))

These devices can also work in conjunction with certain types of GRI when placed upstream for pretreatment purposes (Figure 28). They have few siting constraints due to their compact size, durability, and suitability for a wide range of subsurface conditions.

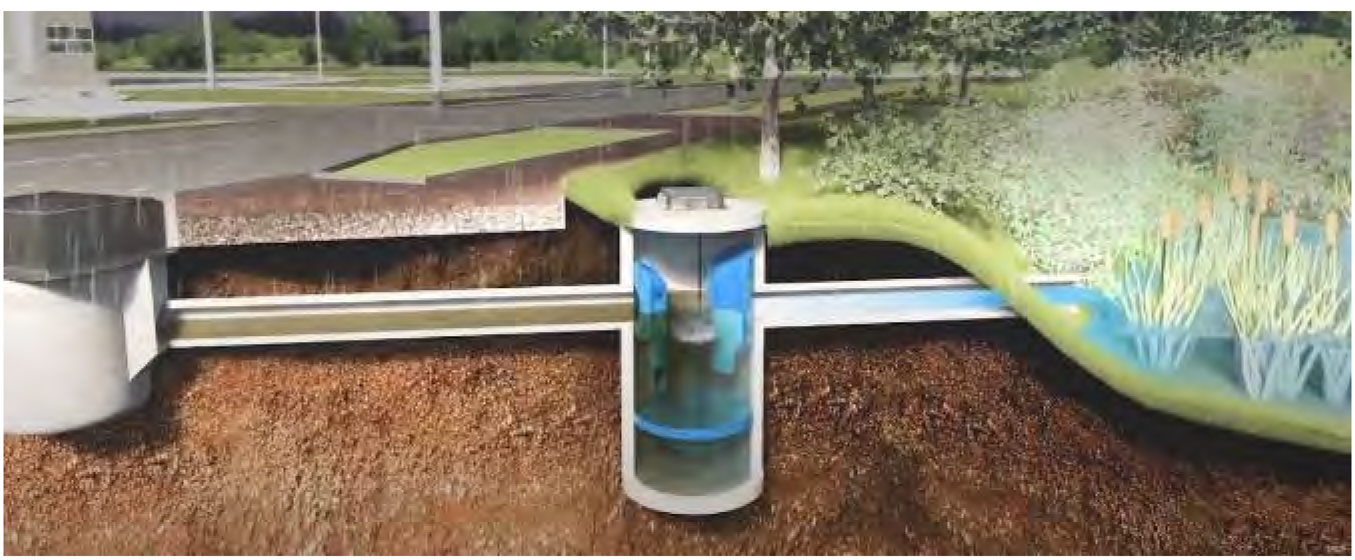


Figure 28: From storm sewer to stormwater treatment device to large green facility (Source: Hynds)

Stormwater treatment devices are recommended for consideration in all basins of the city, at various treatment rates (Figure 29). Specifics regarding placement, types of devices, and flow rates will be determined during detailed watershed planning.

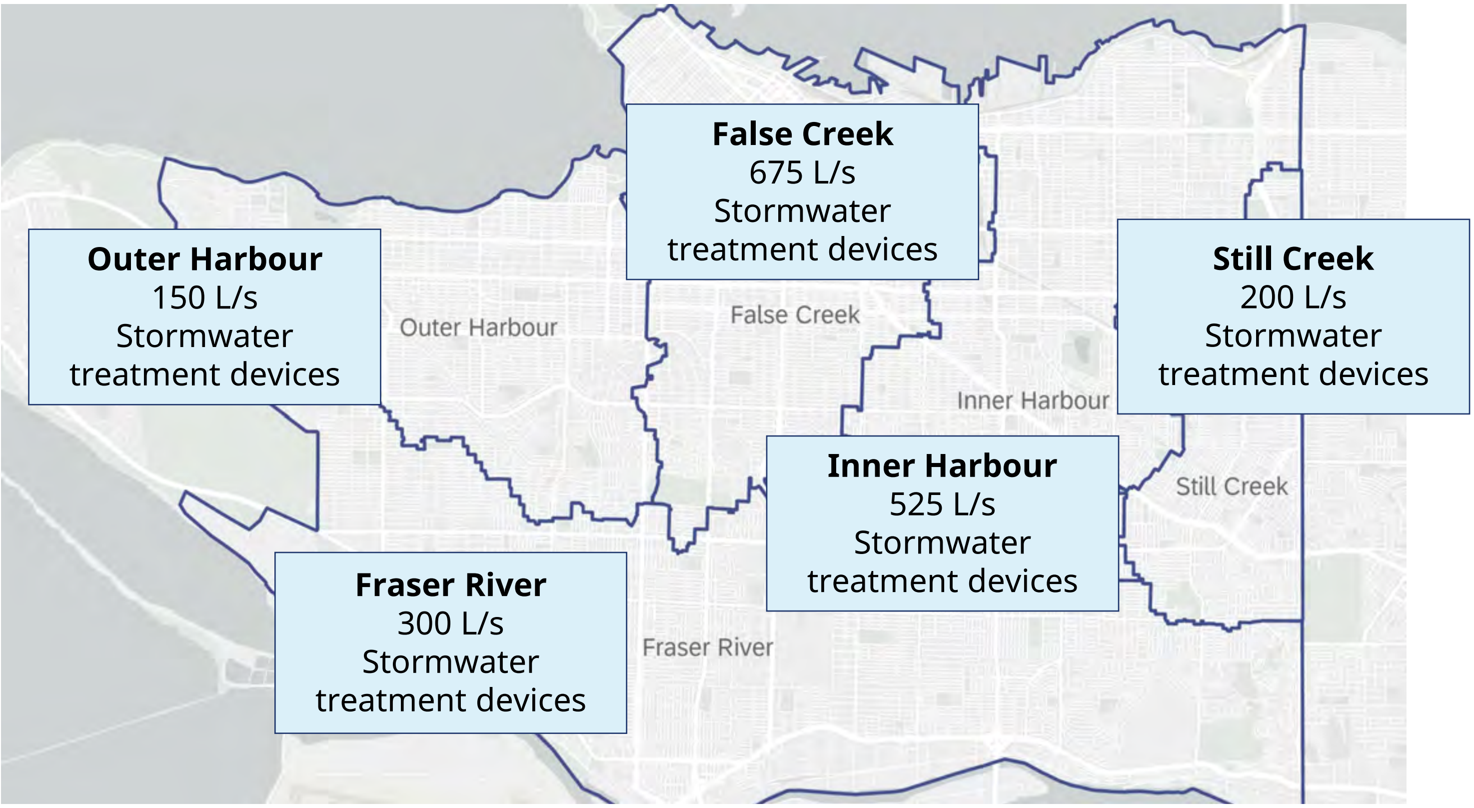


Figure 29: Stormwater Treatment Devices, with varying treatment rates per basin, can help reduce rainwater runoff pollution to waterways

The Healthy Waters Plan includes **$120 million** of capital and operating costs for Stormwater Treatment Devices.

3.1.7 Optimize Rainwater Management Policy for Redevelopment

As Vancouver continues to grow with higher-density development, the amount of impervious surfaces (i.e. areas that don't absorb rainwater) will increase. If not mitigated, this could lead to a higher risk of overland flooding, sewer backups, CSOs, and pollution from urban runoff.

In 2019, the Council adopted the Rain City Strategy, which recommended a 24 mm retention-based policy for redevelopment. This policy aimed to prevent the first 24 mm of rainfall from entering the pipe system through infiltration, evapotranspiration, and reuse. The Rain City Strategy also set a goal to eventually increase this retention policy to 48 mm. Subsequently, the City implemented a 24 mm volume capture requirement, with a preference for retention-based solutions for properties that needed a zoning change before redevelopment, or for redevelopments located in the Cambie Corridor or Broadway Plan areas.

In 2024, this requirement was updated so that all new "Part 3" buildings (complex buildings over three stories or larger than 600 m^2) must have on-site detention and/or retention of the first 24 mm of rainfall over the entire site area. As retention is typically more expensive, most developments are expected to utilize detention storage with peak flow control to address this target. This policy update also streamlined the development process and reduced development costs for complex buildings. A detention tank requirement for smaller buildings will also come into effect in 2025, which will expand the use of detention storage for buildings of all types across the city.

Detention methods, which involve collecting rainwater on-site in a tank and slowly releasing it back into the system, are typically more cost-effective and easier to implement than retention-based standards. The current detention-based standard allows rainwater to be released at approximately 65 to 110 litres per second per hectare. While this release rate serves to reduce downstream flooding risks, it is not low enough to mitigate increasing CSO risks caused by the loss of permeable land through densification. The detention requirement for larger and complex buildings is based on pre-development rainwater infiltration and runoff conditions, which vary from site to site. Detention tanks also provide the opportunity for the reuse of rainwater if incorporated with a non-potable water system.

A 24 mm retention-based policy offers much better overall CSO performance than the current 65 to 110 litres per second per hectare release rate standard. It helps preserve sewer capacity and reduce CSOs while also providing benefits like increased habitat, urban heat mitigation, and reduced rainwater runoff pollutants. However, this standard is more expensive to implement and is challenging for developments with insufficient land for rainwater infiltration and other technical barriers. Figure 30 summarizes the estimated capital costs of 24 mm retention standards for various building types.

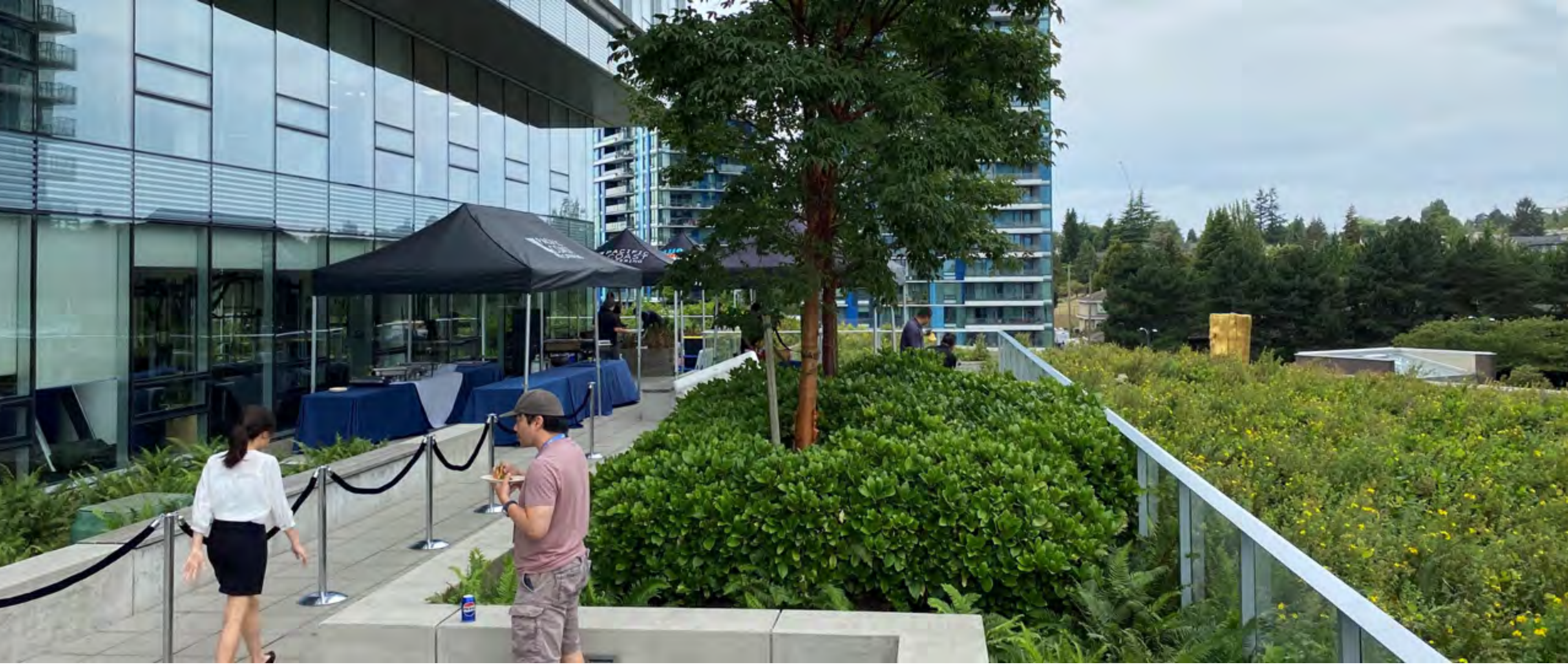
Building Type	Gross Floor Area (m2)	Capital Cost with 3m infiltration setback (Approx. $)*	Capital Cost with 5m infiltration setback (Approx. $)*
Small Lot Residential**	375	$56,000	$130,000
Low Rise Residential	3,000	$340,000	$720,000
Mid Rise Residential	11,700	$430,000	$1,260,000
High Rise Residential	16,800	$200,000	$410,000

Figure 30: Estimated Capital Costs for various building types to achieve a 24 mm rainwater retention standard

Notes to table:
* Costs taken from Pathways Study by Lotus Water in consultation with internal and development community stakeholders. Costs are represented for both a 3 metre setback and a 5 metre setback for infiltration from building foundations. The current requirement is for infiltration to occur no closer than 5 metres from a building foundation. Costs are represented for both 3m and 5m setbacks to show how this cost changes with differing setback requirements.
** Potential opportunities for cost savings for small lot residential need to be explored (e.g. hybrid detention/retention tank approach recommended by City of North Vancouver.)

A sensitivity analysis using the Mass Balance Model (MBM) tool was used to compare performance of a 24 mm retention standard with on-site detention tanks. This analysis evaluated detention tanks with release rates of 65 L/s/ha, 25 L/s/ha, and 3.5 L/s/ha (similar to City of Philadelphia's rate). The preliminary results showed that while the 65 and 25 L/s/ha release rates did not reduce CSOs, the 3.5 L/s/ha release rate outperformed the 24 mm retention standard on CSO reduction. These results need to be confirmed through more detailed hydrodynamic system modelling in order to fully account for the detention tank and sewer system hydraulics which are absent from the MBM.

All detention tank release rates resulted in a 30% higher total suspended solids (TSS) load compared to the 24 mm retention standard. This is because detention tank approaches are not designed to remove rainwater runoff pollution from private properties.



Work has also been underway to evaluate how different release rates from detention tanks can help lower the costs of upgrading sewer capacity as the city grows. Using the Manitoba Catchment model, different release rates were analyzed. The results, shown in Figure 31, indicate that lower rainwater detention tank release rates can significantly reduce the cost of capacity upgrades.

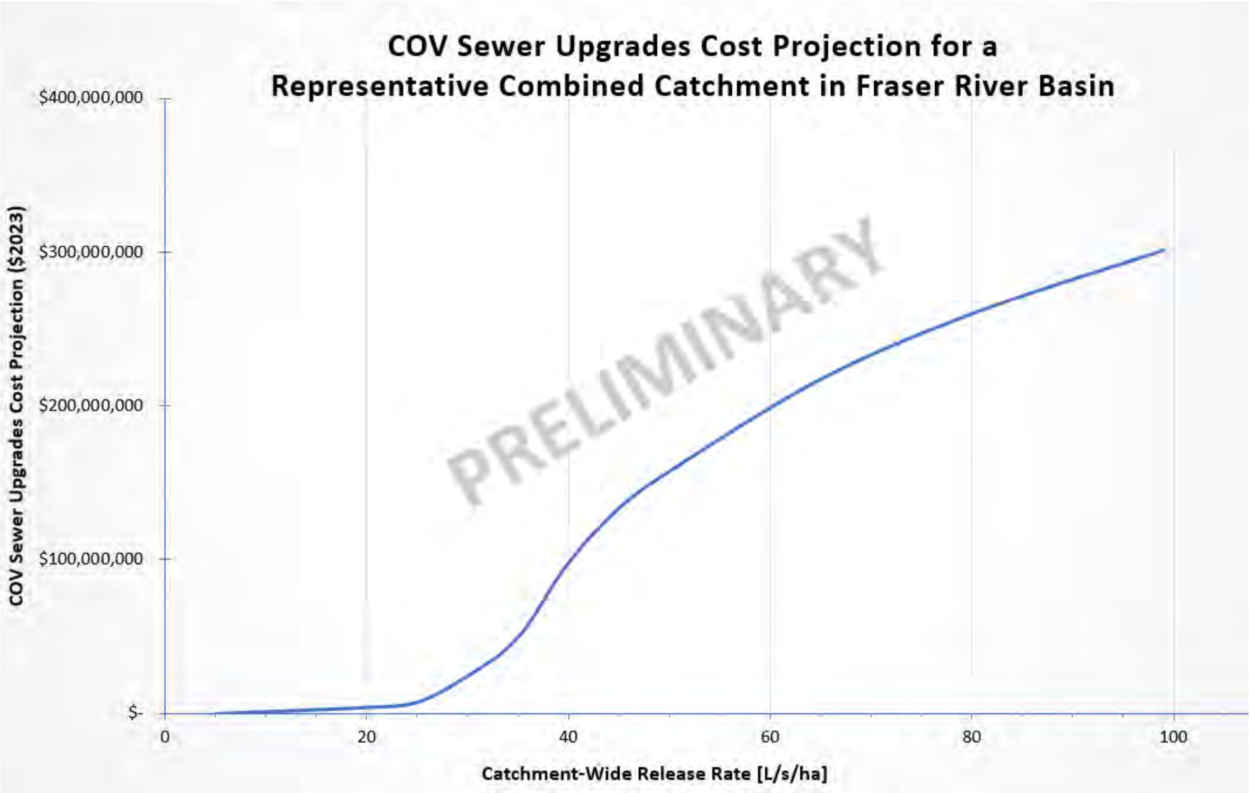


Figure 31: Catchment-Wide Release Rate vs.COV Sewer Upgrades Cost Projection ($2023)

Preliminary analysis completed recently by City of Vancouver staff also suggests that using a staged flow control detention tank configuration may be a viable and cost-effective approach for managing both flooding and CSO risks. More evaluation of detention-based and hybrid retention-detention based alternatives is required.

Cost implications for redevelopment will need to be defined through the rainwater management policy optimization process, to be completed during Phase 3 work.

Recommendations for Phase 3 work include:

Complete an evaluation of different detention tank configurations for larger buildings

This includes considering staged designs that have two components: one for storing water with a low release rate to manage combined sewer overflows (CSOs), and another for storing water with a higher release rate to prevent flooding during heavy rainfall. The goal is to find a solution that addresses system capacity, flooding, and CSO risks, while also minimizing impacts to affordability. It is recommended that this work also consider tank design options that enable the non-potable reuse of rainwater, to be implemented as part of the redevelopment, or retrofittable later.

Explore cost-effective opportunities for retention or hybrid retention-detention based solutions

Considering appropriate building typologies and geographical factors

Consult with the development industry to ensure that solutions are affordable and easy to implement

3.2 Options to Explore Further in Phase 3

Through the Phase 2 analysis and engagement process, a number of Options were identified which potentially provide optimal value-for-money outcomes when considering critical risks to be managed. These Options require further work to assess feasibility from a technical, financial, and risk perspective before any recommendations to implement are made.

3.2.1 CSO Rapid Treatment and Storage

CSO rapid treatment facilities are commonplace in jurisdictions where there has been a regulatory mandate to accelerate action on CSOs. CSO rapid treatment facilities typically include a staged solids removal process followed by disinfection to kill pathogens.

CSO storage is also a common practice, which typically involves constructing an underground facility to hold combined sewage during rainfall events, gradually releasing it to a downstream wastewater treatment plant (see Figure 32 for examples).

For CSO rapid treatment and CSO storage to provide maximum value-for-money, it is recommended that opportunities be explored for early implementation, to maximize pollution reduction while sewer separation activities progress. Completing sewer separation to the point of diminishing returns allows facilities to be constructed at a smaller scale and cost while achieving CSO elimination outcomes. These options also have potential synergies with operational changes to the system, such as using the Yukon Gate to increase flows to the Inner Harbour for wet weather treatment.

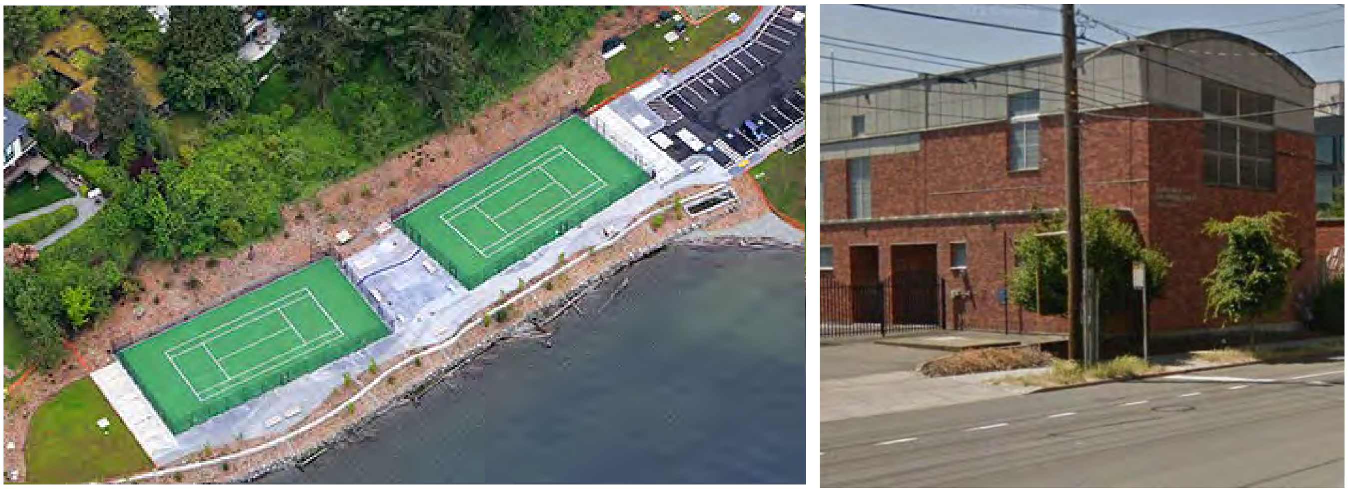


Figure 32: Examples of CSO Rapid Treatment and Storage in Seattle, Washington (left) and King County, Washington (right)

Healthy Waters Plan recommends a feasibility study to evaluate the viability of CSO rapid treatment approaches in the Inner Harbour Basin (responsible for 75% of the city's CSO discharges) and the Fraser River Basin, and feasibility analysis of CSO storage approaches in the Outer Harbour Basin (Figure 33).

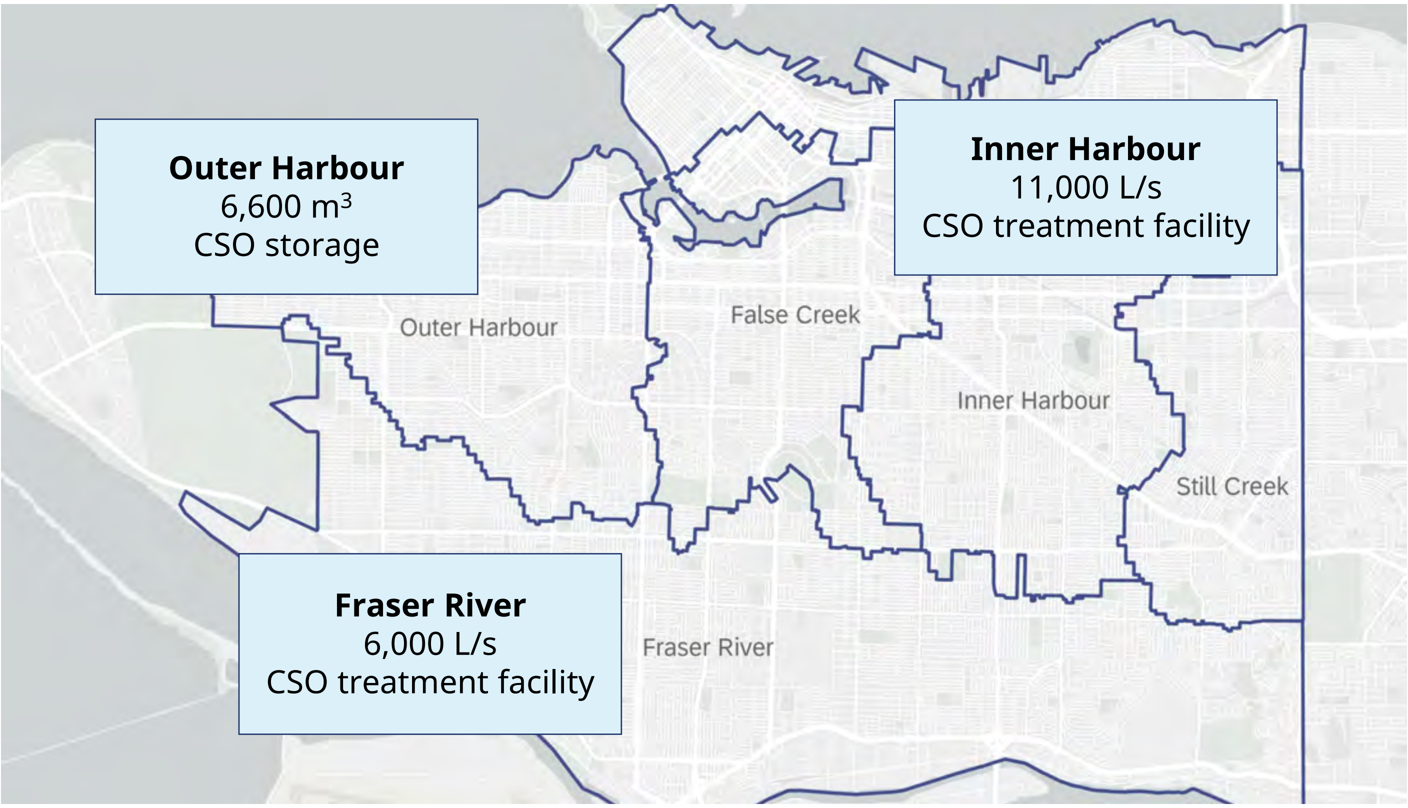


Figure 33: Potential locations for CSO Rapid Treatment and Storage Facilities

Depending on the feasibility analysis results, further discussions with Metro Vancouver and Burnaby will be needed to assess ownership and operations models. Extensive engagement with partners, stakeholders, and the public would also be necessary to consider siting, environmental impacts, and other important aspects.

The Healthy Waters Plan includes **$640 million** of capital and operating costs for CSO rapid treatment and storage facilities, subject to further feasibility analysis.

If this Option proceeds, approximately 93% of the City's sewer network would be separated by 2075, with separation work continuing into the future timed with renewal needs. CSO rapid treatment and storage would need to be implemented in an earlier timeframe to maximize early reductions to pollutant loadings. If CSO rapid treatment and storage do not proceed, higher investments in sewer separation will be necessary to achieve CSO elimination objectives (100% of the network will need to be separated by 2075).

3.2.2 Downspout Disconnection Retrofit Policy

Downspout Disconnection refers to the practice of separating the rooftop drainage of a building from the sewer network. Rainwater from a building's roof, which previously flowed directly into the sewer system, is redirected to flow into the ground or overland to road and laneway drainage. This may also allow for some infiltration of rainwater into the ground and can also be used to divert rainwater from sanitary sewers for properties that have combined sanitary and rainwater plumbing.

Since 1987, all new buildings in the City have been required to connect their roof drainage directly to the sewer network through service connections. This drainage can either flow into a combined property connection pipe or into the rainwater pipe for separated properties. Water from building roofs significantly contributes to CSOs and impacts sewer network capacity.

Downspout disconnection was a popular Option amongst participants in the Healthy Waters Plan engagement process. Reasons for this included potential benefits of reducing the burden on the pipe network and increasing opportunities for infiltration at a relatively low-cost compared to other investment options. Different jurisdictions implement downspout disconnections in various ways. For example:

In Portland, where the sewer network is largely combined, an incentive program has been in place for about two decades to encourage property owners to disconnect their downspouts. Roof drainage is diverted to an "infiltration pit" that allows water to seep into the ground (Figure 34). This program has cost-effectively contributed to significant reductions in CSOs.

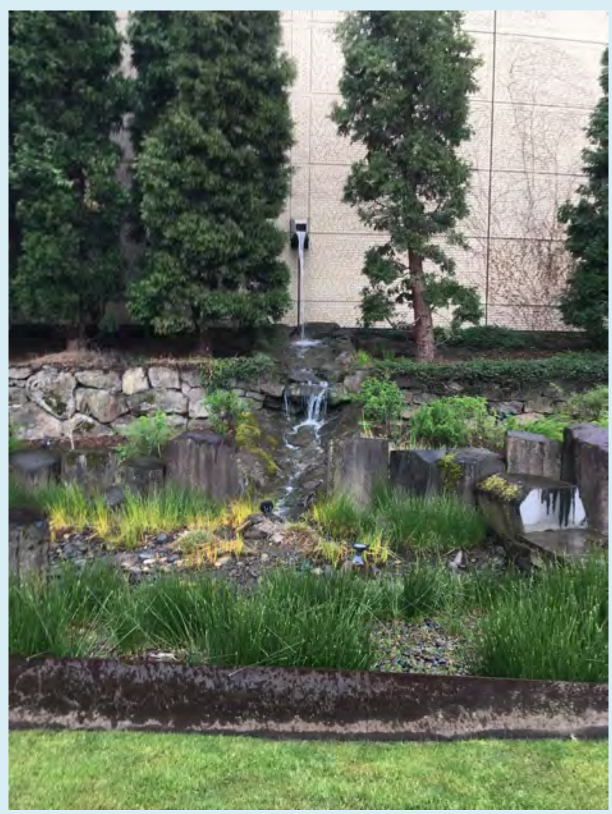


Figure 34: Example of a Downspout Disconnect in Portland Oregon

The City of Toronto began a voluntary downspout disconnection program in 1999, targeting areas with combined sewers. Roof drainage is directed to flow overland, infiltrating into the ground and then into rainwater pipes in streets and laneways. Since 2016, the program has included mandatory requirements and expanded to address flooding risks and combined sewer overflows (CSOs). Toronto also offers financial assistance to disadvantaged populations to cover disconnection costs.

Since 1977, the City of Surrey has not allowed new single-family homes to connect roof downspouts to the city's separated sewer system. Exemptions are made for infills and on a case-by-case basis for areas with identified geotechnical risks. The key objectives are to minimize impacts on sewer capacity by reducing the amount and rate of rainwater runoff entering the sewers and to reduce erosion in creeks.

Early in the engagement process, concerns were raised about the potential risks of downspout disconnection, such as basement flooding or improper drainage impacting building foundations. In response, the Option was modeled with conservative assumptions relating to the amount of roof space available for disconnection and the assumption that all water from disconnected downspouts would flow overland to street drainage with minimal infiltration. Under these conservative assumptions and also considering modelling was limited to a future year with sewers substantially separated, modelling did not demonstrate significant reductions in CSOs or rainwater runoff pollutants.

However, downspout disconnection could potentially be an effective medium-term measure to help separate rainwater from combined property connections. As outlined in Section 3.1.1, a proactive program to separate combined properties is critical for reducing CSOs and removing rainwater from the sewer system. Downspout disconnection is one potential solution to be explored in further feasibility analysis. If this option were to be pursued, it is critical that potential risks to building foundations be addressed. In addition, a City bylaw which currently prohibits the direction of property drainage to streets and laneways would need to be updated.

The Healthy Waters Plan includes **$60 million** allocated for downspout disconnections, which is subject to feasibility analysis.

3.2.3 Managing Flooding Risk Associated with Extreme Rainfall Events

The Healthy Waters Plan evaluated various strategies to mitigate overland flood risk associated with extreme rainfall, such as implementing large amounts of green infrastructure and using grey infrastructure like tanks in public spaces and floodable streets. However, these infrastructure improvements can be costly relative to the degree of flooding prevention provided. Green infrastructure Options were found to offer additional benefits beyond flood reduction, while grey infrastructure Options provided limited risk reduction relative to their cost. The evaluation also considered prohibiting new development in high-risk flood areas, which reduces risk but limits the availability of land for housing and other critical needs.

As part of the effort to enhance flood resilience in new developments, more cost-effective alternatives are being explored. It is recommended that an Extreme Rainfall Assessment, as outlined in the Climate Change Adaptation Strategy, be completed to define development policy and investment needs.

One potential outcome could the introduction of a flood-proofing policy to protect new developments located in flood-prone areas, at an estimated cost of approximately $1 per buildable square foot of new floorspace. Additionally, infrastructure strategies will be evaluated to enhance overall resilience. Cost implications will need to be defined as part of Extreme Rainfall Risk Evaluation and reported back at a later date.

3.2.4 Strengthen Existing Pollution Prevention Including Source Controls

Street sweeping helps maintain the performance of sewer and drainage infrastructure by preventing pollutants and organic materials (like leaf litter, debris, and trash) from entering the water system. Street Sweeping includes cleaning streets to improve water quality and drain age infrastructure performance (Figures 35 and 36).

Figure 35: Street sweeping vehicle cleaning a street in Vancouver

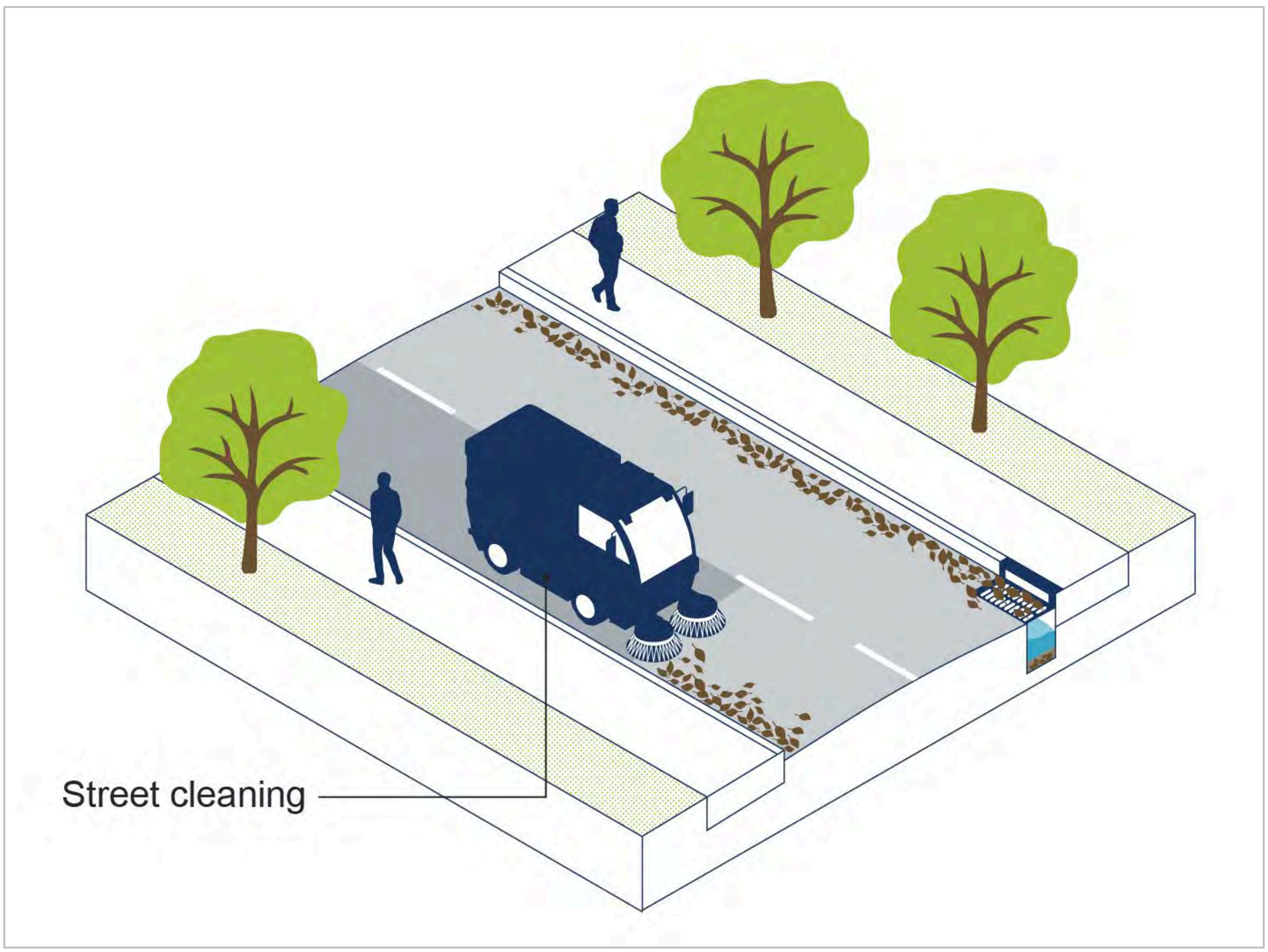


Figure 36: Street sweeping vehicle

Street sweeping enhances environmental water quality by removing particulate matter from rainwater runoff before it enters the drainage system (Figure 37). This is especially critical for areas of the city with separated sewers. Street sweeping also helps to prevent the clogging of catch basins and promotes roadway safety for drivers and cyclists by clearing garbage, debris, and sediment from the streets.

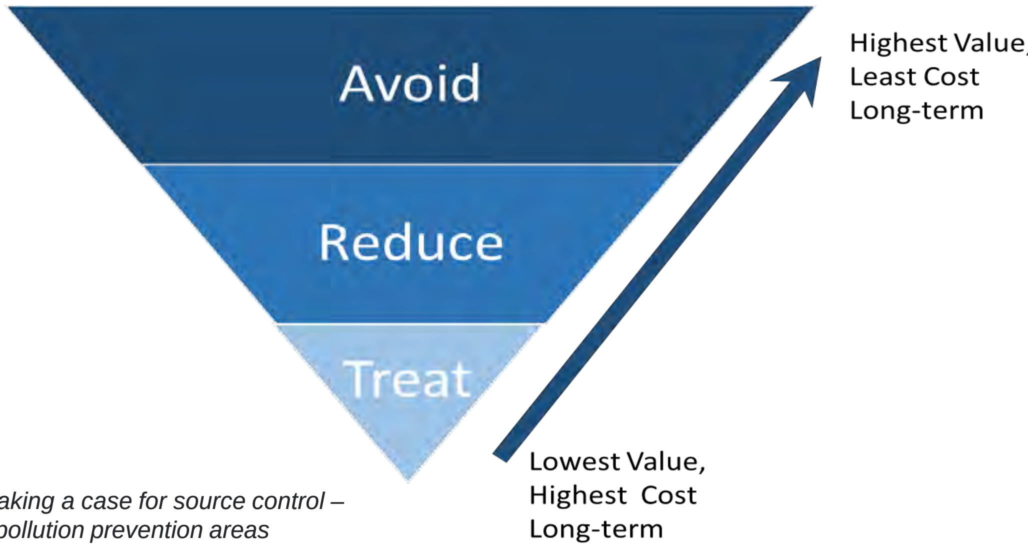


Figure 37: Making a case for source control – hierarchy of pollution prevention areas

A source control pollution prevention program must consider a range of substances that are potentially harmful to aquatic ecosystems and may be difficult for wastewater treatment plants for GRI to remove. Examples include microplastics, which are discharged in large quantities through the laundering of synthetic fabrics, pharmaceuticals, household, commercial and industrial wastes. A range of actions may be effective, including public education, pollution prevention regulations and lobbying senior levels of government to have certain substances banned from the supply chain. Metro Vancouver is the lead agency for pollution prevention across the region and needs strong support from the City of Vancouver on certain actions within the City’s control.

Phase 3 will define a broader source control program to prevent harmful substances from entering the pipe system. In addition to evaluating opportunities for enhanced street sweeping, a broader evaluation of opportunities ranging from land use planning opportunities and public education programs to pollution-prevention regulations will be considered. As part of this, the City should take a coordinated approach building upon Metro Vancouver’s programs.

3.3 Compulsory Items Factored into the Plan

Compulsory costs have also been factored in the Healthy Waters Plan, including core O&M programs, capacity upgrades, asset management and addressing the need to adapt lowland drainage systems to sea level rise. Examples of these compulsory items are:

Pipe Capacity Projects to Support Redevelopment: These projects involve upgrading and expanding existing sewage and drainage pipes to handle increased flows from new developments and higher population densities. This ensures the system can manage additional wastewater and stormwater without impacting current levels of service.

Renewal, Rehabilitation, and Repair of End-of-Life Assets: This includes the ongoing renewal, rehabilitation, and repair of aging infrastructure such as pipes, pump stations, and other critical assets. Renewal includes enhancement to levels of service as needed for customers. Regular maintenance and timely upgrades are essential to prevent failures as well as reduce the risk of overflows and sewer backups into private properties.

Operational Programs: These programs cover the day-to-day operations and maintenance of the sewer and drainage systems. This includes routine inspections, cleaning, and minor repairs to ensure the systems function efficiently. Operational programs also involve monitoring and managing the performance of the sewage and drainage systems to quickly address any issues that arise.

Adapting Sewers and Drainage Systems to Sea Level Rise: This includes establishing new pressurized drainage trunk sewers or outfalls (tight pipes), drainage pump stations, and tide gates in an integrated manner with diking and other shoreline protections. These investments are necessary to safely convey rainwater into receiving waters during high tide and storm surge events, and to prevent sea and river water from flowing back into the system.

These compulsory items are critical for maintaining a resilient and efficient sewer and drainage system in Vancouver. They ensure the city can meet current demands, support future growth, and protect residents and the environment from the impacts of climate change and aging infrastructure.

The Healthy Waters Plan includes **$3.5 billion** of capital and operating costs for compulsory items.

3.4 Performance of the Healthy Waters Plan

This section compares the performance of the Healthy Waters Plan with the "Current Trajectory" and "100% Sewer Separation by 2050" benchmarks. Figure 38 summarizes the options included in the Healthy Waters Plan and benchmark pathways.

	Pathway Type		
Options	**Healthy Waters Plan (modelling year: 2050 and 2075)**	**Complete Separation by 2050 (modelling year: 2050)**	**Current Trajectory (modelling year: 2050 and 2075)**
Sewer Separation	Approximately 93% of the system will be separated. Still Creek (currently fully separated) and False Creek will be fully separated by 2075. Other basins will be fully separated beyond 2075, achieved by bottom-up separation approach.	Fully separated by asset-driven approach	Fully separated by asset-driven approach
GRI on Public Property	503ha of impervious area managed with green streets, blue green corridors, and floodable wetlands and public spaces	None assumed. GRI is not required in the LWMP	388ha impervious area managed with green streets
Stormwater Treatment	Citywide treatment: 1,850L/s	None assumed	None assumed
RWM Policy *Subject to staged detention tank and/or hybrid retention/detention solutions feasibility study*	24mm-standard onsite rainwater management policy for redevelopment	Detention tank required on private realm redevelopment	Detention tank required on redevelopment
CSO Rapid Treatment and Storage *Subject to evaluation to assess opportunities for accelerated reductions*	Outer Harbour storage: 6,600m^3 Inner Harbour treatment: 11,000L/s Fraser River treatment: 6,500L/s	None assumed	None assumed
Street Sweeping *Subject to source control analysis*	Every 4 days	Every 8.5 days	Every 8.5 days

Figure 38: Summary of options included in Healthy Waters Plan pathway and comparators

The results of analysis presented in this section reflect adoption of a 24mm retention standard for redevelopment. A retention standard provides extensive benefits across multiple goal areas. Late in the Phase 2 process, significant affordability and technical viability concerns were raised regarding implementation of a 24 mm retention policy. Performance outcomes will need to be reassessed during Phase 3 considering optimization of rainwater management policy as well as the phasing of infrastructure investments across the city.

3.4.1 Goal Area 1: Healthy Waterways

For Goal Area 1: Healthy Waterways, performance has been assessed using the MBM tool for Fecal Coliform and TSS pollutant loadings, as well as the frequency and total volumes of CSO discharges. To address uncertainty around the feasibility of the proposed CSO rapid treatment and storage facilities, the results also include a Right-Sized Pathway "Type A" scenario for reference. This scenario assumes full separation of the sewer network by 2075, rather than incorporating rapid treatment and storage options.

3.4.1.1 Fecal Coliform

Fecal coliform was used as the primary indicator in the MBM to represent the human health risks associated with CSOs and rainwater runoff. CREF-based risk factors were applied to account for the relative risks from different sources:

Rainwater runoff: A risk multiplier of 1 was used for fecal coliform from rainwater runoff due to its predominantly non-human sources and lower pathogen loadings compared to sanitary-sourced fecal coliform. However, the homelessness crisis has introduced more human waste into rainwater runoff, which is difficult to quantify.

Sanitary sewage: A risk multiplier of 2 was assigned to fecal coliform from sanitary sewage, reflecting a higher proportion of human-sourced waste and associated pathogen loading.

Figure 39 presents the MBM estimates of fecal coliform loadings for the Current Trajectory (2019), 100% Sewer Separation by 2050 (the LWMP target year for CSO elimination), and the Healthy Waters Plan.

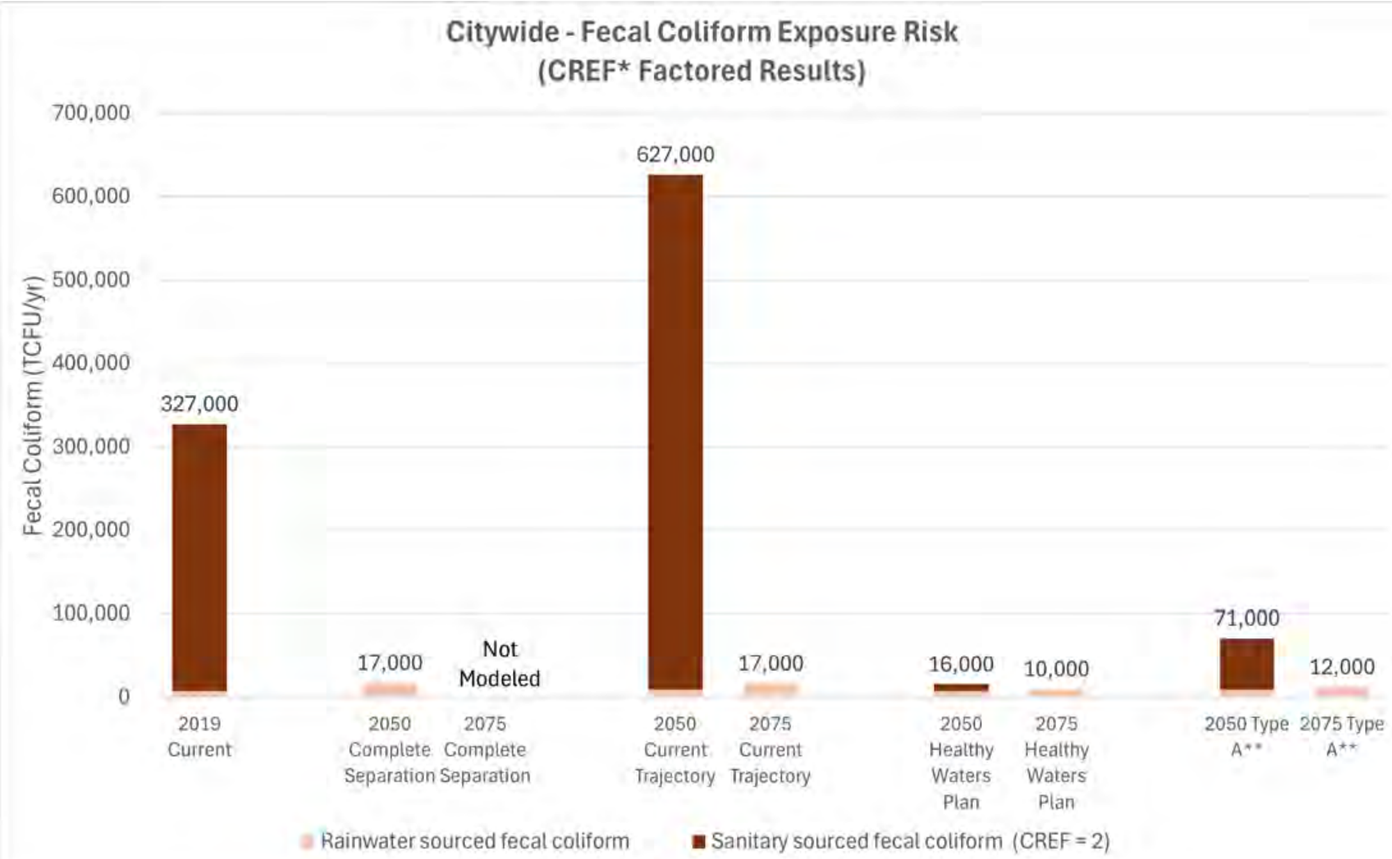


Figure 39: Forecast fecal coliform loadings (CREF factored results)- Citywide

Summary of Findings:

Current Trajectory Pathway: By 2050, fecal coliform loadings will nearly double, primarily due to the impacts of population growth and future climate-driven rainfalls combined with unseparated combined property connections which serve a barrier to diverting stormwater away from Metro Vancouver infrastructure. By 2075, fecal coliform loadings from sanitary sewage are expected to be nearly zero, with sources limited to rainwater runoff. Achieving this outcome would require all property connections to be separated through redevelopment, which is highly uncertain.

100% Sewer Separation by 2050 Pathway: By 2050, sanitary sourced fecal coliform is fully eliminated, with a residual amount of 17 trillion colony forming units remaining from rainwater runoff sources. Predictions for 2075 were not made due to uncertainties about investments in GRI between 2050-2075 and financial unviability of achieving full separation by 2050.

Healthy Waters Plan: By 2050, the Healthy Waters Plan is forecast to achieve a reduction in CREF-factored fecal coliform loadings equivalent to the 100% Sewer Separation by 2050 Pathway. This is due to a bottom-up approach to sewer separation and the assumption that CSO rapid treatment facilities would be implemented for the Inner Harbour and Fraser River, along with a CSO storage facility for the Outer Harbour. Smaller improvements to fecal coliform performance is forecast between 2050 and 2075, due to loadings being substantially eliminated in prior decades

Healthy Waters Plan Alternative Scenario (Type A): If CSO rapid treatment and storage is not feasible, the Healthy Waters Plan would reduce CREF-factored fecal coliform loadings by approximately 80% by 2050. While this reduction is less than what the 100% Sewer Separation by 2050 Pathway would achieve, it represents a significant improvement over the Current Trajectory. By 2075, this approach would achieve an equivalent outcome to the other benchmark pathways that include full separation.

3.4.1.2 Total Suspended Solids (TSS) Discharge

Total Suspended Solids (TSS) was used as the primary indicator in the MBM to represent the ecological risks associated with contaminants in sanitary sewage and rainwater runoff. TSS also has human health implications when considering the consumption of finfish and shellfish. Based on CREF analysis, both sanitary sewage and rainwater runoff are assumed to have a risk multiplier of 1.

Rainwater runoff: Total suspended solids TSS represents a variety of contaminants, including pollutants from transportation sources, such as oil, tire, and brake dust, as well as contaminants from residential and commercial properties, like microplastics released from dryer vents.

Sanitary sewage: TSS in sanitary sewage represents a wide range of contaminants from sanitary, household, commercial, and industrial sources.

Figure 40 presents the MBM estimates of TSS loadings for the Current Trajectory (2019), 100% Sewer Separation by 2050 (the LWMP target year for CSO elimination), and the Healthy Waters Plan.

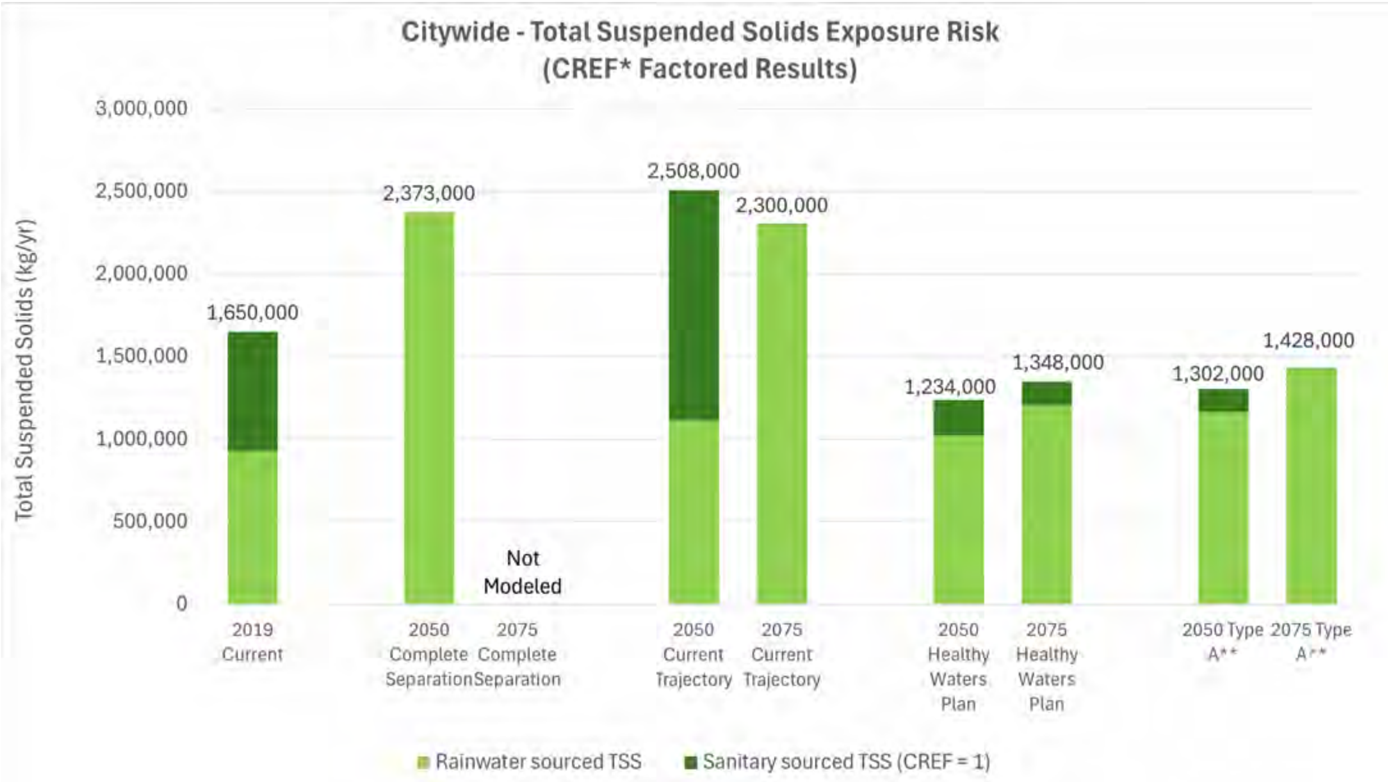


Figure 40: Forecast TSS loadings (CREF factored results) – Citywide

Summary of Findings:

100% Sewer Separation by 2050 Pathway: By 2050, this Pathway would fully eliminate TSS loadings from sanitary sources. However, overall TSS would increase by over 40% due to the diversion of rainwater runoff from the wastewater treatment plant to stormwater outfalls. This pathways does not provide for GRI or grey infrastructure solutions for stormwater treatment.

Current Trajectory Pathway: By 2050, this Pathway would increase TSS loadings by approximately 50%, largely from sanitary sources due to the anticipated rise in CSO discharges. By 2075, sanitary-sourced TSS is expected to be largely eliminated, assuming redevelopment achieves 100% separation of combined property connections. TSS would still increase by 40% due to rainwater runoff alone as this pathway only provides for limited GRI investments compared to the above pathway.

Healthy Waters Plan: By 2050, TSS loadings would be reduced by 25%, primarily from sanitary source reductions. This is due to the bottom-up approach to sewer separation combined with CSO rapid treatment and storage solutions. This trend continues to 2075, with increases in rainwater runoff TSS being partially mitigated by investments in GRI and in-line grey stormwater treatment devices. The remaining TSS pollutant loading would be 90% sourced from rainwater runoff and 10% from the effluent of proposed CSO rapid treatment facilities.

Healthy Waters Plan Alternative Scenario (Type A): If CSO rapid treatment and storage are not viable, the Healthy Waters Plan Pathway would achieve a 20% reduction in CREF-factored TSS loadings by 2050 and over 10% by 2075 compared to 2019 levels. This alternative Pathway would outperform both the 100% Sewer Separation by 2050 and Current Trajectory Pathways by over 50% in 2050.

3.4.1.3 Frequency and Volume of CSO Events

The MBM was also used to estimate the frequency and volume of CSO events (see Figure 41). These metrics are crucial for addressing the regulatory focus on eliminating CSOs.

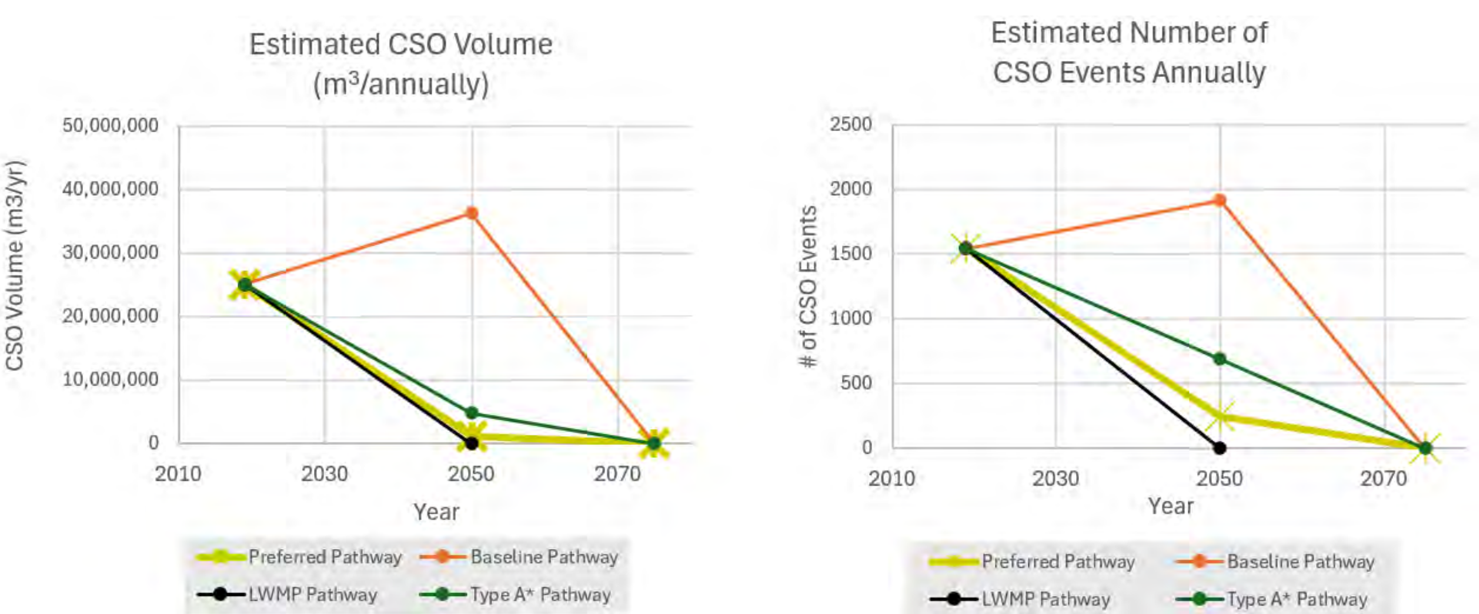


Figure 41: Forecast frequency and volume and frequency of CSO events – Citywide

Summary of Findings:

100% Sewer Separation by 2050 Pathway: Expected to fully eliminate CSOs by 2050.

Current Trajectory Pathway: Frequency of CSO events is expected to increase until 2050, then reduce to zero by 2075, assuming a fully separated network of mainline sewers and property connections.

Healthy Waters Plan: Expected to reduce the frequency of CSOs by over 80% and the total volume by 95% by 2050, with CSO discharges being much more diluted by rainwater than current CSOs. Both the frequency and volume of CSOs are forecast to be zero by 2075.

Healthy Waters Plan Alternative Scenario (Type "A" if CSO rapid treatment and storage are not viable): Expected to reduce the frequency of CSO events by 55% and the total volume by 80% by 2050. CSOs are forecast to be fully eliminated by 2075.

3.4.2 Goal Area 2: Healthy and Livable Watersheds

Goal Area 2 focuses on performance measures related to the health of the City's urban watersheds, considering climate change, ecosystem health, and livability. For this goal area, the comparison is limited to the Current Trajectory Pathway, as the 100% Sewer Separation by 2050 Pathway does not include forecast investments beyond 2050. Figure 42 summarizes the performance outcomes for the year 2075. Results presented in this section are subject to further feasibility analysis for rainwater management policy optimization as well as CSO rapid treatment and storage.

	Goal 2				
Criteria	Rainwater infiltrated and evaporated	Restoration of pervious area and reduction in urban heat	Reduction in impervious surfaces	Improved natural drainage connectivity	Riparian area created (marine or freshwater)
Current Trajectory	5.2 million m^3/year	200,000	0 m^3	0 km	0 m^3
Healthy Waters Plan	26.3 million m^3/year	760,000	7.83 million m^2	26 km	43,850 m^3
	↑ 410% Volume of a football field filled about 300 meters high	↑ 280% ~76 Vancouver city blocks	~ 783 Vancouver city blocks	Distance from Vancouver to Port Coquitlam	~4 Vancouver city blocks

Figure 42: Goal Area 2 performance

Summary of Findings:

Rainwater Infiltrated and Evaporated: This performance measure addresses the Rain City Strategy's goals of restoring the natural water cycle and improving watershed health. It also reflects reduced rainwater load on the sewer network. The Preferred Pathway shows a 410% improvement over the Current Trajectory Pathway, due to the 24 mm retention policy for rainwater management and significant investments in GRI in streets and public spaces.

Restoration of Pervious Area: This indicator relates to reducing urban heat and improving the natural water cycle. The Healthy Waters Plan Pathway provides a 280% improvement over the Current Trajectory Pathway, due to the 24 mm retention policy and increased investments in GRI in streets and public spaces.

Reduction of Impervious Surfaces: This measure tracks the removal of impervious areas in the city, which helps reduce urban heat and benefits the natural water cycle. The Healthy Waters Plan Pathway reduces impervious surfaces by approximately 780 hectares across the city, primarily due to the 24 mm rainwater retention policy for redevelopment. The Current Trajectory Pathway does not achieve any reductions in comparison.

Improving Natural Drainage Connectivity: This indicator relates to ecosystem health within watersheds and livability objectives, extending beyond traditional sewer and drainage services. The Healthy Waters Plan Pathway creates 26 km of connected drainage ways through Blue Green Systems, waterway restoration, and vegetated rainwater channels.

Riparian Area Created: This measure represents the goal of improving ecosystem health within watersheds by increasing habitat and biodiversity. The Healthy Waters Plan Pathway increases riparian areas by approximately 4 hectares across the city, supported by enhanced large green facilities, waterway restoration, and vegetated rainwater channels.

3.4.3 Goal Area 3: Adaptive to Risk and Uncertainty

This goal area addresses key risks such as sewer backups, flooding, seismic events, and capacity shortfalls. For Phase 2,MCDA analysis has focused on two key performance measures: (1) the percentage of the population in flood-risk areas affected by extreme weather-driven flooding, and (2) the volume of rainwater detained, which helps preserve system capacity and prevent flooding. For the same reasons as Goal Area 2, the Healthy Waters Plan is only compared to the Current Trajectory Pathway. Figure 43 summarizes the performance of these two key measures. Results presented in this section are subject to further feasibility analysis for rainwater management policy optimization.

	Goal 3	
Criteria	**% reduction in population impacted by overland flooding**	**Volume of rainwater detained**
Current Trajectory	0%	157,800 m^3/year
Healthy Waters Plan	49%	740,890 m^3/year

↑ 370%

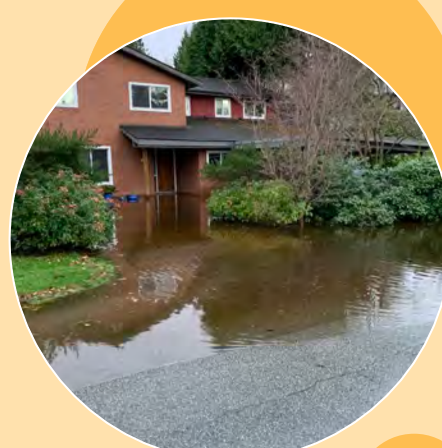
Volume of a football field filled about 8 meters high

Figure 43: Goal Area 3 performance

Goal Area 3 performance is largely driven by flood-proofing policies:

Up to 50% reduction in the population impacted by overland flooding: This is mainly achieved through flood-proofing redevelopment in areas at risk of flooding. This policy already exists in areas exposed to sea level rise and includes building entryways at sufficient grades to avoid water ingress.

Further analysis and community engagement are recommended to assess and implement a policy for other areas of the city exposed to overland flooding that are not covered by existing flood-proofing policies for established flood plains. This work will take place within the Extreme Rainfall Risk Assessment initiative.



Phase 2 also considered alternative approaches, including restricting redevelopment in flood-prone areas and investing in grey infrastructure for rainwater detention and flood protection.

Restricting redevelopment in flood-prone areas was not viewed positively due to its impact on land availability for affordable housing and other needs, especially when design approaches are available to mitigate this risk.

Grey infrastructure investments carried a significantly higher cost burden compared to flood-proofing policies for a similar level of investment.

The Performance Measure, "Volume of Rainwater Detained" was also assessed as it's a key proxy metric related to the need to preserve existing capacity in the sewer system but direct assessment of changes to sewer backups was not completed in Phase 2 due to limitations of available modeling tools. The Healthy Waters Plan achieved a 370% increase over the Current Trajectory Pathway.

Results presented in this section are subject to further feasibility analysis for rainwater management policy optimization. Additional analysis will be required in Phase 3 and beyond to address the following objectives within this goal area: (1) Adapting the Sewer and Drainage System to Sea Level Rise and (2) Improving Seismic Resilience. As a placeholder, the Healthy Waters Plan includes an allowance for Drainage Pump Stations and Tide Gates, which will be needed to drain low-lying areas protected by dikes during high tides and storm surge events.

3.4.4 Overall MCDA Comparison

Figure 44 provides a summary on the performance of the Healthy Waters Plan Pathway compared to the Current Trajectory Pathway.

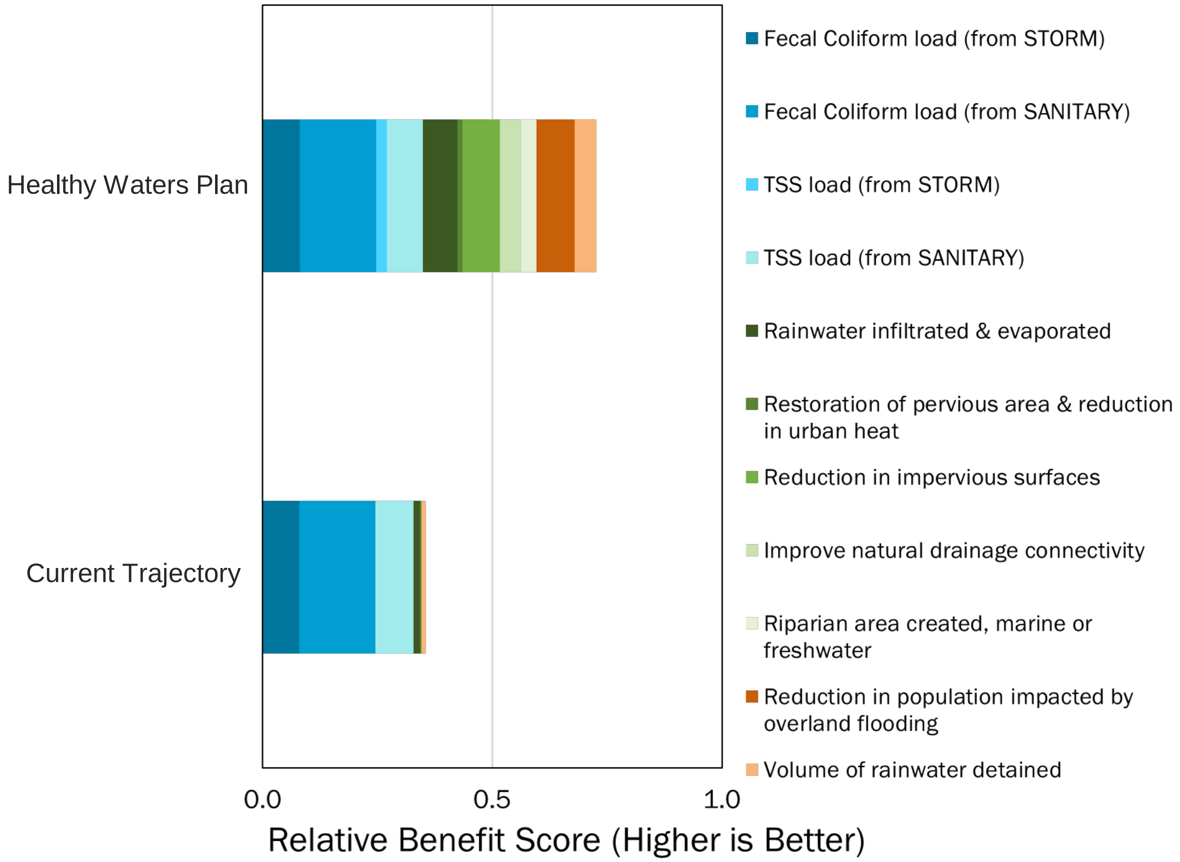


Figure 44: MCDA summary results for year 2075

The Healthy Waters significantly outperforms the Current Trajectory for each of the three Goal Areas, within the same defined funding envelope. In summary, the Healthy Waters Plan:

1. **Delivers approximately equivalent performance for fecal coliform** (primary public health impact indicator) **by 2050 as the 100% Sewer Separation by 2050 Pathway and outperforms it in terms of TSS pollutants** (primary ecological impact indicator).
2. **Provides an affordable opportunity to align with the 100% Sewer Separation by 2050 Pathways' water quality outcomes while also achieving a wider range of objectives**, such as healthier waterways, green space creation, urban flood resiliency, reducing urban heat, creating biodiversity and tree canopy, improving livability, and offering more affordable rates to ratepayers.

Due to uncertainties in forecasting related to climate change, population growth, redevelopment rates, regulatory changes, and the feasibility of certain options (e.g., CSO rapid treatment), an adaptive pathway approach[7] is necessary for the final Plan to be developed in Phase 3. Phase 3 will detail the sequencing of actions, basin prioritization, Financial Plan, interim milestones, pivot points in the Adaptive Implementation Plan, and alternative recommended actions for the Healthy Waters Plan.

[7] An adaptive pathway approach is a flexible, decision-focused strategy that provides pivot points for change to address key items of uncertainty including but not limited to climate change, growth, and regulatory requirements.

3.5 LWMP Alignment

As outlined in Section 3.2.3, completing sewer separation by 2050 is not viable due to financial factors. The Healthy Waters Plan offers a more financially viable alternative to fully separating the sewer network by 2050, while potentially achieving a greater reduction in pollution loading from both sanitary and rainwater runoff sources. The Healthy Waters Plan also delivers on a broader range of objectives, including expanded and enhanced green spaces, improved watershed health, and effective flood and rainwater management policies to mitigate future risks associated with population growth and climate change.

Although the Healthy Waters Plan potentially surpasses the water quality performance of the 100% Sewer Separation by 2050 Pathway for in year 2050, it does not fully eliminate CSOs from all storm events less or equal to the 5-year return period, which is a requirement under the 2011 LWMP. However, it achieves an equivalent outcome in CREF-factored fecal coliforms and higher performance levels for TSS.

The Healthy Waters Plan Pathway aligns with the objectives of the BC Municipal Wastewater Regulation but would require changes to the LWMP, requiring approval of GVS&DD Board as well as the Province of BC. For the current LWMP update process, it is not expected that there will be changes to the key commitments of separating 1% of the system annually or eliminating CSOs by 2050. However, it is anticipated that there will be new commitments to address pollution in rainwater runoff. Subject to Phase 3 outcomes and in accordance with direction received from the BC Ministry of Environment and Climate Change Strategy, it is possible that the City will be seeking a future mid-term amendment to the LWMP to align with the Healthy Waters Plan.

3.5.1 Opportunity for a Mid-Term Amendment to the LWMP

City of Vancouver and Metro Vancouver staff have engaged in discussions with the BC Ministry of Environment and Climate Change Strategy about aligning the Healthy Waters Plan with the LWMP. Guidance has been provided on the procedural requirements necessary for an application to amend the LWMP after the current update process. This application would be made following the conclusion of Phase 3 work, with any changes subject to approval by the GVS&DD Board and the Provincial Ministry. The Provincial Ministry has indicated that approvals would be contingent on the outcome of the technical analysis and feedback received through the engagement process, and strongly considering the input provided by First Nations.

Given this regulatory uncertainty and other potential future regulatory changes, it is recommended that an adaptive plan be developed in Phase 3. This would provide flexibility for future adjustments to plan implementation, ensuring that the Healthy Waters Plan remains resilient and effective in achieving its long-term goals.

3.6 Financial Considerations

This funding constraint for the Healthy Waters Plan include the total funding capacity, the annual funding capacity and the eligibly of different funding sources for various investments. As part of Phase 3, the timing of specific infrastructure investments will need to be aligned with the forecast funding sources such as the sanitary sewer utility fees, property taxes, and UDCLs and the City's debt strategy to support rate stability.

As shown in Figure 45, significant investments current planned for prior to 2050 including CSO rapid treatment and storage and stormwater trunk projects, to accelerate CSO reductions exceed forecast capacity during the initial years of the plan. Timing of investment or funding capacity will be addressed as part of Phase 3.

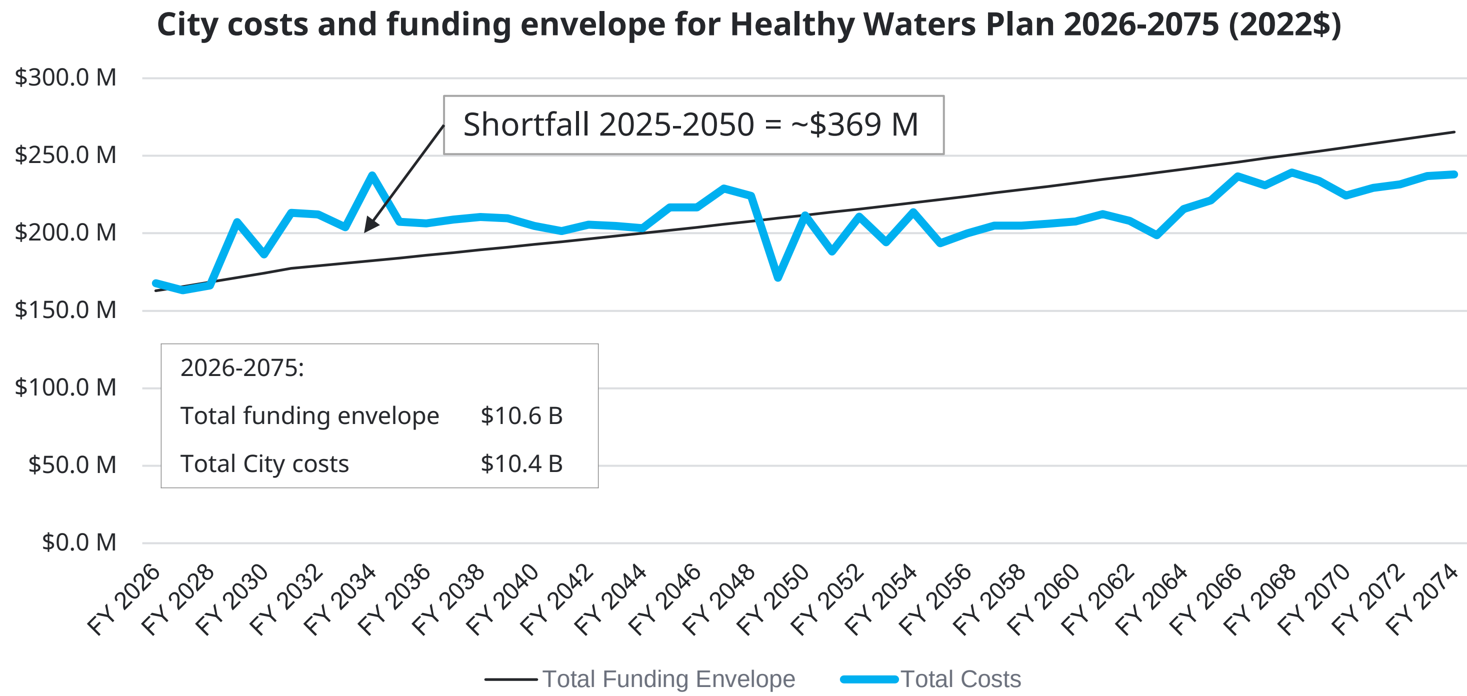


Figure 45: Healthy Waters Plan cost forecast compared to funding envelope

Considerations in these forecasts included:

- Current capital and operating cost assumptions for the system and planned investments.
- The City's current sewer funding capacity supported primarily by property tax, utility fees and the UDCL, excluding amounts for Metro Vancouver levies.
- Increases in funding tied to population growth and a proportionate share of the City's infrastructure levy.
- The number and cost of lateral connections likely to need separation into sanitary sewer and drainage channels over the forecast period.
- That cost escalation for planned investment will need to be passed on through rates and fees or addressed through improved technologies or efficiency.

Cost forecasts for the Current Trajectory and Healthy Waters Plan, as well as intermediate scenarios, relied partly on the Options Costs Tool outlined in Appendix B. These forecasts included assumptions about the shares of costs expected to be required from developers and property owners by regulation (including the building code) and by conditions of development (including during rezoning). Examples include rainwater management and flood-proofing policies for redevelopment.

Given current expectations about the funding envelope and the desire to maintain its integrity, financial considerations in Phase 3 will factor in:

1. **Unit Costs:** Impacts of significant changes, particularly increases, in unit costs of investment projects involved in the Preferred Pathway.

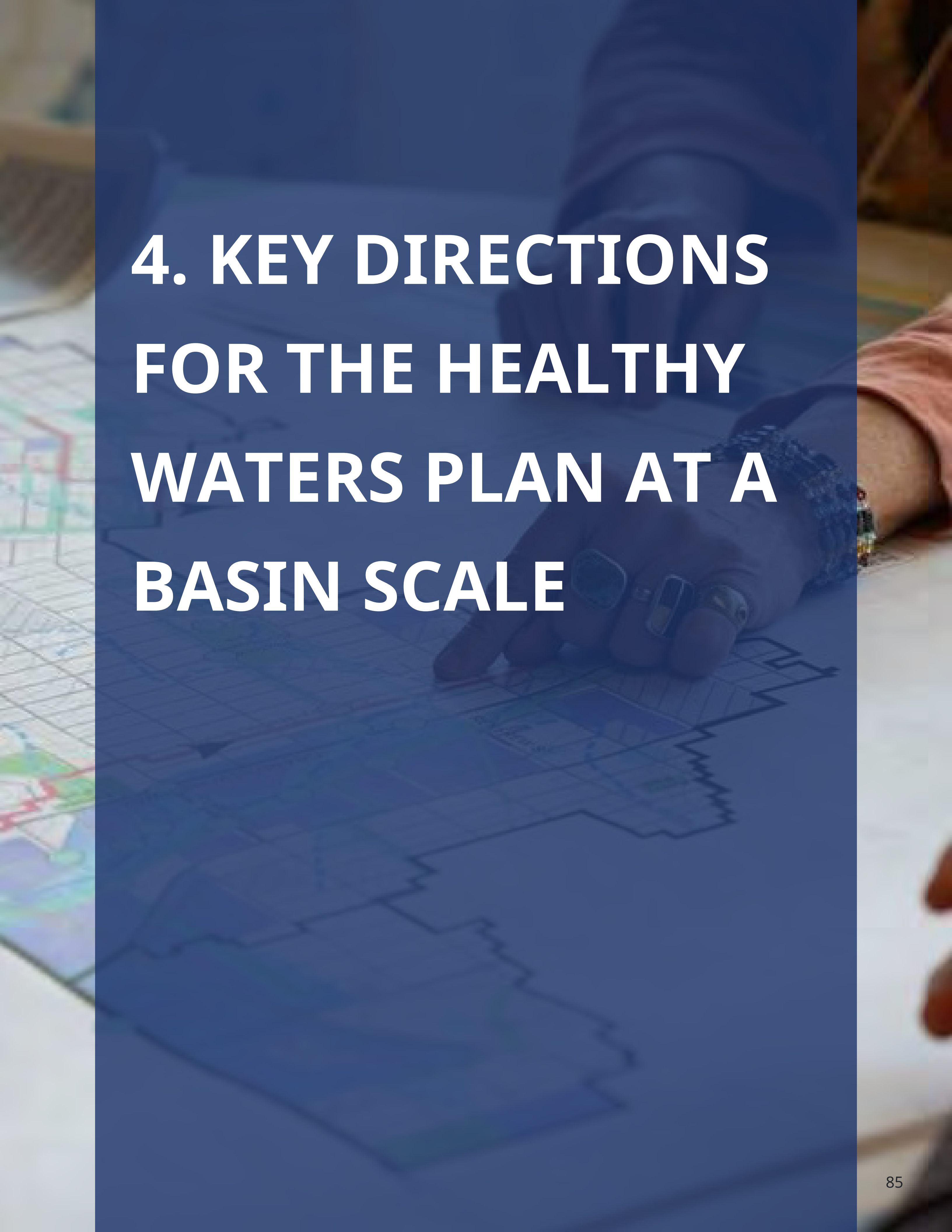
2. **Investment Mix**: Significant changes in the amounts and mixtures of investments considered desirable to achieve water quality outcomes.

3. **Pace of Investment**: Modifications to the pace of investments in the basins and overall, increasing investment variability from one period to the next and consequently increasing pressure on underlying funding sources (utility fees, property tax, and UDCLs).

4. **Funding Mix and Rate Design**: Review the relative contribution of the key funding sources supporting the sewer and drainage system and the City's approach to rate-setting, ensuring ability to adapt to change in investment requirements including changes driven by 5 and 6 below.

5. **Modifications to LWMP**: New information regarding the progress or lack thereof in modifications to existing LWMP requirements that necessitate a change in the pace and/or amounts of network investments.

6. **Regulatory and Senior Government Requirements**: Regulatory or other changes made by the city or senior governments in the near future that impact the nature and/or implementation of the Preferred Pathway.



4. KEY DIRECTIONS FOR THE HEALTHY WATERS PLAN AT A BASIN SCALE

Each of Vancouver's five drainage basins presents unique challenges and opportunities due to differences in infrastructure, land use mix, social factors, receiving water body characteristics, and other factors. Additional considerations include responding to needs identified by local Nations and addressing differences between basins in terms of existing ecological assets, urban heat, and equity for disadvantaged populations.

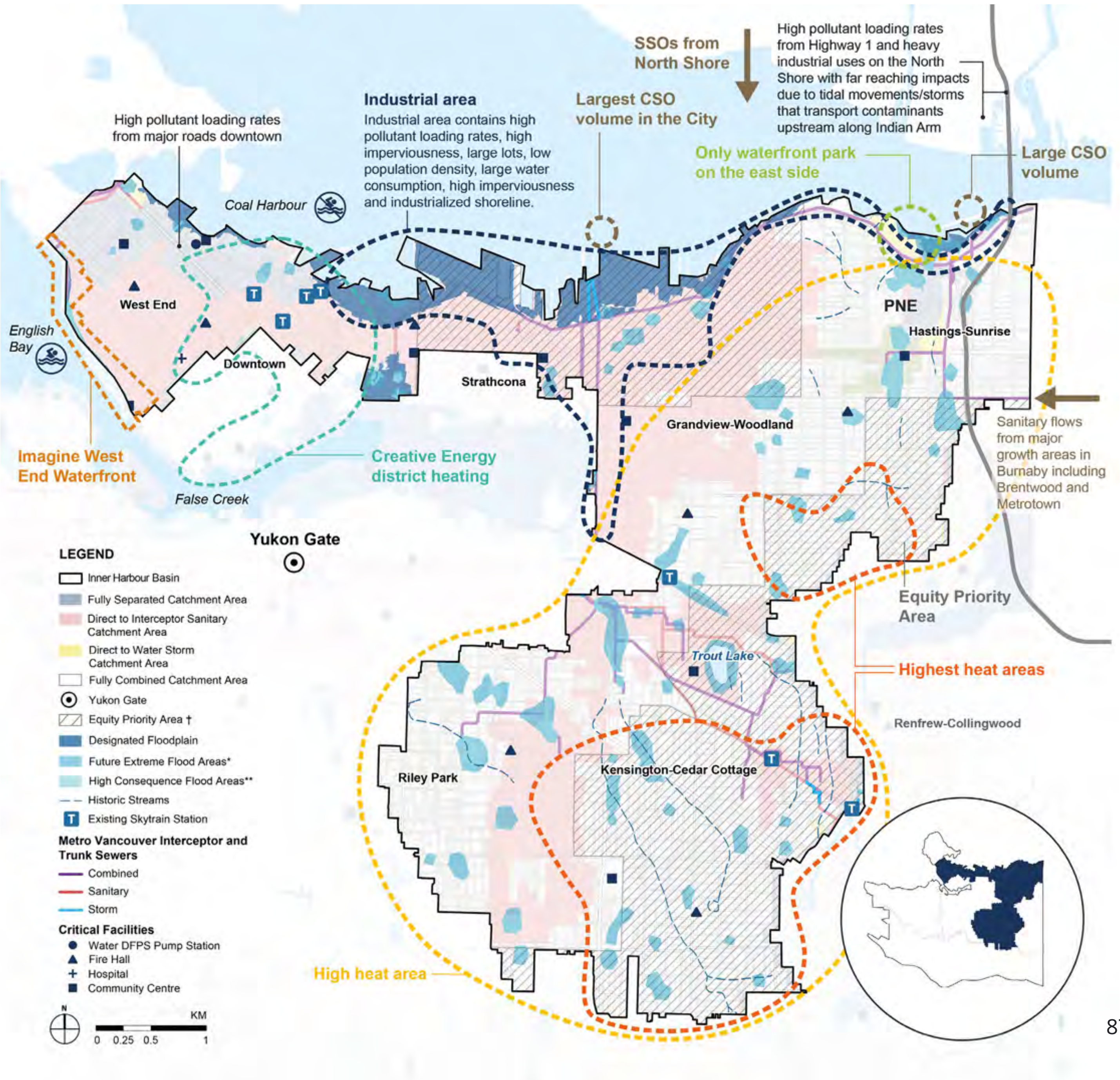
For each drainage basin, the Healthy Waters Plan outperforms the Current Trajectory Pathway and meets or exceeds the 100% Sewer Separation by 2050 Pathway in reducing fecal coliform and TSS pollution. Healthy Waters Plan Pathway also delivers a broader range of benefits compared to the Current Trajectory Pathway.

HWP Partners and Stakeholders discuss basin-specific moves at the Basin Planning Charrette

4.1 The Inner Harbour Basin

4.1.1 Characterization of the Inner Harbour Basin

The Inner Harbour Basin comprises of the lands in the majority of the downtown peninsula and a significant portion of the city's northeast, and includes the West End, Gastown, Downtown Eastside, Grandview-Woodland, Hastings-Sunrise, Kensington-Cedar Cottage and portions of Riley Park neighbourhoods. It features diverse land uses, from the high-density skyscrapers, hardscaped industrial and port lands to low and medium-density leafy residential areas.



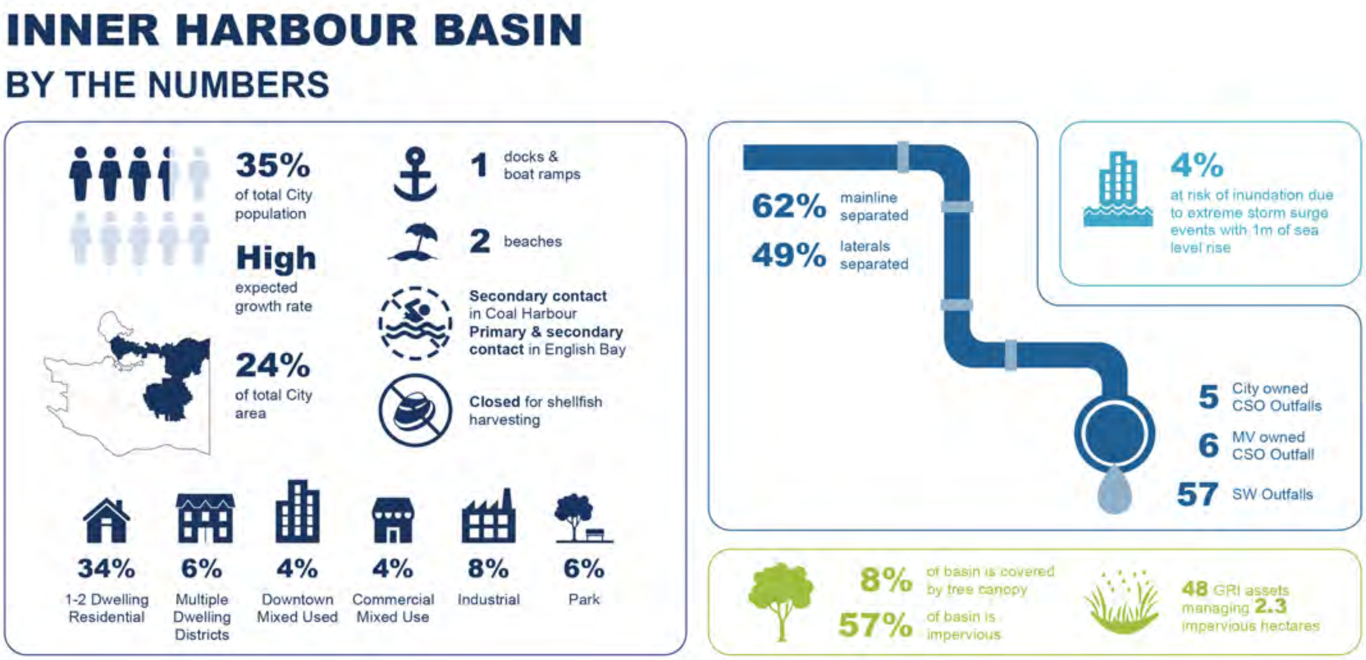


Figure 46: Gestalt Map and summary statistics for the Inner Harbour basin

Approximately one-third of Vancouver's residents live in this basin, with the population expected to grow by 54% by 2075. This growth includes areas near rapid transit stations, which are subject to new zoning policies that allow for high-density development. This basin also has areas with high socioeconomic vulnerability, which overlap with urban heat islands exacerbated by low tree canopy cover.

> To address the need for water quality improvements and enable the reopening of finfish and shellfish harvesting, the Tsleil-Waututh Nation has developed the Burrard Inlet Action Plan. This Plan establishes new water quality objectives for Burrard Inlet, including the Inner Harbour, Outer Harbour, and False Creek.
>
> The Plan envisions a healthy Inlet, emphasizing water quality and the reduction of contaminants. To learn more about the history of the Tsleil-Waututh Nation, ways to improve water quality, and methods to minimize contaminants carried by rainwater, explore the Stormwater StoryMap.

Figure 46 provides an illustrative description of the Inner Harbour Basin. Key issues to be addressed include:

Water Quality	The Inner Harbour receives approximately 75% of the city's annual CSO volumes, including inflows from the Still Creek basin and northwest Burnaby. High CSO volumes are partly due to the operation of the Yukon Gate control on the 8th Avenue Interceptor, which prioritizes water quality at swimming beaches in the Outer Harbour and recreational uses in False Creek.

Water Quality	Creek. During rainfall events exceeding about 5mm to 10mm, the Yukon Gate typically closes, discharging untreated sanitary sewage and rainwater runoff from the Inner Harbour, Still Creek, and Northeast Burnaby sewershed catchments into Burrard Inlet.
Watershed Health	Large portions of this basin are highly urbanized, including industrial, port, and high-density residential and commercial areas, which are largely impervious. It also includes residential areas with high socioeconomic vulnerability, intersecting with high urban heat islands due to low tree canopy coverage.
Risk and Uncertainty	Portions of this basin are vulnerable to overland flooding during extreme rainfall events. However, it is less vulnerable to tidal influences and sea level rise compared to other basins.

Appendix D provides a comprehensive summary of basin characterization information for the Inner Harbour and other basins.

4.1.2 Healthy Waters Plan for the Inner Harbour Basin

Figure 47 summarizes the Healthy Waters Plan for the Inner Harbour basin, which utilizes approximately 24% of the citywide funding envelope.

PATHWAY OPTION HIGHLIGHTS

Sewer and Drainage Network	Cost	% Separated
Separation to point of diminishing returns + Renewal and Rehab	$647.1 M (100% public) $268.9 M (100% public)	~94% by 2075*

Green Rainwater Infrastructure	Cost (public / private)	Area Managed	
Floodable Wetlands & Public Spaces	$115 M (77% / **23%**)	60 ha	7% of max
Blue Green Corridors in Public ROW	$78.8 M (76% / **24%**)	20 ha	16% of max
Green Streets in Public ROW	$46.6 M (80% / **20%**)	20 ha	2% of max

Policies	Cost (public / private)	Area Managed
Private Downspout Disconnect - Retrofit	$15 M (30% / **70%**)	113 ha
Public Downspout Disconnect - Retrofit	$0.6 M (100% public)	26 ha
24mm Retention - Redevelopment	$2,340.4 M (**100% private**)	~8,000 lots 26% of lots

Grey Infrastructure	Cost	Treatment Rate/Capacity/#
CSO Rapid Treatment Facility	$300.1 M (100% public)	11,000 L/s
Grey Stormwater Treatment	$33.5 M (100% public)	525 L/s
New Drainage Pump Stations & Tide Gates	$35 M (100% public)	2 Pump Stations

* Inner Harbour is separated 88% to point of diminishing returns + 6% for asset renewal

Figure 47: Healthy Waters Plan Option highlights - Inner Harbour

Highlights include:

Prioritizing Bottom-Up Sewer Separation: Achieving effective separation rate of 88% by 2075 (92% of mainline sewers including all renewals), with further separation continuing in later years (Figure 48). A CSO rapid treatment facility could potentially be implemented early in the plan to significantly reduce sanitary and rainwater runoff loadings. A comprehensive feasibility analysis is recommended to assess costs, benefits, risks, technology options, and other factors. An adaptive plan is needed to achieve 100% separation before 2075 if CSO rapid treatment cannot progress. In addition to the $647 million allocated for bottom-up separation, $269 million has been allocated to renew and rehabilitate upstream sewers that are at the end of their life.

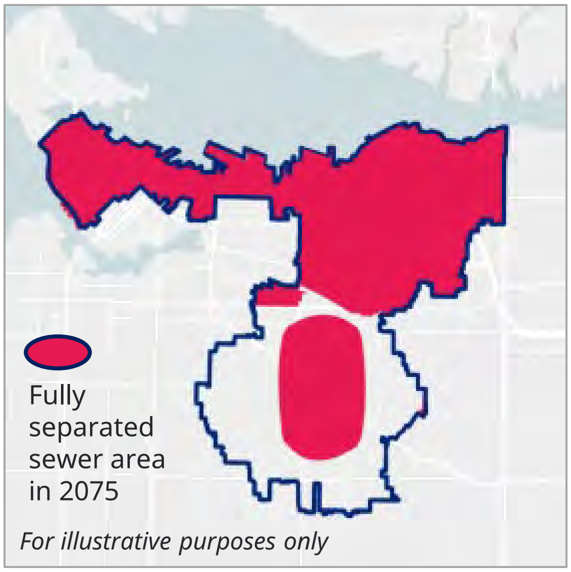


Figure 48: Inner Harbour at 88% effective separation in 2075 under the Healthy Waters Plan

Expanding the Public Area Managed with GRI: Compared to 2.3 ha today, the Healthy Waters Plan recommends using GRI to manage 100 ha of impervious area.

Ecosystem Health: This will enhance the riparian area by 10,000 square metres and reduce impervious areas draining directly to the sewer system by 190 hectares. The use of in-line grey stormwater treatment devices will further reduce the volume of rainwater runoff pollutants entering the Inner Harbour.

Flood Policy for Redevelopment: This policy may reduce the population affected by extreme overland flooding by 50%.

4.1.3 Anticipated Performance Outcomes for the Inner Harbour Basin

A summary of the performance of key indicators is provided below (Figure 49). See Appendix E for a more detailed assessment of the comparative performance of the Healthy Waters Plan for each basin.

Fecal Coliform: The Healthy Waters Plan is anticipated to nearly eliminate fecal coliform discharged from the sewer & drainage system into the Inner Harbour. Most of the remaining fecal coliform are rainwater sourced.

TSS: The Healthy Waters Plan is anticipated to reduce TSS discharged from the sewer & drainage system into the Inner Harbour by more than a third. Most of the remaining TSS are rainwater sourced.

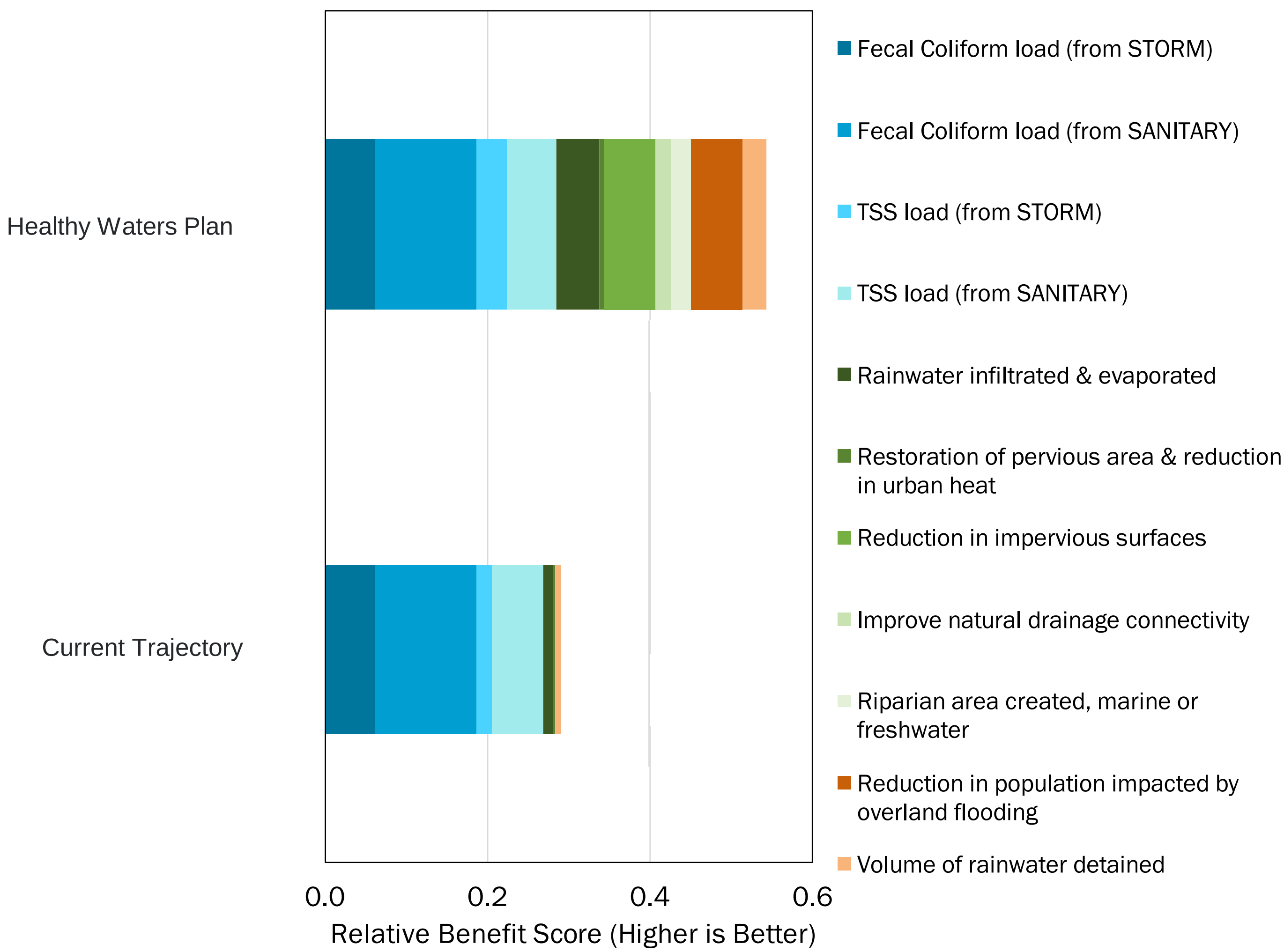
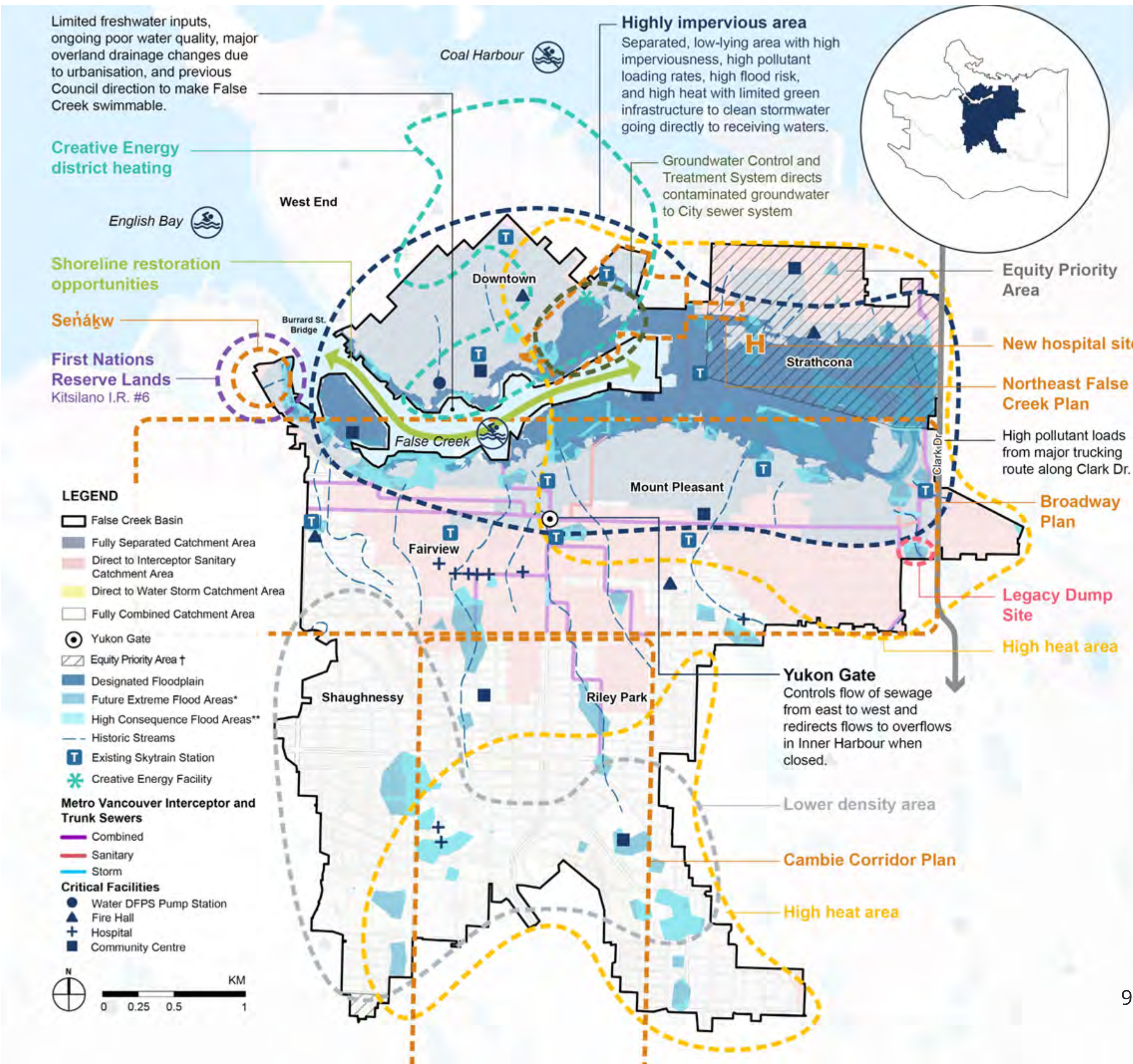


Figure 49: Overall MCDA performance for the Inner Harbour Basin

4.2 The False Creek Basin

4.2.1 Characterization of the False Creek Basin

The False Creek Basin is a highly urbanized area located in the center of the city, comprising the Yaletown, Strathcona, Mount Pleasant, Fairview, Shaughnessy, South Cambie and Riley Park neighbourhoods, as well as Senakw. The population is expected to grow by 110% by 2075, along with significant growth in the commercial and institutional sectors. The False Creek Basin is a microcosm of the larger city, with a broad range of land uses all coexisting within a constrained urban environment.



FALSE CREEK BASIN
BY THE NUMBERS

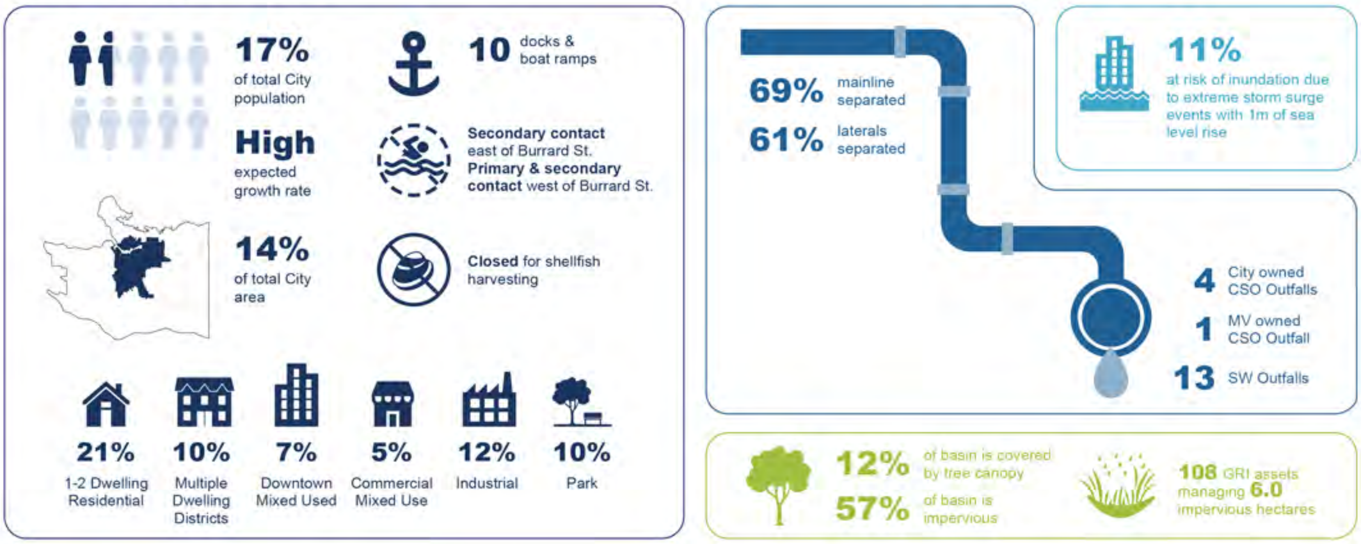


Figure 50: Gestalt Map and summary statistics for the False Creek basin

It has significantly lower tree canopy coverage compared to the citywide average, and despite its proximity to False Creek, poor water quality limits primary access. Key challenges in this basin include urban heat, groundwater issues, and flooding related to rainfall.

Sanitary sewage drains to the Metro Vancouver-operated 8th Avenue Interceptor, which continues west through the Outer Harbour Basin and then south to the Iona Island Wastewater Treatment Plant. Significant reductions in CSOs have already been achieved in this area through sewer separation work and the operation of the Yukon Gate control structure on the 8th Avenue Interceptor to restrict flows from the Inner Harbour.

Figure 50 provides an illustrative description of the False Creek basin. Key issues to be addressed include:

Water Quality	False Creek is popular for recreational activities (e.g., Dragon Boat Festival) and has seen ecosystem improvements in recent years (e.g., the return of herring and other aquatic species). It takes approximately seven days for this water body to flush, making it particularly vulnerable to CSOs as well as TSS from separated stormwater.
Watershed Health	Areas of this basin, including downtown, False Creek, and the Broadway corridor, are highly urbanized with increasing impervious surfaces. Much of this basin also has a history of heavy industrial use, resulting in ground contamination that must be considered in infrastructure planning.

Risk and Uncertainty	Flood plain areas have experienced flooding in recent years, with risks significantly elevated when atmospheric river events coincide with high tides and a rapidly increasing population. The False Creek Flats area, extending east towards Clark Drive, is also at risk from future sea level rise and includes the site of the new St. Paul's Hospital (under development) as well as critical rapid transit and electrical infrastructure. The soils in this area are also more vulnerable to seismic events, which is a potential consideration for infrastructure planning and design. Historically False Creek extended eastwards to near Clark Drive and was fed by several now-buried and culverted streams.

Appendix D provides a comprehensive summary of basin characterization information for the False Creek and other basins.

4.2.2 Healthy Waters Plan for the False Creek Basin

Figure 51 summarizes the Healthy Waters Plan Pathway for the False Creek basin, which would utilize approximately 17% of the citywide funding envelope.

PATHWAY OPTION HIGHLIGHTS

Sewer and Drainage Network	Cost	% Separated
Complete separation	$301.8 M (100% public)	~100% separated by 2075*
+ Renewal and Rehab	$254.7 M (100% public)	

Green Rainwater Infrastructure	Cost (public / private)	Area Managed	
Floodable Wetlands & Public Spaces	$76.7 M (75% / **21%**)	55 ha	7% of max
Blue Green Corridors in Public ROW	$78.8 M (76% / **24%**)	20 ha	28% of max
Green Streets in Public ROW	$55.2 M (81% / **19%**)	20 ha	4% of max
Vegetated Rainwater Channel – 500m	$4.6 M (100% public)		

Policies	Cost (public / private)	Area Managed	
Private Downspout Disconnect - Retrofit	$2.5 M (30% / **70%**)	19 ha	
Public Downspout Disconnect - Retrofit	$0.3 M (100% public)	11 ha	
24mm Retention - Redevelopment	$1,703.7 M (**100% private**)	~6,200 lots	55% of lots

Grey Infrastructure	Cost	Treatment Rate/Capacity/#
Grey Stormwater Treatment	$42.9 M (100% public)	675 L/s
New Drainage Pump Stations & Tide Gates	$39 M (100% public)	5 Pump Stations

* False Creek is separated 100% to point of diminishing returns

Figure 51: Healthy Waters Plan Option highlights - False Creek

Highlights include:

100% Separation of the Sewer Network by 2075 (Figure 52): Pathways analysis also considered using CSO rapid treatment and storage for this area, but it was determined that land uses and available space would make siting very difficult. Additionally, the Terminal and Downtown catchments are already at or very near fully separated, the remaining catchment, Cambie/Heather, has almost 60% of mainline sewers separated.

It is also recommended that tight pipe solutions be evaluated as part of sewer separation studies for this area, to reduce reliance on drainage pump stations which will be needed in response to sea level rise, and to reduce flooding risk to the extensive lowland areas of this basin.

Figure 52: False Creek basin at 100% effective separation in 2075 under the Healthy Waters Plan

Expanding the Public Area Managed with GRI: Compared to 6 ha today, the Healthy Waters Plan recommends using GRI to manage 95 ha of impervious area.

Ecosystem Health: This pathway will enhance the riparian area by 10,000 square metres and reduce impervious areas draining directly to the sewer system by 148 hectares. The use of in-line grey stormwater treatment devices will further reduce the volume of rainwater runoff pollutants entering False Creek.

Flood Policy for Redevelopment: This policy may reduce the population affected by extreme overland flooding by 50%. Additional actions will be necessary to protect the area from sea level rise, which is beyond the scope of this analysis.

4.2.3 Anticipated Performance Outcomes for the False Creek Basin

A summary of the performance of key indicators is provided below (Figure 53). See Appendix E for a more detailed assessment of the comparative performance of the Healthy Waters Plan for each basin.

Fecal Coliform: The Healthy Waters Plan is anticipated to nearly eliminate fecal coliform discharged from the sewer & drainage system into False Creek. Due to the completion of sewer separation in the False Creek Basin, the remaining fecal coliform is rainwater sourced.

TSS: Due to the completion of sewer separation in the False Creek Basin, the Healthy Waters Plan is anticipated to increase TSS discharged from the drainage system into False Creek by more than a third. However, the remaining TSS is rainwater sourced and much of that rainwater will be treated by GRI and Stormwater Treatment Devices.

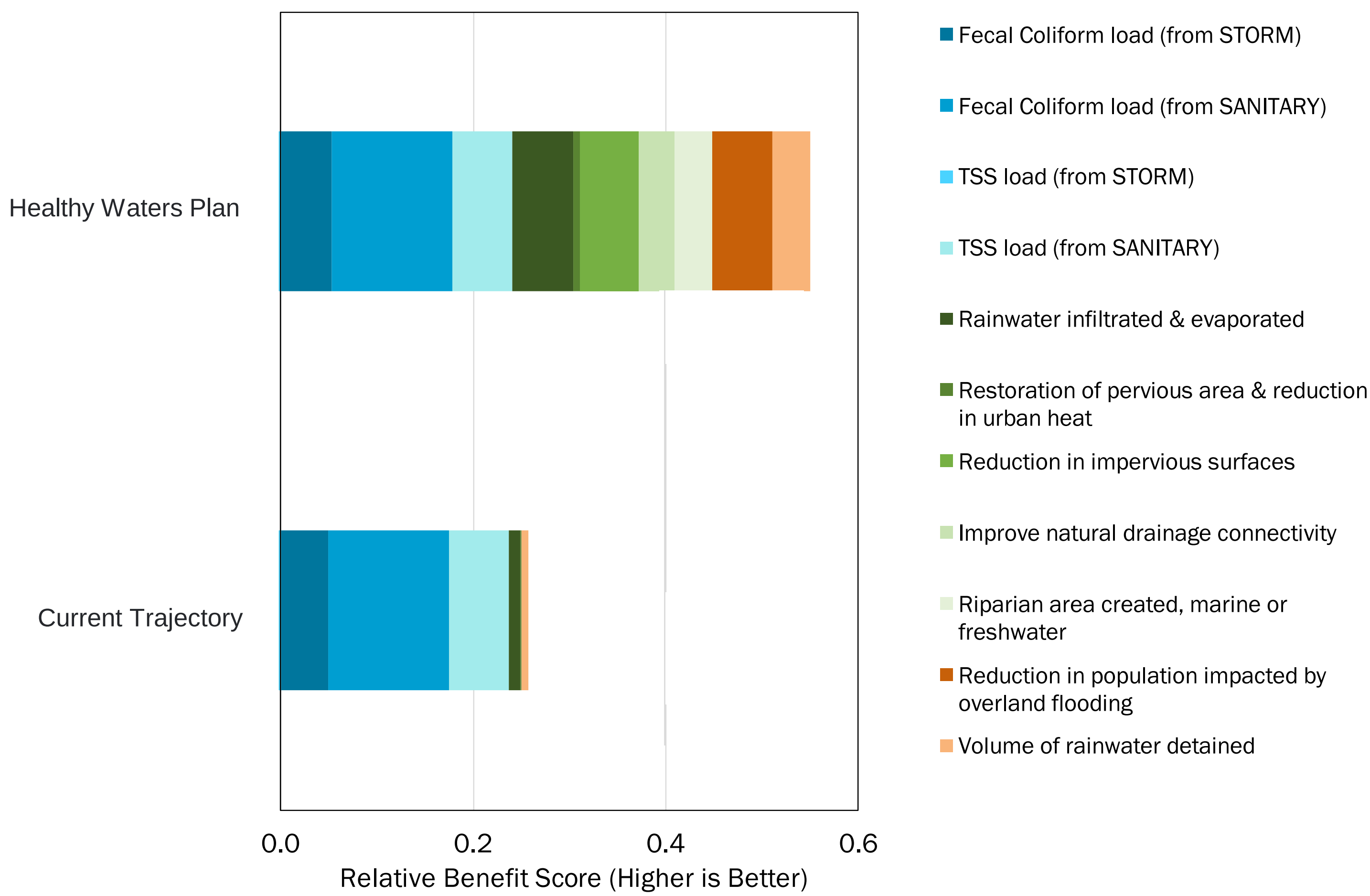
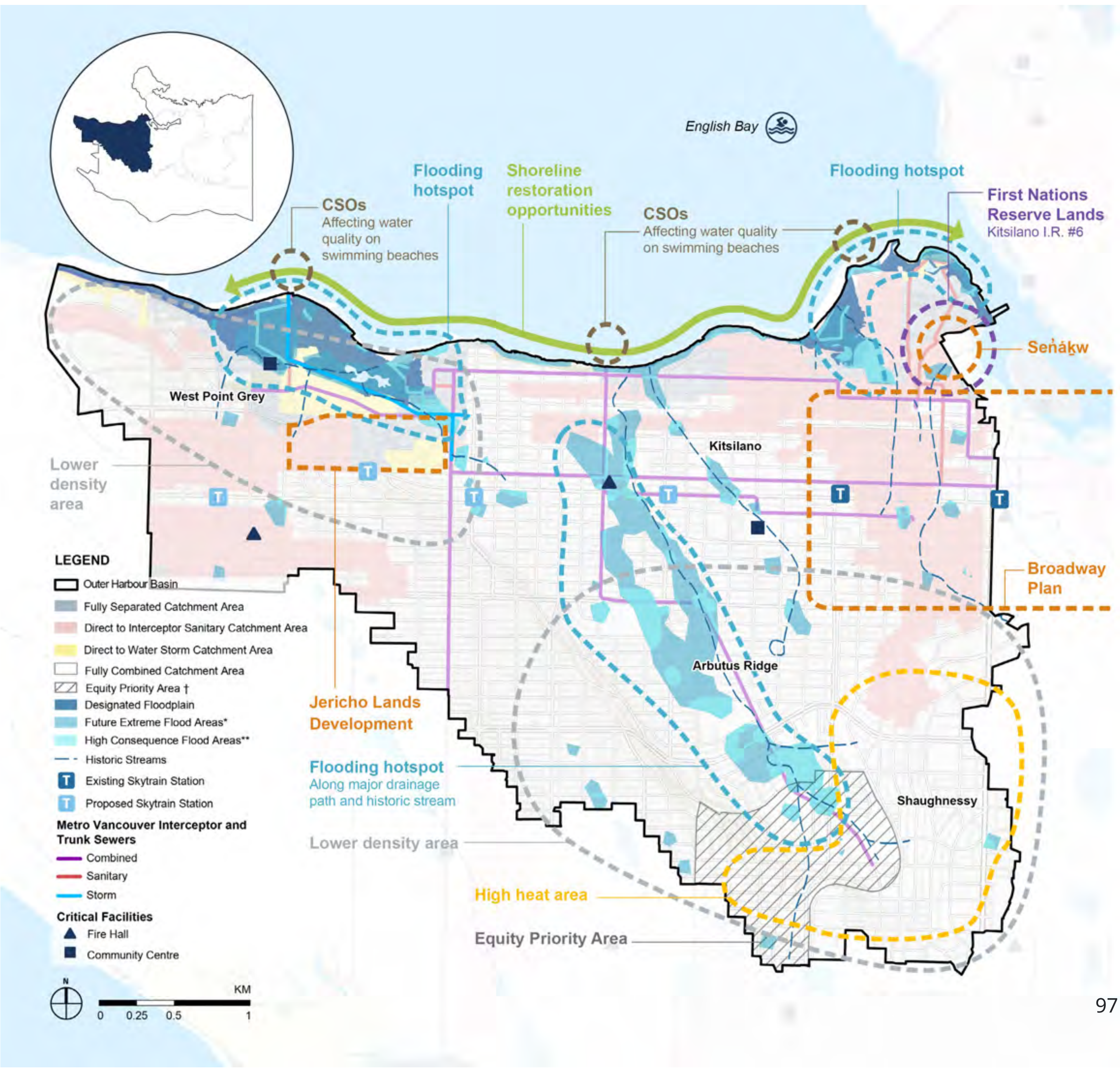


Figure 53: Overall MCDA performance for the False Creek Basin

4.3 The Outer Harbour Basin

4.3.1 Characterization of the Outer Harbour Basin

The Outer Harbour Basin is situated in the northwest quadrant of the city and comprised of the West Point Grey, Kitsilano, Arbutus Ridge, and portions of the Dunbar-Southlands and Shaughnessy neighbourhoods. The basin is primarily characterized by single-family residential areas and is home to Jericho Lands, a major First Nations-led development that will include 16,000 new units of transit-oriented housing. Currently, 15% of the city's population resides in Outer Harbour, with an expected growth of 136% by 2075.



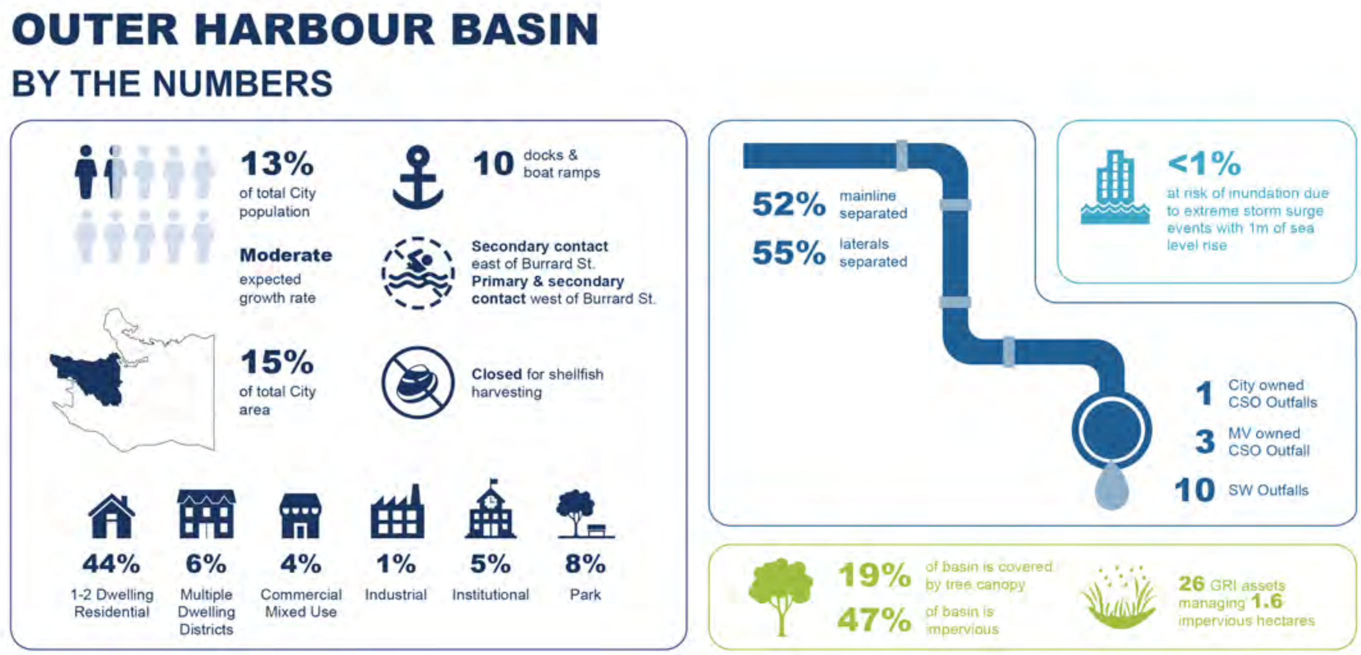


Figure 54: Gestalt Map and summary statistics for the Outer Harbour basin

Sanitary sewage in this area drains to both the Metro Vancouver 8th Avenue Interceptor and English Bay Interceptor, continuing to the Highbury Interceptor and then south to the Iona Island Wastewater Treatment Plant. Significant reductions in CSOs have been achieved over the years through sewer separation activities and the operation of the Yukon Gate control structure on the 8th Avenue Interceptor to restrict flows from the Inner Harbour.

Most of the City's swimming beaches are located in this basin, along with extensive First Nations cultural sites.

Figure 54 provides an illustrative characterization of the Outer Harbour Basin. Key issues to be addressed include:

Water Quality	This basin has the lowest frequency and volume of CSOs among the city's combined sewer basins. This is due to the operation of the Yukon Gate control structure on the Metro Vancouver 8th Avenue Interceptor, which cuts off flows east of Yukon Street to protect water quality at swimming beaches. TSS discharges in this area are also very low, as most rainwater is diverted to the Iona Island Wastewater Treatment Plant.
Watershed Health	This basin is the least urbanized in the city and boasts the largest tree canopy coverage among all basins. As a result, residents experience lower exposure to the urban heat island effects associated with climate change compared to other areas. There are extensive opportunities for shoreline restoration along its largely recreational and non-industrial waterfront.

Risk and Uncertainty	Areas of this basin are at elevated risk of flooding from extreme rainfall events and sea level rise.

Appendix D provides a comprehensive summary of basin characterization information for the Outer Harbour and other basins.

4.3.2 Healthy Waters Plan for the Outer Harbour Basin

Figure 55 summarizes the Healthy Waters Plan Pathway for Outer Harbour basin, which would utilize approximately 17% of the citywide funding envelope.

PATHWAY OPTION HIGHLIGHTS

Sewer and Drainage Network	Cost	% Separated	
Separation to point of diminishing returns	$445.3 M (100% public)	89% by 2075*	
+ Renewal and Rehab	$171.1 M (100% public)		

Green Rainwater Infrastructure	Cost (public / private)	Area Managed	
Floodable Wetlands & Public Spaces	$55.4 M (77% / **23%**)	31 ha	8% of max
Blue Green Corridors in Public ROW	$65.7 M (79% / **21%**)	17 ha	20% of max
Green Streets in Public ROW	$45.4 M (75% / **24%**)	18 ha	3% of max
Vegetated Rainwater Channel – 500m	$4.6 M (100% public)		

Policies	Cost (public / private)	Area Managed	
Private Downspout Disconnect – Retrofit	$9.0 M (30% / **70%**)	69 ha	
Public Downspout Disconnect – Retrofit	$0.2 M (100% public)	9 ha	
24mm Retention - Redevelopment	$1,489.9 M (**100% private**)	~6,100 lots	36% of lots

Grey Infrastructure	Cost	Treatment Rate/Capacity/#
CSO Tank	$160.4 M (100% public)	6,600m^3
Grey Stormwater Treatment	$9.7 M (100% public)	150 L/s
New Drainage Pump Stations & Tide Gates	$74 M (100% public)	7 Pump Stations

* Outer Harbour is separated 78% to point of diminishing returns +11% for asset renewal

Figure 55: Healthy Waters Plan Option highlights – Outer Harbour

Highlights include:

Prioritizing Bottom-Up Sewer Separation: Achieving effective separation rate of 78% of by 2075 (89% of mainline sewers including all renewals), with further separation continuing in the years that follow (Figure 56). A CSO storage facility could be implemented early in the Plan to significantly reduce sanitary and rainwater runoff loadings and free up capacity in the 8th Avenue Interceptor for flows from eastern basins during rainfall events. A comprehensive feasibility analysis is recommended to assess costs, benefits, risks, technology options, and other factors.

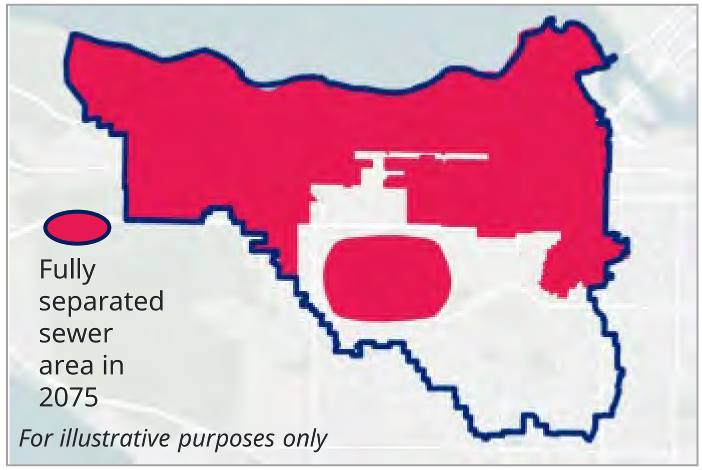


Figure 56: Outer Harbour basin at 78% effective separation in 2075 under the Healthy Waters Plan

An Adaptive Pathways approach is also needed to achieve 100% separation before 2075 if CSO storage is not feasible or cannot progress. In addition to the $445 million allocated for bottom-up separation, $171 million has been allocated to renew and rehabilitate upstream sewers that are at the end of their life.

It is also recommended that tight pipe solutions be evaluated as part of sewer separation studies for this area, to reduce reliance on drainage pump stations which will be needed in response to sea level rise, and to reduce flooding risk to lowland areas of this basin around Jericho and Kitsilano beaches.

Expanding the Public Area Managed with GRI: Compared to 1.6 ha today, the Healthy Waters Plan recommends using GRI to manage 66 ha of impervious area.

Ecosystem Health: This will enhance the riparian area by 5,000 square metres and reduce impervious areas draining directly to the sewer system by 146 hectares. The GRI investments in this area are lower than in other basins due to the relatively high amount of tree canopy and greenspace already present in the basin. Additionally, in-line grey stormwater treatment devices will be used to help reduce rainwater runoff pollutants entering the Outer Harbour.

Flood Policy for Redevelopment: This policy may reduce the population affected by extreme overland flooding by 65%.

4.3.3 Anticipated Performance Outcomes for the Outer Harbour Basin

A summary of the performance of key indicators is provided below (Figure 57). See Appendix E for a more detailed assessment of the comparative performance of the Healthy Waters Plan for each basin.

Fecal Coliform: The Healthy Waters Plan is anticipated to nearly eliminate fecal coliform discharged from the sewer & drainage system into the Outer Harbour. The remaining fecal coliform is rainwater sourced.

TSS: Due to the advancement of sewer separation in the Outer Harbour Basin, the Healthy Waters Plan is anticipated to modestly increase TSS discharged from the drainage system into the Outer Harbour. However, the remaining TSS is rainwater sourced and much of that rainwater will have been treated by GRI

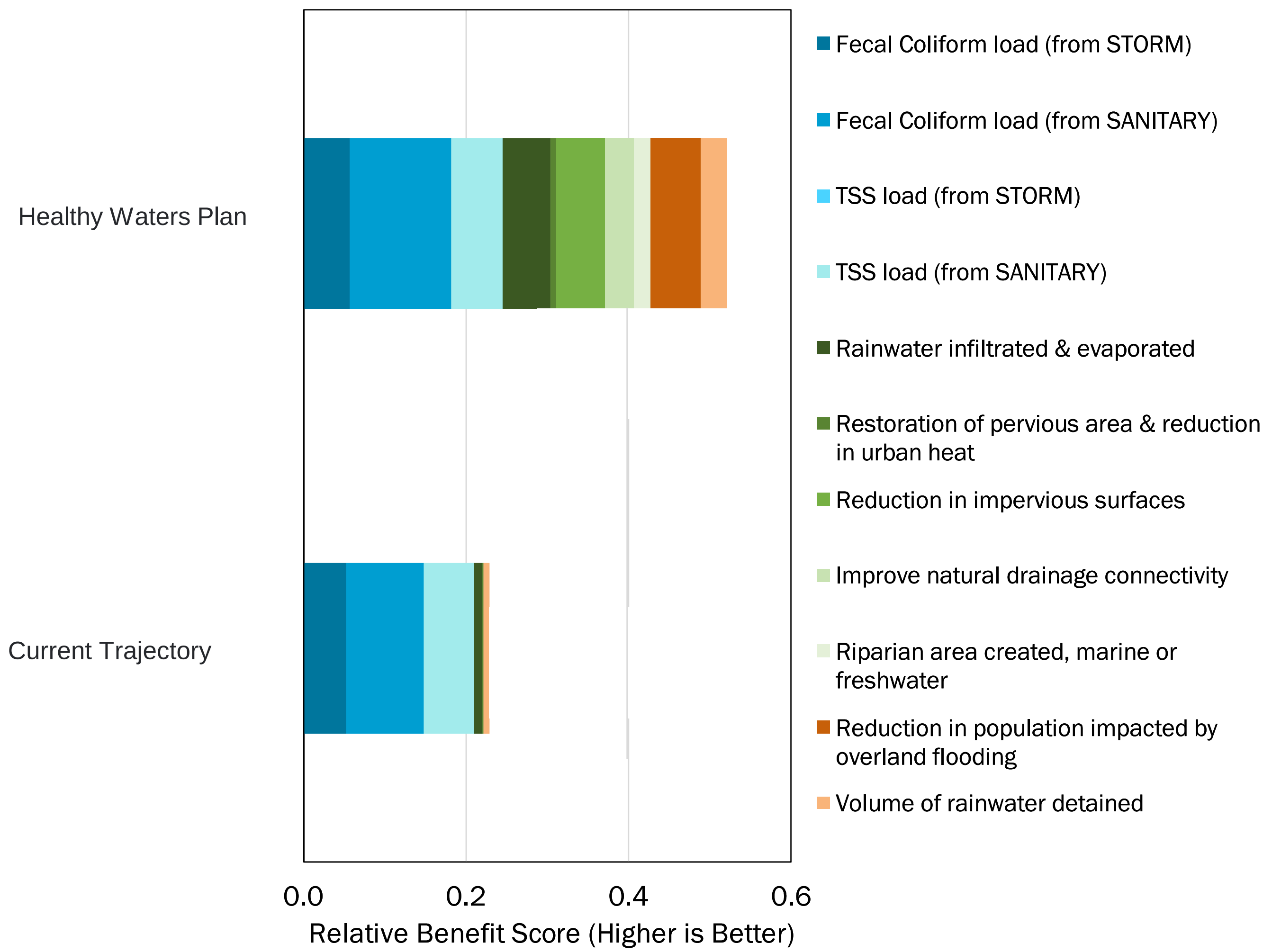
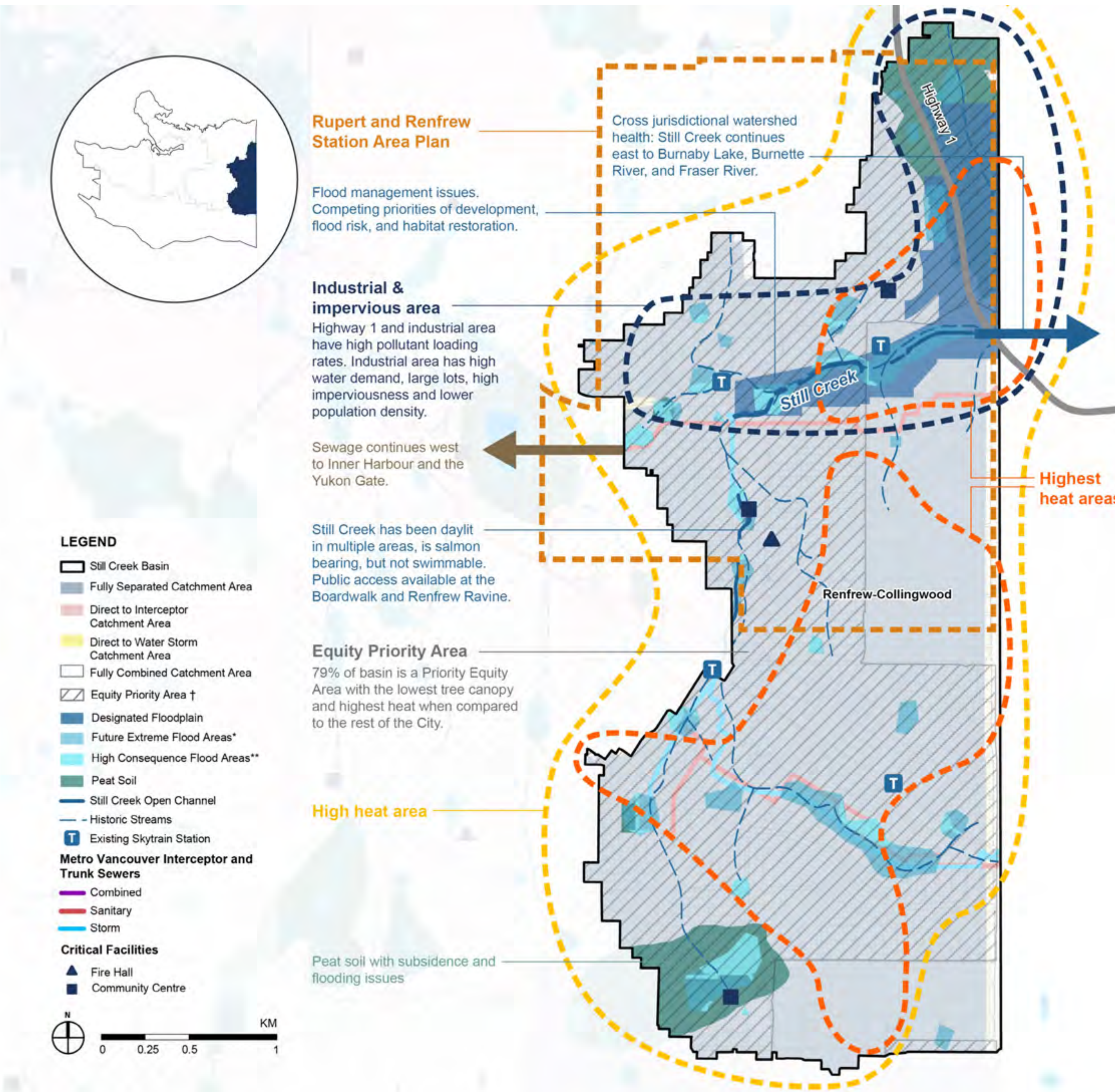


Figure 57: Overall MCDA performance for the Outer Harbour Basin

4.4 The Still Creek Basin

4.4.1 Characterization of the Still Creek Basin

The Still Creek basin, located in the east part of the city bordering Burnaby, is the smallest of all the basins and is comprised of the Renfrew-Collingwood and portions of the Hastings-Sunrise & Killarney neighbourhoods. Most of the basin is residential, with commercial and light industrial uses generally in and adjacent to flood plain areas. As the most recently developed area of the city, it started with a separated sewer system, with minor elements functioning as combined.



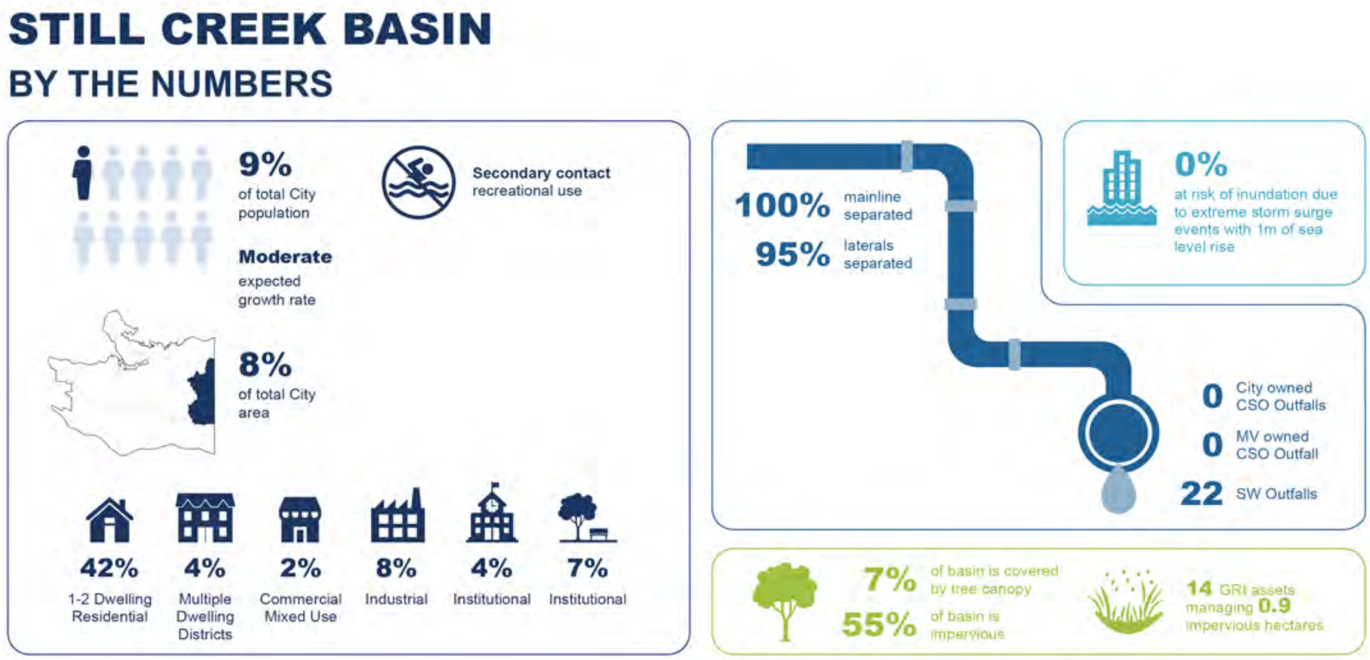


Figure 58: Gestalt Map and summary statistics for the Still Creek basin

There is approximately 2 km of open creek channel that serves as the drainage conveyance pathway for the basin. As one of the last remaining open channel creeks in Vancouver providing aquatic habitat (including salmon), Still Creek is unique. Still Creek has the smallest population and is expected to grow by approximately 40% by 2075, a lower rate compared to other basins. However, it includes three rapid transit stations anticipated to see high-density redevelopment.

Large portions of the basin have overlapping socioeconomic vulnerabilities, intersecting with the highest urban heat areas and the lowest tree canopy coverage in the city. The Rupert & Renfrew station area Plan aims to address some of these vulnerabilities.

Figure 58 provides an illustrative characterization of the Still Creek basin. Key issues to be addressed include:

Water Quality	While the local sewer system in this area is separated, sanitary sewage is directed to the combined Metro Vancouver 8th Avenue Interceptor and overflows into the Inner Harbour when the Yukon Gate control structure is closed. Investigative work has also been ongoing to identify illegal combined and sanitary property cross-connections that likely contribute to fecal coliform contamination in Still Creek. Rainwater runoff pollution also poses a risk to the salmon that spawn in Still Creek.
Watershed Health	The Still Creek Basin has a high proportion of impervious surfaces, matching levels in the Inner Harbour and False Creek Basins. It also has the smallest tree canopy and highest exposure to urban heat of any basin. It also includes one of the only open channel creeks in the city with associated habitat areas adjacent to the creek.

Risk and Uncertainty	Flooding risks in Still Creek have been identified through preliminary high-level modeling, and flooding is expected to worsen in the future. This risk is magnified in lower areas of the watershed that extend into Burnaby.

Appendix D provides a comprehensive summary of basin characterization information for the Outer Harbour and other basins.

4.4.2 Healthy Waters Plan for the Still Creek Basin

Figure 59 summarizes the Healthy Waters Plan Pathway for Still Creek basin, which would utilize approximately 9% of the citywide funding envelope.

PATHWAY OPTION HIGHLIGHTS

Sewer and Drainage Network	Cost	% Separated
Complete separation	$0.7 M (100% public)	~100% separated by 2075
+ Renewal and Rehab	$329.2 M (100% public)	

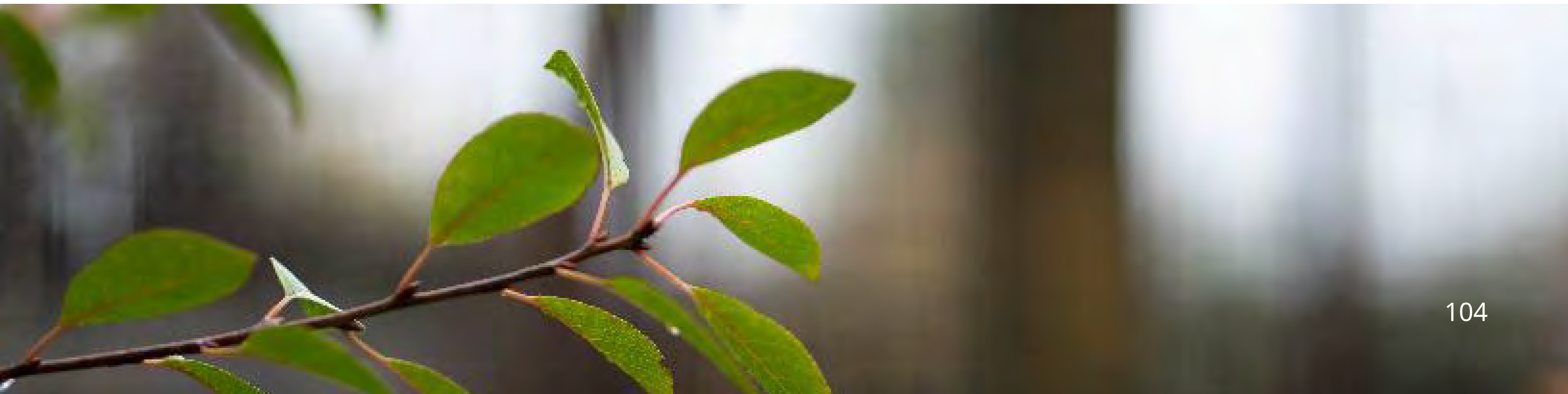
Green Rainwater Infrastructure	Cost (public / private)	Area Managed	
Floodable Wetlands & Public Spaces	$43.2 M (79% / **21%**)	30 ha	7% of max
Blue Green Corridors in Public ROW	$46 M (75% / **25%**)	12 ha	41% of max
Green Streets in Public ROW	$25.7 M (79% / **21%**)	10 ha	4% of max
Waterway Restoration & Vegetated	$3.6 M (100% public)		
Rainwater Channel ~ 2km	$16.7 M (100% public)		

Policies	Cost (public / private)	Area Managed	
Private Downspout Disconnect – Retrofit	$8.4 (30% / **70%**)	64 ha	
Public Downspout Disconnect – Retrofit	$0.2 M (100% public)	9 ha	
24mm Retention - Redevelopment	$511.6 M (**100% private**)	~2,000 lots	19% of lots

Grey Infrastructure	Cost	Treatment Rate
Grey Stormwater Treatment	$12.7 M (100% public)	200 L/s

* Still Creek is separated 100% to point of diminishing returns

Figure 59: Healthy Waters Plan Option highlights – Still Creek



Highlights include:

Renewal and Rehabilitation: Addressing end-of-life assets in the separated sewer network, along with minor works to address combined assets and the investigation and elimination of cross-connections to Still Creek (Figure 60).

Expanding the Public Right of Way Area Managed with GRI: Increasing this area from 10 hectares to nearly 52 hectares, removing 48 hectares of impervious surfaces,

Ecosystem Health: This will enhance 9,000 square metres of riparian area. Additionally, in-line grey stormwater treatment devices will be used to help reduce rainwater runoff pollutants entering Still Creek, supporting critical salmon habitat improvement work.

Flood Policy and 24 mm Rainwater Retention Policy for Redevelopment: Implementing these policies to enhance flood resilience and manage rainwater effectively.

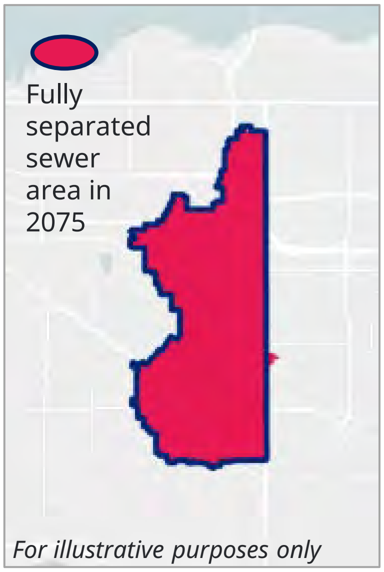


Figure 60: Still Creek basin at 100% separation in 2075 under the Healthy Waters Plan

4.4.3 Anticipated Performance Outcomes for the Still Creek Basin

A summary of the performance of key indicators is provided below (Figure 61). See Appendix E for a more detailed assessment of the comparative performance of the Healthy Waters Plan for each basin.

Fecal Coliform: Given the advanced level of sewer separation already in the Still Creek Basin, fecal coliform loads will continue to remain low.

TSS: The Healthy Waters Plan is anticipated to further reduce TSS pollution through the use of stormwater treatment devices and GRI.

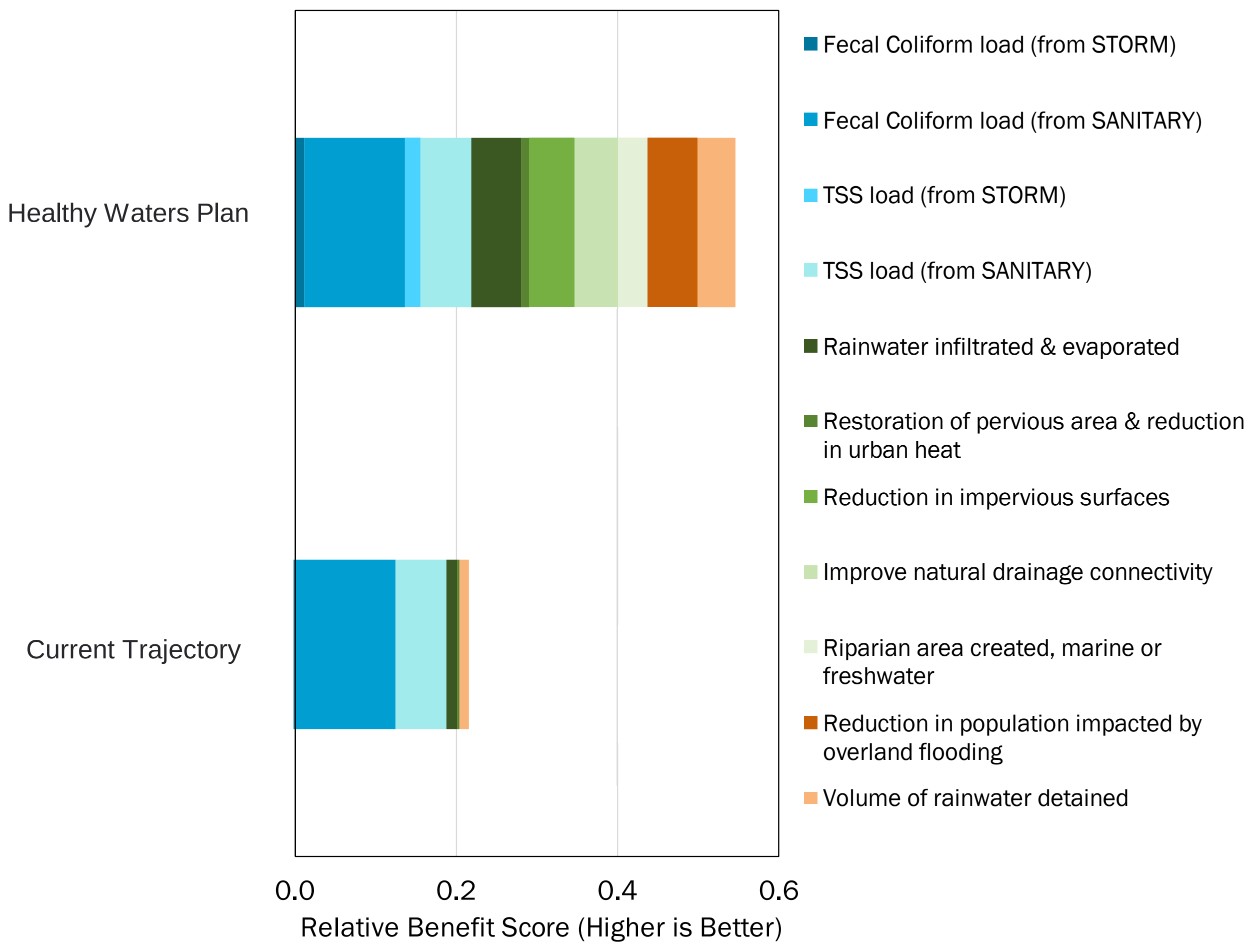
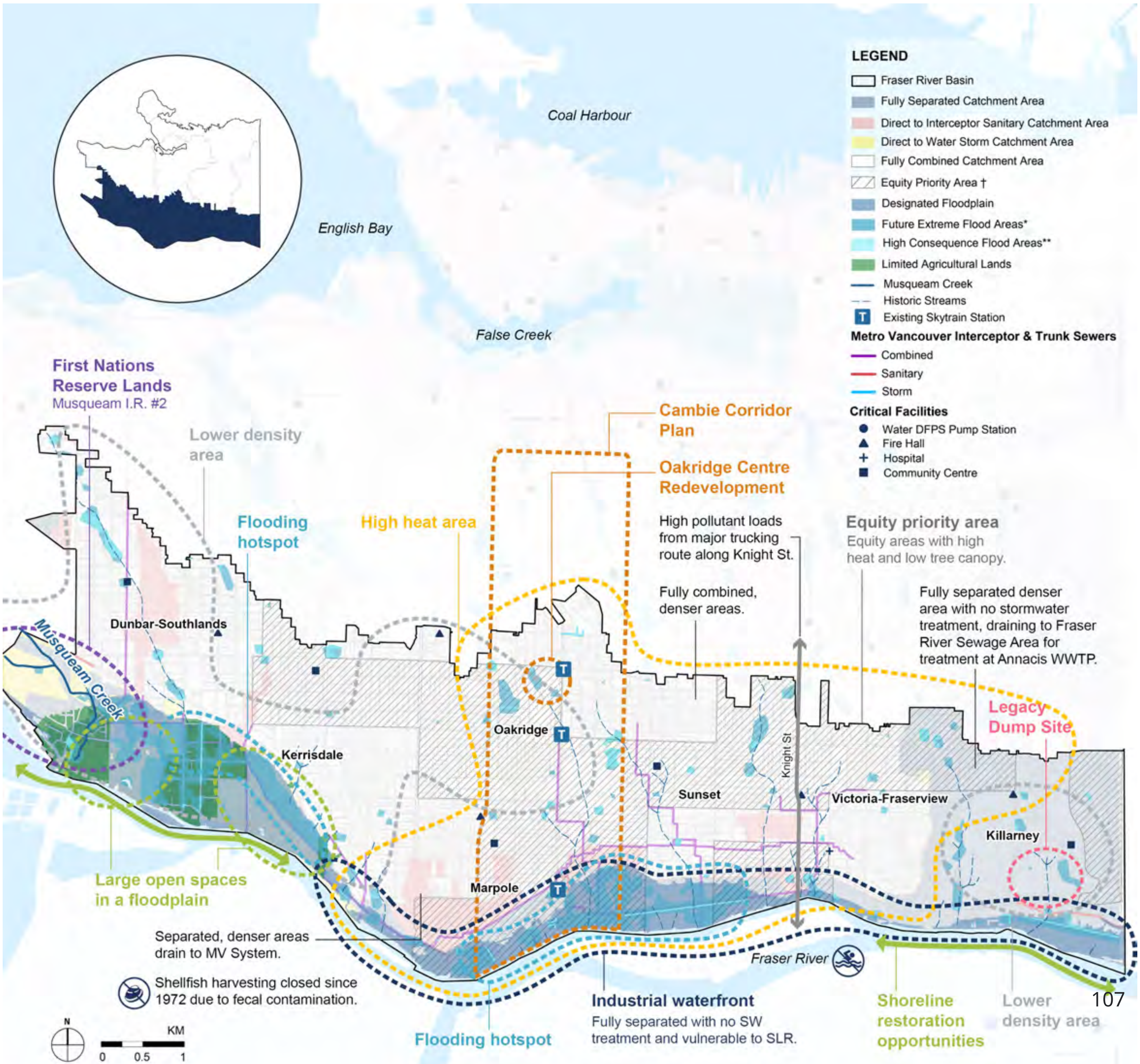


Figure 61: Overall MCDA performance for the Still Creek basin

4.5 The Fraser River Basin

4.5.1 Characterization of the Still Creek Basin

Covering the southern half of the city, the Fraser River basin is the largest basin in Vancouver, and comprises the Marpole, Kerrisdale, Oakridge, Sunset, Victoria-Fraserview, Champlain Heights and large portions of the Dunbar-Southlands & Killarney neighbourhoods. It has a lower population density compared to most of the city. However, significant growth is expected, particularly in the River District, Oakridge, and Cambie Corridor areas, with a 104% population growth forecast by 2075.



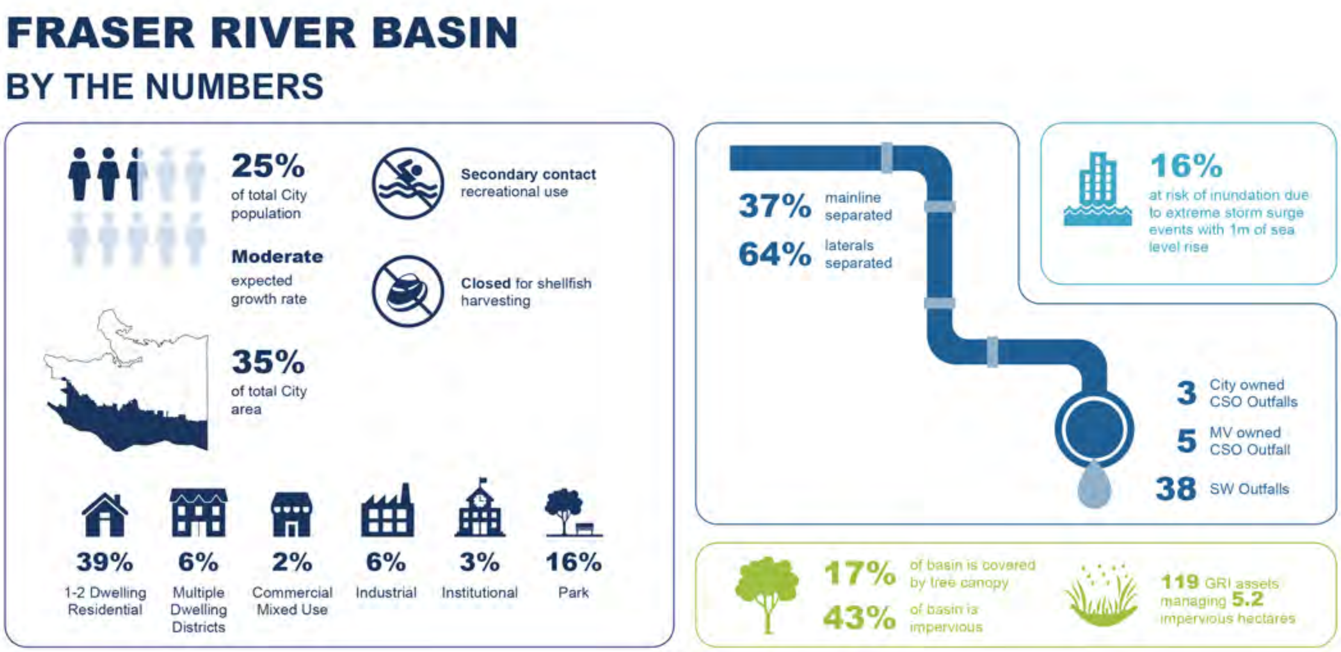


Figure 62: Gestalt Map and summary statistics for the Fraser River basin

Residential land uses dominate this basin, except for the extensive industrial and port lands located on the Fraser River Flood Plain between Granville Street and Argyle Street.

The xʷməθkʷəy̓əm primary reserve area (Musqueam 2) is in the southwest portion of the basin, with Musqueam Creek flowing through it. The basin is socioeconomically diverse, with large portions experiencing overlapping socioeconomic vulnerability, higher urban heat, and lower tree canopy coverage.

Figure 62 provides an illustrative characterization of the Fraser River basin. Key issues to be addressed include:

Water Quality	This basin drains into the North Arm of the Fraser River, a vital salmon-bearing waterway. Musqueam Creek, an essential habitat for salmon spawning, holds significant cultural value for the Musqueam Nation. Rainwater runoff from the basin's low-lying industrial areas is already separated from the sewer system and discharges without treatment into the Fraser River. Much of the basin is functionally combined, with some sanitary connections from separated properties discharging directly to Metro Vancouver interceptors. Unlike the other basins in the city, it does not compete for limited capacity in the Metro Vancouver 8th Avenue and Highbury interceptors. However, conveyance capacity within the basin is strained during larger storm events, and rainwater inflows impact the capacity and treatment effectiveness of the Iona Island WWTP.

Watershed Health	The Fraser River Basin has the second highest tree canopy cover among the basins. It also has less impervious surface area compared to other basins. However, a high proportion of this basin is exposed to urban heat, which intersects with populations
Risk and Uncertainty	Low-lying areas of this basin are particularly vulnerable to flooding from sea level rise and extreme weather events. Frequent flooding is exacerbated by the limited diking along the Fraser River, putting the Musqueam Indian Band at significant risk. Future shoreline protection efforts will need to be paired with investments in drainage pump stations and tide gates to mitigate these challenges effectively.

Appendix D provides a comprehensive summary of basin characterization information for the Outer Harbour and other basins.

4.5.2 Healthy Waters Plan for the Fraser River Basin

Figure 63 summarizes the Healthy Waters Plan Pathway for Fraser River basin, which would utilize approximately 33% of the citywide funding envelope.

PATHWAY OPTION HIGHLIGHTS

Sewer and Drainage Network	**Cost**	**% Separated**	
Separation to point of diminishing returns	$1,122.7 M (100% public)	~88% separated by 2075	
+ Renewal and Rehab	$379.3 M (100% public)		
Green Rainwater Infrastructure	**Cost (public / private)**	**Area Managed**	
Floodable Wetlands & Public Spaces	$192.3 M (77% / **23%**)	110 ha	5% of max
Blue Green Corridors in Public ROW	$154.8 M (76% / **24%**)	40 ha	20% of max
Green Streets in Public ROW	$102.3 M (79% / **21%**)	40 ha	4% of max
Vegetated Rainwater Channel – 1km	$9.3 M (100% public)		
Policies	**Cost (public / private)**	**Area Managed**	
Private Downspout Disconnect – Retrofit	$25 M (30% / **70%**)	184 ha	
Public Downspout Disconnect – Retrofit	$0.4 M (100% public)	16 ha	
24mm Retention - Redevelopment	$2,617.2 M (**100% private**)	~10,400 lots	35% of lots
Grey Infrastructure	**Cost**	**Treatment Rate**	
CSO Rapid Treatment Facility	$179.3 M (100% public)	6,000 L/s	
Grey Stormwater Treatment	$19.4 M (100% public)	300 L/s	
New Drainage Pump Stations & Tide Gates	$275 M (100% public)	19 Pump Stations	

* Fraser River is separated 77% to point of diminishing returns + 12% for asset renewal

Figure 63: Healthy Waters Plan Option highlights – Fraser River

Highlights include:

Prioritizing Bottom-Up Sewer Separation: Achieving effective separation rate of 77% by 2075 (88% of mainline sewers including all renewals), with further separation continuing in later years (Figure 64). A CSO rapid treatment facility will be implemented early in the Plan to achieve more rapid reductions in sanitary and rainwater runoff loadings compared to a separation-only approach to CSO elimination. A comprehensive feasibility analysis is recommended to assess costs, benefits, risks, technology options, and other factors. An Adaptive Pathways Plan is also needed to achieve 100% separation before 2075 if CSO rapid treatment is not feasible or cannot progress. In addition to the $1.1 billion allocated for bottom-up separation, $390 million has been allocated to renew and rehabilitate upstream sewers that are at the end of their life.

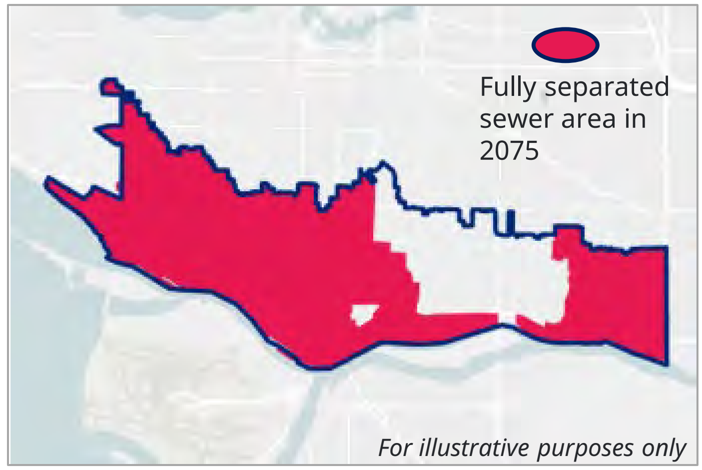


Figure 64: Fraser River basin at 77% effective separation in 2075 under the Healthy Waters Plan

It is recommended that tight pipe solutions be evaluated as part of sewer separation studies for this area, to reduce reliance on drainage pump stations which will be needed in response to sea level rise, and to reduce flooding risk to the extensive lowland areas of this basin.

Expanding the Public Right of Way Area Managed with GRI: Compared to 5.2 ha today, the Healthy Waters Plan recommends using GRI to manage 190 ha of impervious area.

Ecosystem Health: This will enhance the riparian area by 10,000 square metres and reduce impervious areas draining directly to the sewer system by 250 hectares. Additionally, in-line grey stormwater treatment devices will be used to help reduce rainwater runoff pollutants entering the Fraser River.

Flood Policy for Redevelopment: This policy may reduce the population impacted by overland flooding from extreme rainfall by up to 50%. Drainage pump stations and tide gates, in conjunction with shoreline protection measures, investments in large green facilities, and sewer renewal, will also help reduce flooding risk in flood plains and areas exposed to overland flooding.

4.5.3 Anticipated Performance Outcomes for the Fraser River Basin

A summary of the performance of key indicators is provided below (Figure 65). See Appendix E for a more detailed assessment of the comparative performance of the Healthy Waters Plan for each basin.

Fecal Coliform: The Healthy Waters Plan is anticipated to nearly eliminate fecal coliform discharged from the sewer & drainage system into the Fraser River. Due to the advancement of sewer separation and potential introduction of CSO rapid treatment, the remaining fecal coliform is largely rainwater sourced.

TSS: The Healthy Waters Plan is anticipated to increase TSS discharged from the drainage system into the Fraser River by more than a third. However, the remaining TSS is rainwater sourced and much of that rainwater will been treated by GRI. The CREF will be used in Phase 3 to better understand the impacts of this TSS loading.

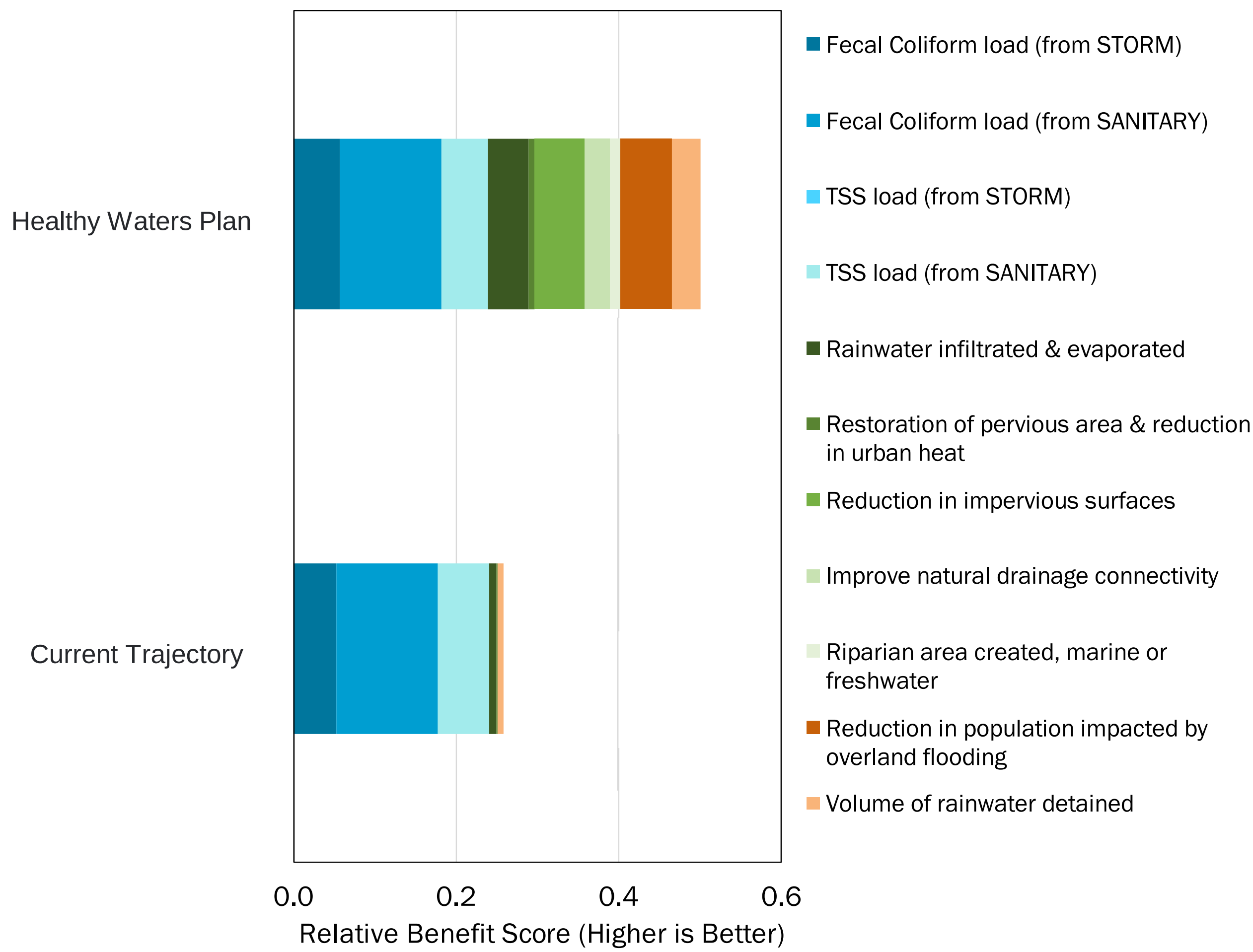


Figure 65: Overall MCDA performance for the Fraser River basin

5. LOOKING AHEAD TO PHASE 3

Phase 3 will build on the Key Directions established in Phase 2. This will include development of an adaptive implementation plan which prioritizes investments across the city, establishes a financial strategy, and defines source control measures. It will also include performance targets to guide watershed planning along with a monitoring plan. Additionally, Phase 3 will also require feasibility analysis for CSO rapid treatment facilities and opportunities identified for further exploration and identify recommended changes to the LWMP for a future amendment application (Figure 66).

Figure 66: Scope of work for Phase 3

5.1 An Adaptive Implementation Plan

The final Plan developed in Phase 3 will outline the overall sequencing of investments across the city. This will begin with the creation of a prioritization framework, which will consider ecosystem and public health risks (informed by CREF analysis, see example in Figure 67), reconciliation and equity objectives. asset condition, and risks including flooding and seismic events.

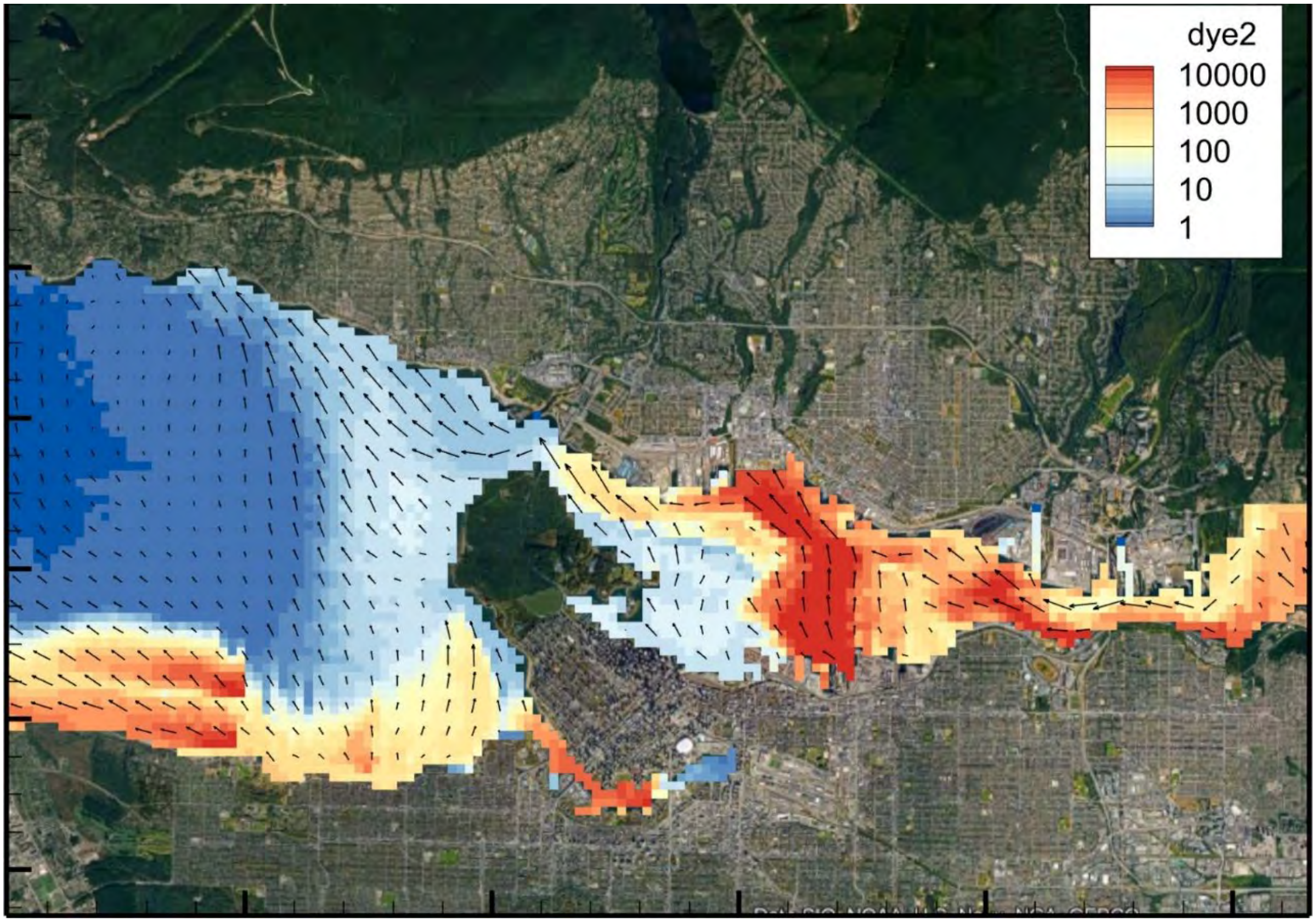


Figure 67: Use of hydrodynamic modelling with CREF to assist with prioritization framework

Further to this, a value-for-money analysis will be conducted to determine the costs and pollution-elimination benefits of completing sewer separation for each catchment within each of the five basins. Upon completion, critical investment needs will be identified for the upcoming Public Infrastructure Investment Framework and future capital plans. The primary objective is to maximize value of investments, addressing the critical needs of environmental protection, livability, and affordability.

An Adaptive Pathways approach will be used for this work (Figure 68). This will provide a framework for future plan adjustments, considering factors such as:

The outcomes of feasibility studies	Future rainfall uncertainty	Improvements in monitoring information or modeling tools	Uncertainty related to future population growth and development

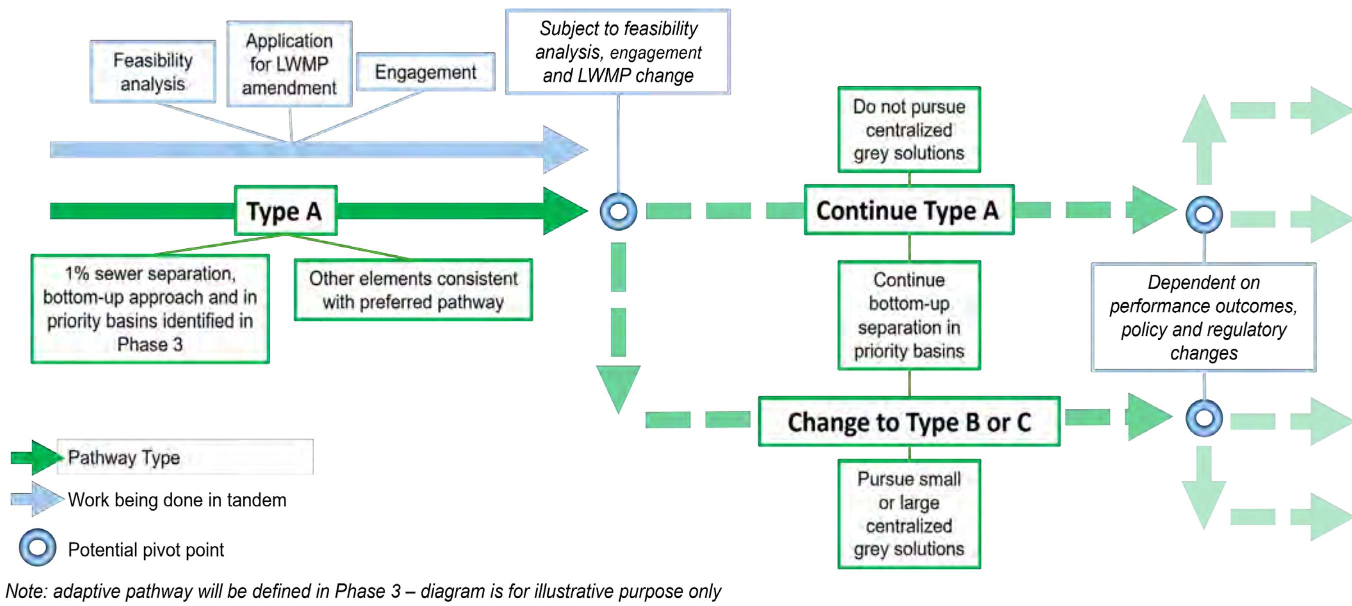


Figure 68: An Adaptive Pathways approach to address uncertainty

An Adaptive Implementation Plan will need to allow for adjustments and re-prioritization as new information becomes available. To guide implementation, key performance indicators and targets will be established at both city and basin levels. Projects and detailed watershed planning efforts will be guided by these targets and the Healthy Waters Plan prioritization framework.

The Plan will also need to consider the capacity of the organization to deliver projects. This includes accounting for time needed to increase resources for designing, constructing and managing projects necessary to achieve the recommended enhanced approach to sewer separation.

5.2 Feasibility Studies

Feasibility analysis will be required in parallel with Phase 3 works, impacting the Adaptive Implementation Plan:

CSO Rapid Treatment and Storage: CSO rapid treatment offers the potential opportunity to reduce pollutant loading on a more rapid timeline and has strong synergies with a bottom-up approach to sewer separation. Feasibility analysis is needed to evaluate technology options, siting constraints, costs, risks, impacts to the Iona WWTP and other factors for CSO rapid treatment facilities in the Inner Harbour and Fraser River Basins, as well as CSO storage in the Outer Harbour. If the outcome is positive, the City and Metro Vancouver will need to further evaluate roles for ownership and operations, and extensive community engagement would be required before implementation. If CSO rapid treatment and storage is deemed infeasible, the Preferred Pathway will need to achieve 100% sewer separation by 2075.

Approach for Proactive Separation of Combined Connections: Phase 2 has determined that relying solely on redevelopment to separate property connections will be insufficient to achieve CSO elimination within the desired timeline. Feasibility analysis will be needed to define how to proactively separate combined connections, considering regulatory and incentive approaches. This analysis will also consider full-scale separation (complete separation of private property plumbing and connection pipes) versus less intensive approaches (e.g., downspout disconnection, switching combined connections from storm mainline to sanitary mainline pipes[9]). In addition to defining the necessary investments, this work will also define necessary changes to relevant bylaws and policy.

Rainwater Management Policy for Redevelopment: Further feasibility analysis and stakeholder engagement are required to define lower-cost approaches to managing rainwater for redevelopment. This includes evaluating detention-tank-based options that protect local system capacity and address flooding and CSO risks. Additionally, further work will assess where the 24 mm retention policy may be implementable, as well as hybrid retention/detention approaches. This work will inform future changes to bylaws and development policy.

[9] Mitigating adjustments to downstream pipes would be required to prevent an increase in stormwater loading on Metro Vancouver interceptor pipes as well as to mitigate capacity impacts to downstream City sanitary sewers. In some areas of the city this may not be a viable solution.

5.3 Establishing Performance Targets and Monitoring

Phase 3 will focus on establishing performance targets that align with the Healthy Waters Plan Goal Areas and Objectives. These targets will be set on both a citywide and basin-specific basis and will serve to guide the subsequent detailed watershed planning work and will also be used to track our performance of investments, policies, and programs over time. Future assessments of system performance will rely on a structured monitoring program to track measurable aspects such as the frequency and volume of CSOs. For metrics that are challenging to assess through direct monitoring, such as pollutant loading within CSOs, the program will need to be supplemented by modeling analyses.

5.4 Source Control and Community Programs

Phase 3 will also define source control actions to address pollution at its source, acknowledging that green and grey infrastructure solutions cannot cost effectively remove all types of pollutants. This work will encompass public education programs, community stewardship initiatives, pollution prevention regulations, and advocacy to senior levels of government for the regulation of certain chemicals in the marketplace. An enhanced approach to street sweeping in separated sewer areas will also need to be defined.

5.5 Financial Strategy

The financial strategy will outline principles for the effective fiscal management of sewage and drainage assets incorporating key drivers such as demand, growth, asset age and condition, levels of service, affordability, and key risks. The strategy will also present funding requirements including funding sources and financing methods to manage investment timelines.

Major components of the financial strategy include identifying financial principles for sustainable planning of the sewage and drainage system that align with the City's Financial Sustainability Guiding Principles. The strategy will layout the plan included investment and regulatory approached and the expected their supporting funding sources. The supporting analysis will also consider the overall affordability of the system.

To support on-going financial planning, a pro-forma tool will be developed to provide both short- and long-range financial forecasts based on established criteria and targets, incorporating sensitivity and what-if analysis options. The Financial Strategy aims to ensure efficient and effective resource allocation, supporting the long-term sustainability and resilience of Vancouver's water resources.

5.6 Define Recommendations for the LWMP Amendment

As discussed in Section 3.5 the BC Ministry of Environment and Climate Strategy has communicated the procedural requirements for a future amendment to the LWMP. Based on the outcomes of the technical analysis within the Healthy Waters Plan, as well as input from First Nations, other municipalities, and the public, the City may apply for an amendment to the LWMP following the completion of Phase 3. Any changes will be subject to approval by GVS&DD Board and the BC Ministry of Environment and Climate Strategy. The implementation actions and Adaptive Pathways Plan defined in Phase 3 will need to address this aspect of regulatory uncertainty.

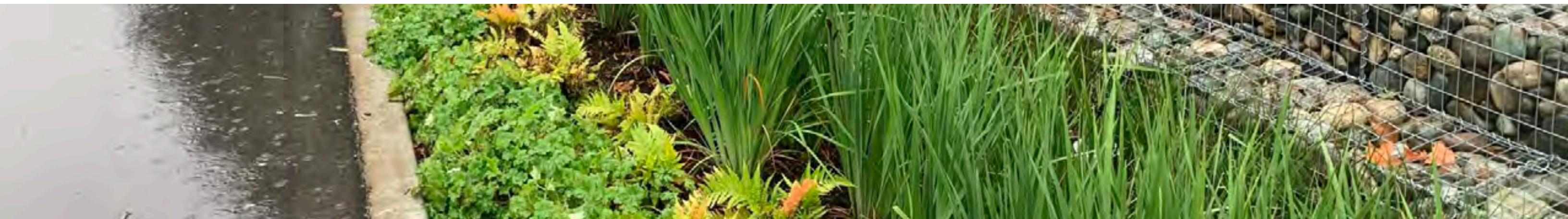
5.7 Integrate Recommendations from Other Initiatives

The UNDRIP Implementation Plan: Pollution to receiving waters and watershed health have both been raised as key issues within the UNDRIP implementation process, which must be addressed in the final Healthy Waters Plan.

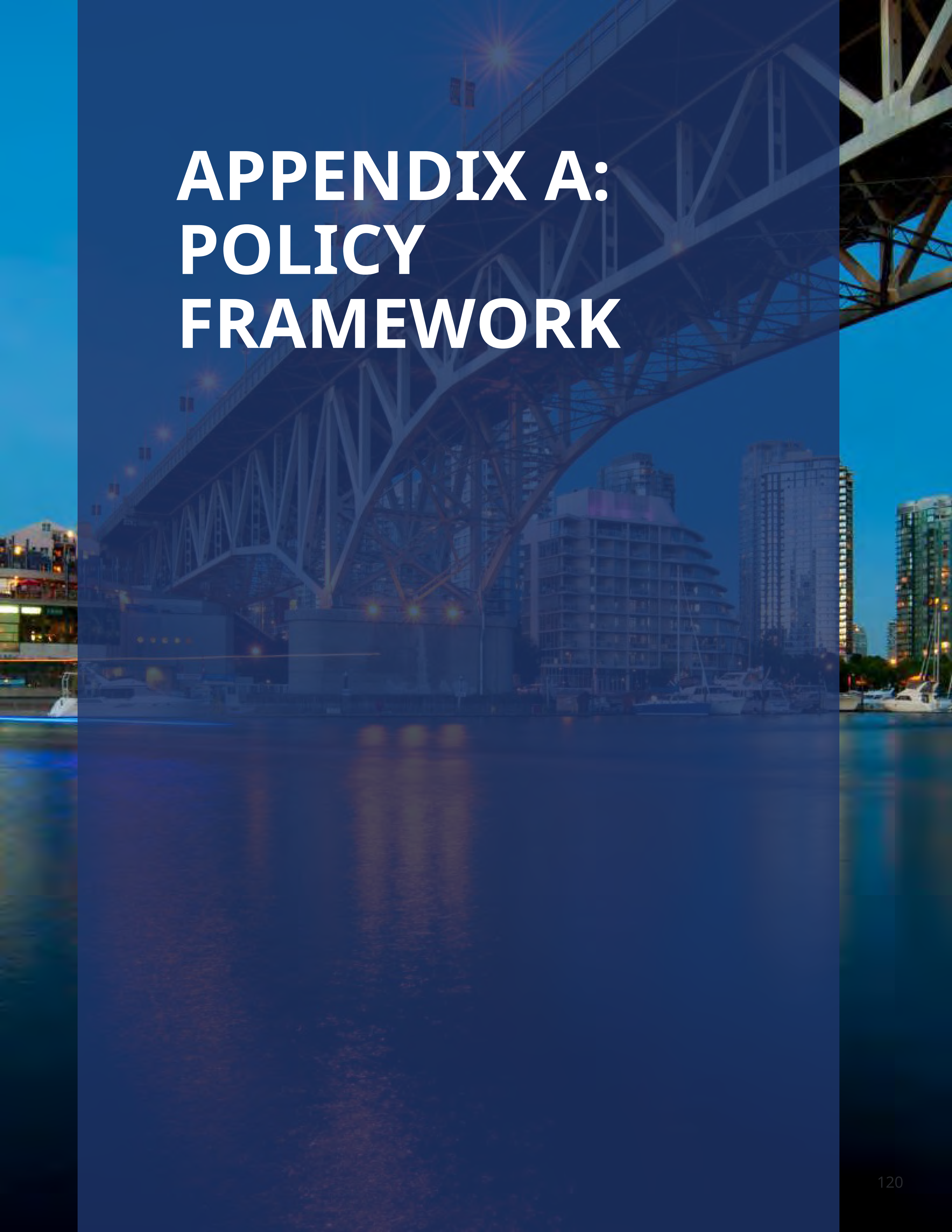
The Burrard Inlet Action Plan: Developed by the Tsleil-Waututh Nation, the Burrard Inlet Action Plan aims to improve water quality and ecosystem health in the Burrard Inlet through targeted pollution reduction and habitat restoration initiatives. The Healthy Waters Plan will reduce combined sewer overflows and enhance stormwater management, which is strongly aligned with BIAP's goals of reducing contaminants and protecting aquatic habitats. The Prioritization Framework developed in Phase 3 will need to be responsive to this initiative.

The Groundwater Strategy: Groundwater inflows into the sewer system potentially have significant implications for system capacity and the capacity requirements for the Iona WWTP upgrade. Groundwater enters the system via leaks in sewer mainlines and property connections and is also pumped into the system by perimeter drainage systems that protect the basements of larger buildings from flooding. Where appropriate, key findings from the Groundwater Strategy may be integrated into the final Healthy Waters Plan.

Ecology Land Use Plan (under Vancouver Plan): Key recommendations of the Ecology and Land Use Planning project related to aligning and designing Blue Green Systems, Green Streets, Floodable Wetlands and Public Spaces, and Waterway Restoration/Vegetated Rainwater Channels to maximize co-benefits such as ecological connectivity, biodiversity protection, and access to nature may need to be incorporated into the Healthy Waters Plan.



APPENDIX A: POLICY FRAMEWORK



Appendix A: Policy Framework

The Healthy Waters Plan integrates existing plans and policies from the City of Vancouver and external partners, building on Metro Vancouver's LWMP to align with internal and external strategies to create a comprehensive approach to water management.

Internally, the Plan builds upon Vancouver Plan's Policy Area 10, which focuses on watersheds and water resources and is aligned with the development of a city-wide Ecological Network as part of the implementation of the Ecology Land Use Planning program of Vancouver Plan. This effort ensures a balanced approach to water management that supports both urban growth and environmental health. By using GRI like permeable pavements, green roofs, and rain gardens, the City can reduce pressure on sewer systems, prevent flooding, and improve local water quality. Additionally, the Plan supports the City's broader climate resilience goals by addressing the impacts of climate change, such as more frequent and intense rain events, ensuring that infrastructure can handle future challenges.

Externally, the City of Vancouver collaborates closely with Metro Vancouver, which manages major regional conveyance pipes and wastewater treatment. This partnership ensures that local and regional water management efforts are coordinated, providing an efficient system for residents. The Plan also follows provincial and federal regulations on water quality and environmental protection, ensuring that Vancouver meets or exceeds legal standards, protecting public health and the environment. For more details on the policies, plans, and strategies aligned with the Healthy Waters Plan, refer to Table 1.

Table 1: Plans and Policies relevant to the Healthy Waters Plan

LEVEL	POLICY NAME	YEAR	DESCRIPTION
City	Sewer Utility Long Range Plan (2010)	2010	A 10-year plan to guide sewer development with a focus on service delivery, sustainability, and eliminating combined sewer overflows by 2050
Regional	Liquid Waste Management Plan (LWMP)	2011	Allows municipalities to develop community-specific solutions for wastewater management that meet or exceed existing regulations.
City	Climate Change Adaptation Strategy (CCAS)	2012	Details actions to mitigate and adapt to climate impacts.
Regional	Burrard Inlet Action Plan	2015	An update to older environmental reviews of the inlet and foster development of a wider consensus on strategic environmental stewardship actions to implement in the near-term.
City	Biodiversity Strategy	2016	Aims to increase the amount and quality of Vancouver's natural areas to support biodiversity and increase access to nature.
City	City-wide Integrated Rainwater Management Plan (IRMP) (2016)	2016	Addresses areas of Vancouver where stormwater is piped directly to either combined sewer or ocean outfalls.
City	VanPlay: Vancouver's Parks and Recreation Services Master Plan	2018	Guides the work of the Vancouver Board of Parks and Recreation. It represents a strong commitment to equitable delivery of excellent parks and recreation opportunities in a connected, efficient manner which celebrates history of the land, place, and culture.
City	Cambie Corridor Plan	2018	Guides long-term growth in areas along Cambie Street and its surrounding neighbourhoods.
City	Rain City Strategy (RCS)	2019	Expands on the IRMP with a renewed focus on valuing rainwater as a resource and goals around water quality, resilience, and livability through healthy urban ecosystems.

Table 1 continued on next page

Table 1: Plans and Policies relevant to the Healthy Waters Plan

LEVEL	POLICY NAME	YEAR	DESCRIPTION
City	Aquatic Environments Action Plan	2020	A strategic framework for guiding City efforts in improving water quality and overall health of aquatic environments.
City	Climate Emergency Action Plan (CEAP)	2020	Actions to reach the necessary carbon pollution reduction targets.
City	UNDRIP Strategy	2022	The work to implement UNDRIP within Vancouver aims to strengthen the government-to-government relationship and respect the protocols of the Host Nations as Aboriginal title holders, while continuing to build relationships with diverse Urban Indigenous communities.
City	Vancouver Plan	2022	A long-range land use strategy to create a more livable, affordable and sustainable city for everyone. It guides the long-term growth of the city in an intentional way, clarifying where growth and change will occur over the next 30 years.
City	Broadway Plan	2022	Outlines opportunities for new housing, jobs, and amenities around the new Broadway Subway in Mount Pleasant, Fairview, and Kitsilano over 30 years.
Regional	Burrard Inlet Water Quality Objectives	2024	Goals to inform resource management decisions and promote the stewardship of water resources in Burrard Inlet by reducing and eliminating contamination.

Table 1 continued on next page

Table 1: Plans and Policies relevant to the Healthy Waters Plan

LEVEL	POLICY NAME	YEAR	DESCRIPTION
City	Climate Change Adaptation Strategy (CCAS) 2024-2025 Update and Action Plan	2024	Outlines the expected changes to Vancouver's climate in the future, identifies the potential impacts of these changes, and recommends a suite of goals and actions to support a comprehensive adaptation approach.
City	Ecology Land Use Plan (ELUP)	In Progress	Part of Vancouver Plan implementation, work under ELUP aims to protect and connect natural habitats within the urban environment.
City	Hazard Risk Vulnerability Assessment (HRVA)	In Progress	Helps enable decision-makers to make informed decisions on how to reduce risk through hazard mitigation and preparation. Recent provincial legislation requires the development of an Emergency Management Plan that considers the hazards from this assessment.

APPENDIX B: ANALYTICAL TOOL DEVELOPMENT

Multi-Criteria Decision Analysis Tool (MCDA)

Multi-Criteria Decision Analysis (MCDA) is a framework that helps in the comparison of choices based on various factors, which is useful when decisions are complex and involve conflicting elements. The Healthy Waters Plan used MCDA to evaluate Options and Pathways (Figure 69). Various tools and models, such as the Mass Balance Model and the Vancouver Sewage Area Model, were used in the evaluation process. This analysis method made the decision-making process transparent and allowed stakeholders to share their preferences and values effectively. In the Healthy Waters Plan, MCDA involved the following steps:

1. **Identification of Criteria**. The first step was to identify the relevant criteria that would be used to measure the performance of Options and Pathways in achieving the Healthy Waters Plan Goals and Objectives. These factors changed based on the specific goals of the decision-making process.
2. **Weighting of Criteria**. Once the criteria were identified, stakeholders assigned weights to each criterion to reflect its relative importance. This weighting process ensured that criteria evaluation reflected the relative importance of Healthy Waters Plan Goals and Objectives.
3. **Evaluation of Alternatives**. With the criteria and weights established, stakeholders compared each Pathway to the business-as-planned Baseline Pathway. This evaluation involved collecting data, conducting analyses, and using modeling tools to assess how well each Pathway performed in relation to the Baseline Pathway.
4. **Scoring and Aggregation**. After evaluating each Pathway, ranking scores indicated how well each Pathway performed in achieving the objectives. These scores were then aggregated using weighted averages to produce an overall score for each Pathway.
5. **Sensitivity Analysis**. In some cases, a sensitivity analysis was conducted to explore the results and assess the impact of uncertainty or variation in the weightings (e.g., what if a Pathway had more green infrastructure). This analysis aided in understanding how changes in assumptions or inputs could alter performance.

6. **Selection of Preferred Pathway**. Based on the results of the MCDA process, a Preferred Pathway was developed that best met the Healthy Waters Plan objectives and priorities. This selection process was informed by the overall analysis scores and qualitative considerations including partner and stakeholder feedback.

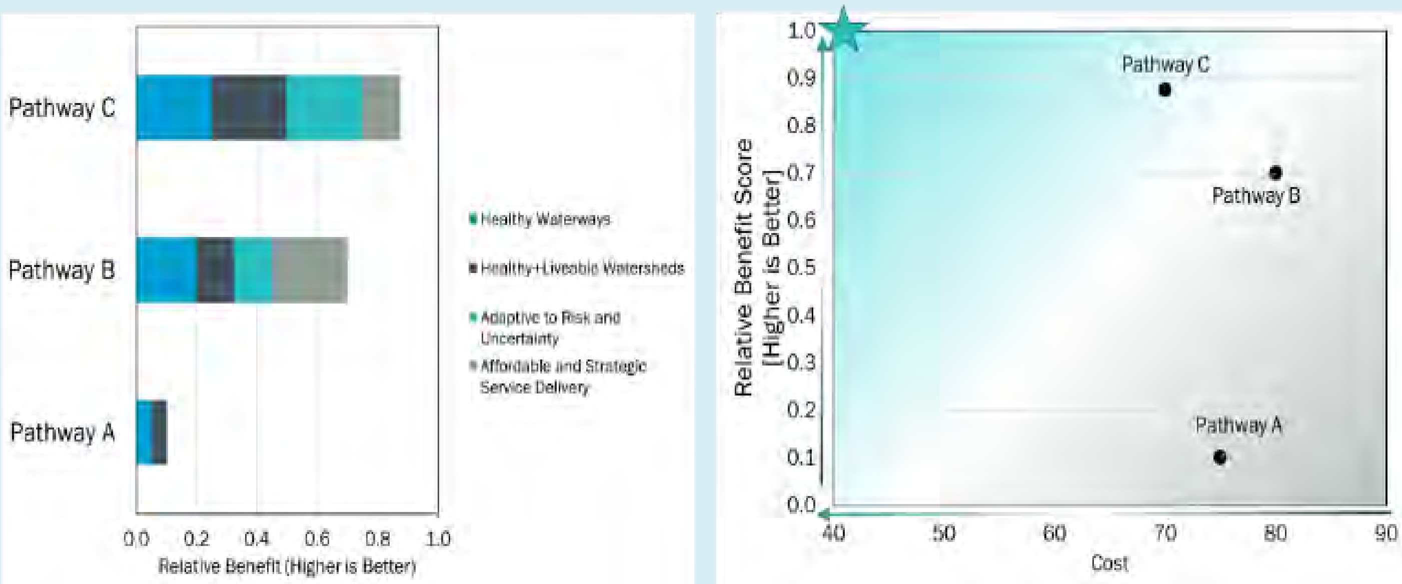


Figure 69: Example of MCDA analysis results showing which pathway type is associated with the most types of benefits.

Mass and Water Balance Model (MBM)

The Mass Balance Model (MBM) is a spreadsheet computational tool that's used to simulate how water flows through Vancouver's and Metro Vancouver's sewer network for a full calendar year. It tracks water from individual land parcels to specific separator catchments which ultimately drain to a wastewater treatment plants like Iona and Annacis or sewer outfall(s) along the way (Figure 70).

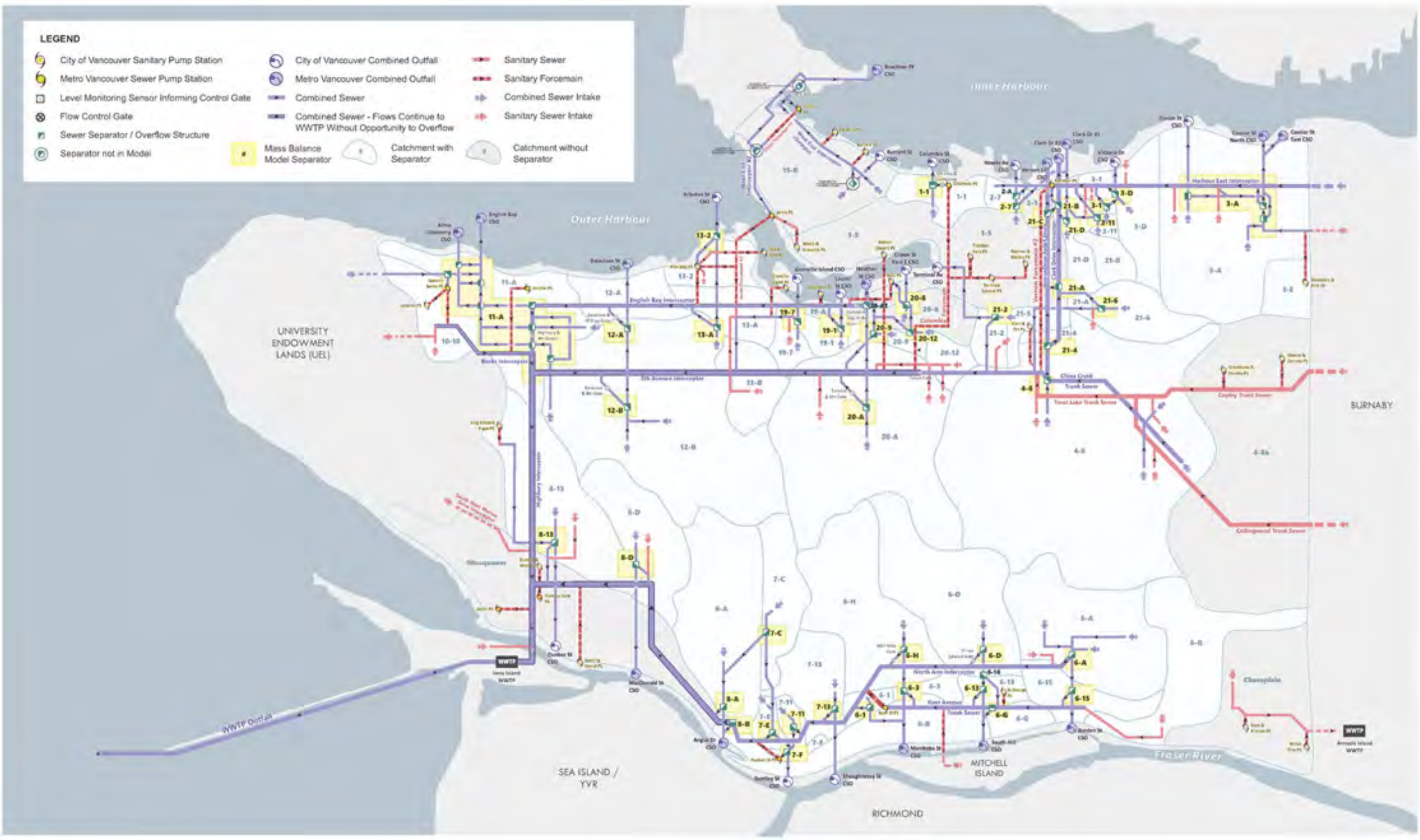


Figure 70: Mass Balance Model Separator Catchment and Sewer Network Schematic

The MBM uses various data sources, such as rainfall patterns, land use, climate change factors, and topography, to simulate different scenarios. This process helps evaluate how well the drainage and wastewater systems perform under different conditions, like varying rainfall, land development, and climate change. The model summarizes the annual the inflow, outflow, and storage of rainwater and sewage at different points in the system. A key output of the MBM is that it provides information about total suspended solids and fecal loadings discharged to each Basin's receiving waters (Figure 71).

It measures how much rainwater soaks into the ground, flows over land, or enters the drainage system through storm drains. It also considers the contributions from other sources such as groundwater seepage and inflow from neighboring jurisdictions. By analyzing the mass balance of water within the system, the model can identify potential areas of concern, like sewer overflows, which indicate water quality issues. It can also evaluate the effectiveness of various management strategies and infrastructure investments (Options) aimed at reducing the risk and improving resilience within the system.

Performance Measures by Basin

			Citywide	Still Creek	Inner Harbour	False Creek	Outer Harbour	Fraser River
Current Scenario	CSO Volume	(m3)	1,200,215	0	98,755	464,742	263,005	373,712
	Treated CSO Volume	(m3)	8,884,021	0	7,276,619	0	0	1,607,402
	Sanitary Portion of CSO*	(m3)	2,036,241	0	1,808,001	18,126	12,263	197,852
	TSS Load in CSO	(kg)	267,628	0	199,017	9,229	5,508	53,873
	Fecal Load in CSO	(TCFU)	4,113	0	594	1,149	702	1,668
	Annual Average Fecal Concentration in CSO	(CFU/100mL)	342,719	0	601,775	247,204	267,095	446,266
	Stormwater Volume Discharged	(m3)	118,798,736	18,521,991	31,366,312	21,583,245	16,472,660	30,854,528
	TSS Load in Stormwater	(kg)	1,078,648	181,812	309,043	204,803	134,595	248,395
	Fecal Load in Stormwater	(TCFU)	7,802	1,340	2,226	1,472	1,014	1,750
	Annual Average Fecal Concentration in Stormwater	(CFU/100mL)	6,568	7,235	7,098	6,820	6,158	5,670
	Com. Stormwater Re-Naturalized by GRI	(m3)	6,211,501	0	1,829,148	651,338	1,363,269	2,367,746
	Sep. Stormwater Re-Naturalized by GRI	(m3)	9,091,527	1,335,558	2,195,383	2,123,869	1,525,814	1,910,903
	Separated Stormwater Cleaned & Discharged by GRI	(m3)	267,496	55,440	38,186	104,963	28,893	40,015
2019 Baseline	CSO Volume	(m3)	25,059,089	0	18,546,904	1,203,883	1,859,125	3,449,177
	Treated CSO Volume	(m3)	0	0	0	0	0	0
	Sanitary Portion of CSO*	(m3)	5,354,534	0	4,594,890	92,566	350,706	316,373
	TSS Load in CSO	(kg)	1,095,047	0	851,699	40,510	68,715	134,124
	Fecal Load in CSO	(TCFU)	161,887	0	132,875	5,372	8,510	15,130
	Annual Average Fecal Concentration in CSO	(CFU/100mL)	646,023	0	716,429	446,231	457,741	438,655
	Stormwater Volume Discharged	(m3)	48,031,002	14,291,828	5,800,577	9,028,979	2,050,091	16,859,527
	TSS Load in Stormwater	(kg)	542,059	186,404	66,694	125,679	18,033	145,250
	Fecal Load in Stormwater	(TCFU)	3,866	1,307	473	875	135	1,076
	Annual Average Fecal Concentration in Stormwater	(CFU/100mL)	8,049	9,142	8,158	9,687	6,601	6,385
	Com. Stormwater Re-Naturalized by GRI	(m3)	0	0	0	0	0	0
	Sep. Stormwater Re-Naturalized by GRI	(m3)	0	0	0	0	0	0
	Stormwater Cleaned & Discharged by GRI	(m3)	0	0	0	0	0	0
Scenario Comparison	Change in CSO Volume	(m3)	-23,858,874	0	-18,448,149	-739,141	-1,596,120	-3,075,464
	Treated CSO Volume	(m3)	8,884,021	0	7,276,619	0	0	1,607,402
	Change in Sanitary Portion of CSO*	(m3)	-3,318,293	0	-2,786,889	-74,440	-338,443	-118,521
	Change in TSS Load in CSO	(kg)	-827,420	0	-652,681	-31,282	-63,206	-80,251
	Change in Fecal Load in CSO	(TCFU)	-157,774	0	-132,281	-4,223	-7,808	-13,462
	Change in Annual Average Fecal Concentration in CSO	(CFU/100mL)	-303,304	0	-114,654	-199,028	-190,647	7,611
	Change in Stormwater Volume	(m3)	70,767,735	4,230,164	25,565,736	12,554,266	14,422,569	13,995,001
	Change in TSS Load in Stormwater	(kg)	536,588	-4,592	242,349	79,124	116,561	103,146
	Change in Fecal Load in Stormwater	(TCFU)	3,936	34	1,753	597	879	673
	Change in Annual Average Fecal Concentration in Stormwater	(CFU/100mL)	-1,482	-1,907	-1,060	-2,867	-443	-715
	Change in Com. Stormwater Re-Naturalized by GRI	(m3)	6,211,501	0	1,829,148	651,338	1,363,269	2,367,746
	Change in Sep. Stormwater Re-Naturalized by GRI	(m3)	9,091,527	1,335,558	2,195,383	2,123,869	1,525,814	1,910,903
	Change in Sep. Stormwater Cleaned & Discharged by GRI	(m3)	267,496	55,440	38,186	104,963	28,893	40,015

Figure 71: Mass Balance Model Performance Measure Results Dashboard

Overall, the Mass Balance Model serves as a valuable tool for guiding informed decision-making and investment planning in urban water management. By providing insights into the dynamics of water flow within the city, the model helps to enhance the City's ability to sustainably manage its water resources, protect public health and safety, and promote the overall well-being of residents and the environment.

Overland Flooding Risk Assessment Tool

The Overland Flood Model serves as a vital tool in the evaluation of flood risk and mitigation strategies in Vancouver. At a basin scale, this model provides insights into the percentage of Vancouver's population impacted under various flooding scenarios and potential reduction of such impacts depending on the selection and quantity of Options applied.

Estimating the total population affected by flooding requires gathering two main types of information: population data and data about the extent of flooding. A parcel-scale GIS dataset was created to show both current (2019) and future (2075) population estimates (Figure 72). The extent of overland flooding was determined using data from the City's InfoWorks ICM model, which provided details on flood depth and maximum ponded volume for current rainfall (2018) and future rainfall (2100) conditions during 25-year and 100-year storm events. By overlaying the flooding and population data using GIS, researchers were able to analyze how flood risk changes under different flood conditions.

Findings from the Overland Flood Model were integrated into the MCDA analysis. This integration helped partners, stakeholders, and subject matter experts evaluate the effectiveness of various Options and Pathways in reducing flood risk in each basin.

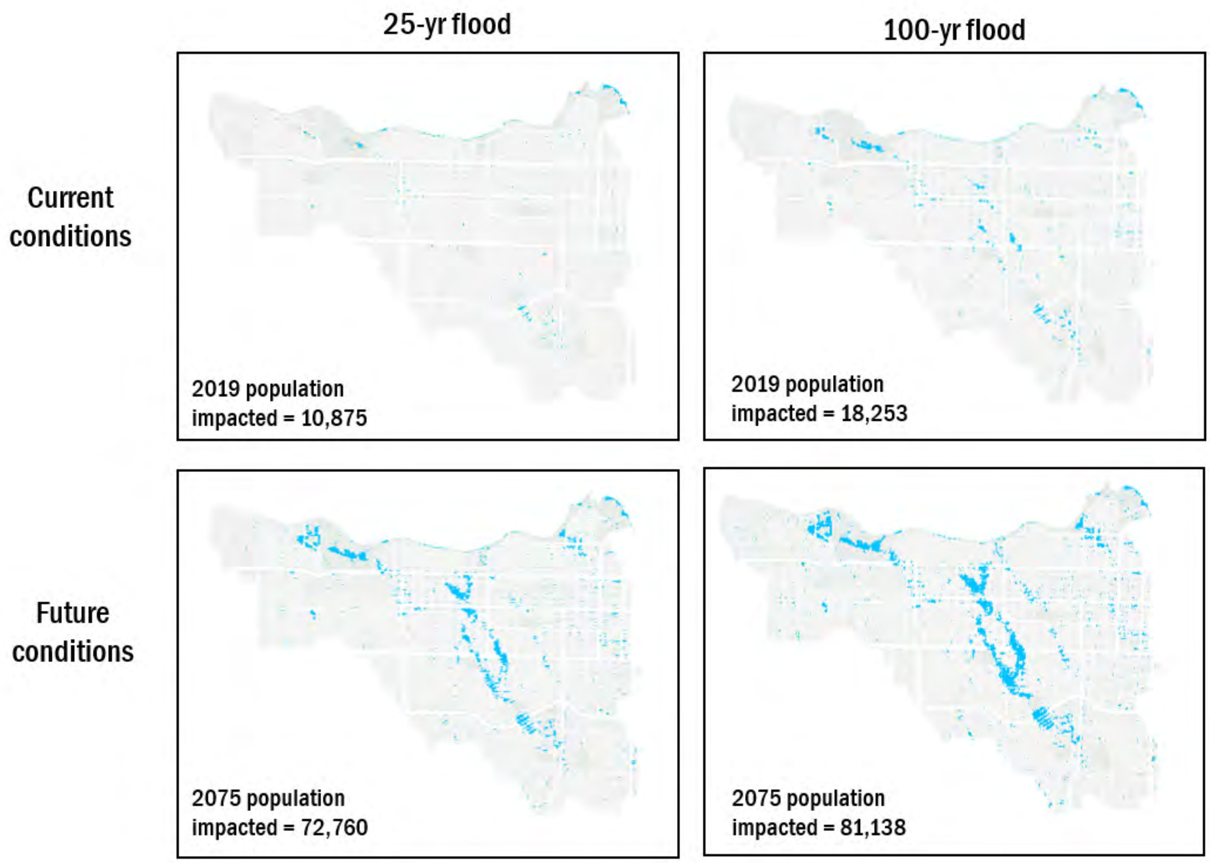


Figure 72: Flooding extent under current (2019) and future (2075) conditions during a 25-year and 100-year flood event

Human and Ecological Health Comparative Risk Evaluation Framework

During Phase 2 of the Healthy Waters Plan, the City began developing an Ecological and Human Health Comparative Risk Evaluation Framework (CREF) to evaluate the risks and benefits that proposed Options and Pathways had on the receiving environment. The CREF used indicator parameters of total suspended solids and fecal coliform from the MBM and calculated their concentrations and plume extents in the receiving waters using a hydrodynamic model (see Figure 73 for example). Development of this framework aligns with Metro Vancouver's previous CSO Hydrodynamic Modeling, Human Health and Ecological Screening Level Risk Assessment modeling, and risk assessment efforts, ensuring that the evaluation process was comprehensive and allowed for informed decision-making.

A key component of the tool was to provide comparative risk scores associated with resulting discharges from the Baseline Pathway and Preferred Pathway to aquatic receiving environments in the Healthy Waters Plan drainage basins. The CREF tool was also developed to provide evaluation of other environmental co-benefits (e.g., upland recharge areas, etc.) as well as a comparative evaluation of benefits arising from the Preferred Pathway.

To evaluate relative human health and environmental risks of modelled discharges and the benefits of management options, CREF includes the following elements:

- **Discharge Characterization:** Metrics related to seasonal effluent quality and loadings in CSO and urban runoff discharges.
- **Discharge and Receiving Water Interaction:** Hydrodynamic modelling (hindcast modelling) of the discharge and analysis of the spatial extents of sanitary and stormwater plumes in receiving environments.

- **Receptor Exposures:** Analysis of sanitary and stormwater plume overlap with human and ecological receptor locations. The receptor locations include input from Xʷməθkʷəy̓əm (Musqueam), Sḵwx̱wú7mesh Úxwumixw (Squamish), and Səlilwətaɬ (Tsleil-Waututh) Nations

- **Environmental Restoration:** Evaluation of environmental co-benefits arising from management options that include actions that regenerate and promote ecological health (e.g., shoreline habitat enhancement).

The Preferred Pathway for each of Vancouver's drainage basins was assessed using the CREF by scoring each element category against a baseline scenario.

CREF will be used in Phase 3 of the Healthy Waters Plan to guide the prioritization of investments to maximize risk reduction and environmental gains in each drainage basin.

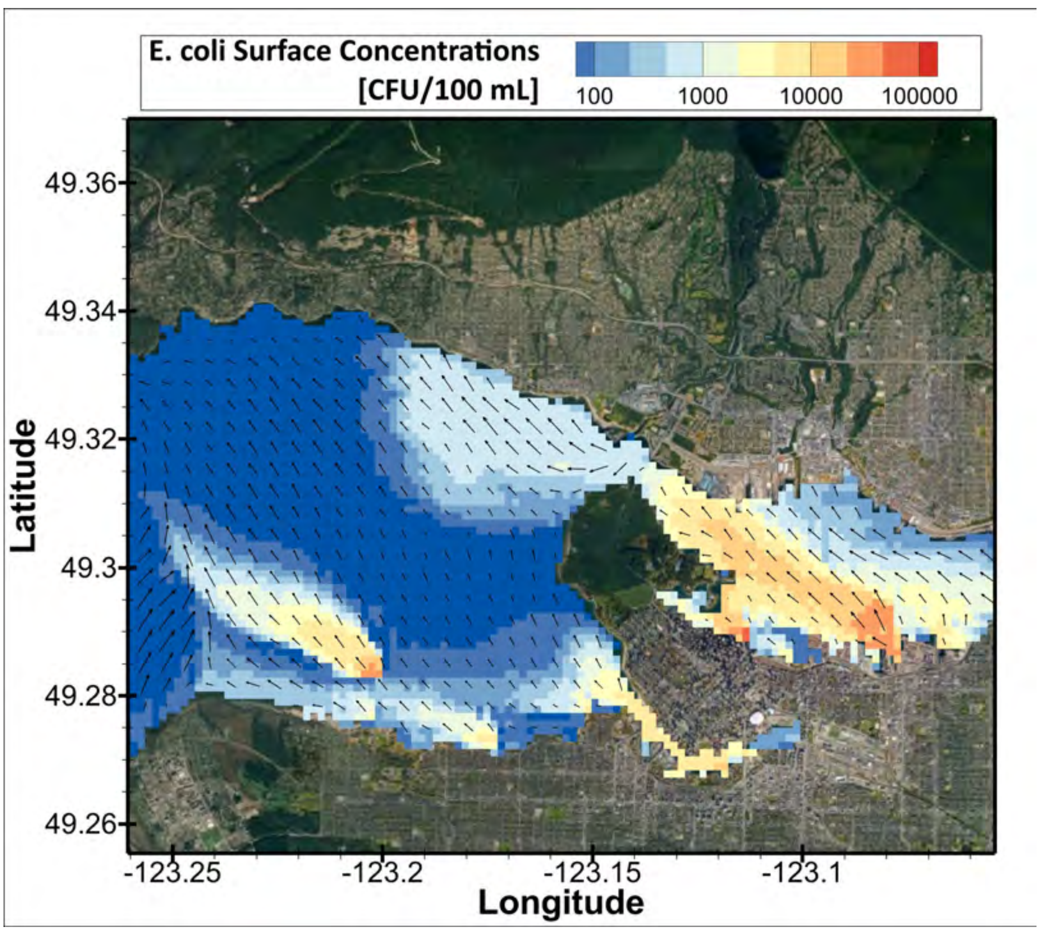


Figure 73: Model results showing e.coli concentrations as a result of discharges from City of Vancouver outfalls using the Mass Balance Model data for January 3, 2019 at 9:00 am

Financial Model, Options Costs Tool, & Tally Sheet

The Financial Model, Options Cost tool, and Tally Sheet were created and utilized to support analysis in Phase 2 of the Healthy Waters Plan. These tools aided in the establishment of Baseline, Alternative, Hybrid, Right-Sized, and Preferred Pathways.

The Financial Model was developed to provide annual revenue forecasts (i.e., the funding envelope) up to 2075, commencing with a business-as-planned scenario known as the Current Trajectory. This Current Trajectory includes projections of sewer investments and operating expenses based on the city's current activities. After establishing the Current Trajectory, the model was used to evaluate costs of the Preferred Pathway, which represents the optimal approach to achieving the Healthy Waters Plan goals and objectives while remaining largely consistent with the budget envelope. Examples of investments under the Current Trajectory include the renewal of existing infrastructure, the ongoing implementation of green infrastructure to manage drainage and improve water quality, and the separation of combined sewer pipes, a requirement under Metro Vancouver's LWMP. These investments are crucial for maintaining and enhancing the city's water management systems. The Preferred Pathway involves somewhat less sewer separation accompanied by a greater extent of green infrastructure implementation, among other modifications.

The Financial Model's revenue forecast is derived from various sources, including property tax, sewer utility fees, UDCLs. This revenue forecast served as a guideline and budget envelope for designing the Right-Sized and Preferred Pathways for each basin over the forecast horizon.

Given uncertainty driven by the variety of larger scale of regional liquid waste investments underway and planned by Metro Vancouver across region the financial model excludes investments by and charges for Metro Vancouver's liquid waste services and focuses on the City's network operations and investments. The impact and affordability of regional liquid waste services will need to be monitored and considered during the continued development of the Healthy Waters Plan and during its implementation.

An **Options Cost** tool was developed to provide indicative unit costs for a range of grey and green infrastructure investments that the City currently undertakes, as well as for new Options being considered for the future. This tool draws on project cost examples from the City's own experience and that of the Healthy Waters Plan project partners. It serves as a primary source for cost assumptions in both the Financial Model and Tally Sheets.

Tally Sheets were created for each of the five drainage basins in the City to estimate the end-state lifecycle costs of various Pathways and to compare these costs with the expected water quality outcomes from the investments. These Tally Sheets were designed to support the Basin Planning Charette, providing a simplified real-time analysis of different investment scenarios.

In Phase 3 of the project, the **Financial Model** will be further refined and adapted to support implementation planning and ensure that the Healthy Waters Plan remains financially sustainable and aligned with the Strategic Framework of Guiding Principles, Goal Areas and Objectives.

Vancouver Sewerage Area Model (VSA)

The Vancouver Sewerage Area (VSA) Model, developed by Metro Vancouver, is the regional urban water model for contributing sewer flows to Iona Wastewater Treatment Plant. It was created using the MIKE URBAN which is a proprietary hydrodynamic modelling software program that is designed to simulate and analyze various aspects of urban water management within the Vancouver sewage area. The VSA Model utilizes advanced computational methods to replicate the complex interactions between rainfall, surface runoff, sewer systems, and wastewater treatment facilities across the region. Its primary purpose is to support decision-making and planning efforts related to sewage infrastructure, flood risk management, and environmental protection.

> At its core, MIKE URBAN integrates detailed data on the physical characteristics of the urban landscape, such as terrain elevation, land use patterns, and drainage infrastructure to simulate how water flows through the urban environment under different scenarios. These scenarios include varying rainfall intensities and land development changes.

This analysis enables stakeholders to assess the effectiveness of existing infrastructure, identify areas of vulnerability to flooding or pollution, and evaluate the potential impacts of proposed development projects or climate change.

The VSA Model's capabilities extend beyond basic hydrological scenarios to include advanced features such as hydraulic modeling of sewer networks, water quality analysis, and real-time control strategies. For example, it can simulate how sewage flows through the city's sewer system during wet weather events, predict the risk of combined sewer overflows, and assess the environmental implications of pollutant discharges into receiving water bodies.

The VSA Model serves as a valuable decision support tool for municipal authorities, water utilities, and other stakeholders involved in urban water management. By providing insights into the complex interactions between urbanization, water infrastructure, and environmental quality, the model enables informed decision-making aimed at enhancing the resilience, sustainability, and overall well-being of Vancouver's urban environment.

The VSA Model was used as the foundational reference model for development of the Mass Balance Model, as it allows for assessment of the conveyance network hydraulics as well as for calibration and validation of water flow estimates at various CSO outfalls.

APPENDIX C: PROCESS OVERVIEW

Performance Measures

An initial step in the Phase 2 process involved the development of Performance Measures with input from the Technical Working Group and Project Advisory Group. These measures were created to evaluate how well proposed Options and Pathways aligned with the Healthy Waters Plan's Principles, Goals, and Objectives.

Performance Measures were estimated using, in preferential order, modeling analysis, data and literature review, and expert judgement. When possible, quantitative measures were utilized. When quantitative measure was not viable, qualitative scoring scales were used with expert judgement to provide insight into the relative performance of Options and Pathways. The development of Performance Measures involved leveraging existing information, stakeholder and partner input, and subject matter expert knowledge. The approach was iterative, and the project team incorporated feedback from stakeholders and partners via multiple forms of engagement and touchpoints. This collaborative effort provided partners, stakeholders, and subject matter experts the opportunity to evaluate success, compare alternatives, identify trade-offs, foster discussion, prioritize information gathering, and ensure transparent decision-making.

Tables 2 through 5 show the determined Performance Measures for each Objective, as well as the mechanism and tool used to evaluate the Performance Measure. The Performance Measures will continue to be refined as new information becomes available.

GOAL 1 - HEALTHY WATERWAYS			
OBJECTIVE	PERFORMANCE MEASURE (PM)	HOW PM IS EVALUATED	ANALYTICAL TOOL USED TO ASSESS PM
1.1 Eliminate pollution of waterways due to sewage from CSO and SSO	Reduction in sewer overflows	Reduction in the volume of sanitary sewage in CSOs and SSOs (volume/year)	Mass Balance Model
1.2 Eliminate pollution of waterways due to urban runoff	Improvement in rainwater cleaned	Volume of stormwater cleaned and discharged to receiving waters (volume/year)	Mass Balance Model
1.1 and 1.2 (see above rows for description)	Removal of pollutants	Reduction in 1. Total suspended solids (TSS) load (mass/year) & 2. Fecal coliform (mass/year)	Mass Balance Model
1.3 Eliminate pollution of waterways due to groundwater	Groundwater kept out of sewage and drainage system	Volume of groundwater kept out of sewage and drainage system (volume/year).	Literature review/Expert Judgement
1.4 Continue to implement pollution source control measures*	Pollution stopped at its source	Pollution source control effectiveness (placeholder: drainage area of pollution hot spots managed; may put as a multiplier for Objective 2.1) *	Spatial Analysis

Table 2: Objectives of Healthy Waters Planning Goal 1 “Healthy Waterways”.

GOAL 2 - HEALTHY & LIVABLE WATERSHEDS

OBJECTIVE	PERFORMANCE MEASURE (PM)	HOW PM IS EVALUATED	ANALYTICAL TOOL USED TO ASSESS PM
2.1 **Restore the retention and absorption of rainwater close to where it falls**	**Infiltration of rainwater**	**Volume of stormwater re-naturalized and removed from all sewer systems (e.g., via infiltration, evaporation, etc.) (volume/year)**	**Spatial Analysis**
2.2 **Restore the amount of natural area within the sewer and rainwater management system**	**Restoration of natural areas & reduction of urban heat** **Change in hardscaped surfaces**	**Restore impervious area to pervious natural area (hectares/year)** **Change in impervious surfaces (hectares/year)**	**Spatial Analysis**
2.3 **Reduce the impact of drought (e.g., on street trees and other natural assets)**	**Re-use of rainwater**	**Volume of rainwater used to offset potable water (volume/year)**	**Mass Balance Model**
2.4 **Restore ecosystem and green infrastructure connectivity and quality**	**Connectivity to natural drainage systems** **Improvement in streamside habitat quality**	**Asset and drainage connectivity to natural systems for blue-green ways (including ditches and swales) and stream corridors (length [kilometers] of new project added)** **Riparian area created, marine or freshwater (hectares)**	**Spatial Analysis**

Table 3: Objectives of Healthy Waters Planning Goal 2 “Healthy & Livable Watersheds”.

GOAL 3 - ADAPT TO RISK & UNCERTAINTY

OBJECTIVE	PERFORMANCE MEASURE (PM)	HOW PM IS EVALUATED	ANALYTICAL TOOL USED TO ASSESS PM
3.2 Minimize overland flooding risk to people, critical infrastructure, and property	Reduction in flooding	Population and area affected by overland flooding (of people at risk or percent of people at risk per basin)	Flooding Analysis
3.3 Minimize sea level rise flooding risk to people, critical infrastructure, and property*	Reduction in sea level rise impacts	Sewer and drainage system can function under sea level rise conditions (yes/no).	Expert Judgment – May use technical analysis as available
3.4 Minimize seismic risk to sewage and drainage services	Improvement to seismic resilience	Progress toward seismic resilience (rating scale by expert judgment [e.g., 1-5]; may be informed by City seismic modeling efforts)	Literature review/Expert Judgement
3.5 Minimize capacity risk due to growth and development	Impact in sewer and drainage capacity	Volume of sanitary sewer and rainwater detained using decentralized means (volume/year)	Mass balance model

Table 4: Objectives of Healthy Waters Planning Goal 3 “Adapt to Risk & Uncertainty”

* Indicates that an Objective and related Performance Measure are subject to change as the Healthy Waters Plan team learns more about the Preferred Pathways.

GOAL 4 - AFFORDABLE & OPTIMAL SERVICE DELIVERY

OBJECTIVE	PERFORMANCE MEASURE (PM)	HOW PM IS EVALUATED	ANALYTICAL TOOL USED TO ASSESS PM
4.1 Minimize the overall investment	**Total overall costs**	**Total lifecycle cost ($/lifetime)**	**Financial Model**
4.2. Minimize public investment requirement	**Total public cost**	**Total lifecycle cost ($/lifetime)**	**Financial Model**
4.3. Minimize private investment requirement	**Total private costs**	**Total lifecycle cost ($/lifetime)**	**Financial Model**
4.4. Maximize the adaptability of investments to manage future uncertainties	**Costing of 4.1-4.3 under different scenarios (e.g., differing growth forecasts or accelerated climate change)**	**Total lifecycle cost ($/lifetime)**	**Financial Model**

Table 5: Objectives of Healthy Waters Planning Goal 4 “Affordable & Optimal Service Delivery”

Options Catalogue

The Options Catalogue is a resource to help partners and stakeholders understand and compare different programs, policies, and projects, called "Options." These Options are grouped into four categories: green rainwater infrastructure, grey infrastructure, policies and programs, and operations. They include initiatives like managing sewage overflows, treating rainwater pollution, and reducing risks. Each Option in the Catalogue is detailed with its benefits, limitations, costs, maintenance needs, and other advantages. Various combinations of Options were selected to form pathways, including the final Preferred Pathway (Figure 74).

To create the Options Catalogue, existing resources and Phase 1 initiatives were reviewed, and input was gathered from the Technical Working Group and Project Advisory Group. These groups helped draft a list of potential Options and Categories, including financing programs, capital projects, policies, and partnerships. They also evaluated performance and costs and identified best practices.

Figure 74: The four Option categories and example Options selected to make an example Pathway

Workshops were held to get feedback on the draft and final Options. These workshops involved the Project Advisory Group and Technical Working Group. The feedback was used to refine the list of Options and Categories, draft descriptions, specify performance and costs, and consider location-specific details. Templates for the Catalogue were created, with each Option description usually covering two to three pages, including siting factors, images, drawings, performance metrics, and examples from other cities (Figures 75 to 77).

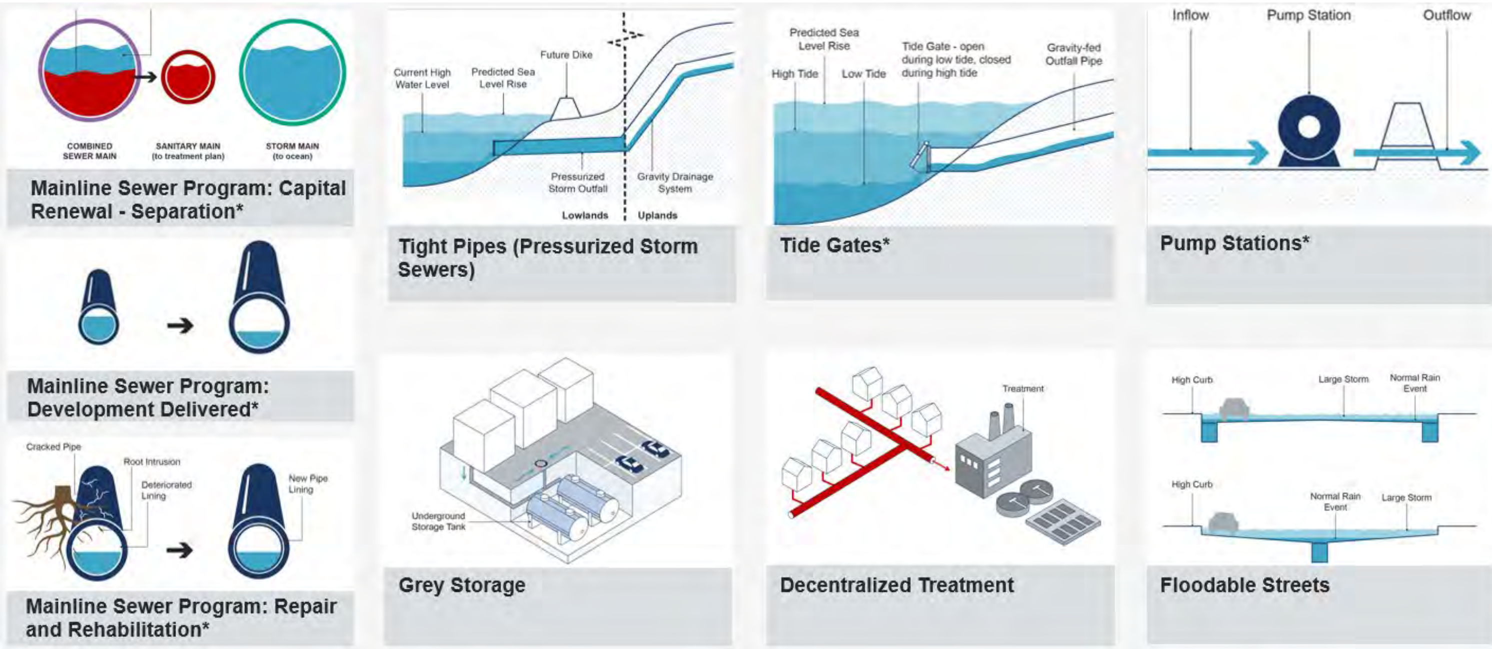
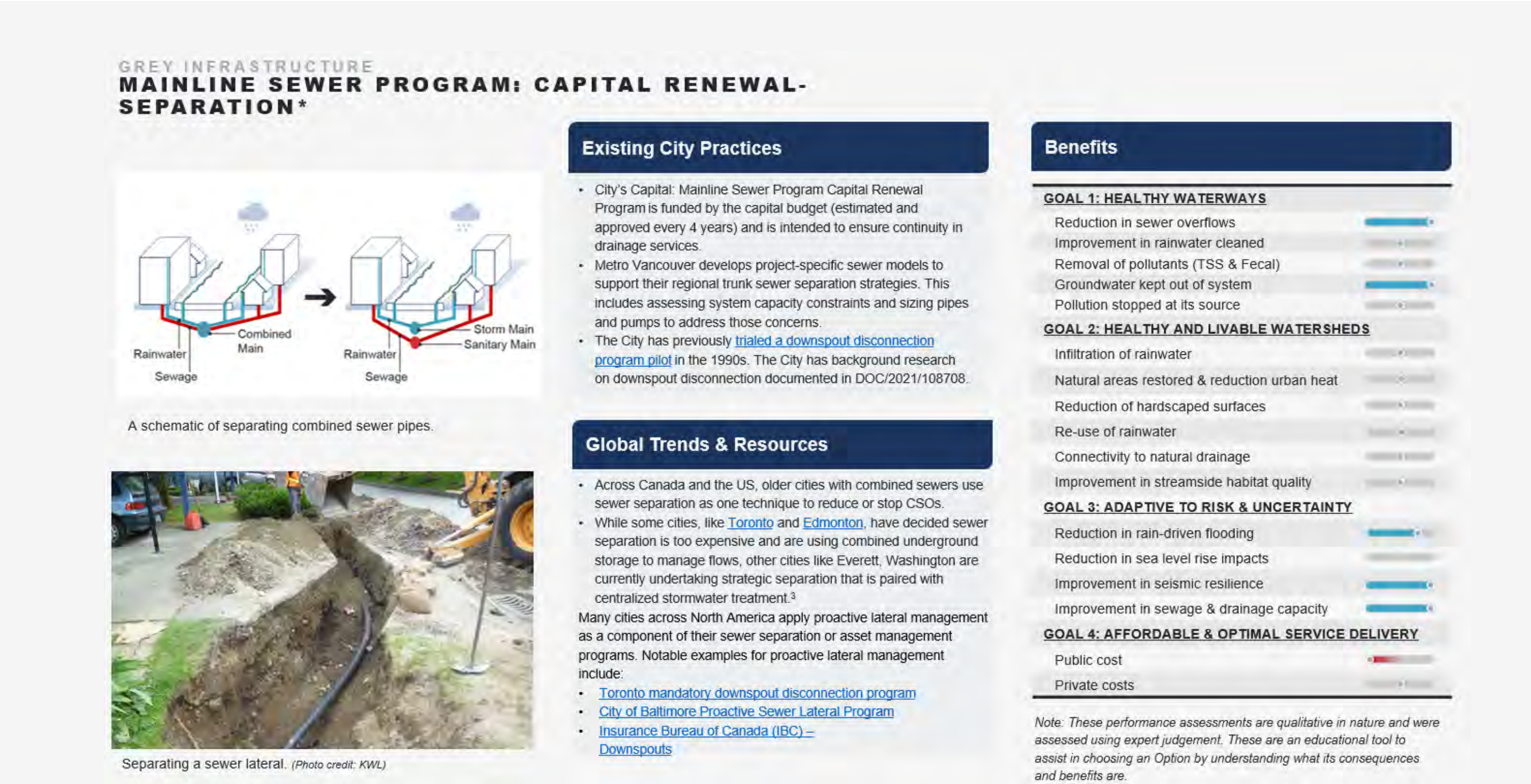


Figure 75: A sample page from the Options Catalogue displaying the various Options associated with the Options Category "Capital Projects: Grey Infrastructure"



GREY INFRASTRUCTURE

MAINLINE SEWER PROGRAM: CAPITAL RENEWAL-SEPARATION*

A schematic of separating combined sewer pipes.

Separating a sewer lateral. *(Photo credit: KWL)*

Existing City Practices

- City's Capital: Mainline Sewer Program Capital Renewal Program is funded by the capital budget (estimated and approved every 4 years) and is intended to ensure continuity in drainage services.
- Metro Vancouver develops project-specific sewer models to support their regional trunk sewer separation strategies. This includes assessing system capacity constraints and sizing pipes and pumps to address those concerns.
- The City has previously trialed a downspout disconnection program pilot in the 1990s. The City has background research on downspout disconnection documented in DOC/2021/108708.

Global Trends & Resources

- Across Canada and the US, older cities with combined sewers use sewer separation as one technique to reduce or stop CSOs.
- While some cities, like Toronto and Edmonton, have decided sewer separation is too expensive and are using combined underground storage to manage flows, other cities like Everett, Washington are currently undertaking strategic separation that is paired with centralized stormwater treatment.[3]

Many cities across North America apply proactive lateral management as a component of their sewer separation or asset management programs. Notable examples for proactive lateral management include:

- Toronto mandatory downspout disconnection program
- City of Baltimore Proactive Sewer Lateral Program
- Insurance Bureau of Canada (IBC) – Downspouts

Benefits

GOAL 1: HEALTHY WATERWAYS
- Reduction in sewer overflows
- Improvement in rainwater cleaned
- Removal of pollutants (TSS & Fecal)
- Groundwater kept out of system
- Pollution stopped at its source

GOAL 2: HEALTHY AND LIVABLE WATERSHEDS
- Infiltration of rainwater
- Natural areas restored & reduction urban heat
- Reduction of hardscaped surfaces
- Re-use of rainwater
- Connectivity to natural drainage
- Improvement in streamside habitat quality

GOAL 3: ADAPTIVE TO RISK & UNCERTAINTY
- Reduction in rain-driven flooding
- Reduction in sea level rise impacts
- Improvement in seismic resilience
- Improvement in sewage & drainage capacity

GOAL 4: AFFORDABLE & OPTIMAL SERVICE DELIVERY
- Public cost
- Private costs

Note: These performance assessments are qualitative in nature and were assessed using expert judgement. These are an educational tool to assist in choosing an Option by understanding what its consequences and benefits are.

Figure 76: A sample page from the Options Catalogue displaying information about one of the Options under "Capital Projects: Grey Infrastructure", titled "Mainline Sewer Program: Capital Renewal Separation"

GREY INFRASTRUCTURE

MAINLINE SEWER PROGRAM: CAPITAL RENEWAL-SEPARATION*

Siting Considerations

Opportunities
- Pipes reaching the end of their service life and pipes with existing combined sewer or downstream treatment capacity constraints must be prioritized.
- Prioritization of separation projects may consider the relative water quality benefit to the receiving water body.
- Coordinating separation with other open trench utility improvements such as repaving, road repair, or maintenance on other buried utilities may enable City to save cost.

Constraints
- The construction of new combined mains is restricted by the Municipal Wastewater Regulation, except in emergency repair situations, necessitating eventual separation.
- Requires an existing downstream storm pipe or outfall present to connect to, with adequate conveyance capacity to accept additional storm flows.
- Complete separation requires disconnecting all rainwater sources from sanitary pipes such as private property service connections (laterals), which are often not cost effective if not in sync with redevelopment activities.
- After separation, a storm pipe must not have any sanitary connections if it is intended to discharge into the receiving waterbodies.

Implementation

Construction & Implementation Needs:
- Strongly suggest pairing sewer separation with water quality improvement Options (e.g., GRI) to have net-positive water quality benefits to receiving waterbodies for the separated storm pipe.
- While upsizing pipes can help with local capacity issues (like sewer backups and flooding), they are most effective when there is enough capacity downstream to convey flows to the treatment plant or outfall so that capacity issues are not moved downstream.
- Pretreatment system at stormwater intake points minimize sediment transport or collection in pipes.
- Difficulties may arise in achieving minimum flushing velocities in pipes, which is crucial to prevent operational and maintenance (O&M) challenges and minimize the risk of odor issues.

Operations & Maintenance Needs:
- Post commissioning stormwater monitoring to ensure complete separation has occurred.
- Replumbing laterals to the right system or replacing laterals due to failure is aligned with good stewardship of the collection system.

Typical Lifespan: Around 100 years depending on initial materials, construction quality, and O&M activities.

Sanitary sewer replacement and separating/replacing a combined private sewer lateral (Photo Credit: Pam Broviak)[2]

Columbia Street mainline sewer separation in progress. *(Photo credit: Dennis Sylvester Hurd via flickr, CC BY 2.0*

Figure 77: The second part of the sample page "Mainline Sewer Program: Capital Renewal Separation"

Basin Characterization & Gestalt Maps

Characterizing each of Vancouver's five drainage basins was a key step in the Healthy Waters Planning process. This initiative enabled the City to define both current baseline conditions and future business-as-planned assumptions and conditions for each basin, providing critical insights for pathway development.

The Basin Characterization process utilized GIS technology to map areas of risk like flooding, sea level rise, priority areas for equity, and seismic activity in all five drainage basins. These maps, referred to as Gestalt Maps, offered stakeholders a comprehensive understanding of the relative risks across each basin. The Basin Characterization process also identified opportunities and challenges, which helped in choosing the best options to meet basin targets. Realistic targets were set for both the city and each basin to match performance goals.

A workshop was held at Creekside Community Centre on January 11, 2024, where stakeholders, partners, and experts discussed the findings and provided input. This workshop allowed for characterization findings to be shared and input to be gathered, fostering a collaborative approach to decision-making in drainage basin management. The Gestalt Maps (Appendix D) provide a visual summary of the key issues and opportunities, as well as important summary statistics for each basin.

Healthy Waters Plan partners and stakeholders discussing Options and Pathways

Basin Planning Charrette and the Development of Hybrid Pathways

A workshop, known as the “Basin Planning Charrette” (Charrette) was held on March 12-13, 2024, at Creekside Community Centre. This event brought together members of the Project Advisory Group, Technical Working Group, and subject matter experts, including staff from xʷməθkʷəy̓əm (Musqueam Indian Band) and səlilwətaɬ (Tsleil-Waututh Nation). Although staff from Sḵwx̱wú7mesh Úxwumixw (Squamish Nation) were unable to join the event, a follow-up meeting was held shortly after the Charrette. The Charrette allowed participants to brainstorm and address challenges in Vancouver’s sewer system, considering technical, financial, and social trade-offs from the Options Catalogue.

The workshop was structured like a board game, where participants took turns implementing different options. Tools like Gestalt Maps, Quick Fact Sheets, and Tally Sheets helped groups develop their best combination of options. This interactive format encouraged a thorough exploration of strategies to improve Vancouver’s sewer system.

Gestalt maps: highlight high-level opportunities and challenges in each basin.

Quick fact sheets: show the Options that can be played, their cost, and their estimated pathway performance.

Tally sheets: provide real time feedback on the impact of each option selection, displaying a pathway performance summary and allowing participants to see the impact of proposals on total suspended solids, fecal coliform loads, public and private costs, and select performance measures relating to the Healthy Waters Plan goals.

During the Charrette, Participants, facilitators, scorekeepers, and notetakers divided into six groups, each with a basin-specific gameboard. They explored two scenarios for each basin (except Still Creek Basin, which is nearly fully separated): a Full Sewage System Separation scenario and a Sewage System Separation Alternatives scenario. To align with Metro Vancouver's Liquid Waste Management Plan, they had to meet constraints on Total Suspended Solids (TSS), Fecal Coliform levels, and budget limits. The goal was to develop pathways that exceeded these constraints, fostering innovative solutions.

Each group developed at least one Hybrid Pathway for the two scenarios. Most teams took turns selecting and implementing options, while some suggested ideas spontaneously. A Scorekeeper entered the chosen options into the Tally Sheet, which calculated the impact on the Healthy Waters Plan's goals and progress towards meeting the constraints. This continued until the budget was exhausted. Each player explained their choices, encouraging discussions about the trade-offs and benefits of different Options.

Healthy Waters Plan partners and stakeholders discussing Options and Pathways

Right-Sized Pathways

After the Charrette, the project team developed three alternative approaches to meeting the constraints called Right-Sized Pathways. These pathways combined the best ideas from the Charrette and highlighted the trade-offs in key planning decisions in a systematic manner. This process helped identify which combination of Options best met the Healthy Waters Plan's goals and objectives, provided the most benefits, was cost-effective, and handled uncertainty well.

Each Right-Sized Pathway (labelled A, B, or C) was primarily defined by their sewer separation strategy. The three pathways—A, B, and C—varied in their sewer separation rates to explore how different levels of funding for green and grey infrastructure could affect water quality outcomes and benefits (Figure 78). This approach ensured the pathways were balanced, financially sustainable, and aligned with the Plan's long-term goals.

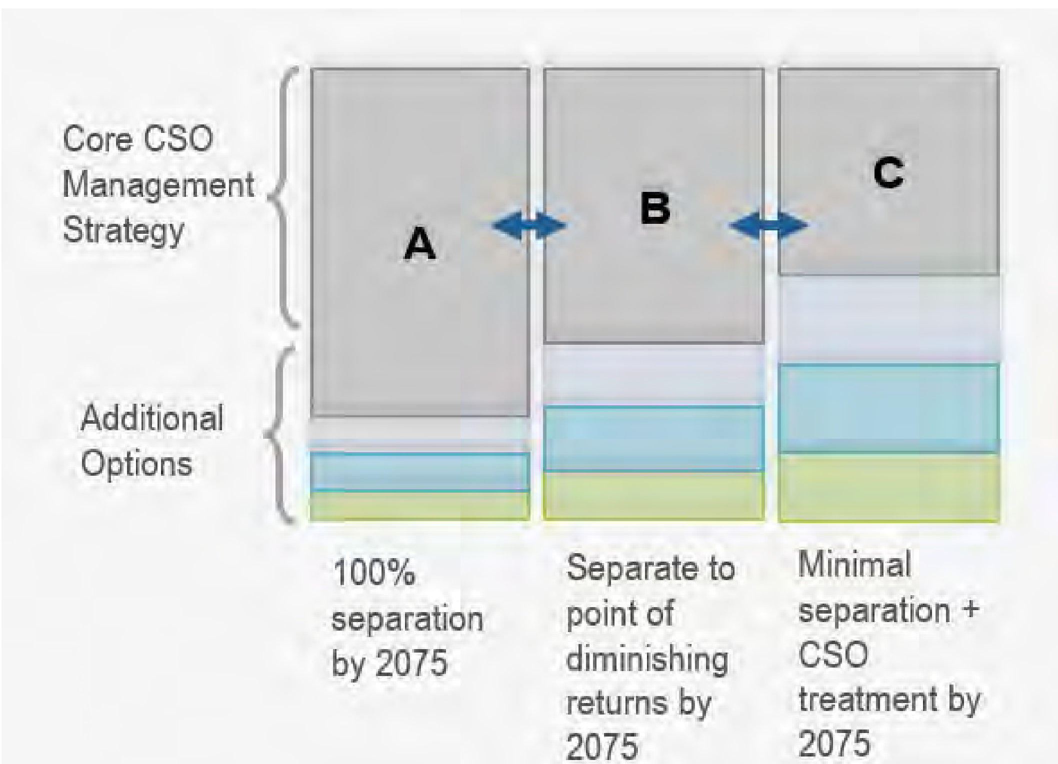


Figure 78: The Right Sized Pathways (A, B, and C) varied the rate of separation to explore how remaining funds could be utilized to provide different levels of water quality outcomes and benefits.

A

Right-Sized Pathway A assumed completion of sewer separation, with small residual envelope dedicated to investments in GRI. It also included a 24 mm rainwater retention policy for redevelopment and other Options.

B

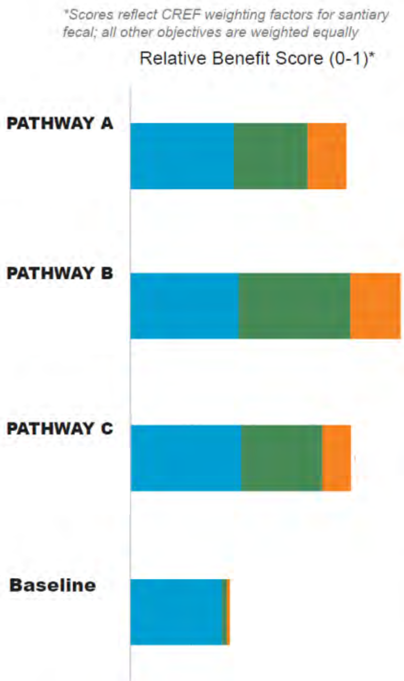
Right-Sized Pathway B assumed that sewer separation work was continued to the point of "diminishing returns", beyond which further investments were not achieving a proportional amount of fecal and TSS loading reductions. This allowed for funding to be redirected to CSO rapid treatment and storage and GRI.

C

Right-Sized Pathway C assumed that separation work was only completed on catchments where separation work is approaching completion or where assets are in critical condition. This allowed for funding to be directed to larger investments in CSO rapid treatment and storage and other Options.

Each right sized pathway type met the basin and citywide constraints established in the Basin Characterization process: TSS loads, fecal coliform loads, and citywide funding envelopes. The methodology for selecting the remaining additional Options beyond the core CSO management strategy involved varying amounts of investments in GRI, private property policies, and operational Options. The team also included options from the larger Options Catalogue that could not be included in the Charrette due to complexity and time constraints.

Each right sized pathway for each basin was modelled and analyzed with the analytical tools to support decision making in developing the Preferred Pathway for each basin. The Options included in each right sized pathway as well as their corresponding relative benefits were aggregated, summarized and compared in the MCDA tool (Figure 79). Modelled results for water quality specific performance measures in year 2050 and 2075 were also highlighted via different set of graphs (Figure 80).



CSO Mgmt Strategy	Total GRI	Creek daylighting	Retrofits	RWM Policy	Flood Policy	Flood Capital Projects
Full separation by 2075 using "bottom up" approach	420 ha managed	SOME Historical creek restoration & Vegetated channel	Downspout disconnect	24 mm	Re-development conditions for flood-proofing	SOME Stormwater storage tanks & Floodable streets
Separate to point of diminishing returns by 2075, CSO tanks & smaller CSO treatment	690 ha managed	ONLY Vegetated channels	Downspout disconnect and/or 24 mm	48 mm	Re-development conditions for flood-proofing	NONE
Minimally separate until 2075 & larger CSO treatment	360 ha managed	MOST Historical creek restoration & Vegetated channel	Downspout disconnect	24 mm	Restrictions to re-delevoment density	MOST Stormwater storage tanks & Floodable streets
Full separation by 2075 using "baseline" separation approach	390 ha managed (green streets only)	0	0	0	0	0

Figure 79: Citywide MCDA results of the Right Sized Pathways

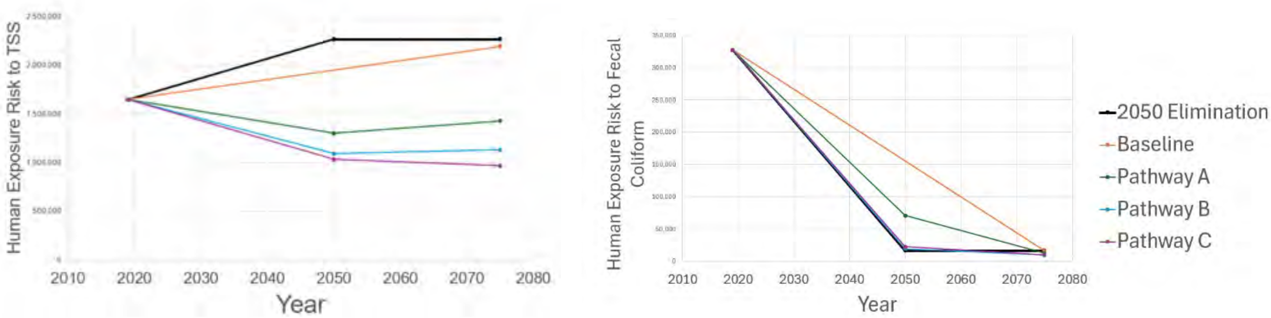


Figure 80: (left) Citywide total annual TSS loading over time; (right) Citywide total annual fecal coliform loading over time, including a CREF weighting factor (x2 on sanitary sourced)

A workshop was held on June 25th, 2024, at City Hall with the Project Advisory Group, Technical Working Group, and subject matter experts. Participants reviewed three pathways and MCDA results for each basin to provide feedback on how to improve them. The workshop aimed to identify trade-offs between the pathways, examine the core CSO management strategy, and discuss gaps and improvements for the optimal pathway.

The workshop had three parts. First, the Healthy Waters Planning team presented the Right-Sized Pathway results. Then, participants split into basin-specific groups to review and discuss results, review the optimal pathway, and suggest improvements. Finally, participants visited other basin tables in an Open House. Feedback on which right sized pathway type was the most appropriate for each basin as well as other ideas shared at the workshop were considered when developing the Preferred Pathway (Figure 81).

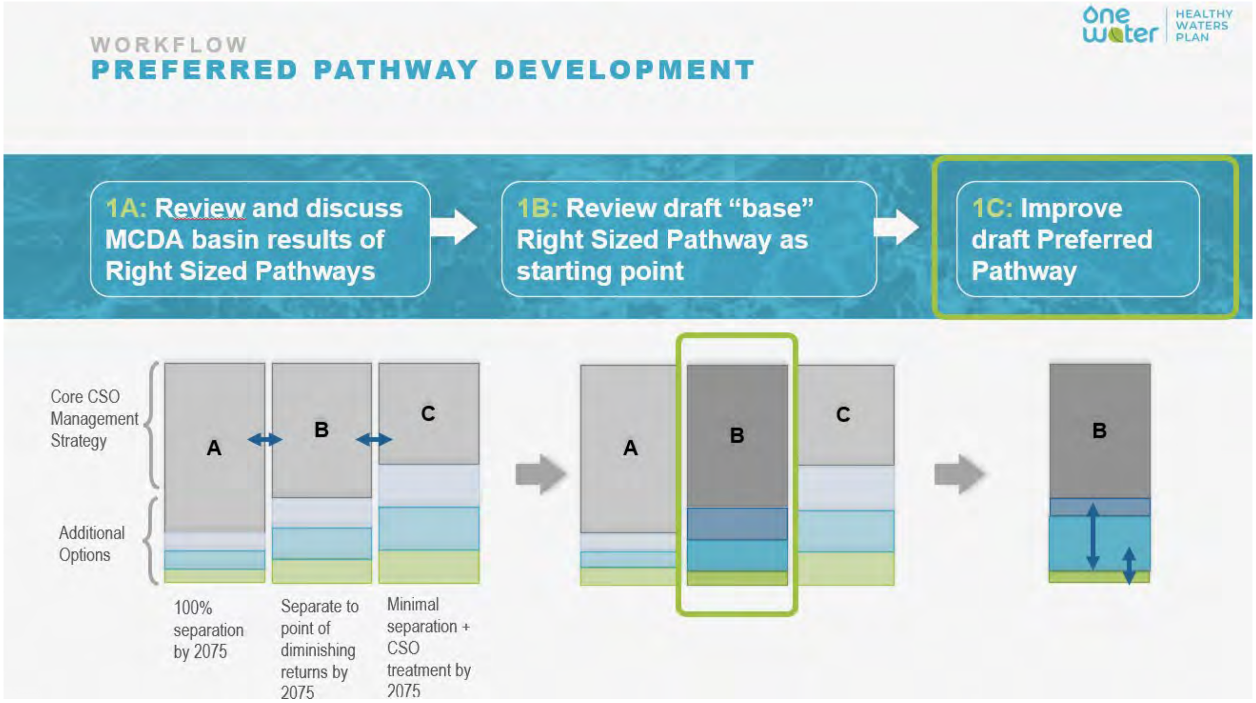
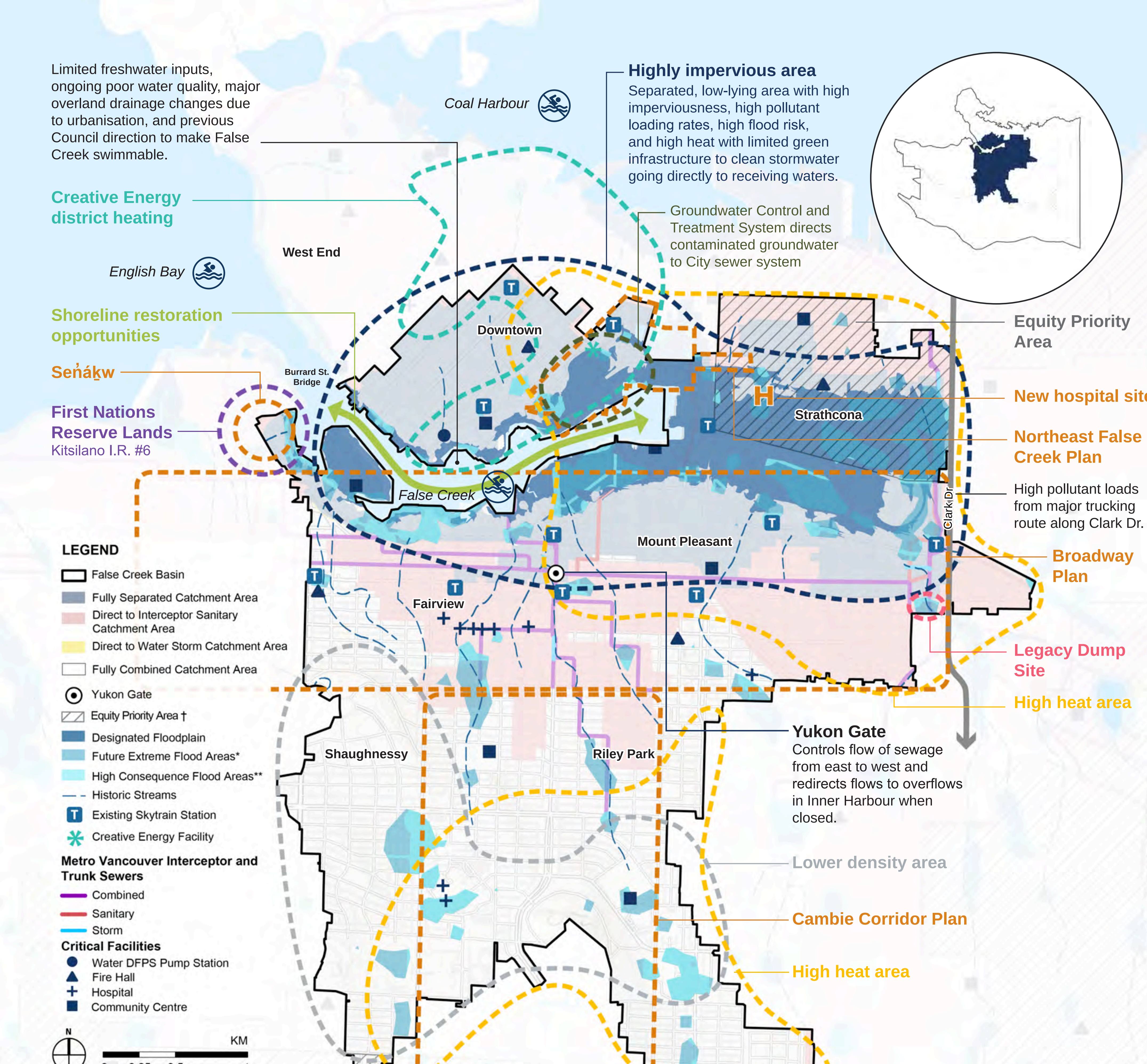


Figure 81: Process to develop Preferred Pathways based on the Right Sized Pathways

Healthy Waters Plan partners and stakeholders discussing Options and Pathways

APPENDIX D: BASIN PLANNING CHARRETTE MATERIALS

FALSE CREEK BASIN
GESTALT MAP



This figure uses data current as of June 2022; †Census tracts which score high on an index of 7 indicators associated with high socio-economic need; *"Future Extreme Flood Areas" represents the overland flooding associated with the year 2100 100-yr return period rainfall. Flood depths less than 30 cm are not shown. These data are to be used at a planning scale only, flooded areas should not be used to indicate parcel-scale flooding; ** "High Consequence Flood Areas" are where Future Extreme Flood Areas overlap with high use areas (skytrain and bus stops, schools, libraries, bikeways, greenways), major roads, and critical facilities.

- False Creek is a heavily used waterfront and waterbody with many access locations for boating, rowing, paddling, and viewing the water.
- Limited freshwater inputs and ongoing poor water quality. Previous Council direction to make False Creek swimmable as soon as possible.
- High levels of metals and legacy contaminants due to the industrial legacy.
- The basin's major conveyance infrastructure includes 11 pump stations, the Yukon Gate control structure, and major interceptors and sanitary trunks.
- The combined system serves 42% of the basin, and 20% has separated sanitary flows directly connect to the MV interceptors
- Creative Energy is the city's largest commercial potable water user, and steam condensate is discharged into city sewers. Peak discharges occur in fall/winter when demands on the sewer system are greatest.
- Major developments:
  - Seṅáḵw of the Squamish Nation will include over 6,000 rental units and is in early construction phases.
  - The Broadway Plan (spans multiple basins): 50,000 new residents and 40,000 new jobs by 2050.
  - Cambie Corridor: 9,800 jobs, 2,800 new social housing units and 20 acres of new parks by 2050 (spans multiple basins)
- The basin has a higher rent burden, a larger population of Indigenous people, and a larger population of seniors, relative to the city average.
- The "median modelled afternoon temperature" is high in the denser Strathcona, Mount Pleasant, and Fairview neighbourhoods.
- Overall, tree canopy cover is less dense as compared to other basins due to the density and urban characteristics of this basin.
- The 2100, 1-metre projected sea level rise would impact 11% of the basin, primarily in the industrial areas, the Vancouver rail yard, and along the shoreline of False Creek.
- The basin has the highest percentage of 2100 sea level rise inundation as compared to all the other basins and overlaps with the Priority Equity Area (does not account for Port property in Inner Harbour Basin).
- Low-lying areas, land below 4.6 metres, include 13% of the Basin by False Creek's shoreline, within the Vancouver rail yards and Downtown.

FALSE CREEK BASIN

BY THE NUMBERS

17% of total City population

High expected growth rate

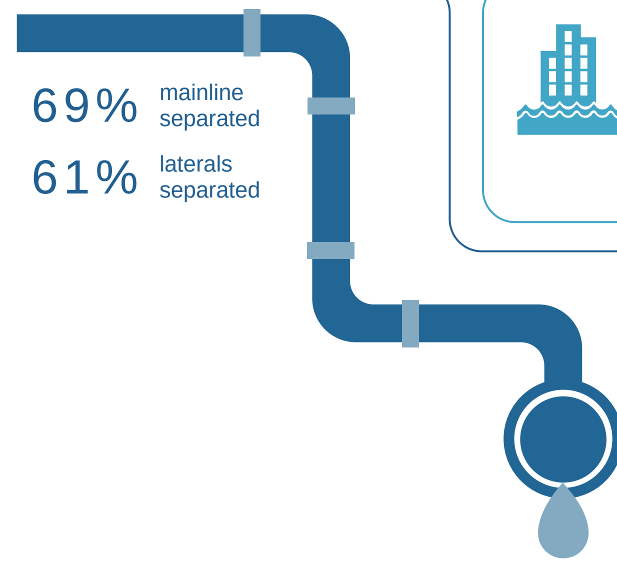
14% of total City area

10 docks & boat ramps

Secondary contact east of Burrard St. **Primary & secondary contact** west of Burrard St.

Closed for shellfish harvesting

21%	10%	7%	5%	12%	10%
1-2 Dwelling Residential	Multiple Dwelling Districts	Downtown Mixed Used	Commercial Mixed Use	Industrial	Park



69% mainline separated

61% laterals separated

4 City owned CSO Outfalls

1 MV owned CSO Outfall

13 SW Outfalls

11% at risk of inundation due to extreme storm surge events with 1m of sea level rise

12% of basin is covered by tree canopy

57% of basin is impervious

108 GRI assets managing **6.0** impervious hectares

False Creek Separation Status

- Contains a former heavily industrialized area along the coastline. It is currently a mix of land uses including medium and high density residential, commercial, and highly impervious industrial.
- Most of the former industrial area is fully separated (blue areas), meaning most untreated stormwater is directly discharged to False Creek. A portion of the stormwater runoff is treated where GRI has been implemented (such as within the Olympic Village neighbourhood).
- Some drainage corridors that historically drained into False Creek flow into interceptors and are conveyed towards the Iona Island WWTP. This has greatly reduced the groundwater and stormwater flows into False Creek.
- The highly impervious portion of the basin within downtown Vancouver is fully separated (blue areas) and discharges mostly untreated stormwater runoff to False Creek.
- Past separation efforts within several upland areas have allowed sanitary sewage from these areas to be directly sent to the interceptors (red areas), reducing the sewage concentration in the False Creek CSOs.
- The most upstream areas of the basin remain combined (white areas).

Water Quality Performance Summary

- Annual TSS discharge is about 131,000 kg, 9% of citywide TSS. 30% of False Creek TSS comes from CSOs, the rest is from stormwater discharges.
- Annual Fecal Coliform discharge is about 1,300 TCFU, 6% of citywide Fecal Coliform. 52% of False Creek Fecal Coliform comes from CSOs, the rest is from stormwater discharges.
- CSO discharge is about 1.2 million cubic meters per year, about 5% of citywide CSO volume.
- When full separation is achieved in 2075, total TSS loads would increase by 173% and total Fecal Coliform loads would increase by 92%.

Capital needs for 2075 planning horizon: $1.9B - $2.4B (2022 CAD)

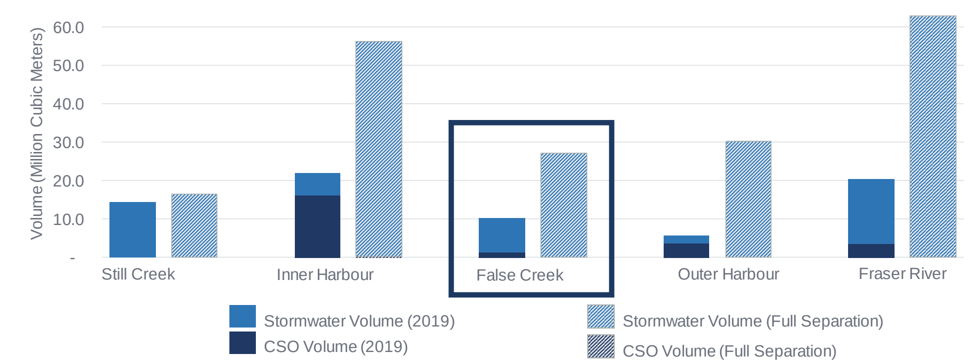
- A moderate population growth of 23% is expected.
- A total of 11 new stormwater pump stations and 10 sanitary pump stations are planned to be installed.
- 20% of new green infrastructure projects planned for the city will be in False Creek basin.

ALL BASINS

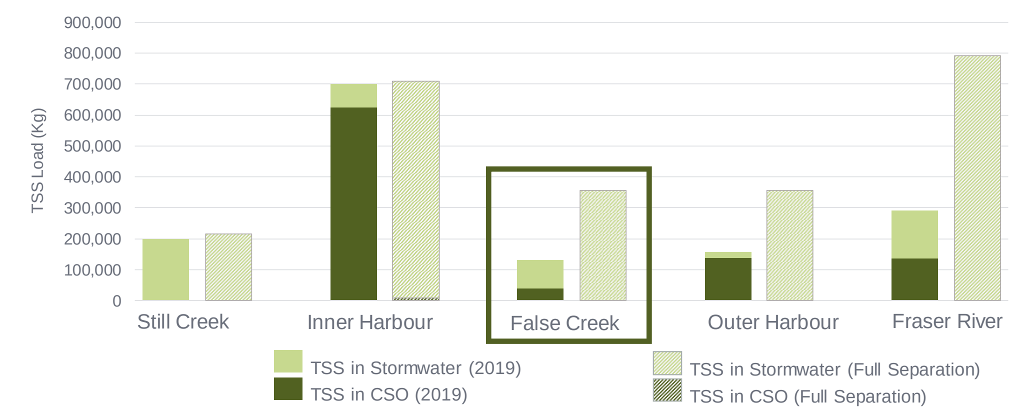
CURRENT CONDITIONS vs. 2075 FULL SEPARATION

1. *TSS: Total suspended solids. An indicator of sediment-bound contaminants*
2. *kg: Kilograms*
3. *TCFU: Trillions of colony forming unit, an indicator of potential fecal contamination*

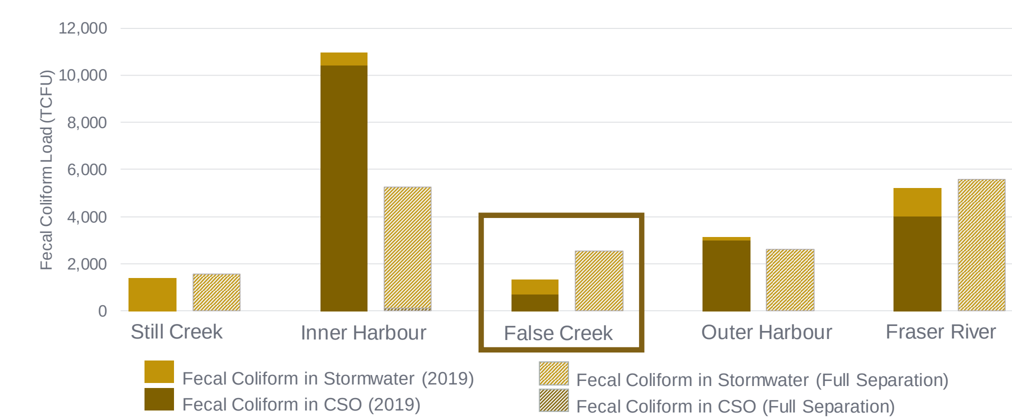
Discharge Volume



Total Suspended Solids (TSS) Load

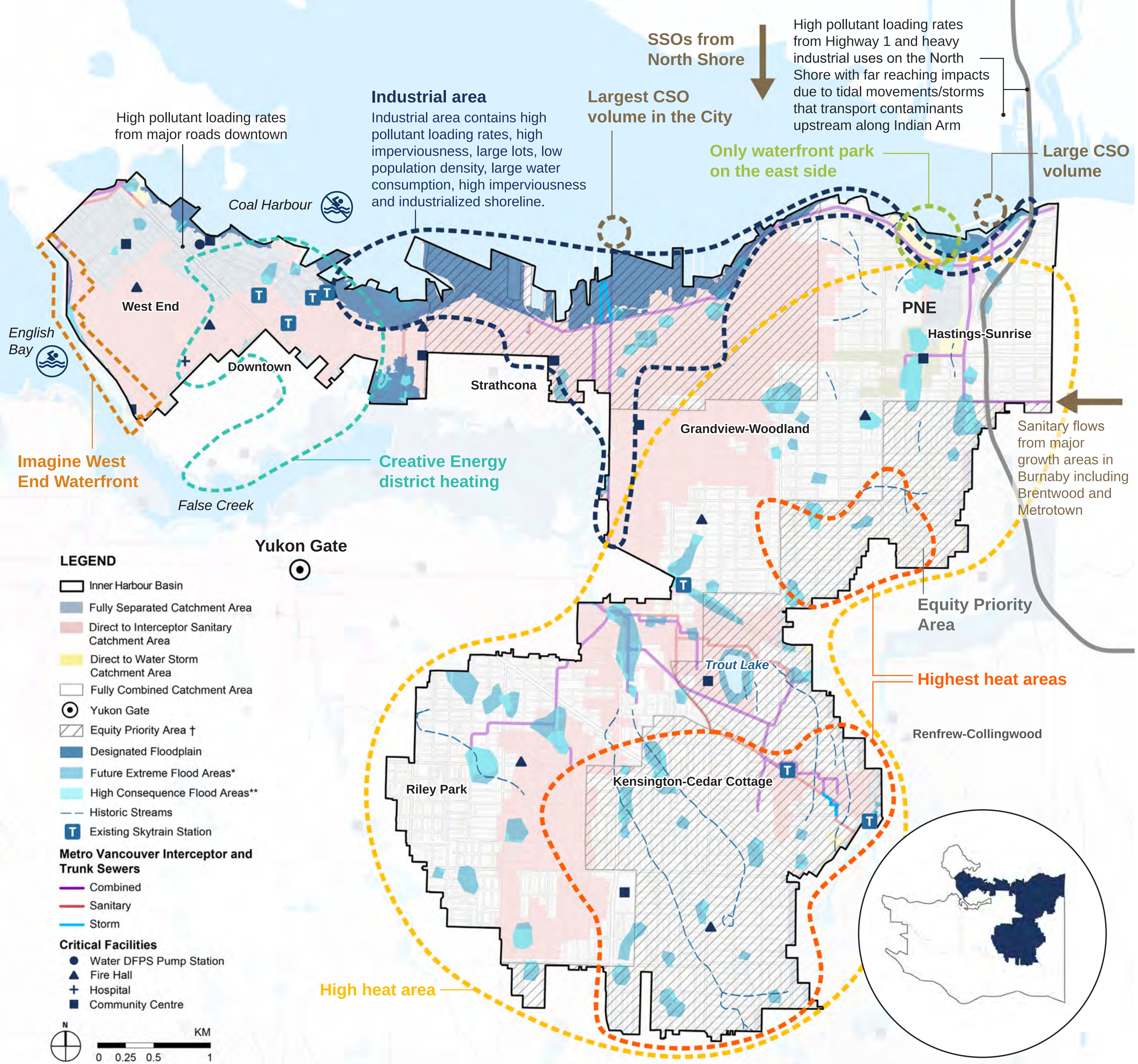


Fecal Coliform Load



This figure uses data current as of June 2022.

INNER HARBOUR BASIN
GESTALT MAP



This figure uses data current as of June 2022; †Census tracts which score high on an index of 7 indicators associated with high socio-economic need; *"Future Extreme Flood Areas" represents the overland flooding associated with the year 2100 100-yr return period rainfall. Flood depths less than 30 cm are not shown. These data are to be used at a planning scale only, flooded areas should not be used to indicate parcel-scale flooding; ** "High Consequence Flood Areas" are where Future Extreme Flood Areas overlap with high use areas (skytrain and bus stops, schools, libraries, bikeways, greenways), major roads, and critical facilities.

- 80% of the City's CSOs in 2020 occurred in this basin (due to how the Yukon Gate operates in protecting west side beaches)
- The waterfront has diverse land uses including Downtown waterfront parks and the sea wall, while moving east is the Port of Vancouver (Canada's largest port) and heavy industrial uses.
- Trout Lake is one of Vancouver's few freshwater lakes.
- All fishing & shellfish harvesting in the Inner Harbour have been closed since 1972 due to poor water quality and the basin is designated for secondary (boating) contact only east of Burrard St.
- The Tsleil- Waututh Nation's Burrard Inlet Action Plan (2017), and the Burrard Inlet Water Quality Objectives (2020-2023) will steer water quality improvements in the Inner Harbour, Outer Harbour, and False Creek for the next 50 years.

- Near the waterfront, there are fully separated areas and areas where the sanitary is connected directly to the interceptor system.
- Drainage has been drastically altered and the southern portion historically drained to the original False Creek
- Creative Energy is the city's largest commercial potable water user, and steam condensate is discharged into city sewers. Peak discharges occur in fall/winter when demands on the sewer system are greatest.

- This basin is socially vulnerable due to low-income households facing unaffordable rental housing, low economic agency, and low individual autonomy.
- Relative to citywide average, the basin has higher rent burden, lower household income, higher prevalence of single parent households, higher prevalence of non-English speaking households, and larger population of seniors
- This basin has the second highest median modelled afternoon temperatures (34.5ºC) and second lowest tree canopy cover (8%).

- Low-lying areas, land below 4.6 metres, include about 2% of the basin.

INNER HARBOUR BASIN

BY THE NUMBERS

35% of total City population

High expected growth rate

24% of total City area

1 docks & boat ramps

2 beaches

Secondary contact in Coal Harbour **Primary & secondary contact** in English Bay

Closed for shellfish harvesting

34%	6%	4%	4%	8%	6%
1-2 Dwelling Residential	Multiple Dwelling Districts	Downtown Mixed Used	Commercial Mixed Use	Industrial	Park

62% mainline separated

49% laterals separated

4% at risk of inundation due to extreme storm surge events with 1m of sea level rise

5 City owned CSO Outfalls

6 MV owned CSO Outfall

57 SW Outfalls

8% of basin is covered by tree canopy

57% of basin is impervious

48 GRI assets managing 2.3 impervious hectares

Inner Harbour Separation Status

- Large portions of this basin are separated but with the storm sewer still acting as the combined sewer (red areas), prioritizing high strength sewage into the interceptors to be conveyed to Iona Island WWTP, discharging CSOs with decreased volumes of sanitary sewage.
- Some areas in downtown Vancouver, near the PNE, and in industrial areas are fully separated (blue areas), sending mostly untreated stormwater discharges directly into Burrard Inlet.
- During wet weather, once the Yukon gate closes, all separated sanitary sewage from the Still Creek basin and parts of Burnaby, as well as sewage from the Inner Harbour basin is diverted to CSO outfalls in this basin. This is to minimize CSOs in False Creek and the Outer Harbour and to preserve the downstream capacity of the 8th Avenue Interceptor.
- The City's largest CSOs, both in volume and frequency, occur in this basin.

Water Quality Performance Summary

- Annual TSS discharge is about 690,000 kg, 47% of citywide TSS. 89% of Inner Harbour TSS comes from CSOs, the rest is from stormwater discharges.
- Annual Fecal Coliform discharge is about 11,000 TCFU, 60% of citywide Fecal Coliform. 95% of Inner Harbour Fecal Coliform comes from CSOs, the rest is from stormwater discharges.
- CSO discharge is about 16 million cubic meters per year, 66% of citywide CSO volume.
- When full separation is achieved in 2075, total TSS loads would increase by 3% and total Fecal Coliform loads would decrease by 52%.

Capital needs for 2075 planning horizon: $3B - $3.7B (2022 CAD)

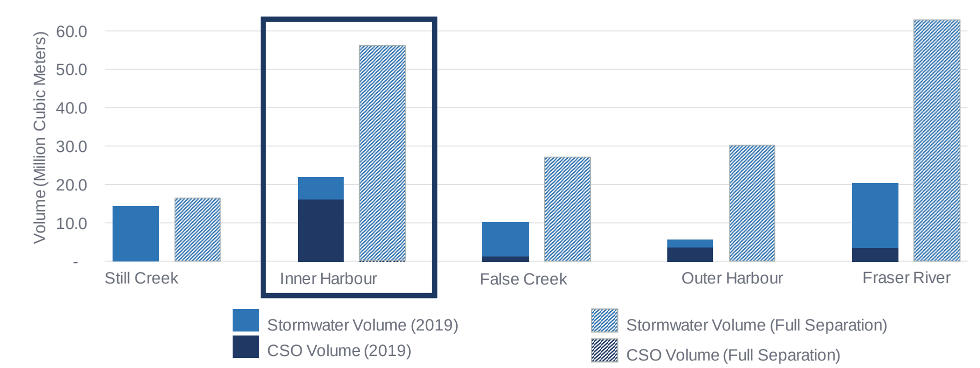
- A moderate population growth of 24% is expected.
- A total of 2 new stormwater pump stations and 2 sanitary pump stations are planned to be installed.
- 28% of new green infrastructure projects planned for the city will be in Inner Harbour basin.

ALL BASINS

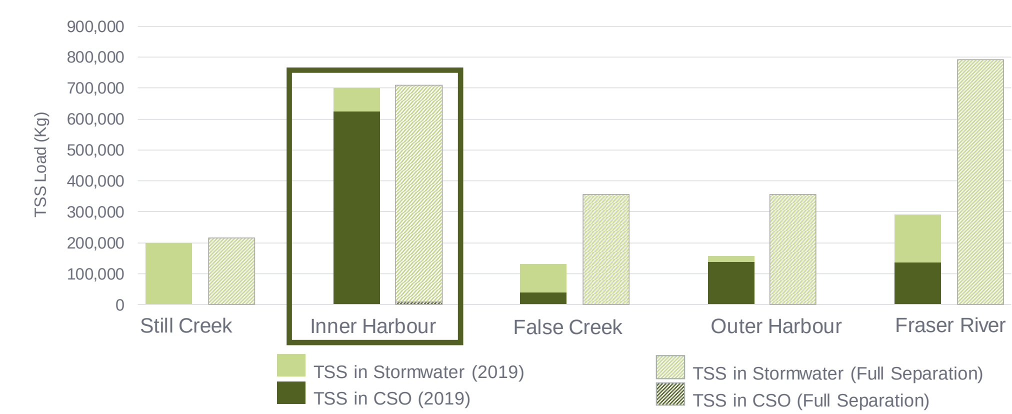
CURRENT CONDITIONS vs. 2075 FULL SEPARATION

1. *TSS: Total suspended solids. An indicator of sediment-bound contaminants*
2. *kg: Kilograms*
3. *TCFU: Trillions of colony forming unit, an indicator of potential fecal contamination*

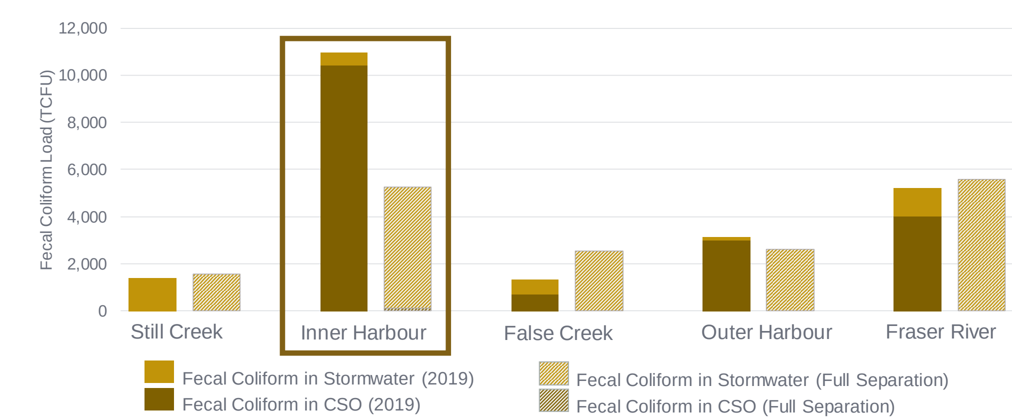
Discharge Volume



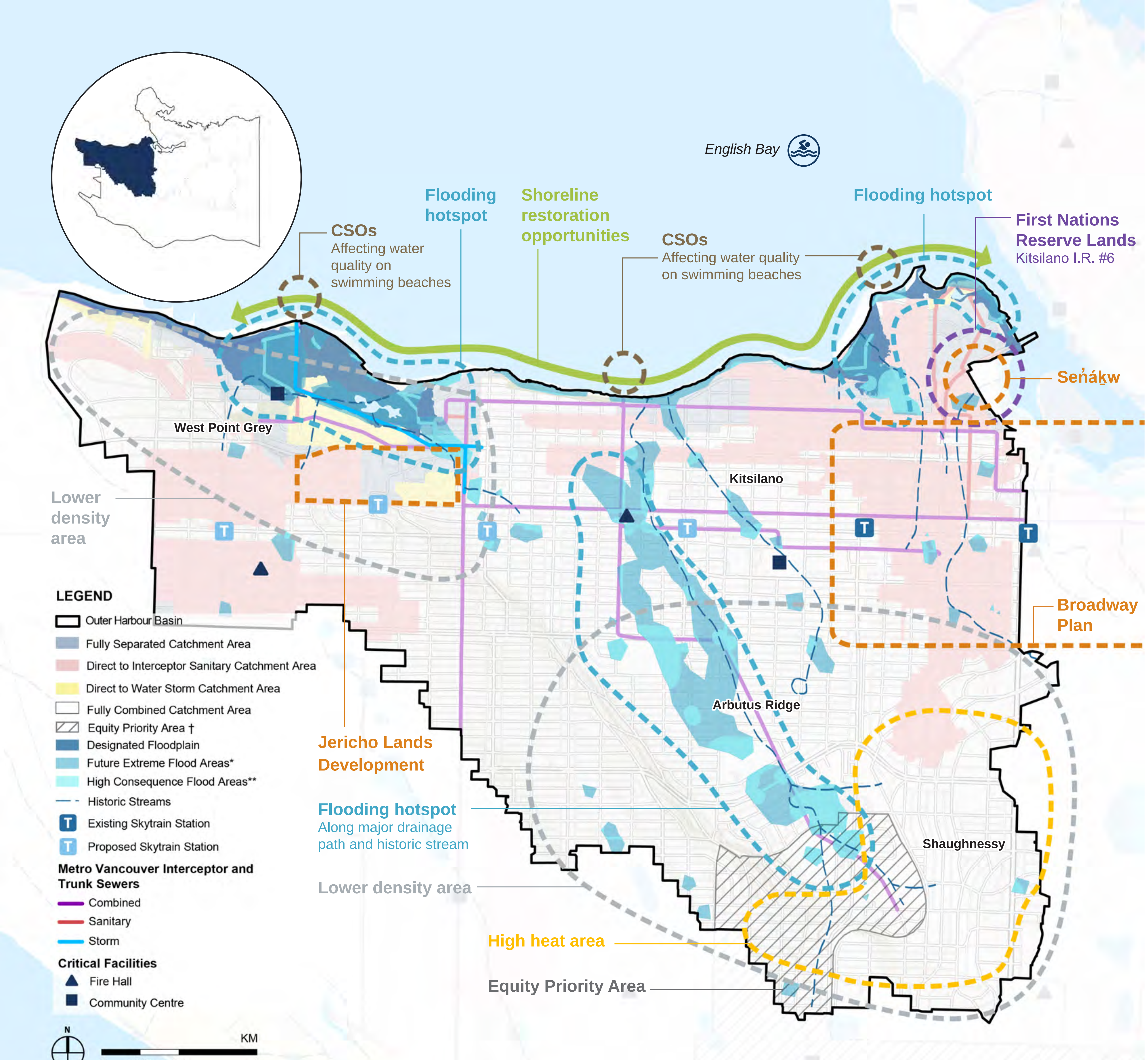
Total Suspended Solids (TSS) Load



Fecal Coliform Load



This figure uses data current as of June 2022.



This figure uses data current as of June 2022; †Census tracts which score high on an index of 7 indicators associated with high socio-economic need; *"Future Extreme Flood Areas" represents the overland flooding associated with the year 2100 100-yr return period rainfall. Flood depths less than 30 cm are not shown. These data are to be used at a planning scale only, flooded areas should not be used to indicate parcel-scale flooding; ** "High Consequence Flood Areas" are where Future Extreme Flood Areas overlap with high use areas (skytrain and bus stops, schools, libraries, bikeways, greenways), major roads, and critical facilities.

OUTER HARBOUR BASIN

GESTALT MAP

- Outer Harbor waterfront is a mix of public beaches and soft edges and includes many public access points and parks.
- It is a designated primary (swimming) contact area. Shellfish harvesting has been closed since 1972 due to poor water quality.

- The City's CSO outfall and ten stormwater outfalls contribute flows along with Metro Vancouver's 3 CSOs along the waterfront.
- 4.2% of the City's 2020 CSO volume was discharged into Outer Harbour and represented 15% of the total CSO events.
- Major conveyance infrastructure includes: 4 pump stations, large sewer mains, and the Highbury interceptor that conveys combined flow to the Iona Island WWTP.
- Approximately 68% of the basin is combined with fully separated areas and areas discharging direct to interceptor system along the waterfront.
- 26 Green Rainwater Infrastructure assets manage 1.6 hectares of impervious area.

- The basin is relatively affluent with a priority equity are in the Arbutus Ridge neighbourhood.
- Social vulnerability is characterized by low-income households facing housing insecurity, economic, social and housing insecurity, and unaffordable rental housing and relatively high individual autonomy.
- The basin has a has relatively a higher rent burden, more seniors and visible minorities.
- High future growth expected in the areas near downtown.
- The urban heat is the lowest in the city and enjoys the highest density of tree canopy.

- These overland flow paths align with buried historic creek paths.
- 4% of the basin is at risk of sea level rise.
- Low-lying areas, make up about 4% of the basin, on the shoreline of False Creek and English Bay

OUTER HARBOUR BASIN

BY THE NUMBERS

13% of total City population

Moderate expected growth rate

15% of total City area

10 docks & boat ramps

Secondary contact east of Burrard St. **Primary & secondary contact** west of Burrard St.

Closed for shellfish harvesting

44% 1-2 Dwelling Residential

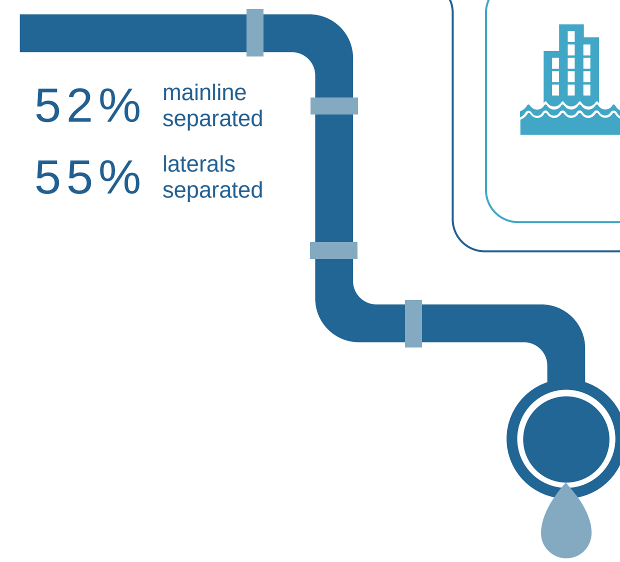
6% Multiple Dwelling Districts

4% Commercial Mixed Use

1% Industrial

5% Institutional

8% Park



1 City owned CSO Outfalls

3 MV owned CSO Outfall

10 SW Outfalls

<1% at risk of inundation due to extreme storm surge events with 1m of sea level rise

19% of basin is covered by tree canopy

47% of basin is impervious

26 GRI assets managing 1.6 impervious hectares

Outer Harbour Separation Status

- This basin contains large waterfront parks that direct discharge mostly untreated stormwater directly into the receiving water (yellow areas).
- Large portions of this basin are separated, but with the storm sewer still acting as the combined sewer (red areas), prioritizing high strength sewage into interceptors to be conveyed to Iona Island WWTP, discharging CSOs with decreased volumes of sanitary sewage.
- During wet weather, the interceptor system can become overwhelmed from combined sewer flows, resulting in CSOs being discharged into the Balaclava and Jericho outfalls. High flows in the Highbury Interceptor trigger the Yukon Gate to close, resulting in upstream overflows in the Inner Harbour basin.
- Some regions adjacent to the shoreline are fully separated (blue areas), sending untreated stormwater directly to the Outer Harbour.
- Some storm mains have separators at the bottom of the basin (blue and red areas). These are intended to collect the dirtiest stormwater (e.g. the first flush of a storm is the dirtiest) and any remaining connected laterals. The first flush of these areas is directed to the interceptor and treated at Iona WWTP.

Water Quality Performance Summary

- Annual TSS discharge is about 152,000 kg, 10% of citywide TSS. 88% of Outer Harbour TSS comes from CSOs, the rest is from stormwater discharges.
- Annual Fecal Coliform discharge is about 3,50 TCFU, 14% of citywide Fecal Coliform. 95% of Outer Harbour Fecal Coliform comes from CSOs, the rest is from stormwater discharges.
- CSO discharge is about 3.7 million cubic meters per year, 15% of citywide CSO volume.
- When full separation is achieved in 2075, total TSS loads would increase by 134% and total Fecal Coliform loads would decrease by 17%.

Capital needs for 2075 planning horizon: $1.9B - $2.4B (2022 CAD)

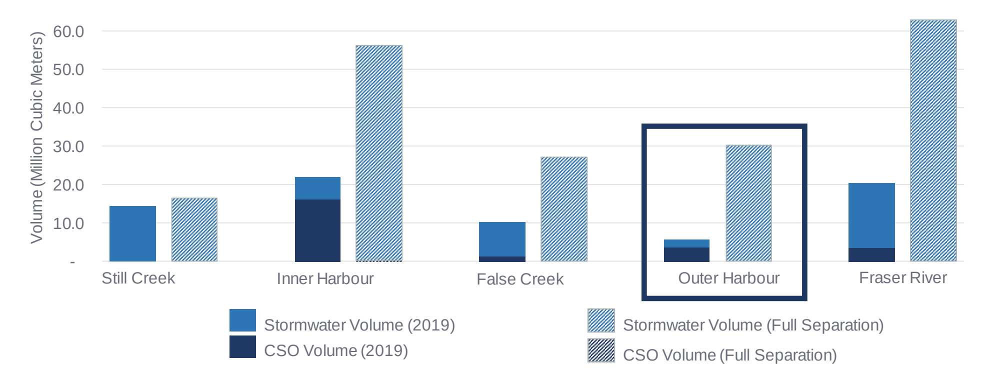
- A moderate population growth of 21% is expected.
- A total of 3 new stormwater pump stations and 3 sanitary pump stations are planned to be installed.
- 14% of new green infrastructure projects planned for the city will be in Outer Harbour basin.

ALL BASINS

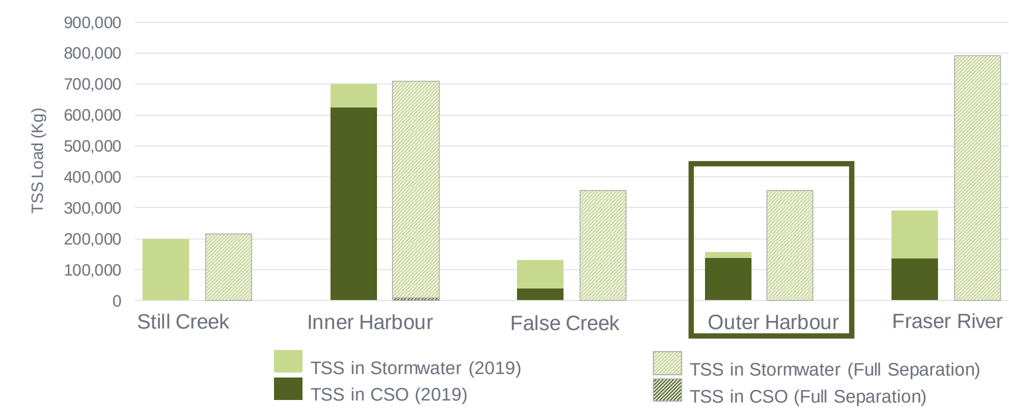
CURRENT CONDITIONS vs. 2075 FULL SEPARATION

1. *TSS: Total suspended solids. An indicator of sediment-bound contaminants*
2. *kg: Kilograms*
3. *TCFU: Trillions of colony forming unit, an indicator of potential fecal contamination*

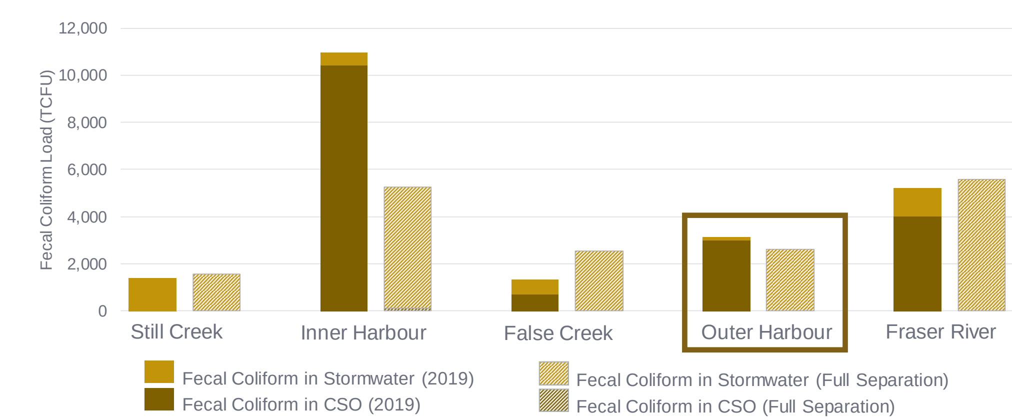
Discharge Volume



Total Suspended Solids (TSS) Load



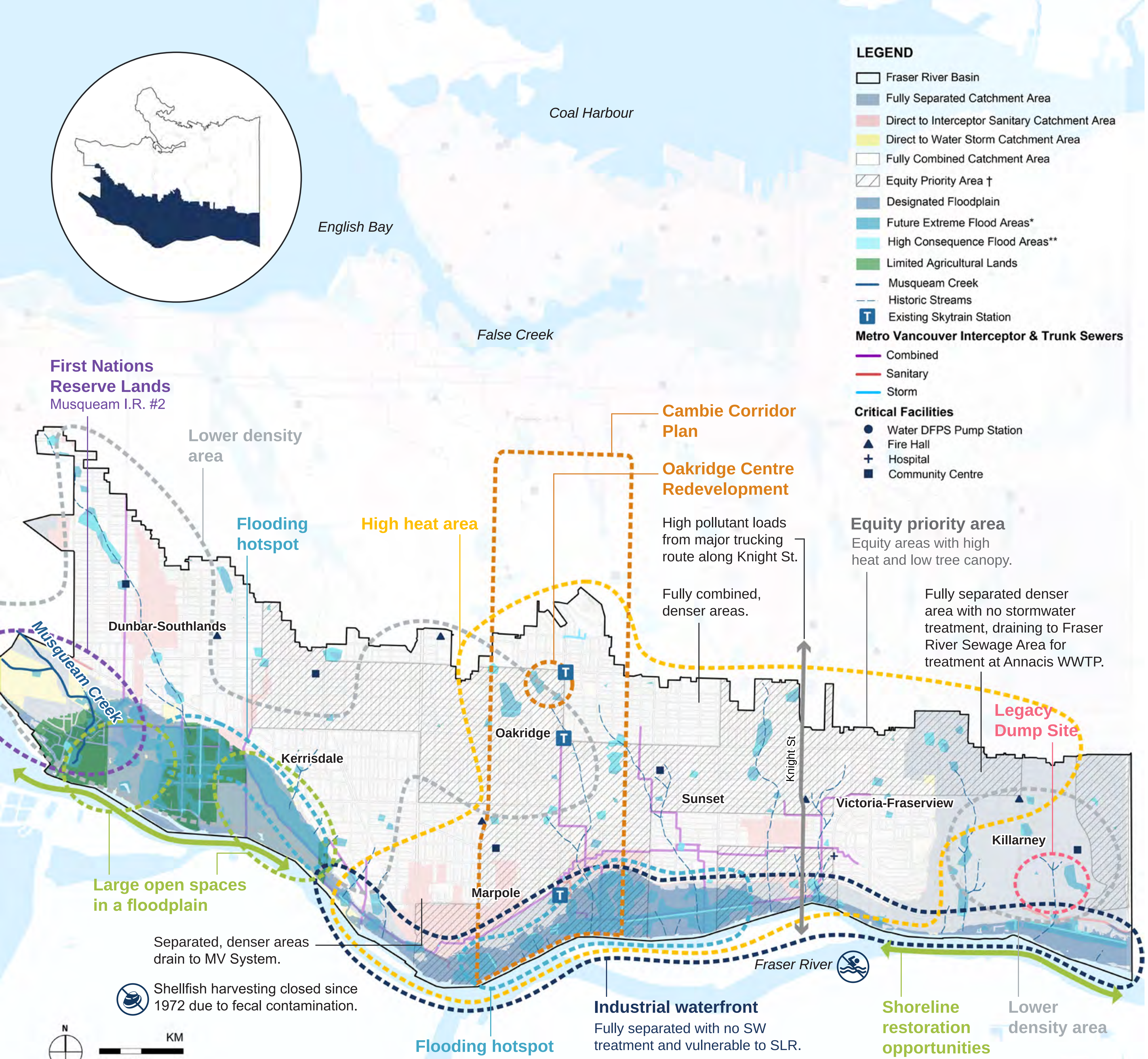
Fecal Coliform Load



This figure uses data current as of June 2022.

FRASER RIVER BASIN

GESTALT MAP



This figure uses data current as of June 2022; †Census tracts which score high on an index of 7 indicators associated with high socio-economic need; *"Future Extreme Flood Areas" represents the overland flooding associated with the year 2100 100-yr return period rainfall. Flood depths less than 30 cm are not shown. These data are to be used at a planning scale only, flooded areas should not be used to indicate parcel-scale flooding; ** "High Consequence Flood Areas" are where Future Extreme Flood Areas overlap with high use areas (skytrain and bus stops, schools, libraries, bikeways, greenways), major roads, and critical facilities.

- The Fraser River basin is the city's largest and covers 36% of the City. It is mainly low-density residential neighbourhoods with a highly industrial waterfront with a mix of commercial, residential, and parklands. The River is designated for secondary (boating) contact and supports significant recreational and commercial salmon fisheries. Shellfish harvesting has been closed since 1972 due to poor water quality.
- The Musqueam Creek has special significance for the Musqueam Indian Band and experiences low baseflows and summer dry creek beds.

- In 2020 the basin's CSOs discharged 14% of the City's CSO total volume and 25% of the total events.
- Major sewage conveyance infrastructure conveys combined flow to the Iona Island WWTP but the Champlain sewershed flows to the Fraser Sewerage Area and the Annacis Island WWTP.
- 119 Green Rainwater Infrastructure assets manager 5.2 hectares of impervious area.

- Priority Equity Areas include Oakridge, Sunset, Kensington, Victoria, and Fraserview neighbourhoods. Moderate and high future growth is expected along 49th St. and between Granville St. and Boundary Rd.
- The basin's tree canopy of 17% and it experiences the City's second highest median temperatures. Several equity areas are also at risk of high temperature
- Future development plans for residential development within the Musqueam Creek Basin will add impervious cover.

- The basin buried historic creeks align with flood risk areas.
- 16% of the Basin's floodplain is at risk of flooding within the Southlands neighbourhood and the Musqueam Creek floods when high tide coincides with heavy rainfall.
- There are water quality concerns in Vivian Creek.
- Sea level induced flooding is anticipated along the River dike.

FRASER RIVER BASIN

BY THE NUMBERS

25% of total City population

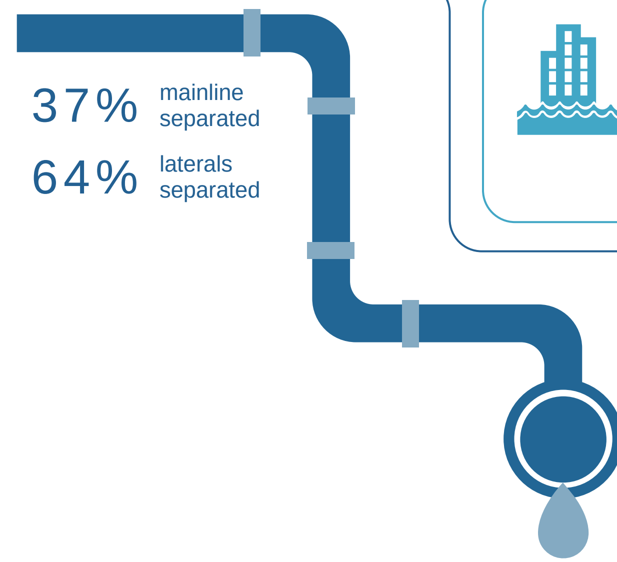
Moderate expected growth rate

35% of total City area

Secondary contact recreational use

Closed for shellfish harvesting

39%	6%	2%	6%	3%	16%
1-2 Dwelling Residential	Multiple Dwelling Districts	Commercial Mixed Use	Industrial	Institutional	Park



37% mainline separated

64% laterals separated

3 City owned CSO Outfalls

5 MV owned CSO Outfall

38 SW Outfalls

16% at risk of inundation due to extreme storm surge events with 1m of sea level rise

17% of basin is covered by tree canopy

43% of basin is impervious

119 GRI assets managing 5.2 impervious hectares

Fraser River Separation Status

- This basin has had very little upland mainline separation (white areas). Separation efforts have been focused on the lowland areas to avoid flooding and pump station bypasses.
- Areas that discharge mostly untreated stormwater directly into the Fraser River are typically large green open spaces (yellow areas).
- The basin has fully separated areas (blue areas) including the Champlain neighbourhood, which was developed as a separate system with mostly untreated stormwater being directly discharged to the Fraser River. The sanitary sewage from this area is directed to the Annacis Island WWTP.

Water Quality Performance Summary

- Annual TSS discharge is about 288,000 kg, 20% of citywide TSS. 46% of Fraser River TSS comes from CSOs, the rest is from stormwater discharges.
- Annual Fecal Coliform discharge is about 5,200 TCFU, 24% of citywide Fecal Coliform. 77% of Fraser River Fecal Coliform comes from CSOs, the rest is from stormwater discharges.
- CSO discharge is about 3.5 million cubic meters per year, 14% of citywide CSO volume.
- When full separation is achieved in 2075, total TSS loads would increase by 175% and total Fecal Coliform loads would increase by 7%.

Capital needs for 2075 planning horizon: $4.3B - $5.3B (2022 CAD)

- A moderate population growth of 27% is expected.
- A total of 6 new stormwater pump stations and 1 sanitary pump stations are planned to be installed.
- 25% of new green infrastructure projects planned for the city will be in Fraser River basin.

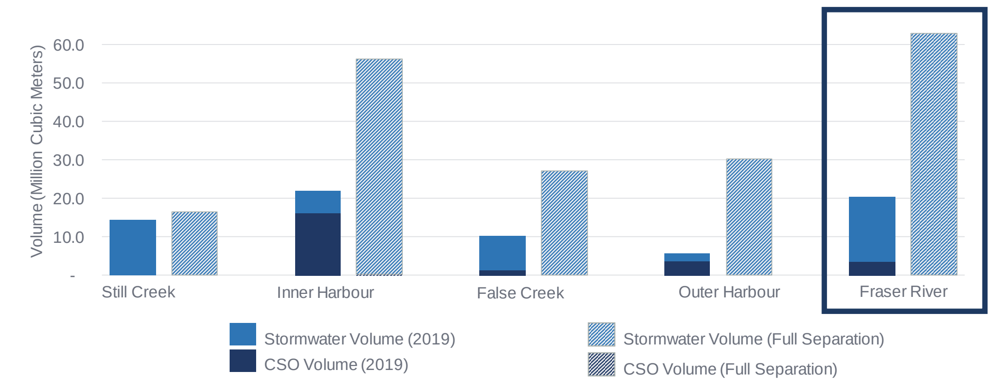
This figure uses data current as of June 2022.

ALL BASINS

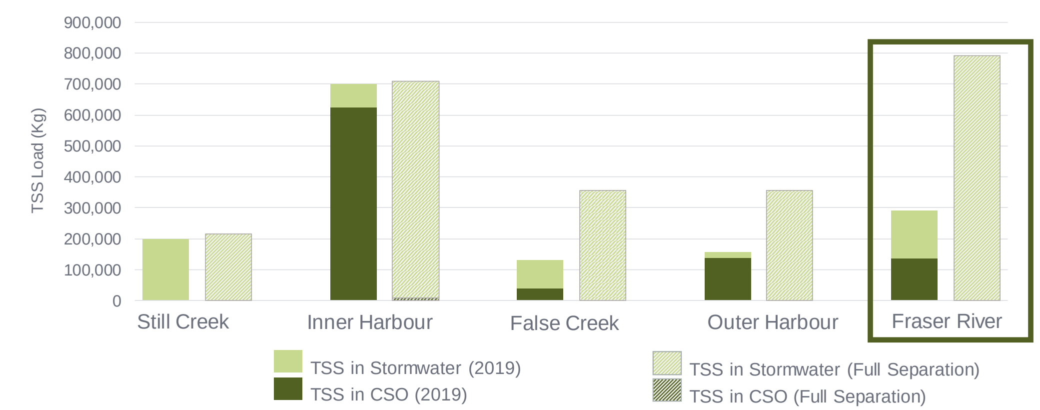
CURRENT CONDITIONS vs. 2075 FULL SEPARATION

1. *TSS: Total suspended solids. An indicator of sediment-bound contaminants*
2. *kg: Kilograms*
3. *TCFU: Trillions of colony forming unit, an indicator of potential fecal contamination*

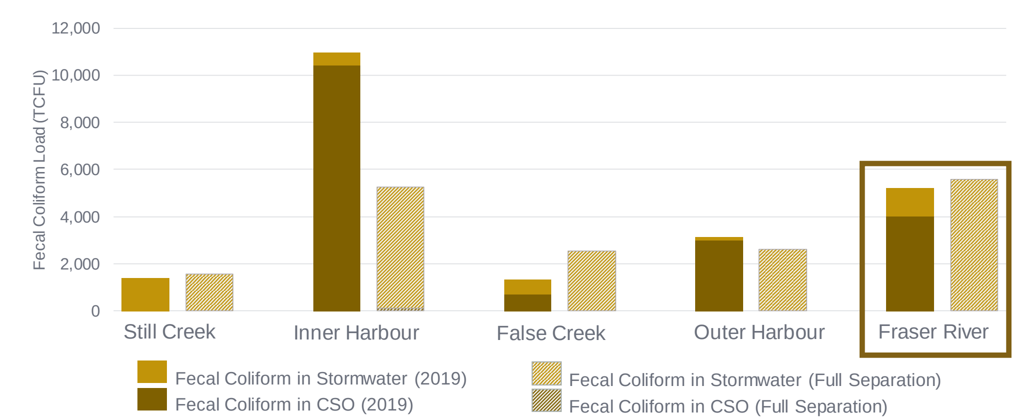
Discharge Volume



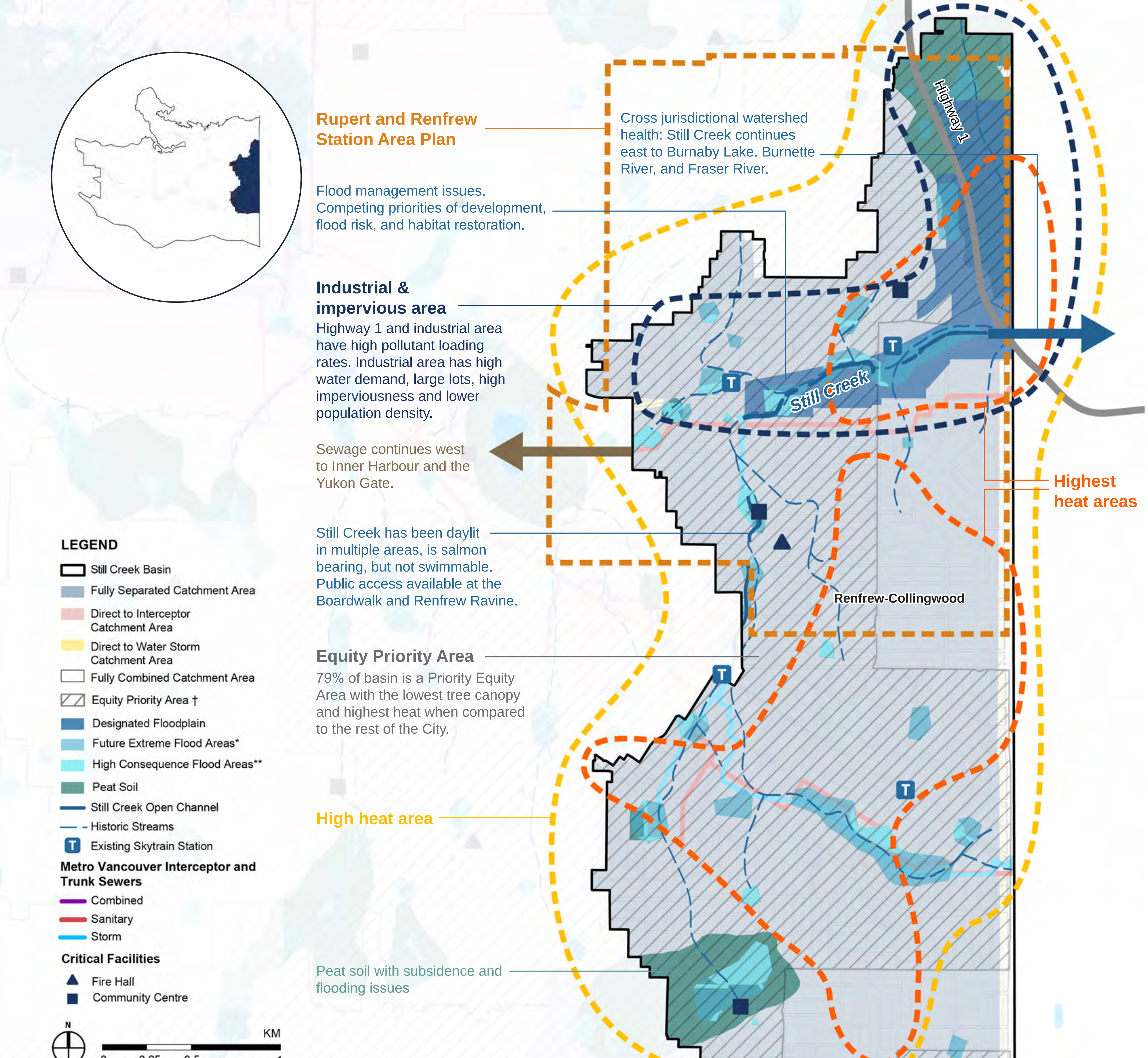
Total Suspended Solids (TSS) Load



Fecal Coliform Load



STILL CREEK BASIN
GESTALT MAP

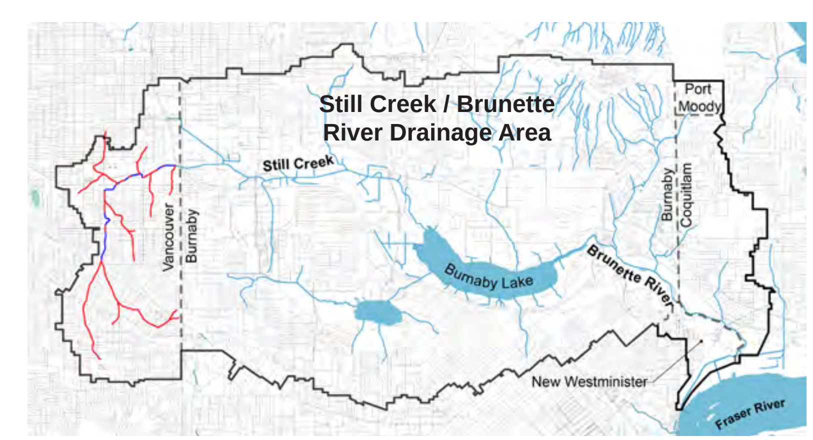


This figure uses data current as of June 2022; †Census tracts which score high on an index of 7 indicators associated with high socio-economic need; *"Future Extreme Flood Areas" represents the overland flooding associated with the year 2100 100-yr return period rainfall. Flood depths less than 30 cm are not shown. These data are to be used at a planning scale only, flooded areas should not be used to indicate parcel-scale flooding; ** "High Consequence Flood Areas" are where Future Extreme Flood Areas overlap with high use areas (skytrain and bus stops, schools, libraries, bikeways, greenways), major roads, and critical facilities.

- The basin is primarily single family residential with a commercial area along Grandview Highway and E. Broadway and industrial/ employment lands in the Grandview Boundary Mixed Employment Area.
- Vancouver's Still Creek Basin is a small portion of a much larger watershed that includes a large land area to the east and drains to the Fraser River.
- Sections of the creek are daylit in the northern portion of the catchment, but most of the creek within Vancouver's jurisdiction has been covered and piped.

- There are no CSO outfalls, but there are 22 stormwater outfalls discharging to Still Creek.
- The basin is 100% fully separated, about 1% is sanitary direct to the interceptor, and 100% of stormwater is direct to waterbody.
- High concentrations of pathogens and other contaminants continue to be measured in the creek pointing to chronic issues with pollution, source controls, cross-connections (wrongly connected combined and separated pipes) and urban runoff.
- The basin's sanitary sewage travels west towards the Iona treatment plant. The major sanitary sewer conveyance infrastructure includes three pump stations and the Collingwood and Copley Sanitary Trunk Sewers.

- Social vulnerability is characterized by low-income newcomers facing economic, social and housing insecurity and low individual autonomy.
- Relative to citywide average, this basin has a lower household income, a higher prevalence of single parent households, a higher prevalence of non-English speaking households, a larger population of visible minorities, and a larger population of Indigenous people.



STILL CREEK BASIN
BY THE NUMBERS

9% of total City population

Secondary contact recreational use

Moderate expected growth rate

8% of total City area

42%	4%	2%	8%	4%	7%
1-2 Dwelling Residential	Multiple Dwelling Districts	Commercial Mixed Use	Industrial	Institutional	Institutional

100% mainline separated

95% laterals separated

0% at risk of inundation due to extreme storm surge events with 1m of sea level rise

0 City owned CSO Outfalls

0 MV owned CSO Outfall

22 SW Outfalls

7% of basin is covered by tree canopy

55% of basin is impervious

14 GRI assets managing 0.9 impervious hectares

Still Creek Separation Status

- Lands in this basin were developed later than other areas of the City, and were constructed with mainline sewers fully separated. Mostly untreated stormwater drains directly to Still Creek in separated storm pipes.
- Still Creek has suspected fecal contamination from untreated sanitary sewage. While extensive investigative work has identified and eliminated a number of cross connections, further investigative work is required to identify and remedy any cross connections that may still exist.
- Still Creek is an important fish bearing creek that feeds the downstream Burnaby Lake and Brunette River water systems with high recreational values. It is a tributary to the Fraser River.
- The Vancouver portion of Still Creek is a small portion of a very large watershed going through three cities: Burnaby, Coquitlam, and New Westminster. An Integrated Stormwater Watershed Plan for the basin focuses on flooding mitigation and reducing pollution going into the creek.
- Community members have voiced concerns about the need to protect riparian areas and water quality.
- Because this basin's sewer mains are separated, future work could focus on stormwater management practices to lessen flooding, improve water quality and any remaining improper cross connections to align with the Integrated Stormwater Management Plan.
- Rainfall dependent infiltration is a large challenge in the separated sanitary sewer, which reduces capacity in downstream combined sewer systems, including at the Yukon Gate.
- This area discharges to 8th Avenue Interceptor upstream of Yukon Gate. Whenever the Yukon Gate closes, all separated sewage from Still Creek is discharged to Inner Harbour.

Water Quality Performance Summary

- Annual TSS discharge is about 200,000 kg, 14% of citywide TSS. 100% of Still Creek TSS comes from stormwater discharges.
- Annual Fecal Coliform discharge is about 1,400 TCFU, 6% of citywide Fecal Coliform. 100% of Still Creek Fecal Coliform comes from stormwater discharges.
- CSO discharge is 0, but stormwater discharge is 14 million cubic meters per year, 30% of citywide stormwater volume.
- When full separation is achieved in 2075, total TSS loads would increase by 10% and total Fecal Coliform loads would increase by 12%.

Capital needs for 2075 planning horizon: $922M - $1.3B (2022 CAD)

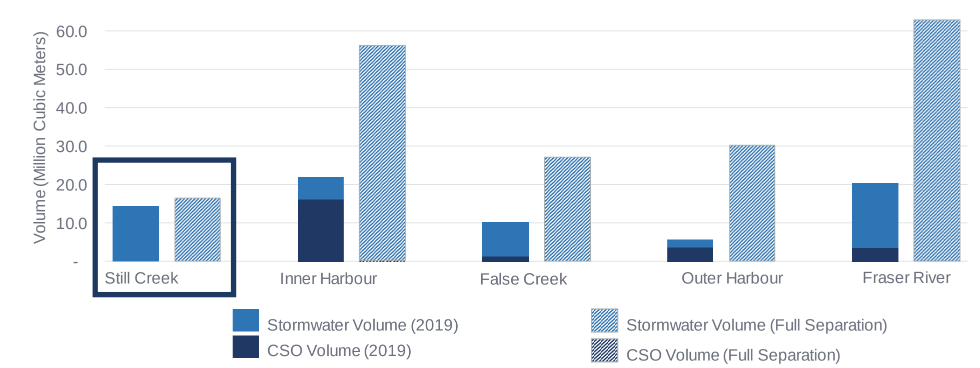
- A small population growth of 5% is expected.
- A total of 3 new sanitary pump stations are planned to be installed.
- 13% of new GRI projects planned for the city will be in Still Creek basin.

This figure uses data current as of June 2022.

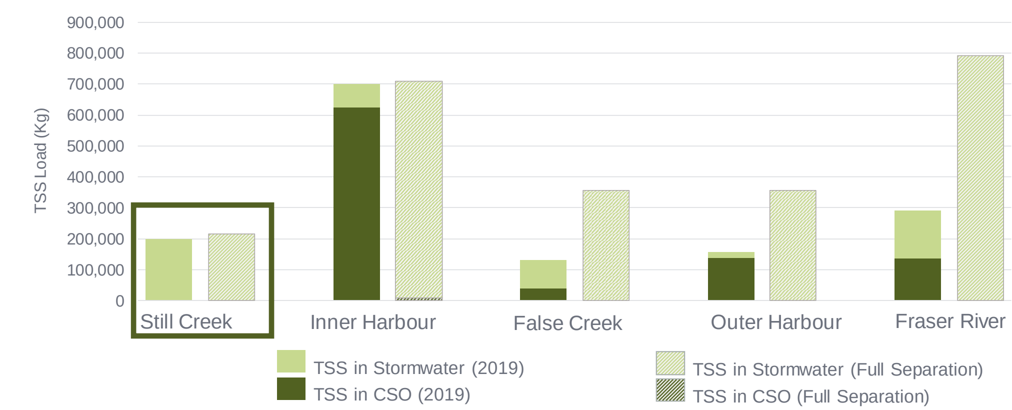
ALL BASINS
CURRENT CONDITIONS vs. 2075 FULL SEPARATION

1. *TSS: Total suspended solids. An indicator of sediment-bound contaminants*
2. *kg: Kilograms*
3. *TCFU: Trillions of colony forming unit, an indicator of potential fecal contamination*

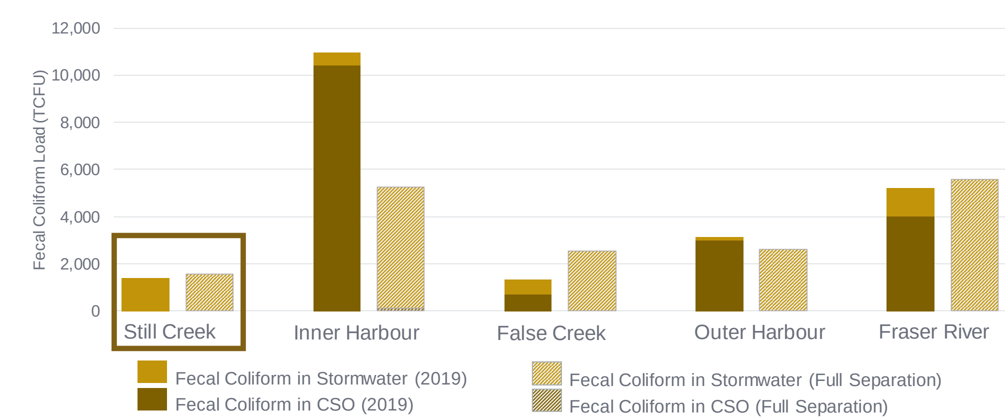
Discharge Volume



Total Suspended Solids (TSS) Load



Fecal Coliform Load



APPENDIX E: HEALTHY WATERS PLAN BASIN-SCALE COMPARATIVE PERFORMANCE

Healthy Waters Plan Basin-Scale Comparative Performance

The results of analysis presented in this appendix reflect adoption of a 24mm retention standard for redevelopment. A retention standard provides extensive benefits across multiple goal areas. Late in the Phase 2 process, significant affordability and technical viability concerns were raised regarding implementation of a 24 mm retention policy citywide and for all forms of development. As part of the recommended optimization evaluation for enhanced detention and hybrid detention-retention based approaches, these performance measures will need to be updated and factored into the Phase 3 implementation planning.

The performance outcomes presented in this appendix also assume the development of CSO rapid treatment and storage facilities, which is subject to feasibility analysis and other steps. Anticipated performance outcomes will need to be updated upon the conclusion of this work.

Inner Harbour Basin Performance

Anticipated Performance Outcomes Include:

- **Fecal Coliform**: The Healthy Waters Plan Pathway provides an equivalent level of performance for the 2050 time-step as the 100% Sewer Separation by 2050 Pathway. Due to the increasing intensity of rainfall events causing more frequent closures of the Yukon Gate, along with population growth in the Inner Harbour, fecal loading is expected to approximately double by 2050 for the Current Trajectory Pathway. By 2075, all Pathways are anticipated to provide a comparable level of performance (Figure 82)

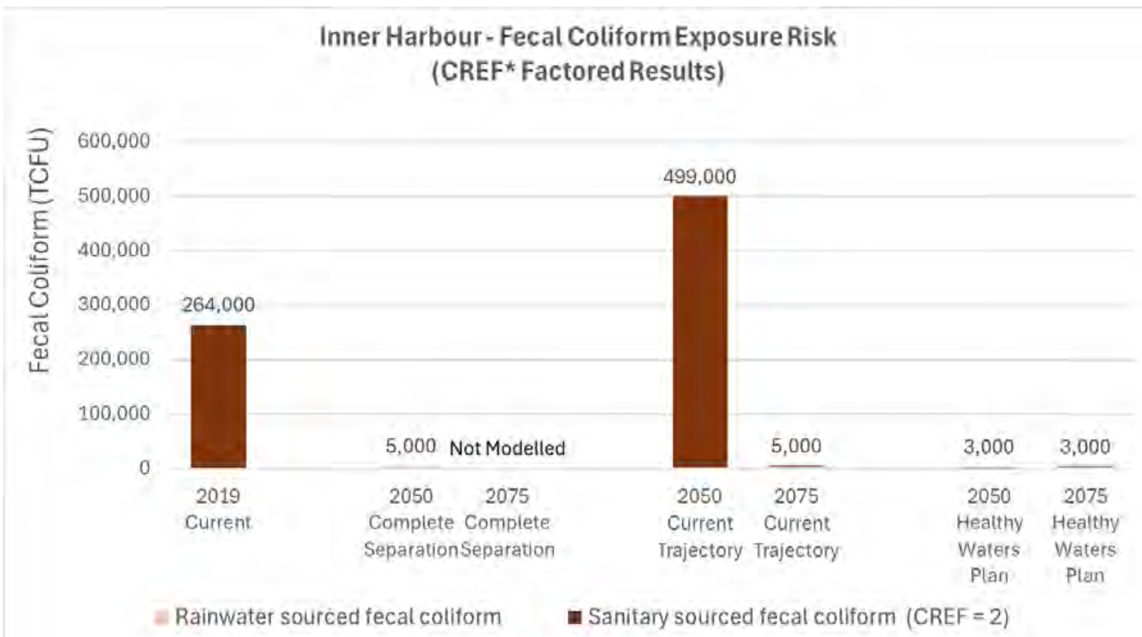


Figure 82 : Fecal Coliform Performance for the Inner Harbour Basin

- **TSS Performance**: By 2050, the Healthy Waters Plan Pathway results in 70% less TSS pollution than the 100% Sewer Separation by 2050 Pathway and 30% less than the Current Trajectory Pathway. This improvement is largely due to CSO rapid treatment, which removes TSS from both sanitary sewage and rainwater runoff. The 24 mm retention policy for redevelopment also contributes to this reduction. By 2075, the Healthy Waters Plan Pathway provides 35% less TSS pollution than the Current Trajectory Pathway (Figure 83).

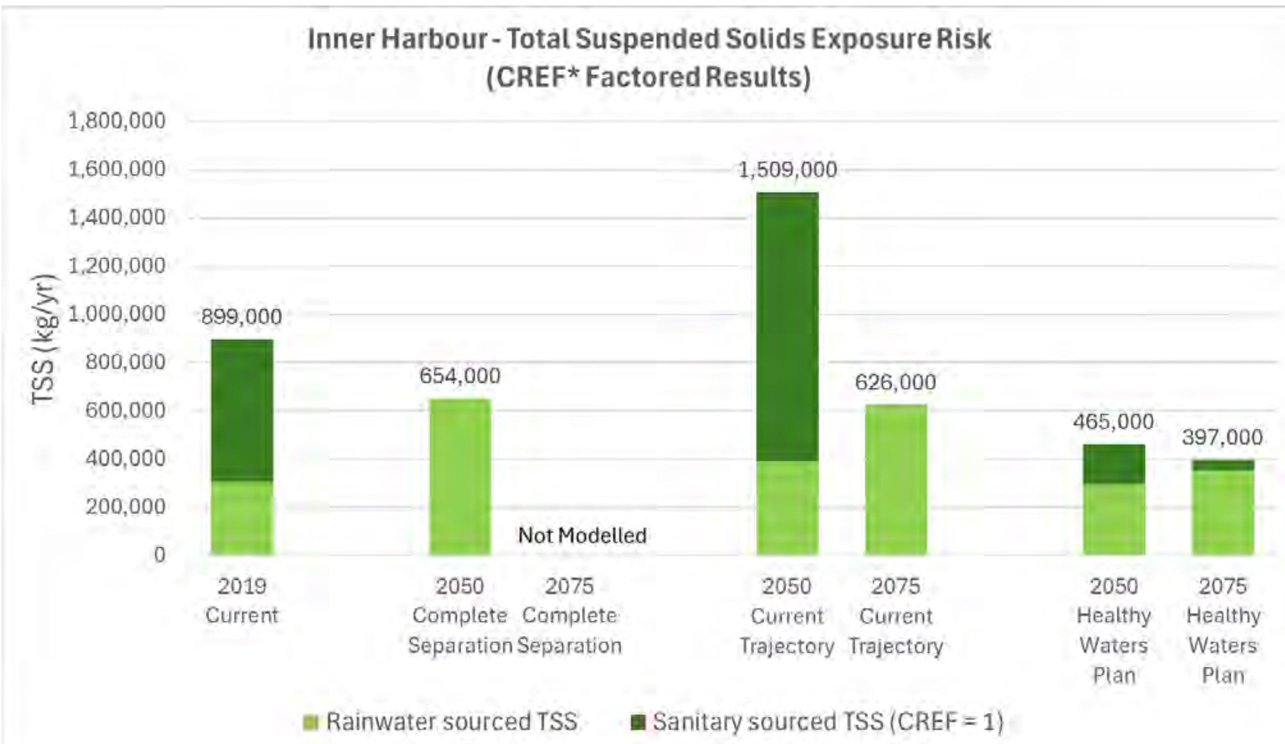


Figure 83: TSS Performance for the Inner Harbour Basin

- **Overall MCDA Performance**: The Healthy Waters Plan Pathway achieves a broader range of objectives compared to the Current Trajectory Pathway (Figure 84). This is primarily due to increased investment in GRI, the application of in-line grey stormwater treatment devices, the use of CSO rapid treatment, and the implementation of 24 mm retention and flood policies for redevelopment.

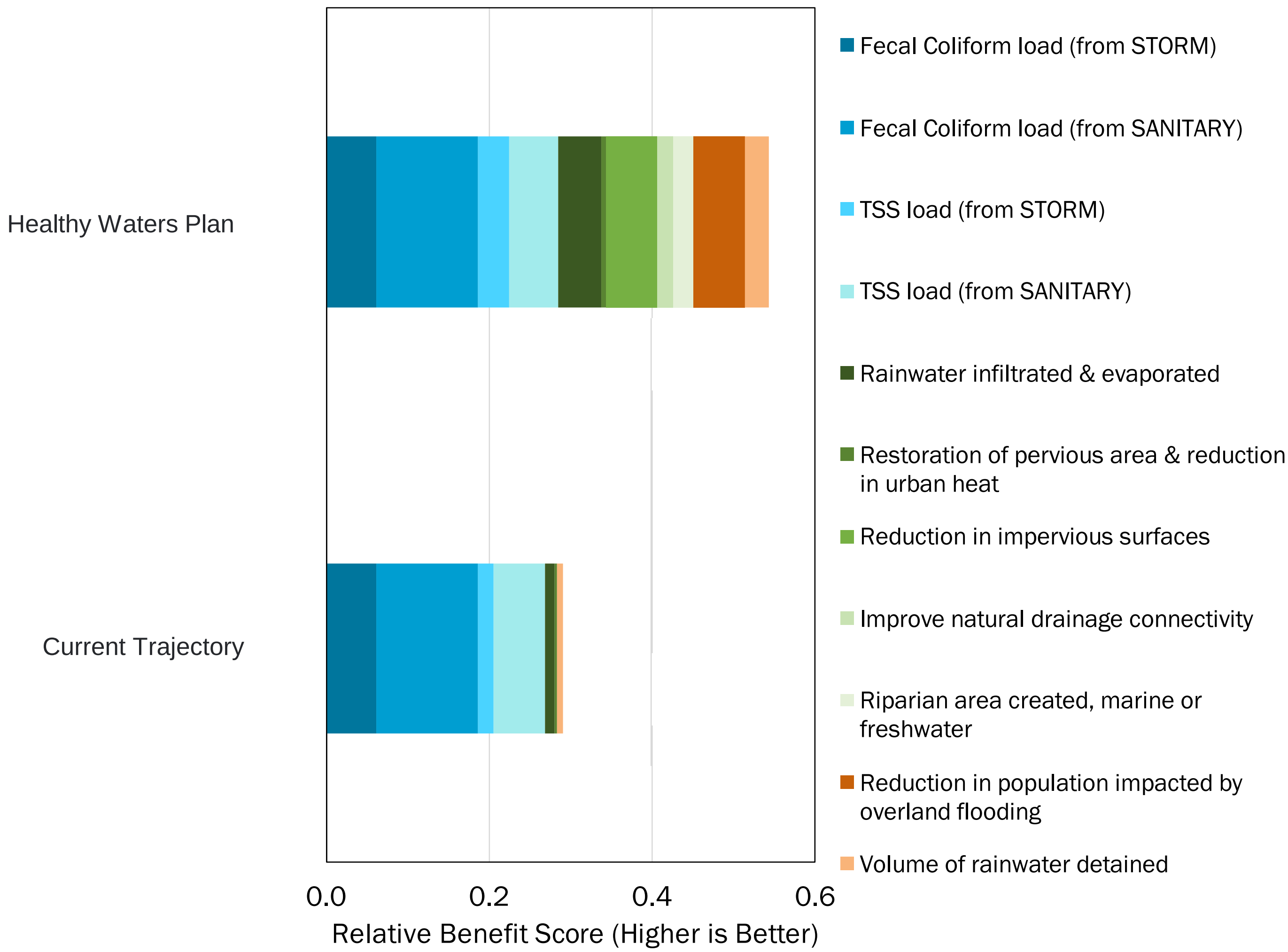


Figure 84: Overall MCDA Performance for the Inner Harbour Basin

False Creek Basin Performance

Anticipated Performance Outcomes Include:

- **Fecal Coliform Performance:** By 2050, the Healthy Waters Plan Pathway results in 25% more fecal coliforms than the 100% Sewer Separation by 2050 Pathway, and 60% less than the Current Trajectories Pathway. By 2075, all Pathways provide comparable performance (Figure 85).

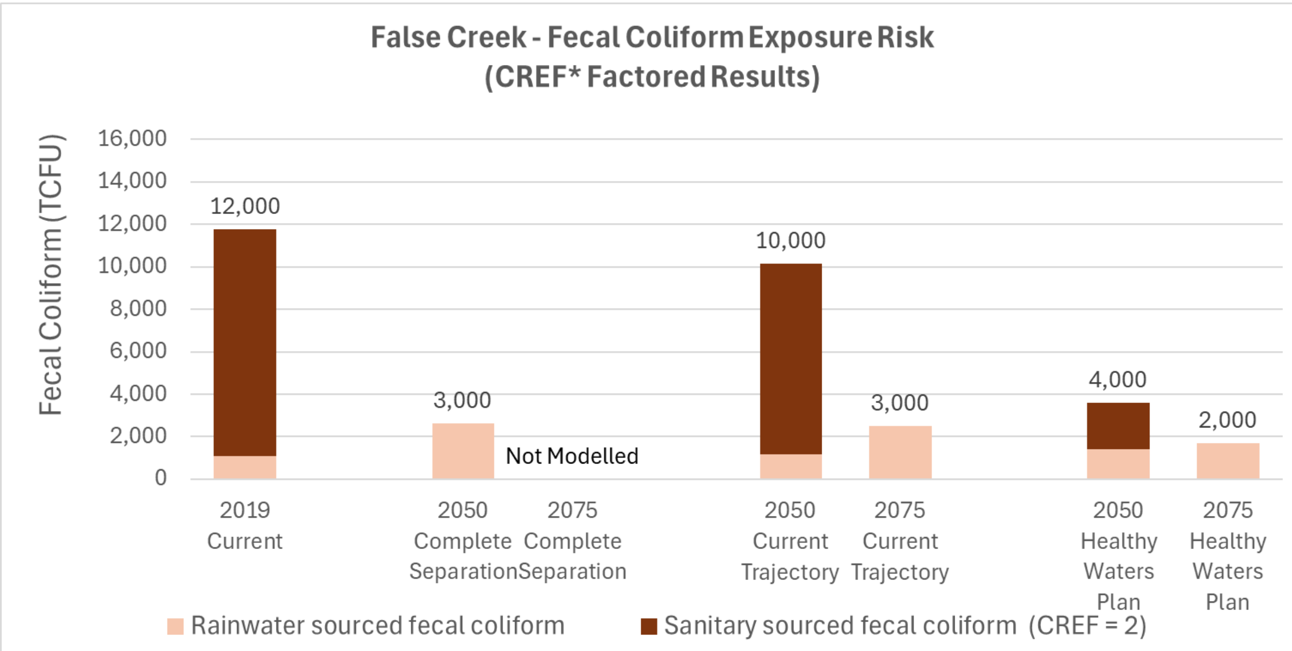


Figure 85: Fecal Coliform Performance for the False Creek Basin

- **TSS Performance:** By 2050, the Healthy Waters Plan Pathway results in 50% less TSS pollution than the 100% Sewer Separation by 2050 Pathway and approximately 10% more TSS than the Current Trajectories Pathway. However, by 2075, the Healthy Waters Plan Pathway significantly outperforms the Current Trajectories Pathway by over 40%, largely due to the full implementation of green infrastructure, stormwater treatment options, and the 24 mm retention policy for redevelopment (Figure 86).

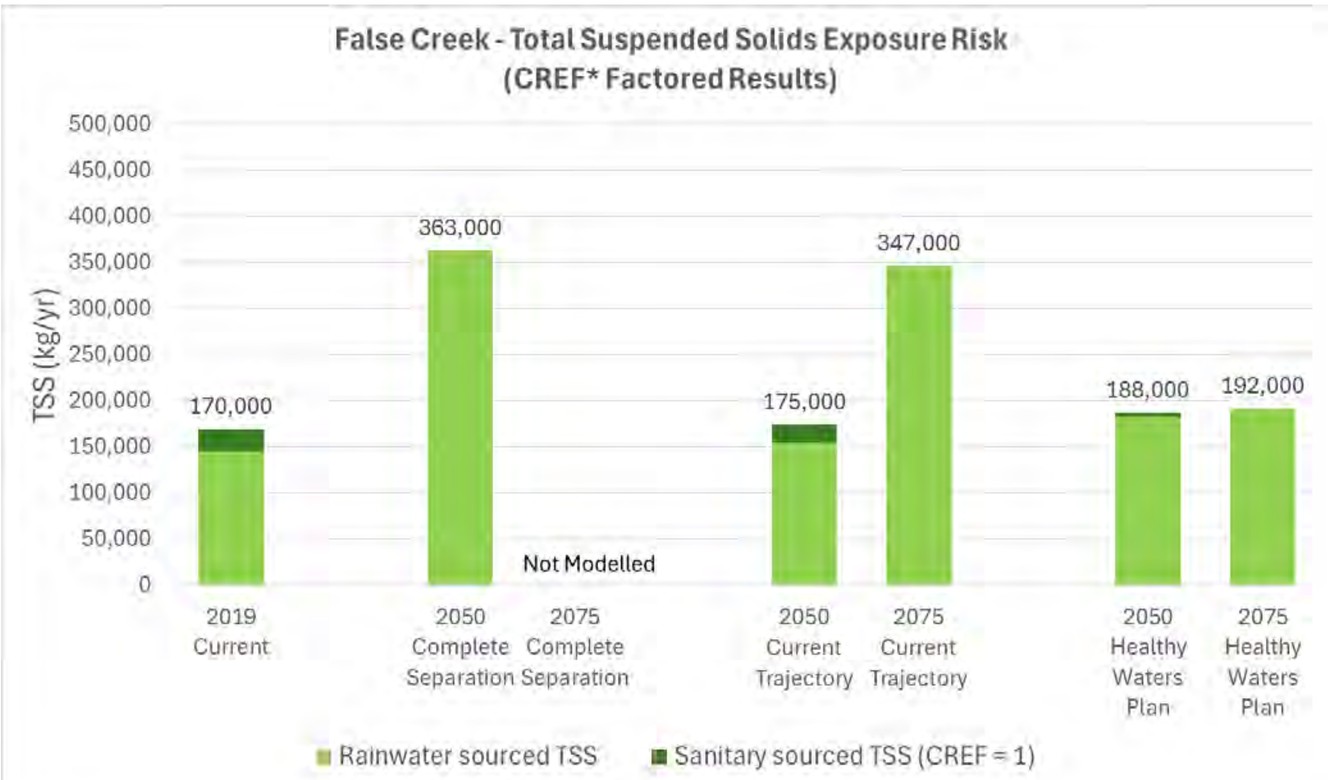


Figure 86: TSS Performance for the False Creek Basin

- **Overall MCDA Performance:** The Healthy Waters Plan Pathway achieves a broader range of objectives compared to the Current Trajectory Pathway (Figure 87). This is primarily due to increased investment in GRI, the application of in-line grey stormwater treatment devices, and the implementation of 24 mm retention and flood policies for redevelopment.

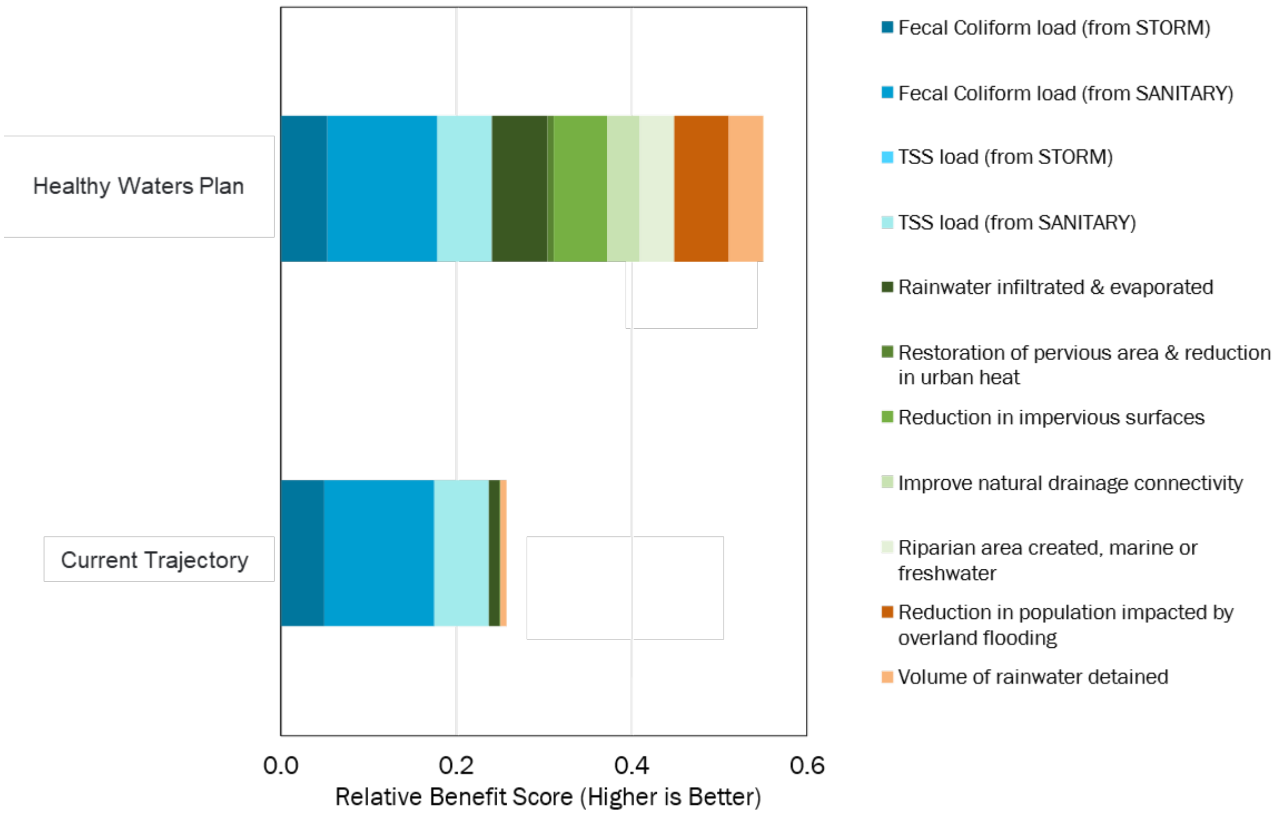


Figure 87: Overall MCDA Performance for the False Creek Basin

Outer Harbour Basin Performance

Anticipated Performance Outcomes Include:

- **Fecal Coliform**: **By 2050, the Healthy Waters Plan Pathway provides comparable performance compared to the 100% Sewer Separation by 2050 Pathway**. During the same period, fecal coliforms is expected to increase threefold for the Current Trajectory Pathway due to population growth and more intense rainfall events. By 2075, all pathways are anticipated to provide a comparable level of performance (Figure 88).

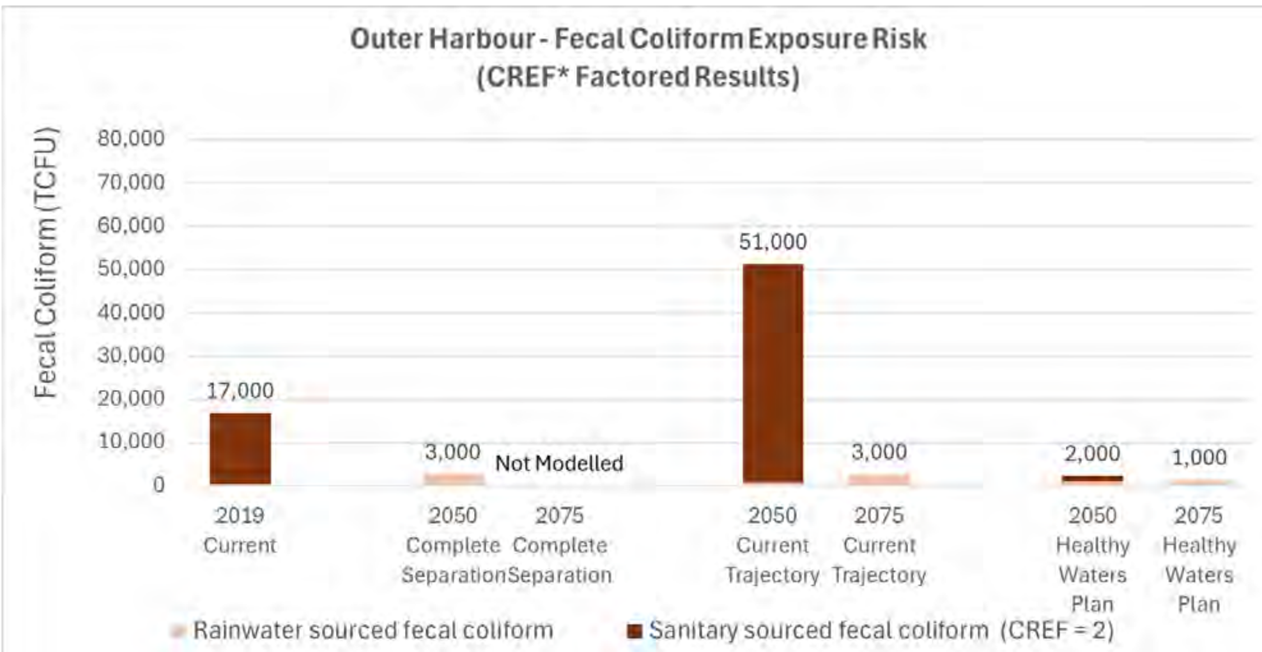


Figure 88: Fecal Coliform Performance for the Outer Harbour Basin

- **TSS Performance: By 2050, the Healthy Waters Plan Pathway results in nearly three times less TSS pollution than the 100% Sewer Separation by 2050 Pathway**. The LWMP Pathway is expected to see a large increase in TSS because rainwater currently going to the Iona Island Wastewater Treatment Plant will be diverted to the Outer Harbour. The Healthy Waters Plan Pathway has a smaller increase due to the use of GRI & in-line grey stormwater treatment devices, and CSO storage. The Current Trajectory Pathway performs better than the 100% Sewer Separation by 2050 Pathway in 2050 because most rainwater is still being conveyed to the Iona Island facility. By 2075, the Current Trajectory Pathway will see TSS pollution levels equivalent to the 100% Sewer Separation by 2050 scenario. The Healthy Waters Plan Pathway will see a modest increase with the expansion of sewer separation work (Figure 89):

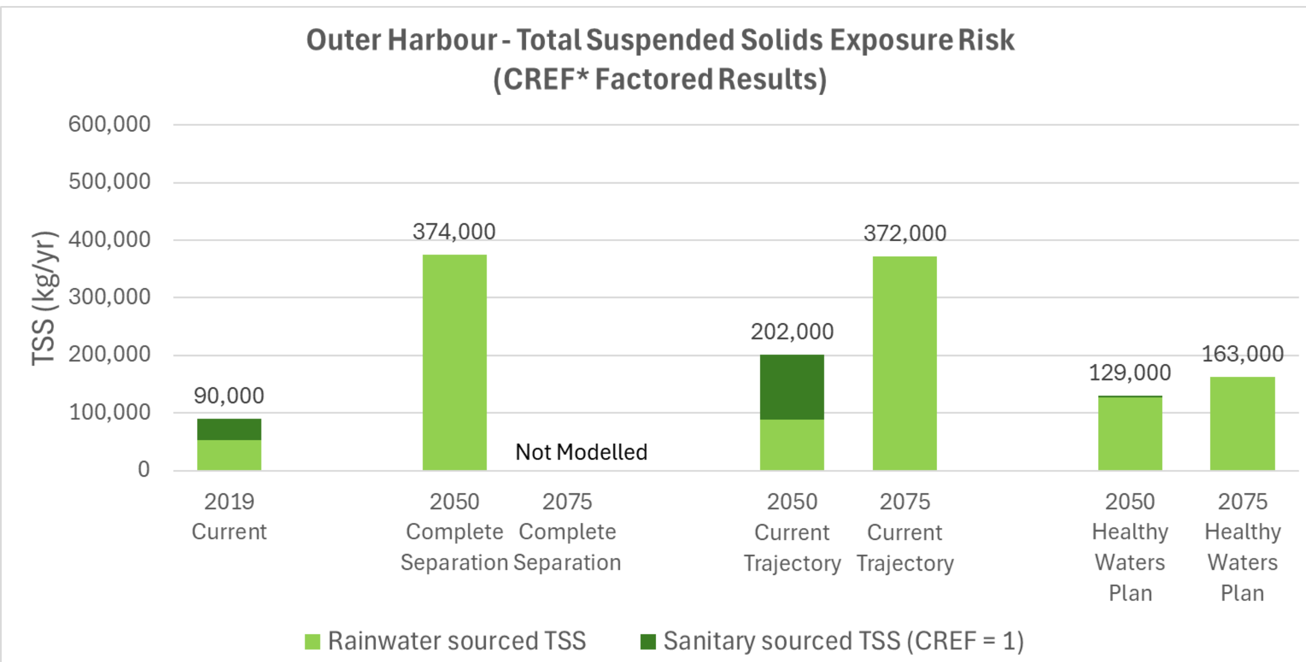


Figure 89: TSS Performance in the Outer Harbour Basin

- **Overall MCDA Performance**: The Healthy Waters Plan Pathway achieves a broader range of objectives compared to the Current Trajectory Pathway (Figure 90). This is primarily due to increased investment in GRI, the application of in-line grey stormwater treatment devices, the use of CSO storage, and the implementation of 24 mm retention and flood policies for redevelopment.

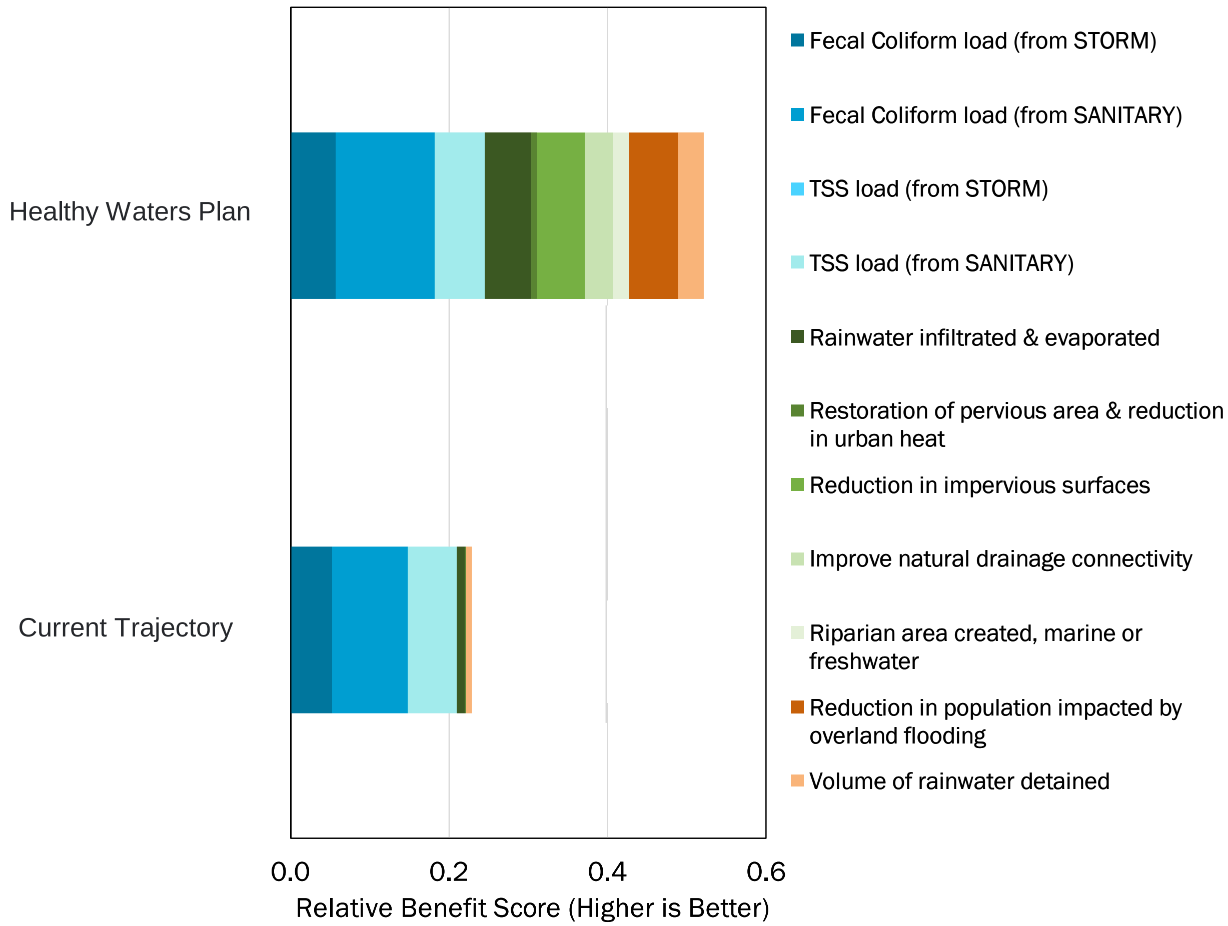


Figure 90: Overall MCDA Performance for the Outer Harbour Basin

Still Creek Basin Performance

Anticipated Performance Outcomes Include:

Fecal Coliform and TSS Performance: The Healthy Waters Plan Pathway outperforms the 100% Sewer Separation by 2050 and Current Trajectory Pathways due to the expanded use of GRI and in-line grey stormwater treatment devices. However, since pollution loading are already relatively low in this basin, all Pathways show similar levels of performance at each time step (2019, 2050, 2075) (see Figures 91 and 92). Note that these are modelled results, which cannot take into account pollution from suspected cross connections to the stormwater system.

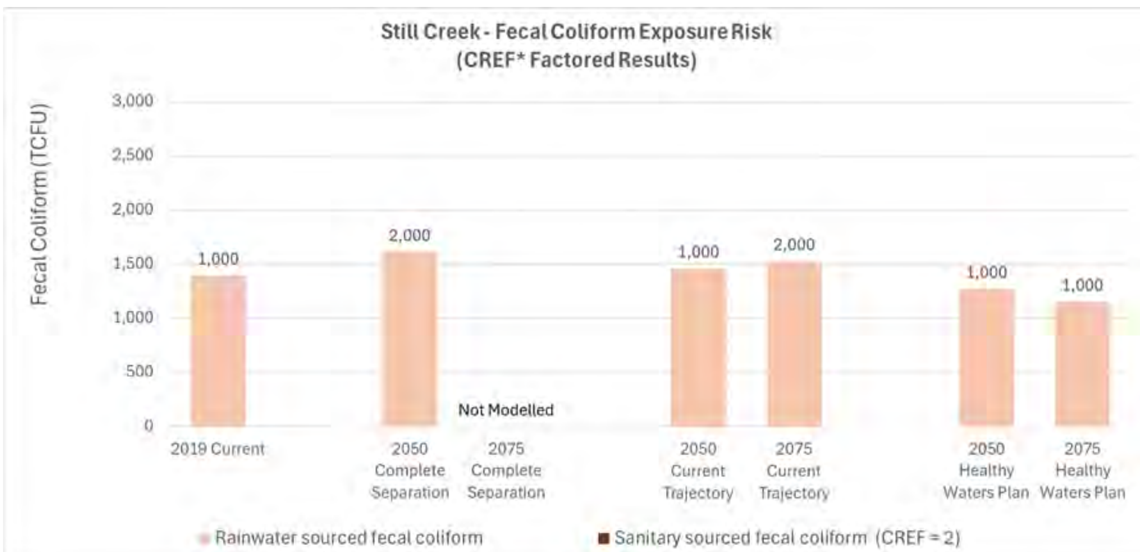


Figure 91: Fecal Coliform Performance for the Still Creek Basin

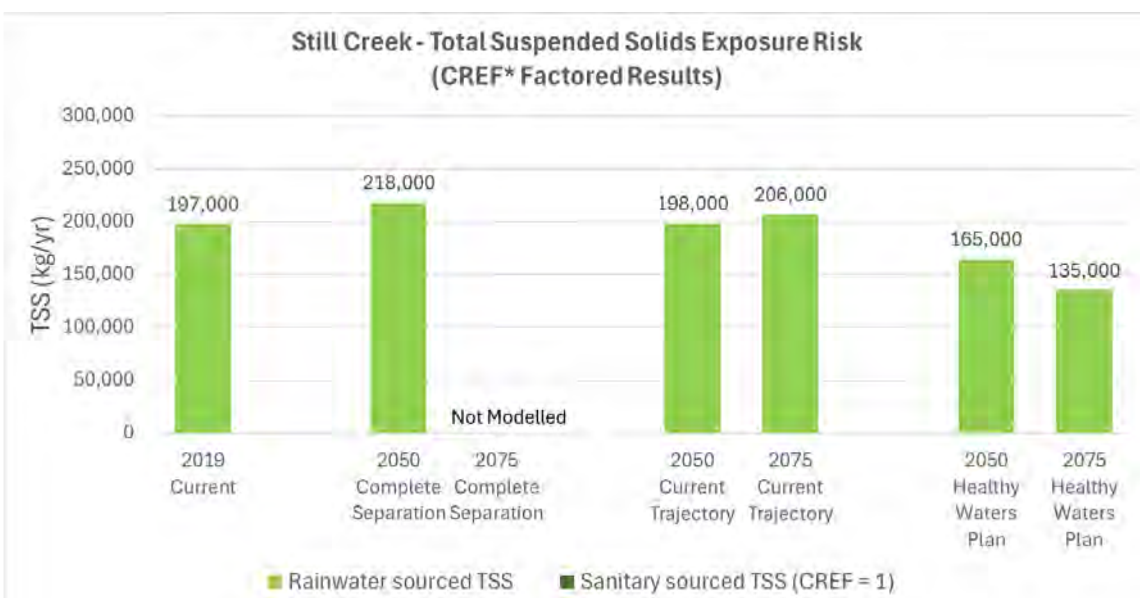


Figure 92: TSS Performance for the Still Creek Basin

- **Overall MCDA Performance:** The Healthy Waters Plan Pathway achieves a broader range of objectives compared to the Current Trajectory Pathway, primarily due to increased investments in GRI, as well as the 24 mm rainwater retention and flood-proofing policies for redevelopment. The allocation of funds to the restoration of Still Creek also contributes to the overall performance outcomes. It should be noted that the Healthy Waters Plan Pathway benefits from a larger funding allocation compared to the Current Trajectory Pathway, due to a reallocation of funds from other basins to address inequities (Figure 93).

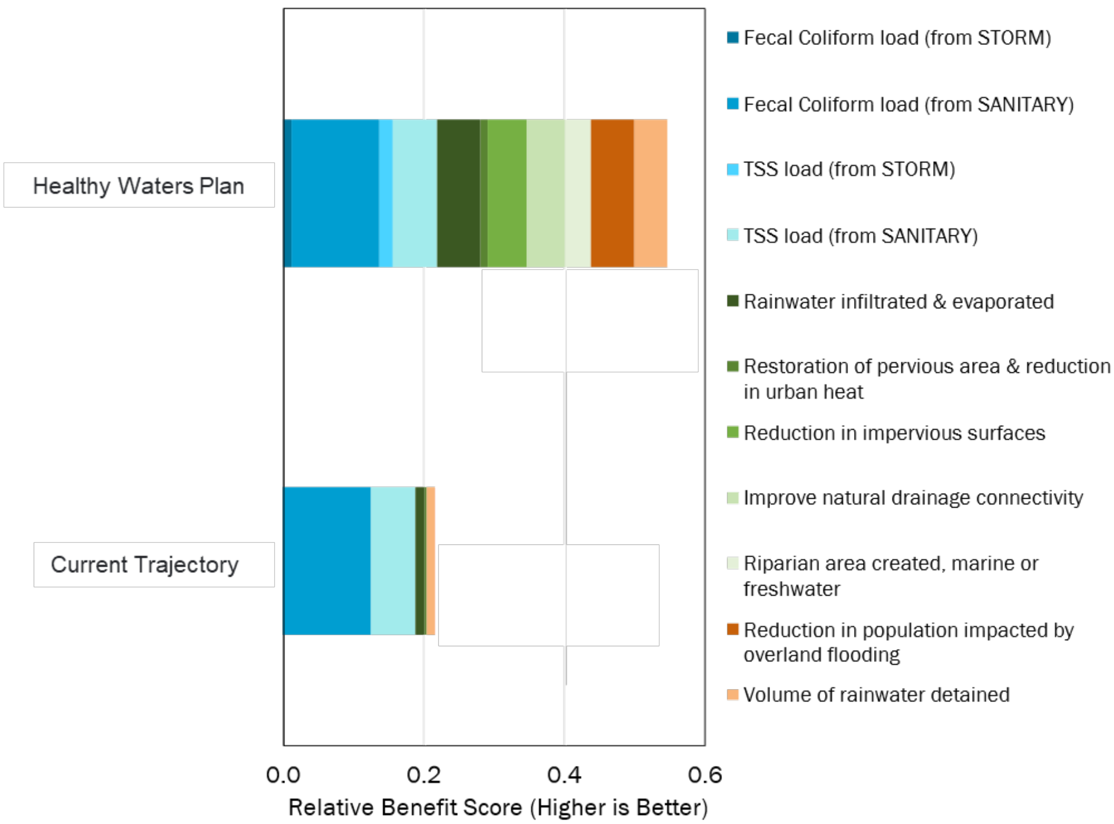


Figure 93: Overall MCDA Performance for the Still Creek Basin

Fraser River Basin Performance

Anticipated Performance Outcomes Include:

- **Fecal Coliform**: **By 2050, the Healthy Waters Plan Pathway provides an equivalent level of performance as the 100% Sewer Separation by 2050 Pathway**. This is largely due to a combination of bottom-up separation and CSO rapid treatment (subject to feasibility analysis). Up to 2050, fecal coliforms are expected to double for the Current Trajectory Pathway due to population growth and increased rainfall intensity. By 2075, all Pathways are anticipated to provide a comparable level of performance (Figure 94):

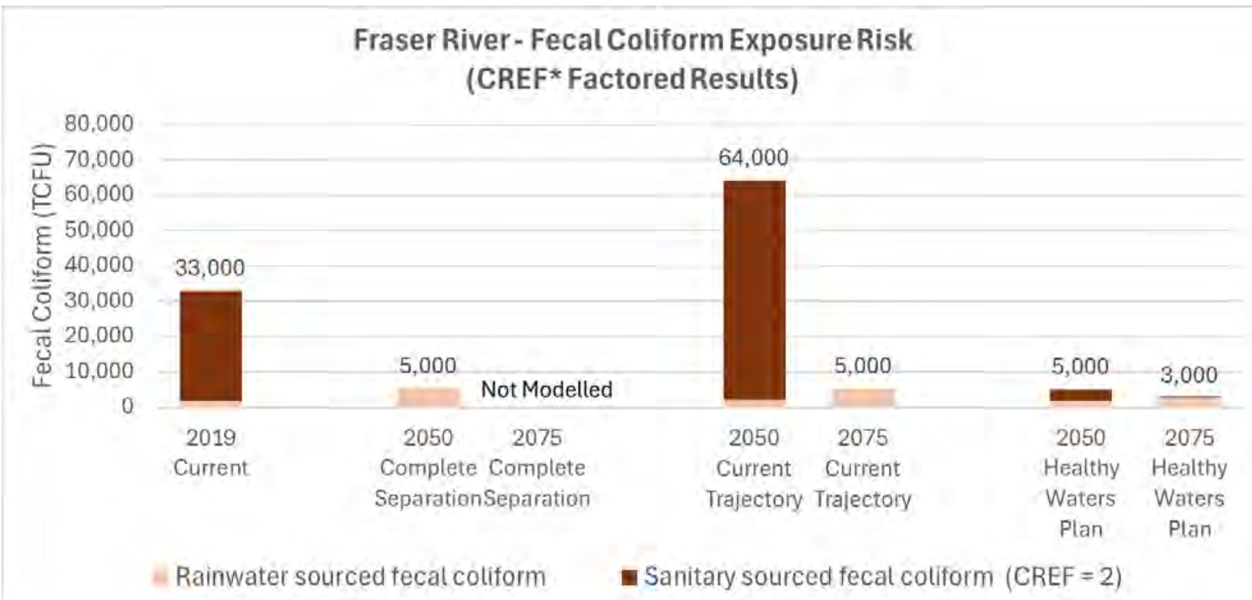


Figure 94: Fecal Coliform Performance for the Fraser River Basin

- **TSS Performance: By 2050, the Healthy Waters Plan Pathway results in 30% less TSS pollution than the 100% Sewer Separation by 2050 Pathway, and significantly outperforms the Baseline Pathway as well.** The 100% Sewer Separation by 2050 Pathway is expected to see a larger increase in TSS because rainwater currently going to the Iona Island Wastewater Treatment Plant will be diverted to the Fraser River. The Healthy Waters Plan Pathway has a smaller increase due to the use of GRI, in-line grey stormwater treatment devices, and CSO rapid treatment. Between 2050 and 2075, the Healthy Waters Plan Pathway will see a 35% increase in TSS due to increasing volumes of rainwater runoff being diverted from the Iona Island WWTP to the Fraser River, and insufficient funding to invest in enough GRI or in-line grey stormwater treatment to fully mitigate the increase (Figure 95).

Figure 95: TSS Performance for the Fraser River Basin

- **Overall MCDA Performance:** The Healthy Waters Plan Pathway achieves a broader range of objectives compared to the Current Trajectory Pathway (see Figure 95). This is primarily due to increased investment in GRI, the application of in-line grey stormwater treatment devices, the use of CSO storage, and the implementation of 24 mm retention and flood policies for redevelopment. This includes a 45% reduction in the number of people exposed to flood risk.

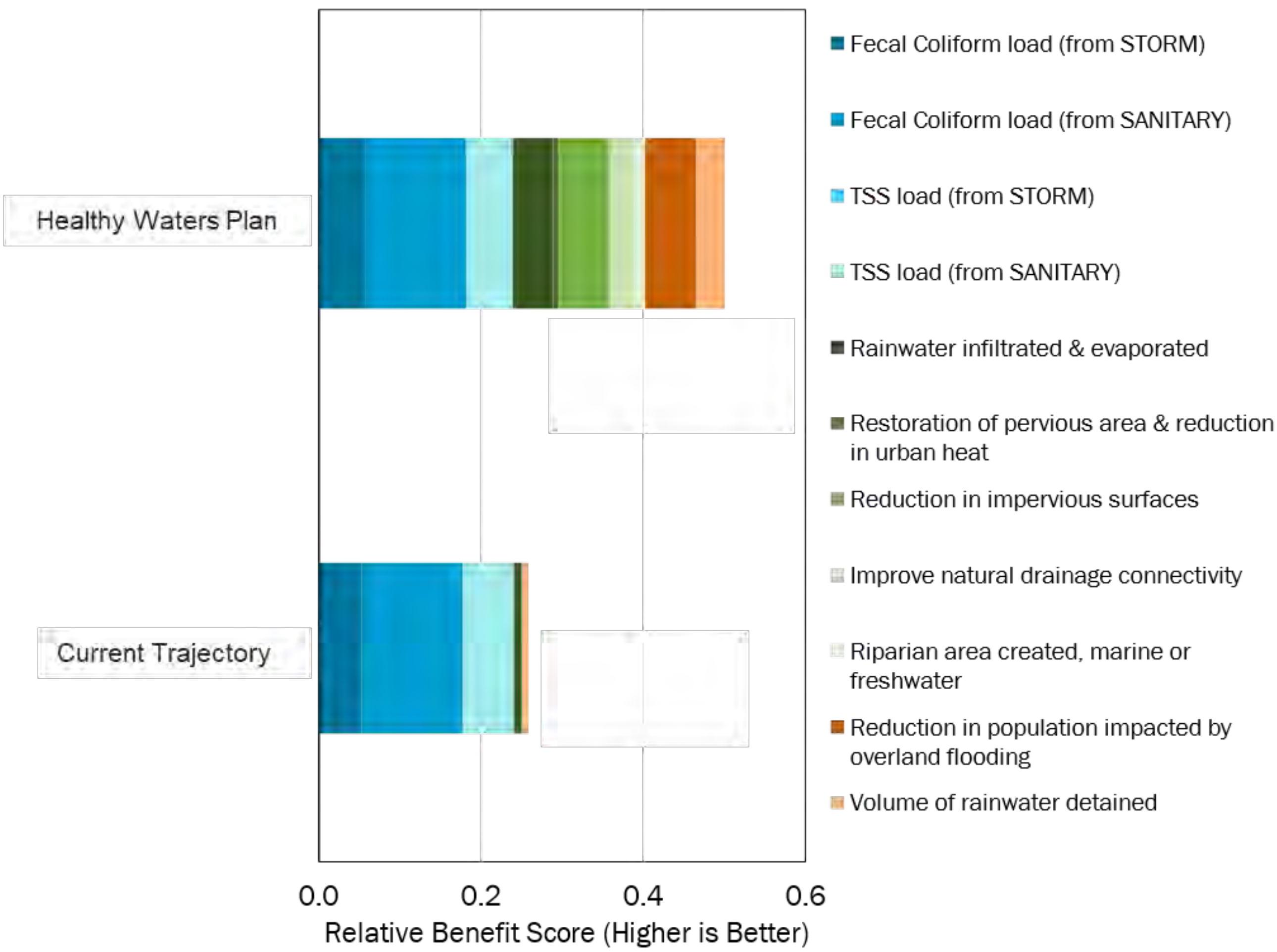


Figure 95: Overall MCDA Performance for the Fraser River Basin