

From: ["van Dyk, Donny"](#)

To: ["Direct to Mayor and Council - DL"](#)

Date: 6/17/2026 3:22:31 PM

Subject: Memo - ENG - City of Vancouver Groundwater Strategy

Attachments: Memo - ENG - City of Vancouver Groundwater Strategy.pdf

Dear Mayor and Council,

Please see the attached memo from Lon LaClaire. A short summary of the memo is as follows:

- Strategy Drivers: Groundwater presents key challenges and opportunities across four areas: reducing wastewater treatment costs, managing land and infrastructure risks, diversifying water supply, and protecting ecosystems.
- Approach: The Groundwater Strategy has been developed through a four-phase process involving staff expertise, an expert panel, and engagement with local Nations. The Strategy emphasizes a phased, adaptive approach to address uncertainty, starting with ten Phase 1 actions (2026–2030) focused on closing knowledge gaps, reducing risks, and streamlining internal processes.
- Benefits: Expected benefits include simplification of development review processes, cost savings in wastewater treatment and conveyance infrastructure, better risk mitigation, improved water resilience, and enhanced ecosystem health.
- Next steps: Phase 1 implementation will continue until 2030, after which results will be evaluated to inform and prioritize Phase 2 actions based on service needs and cost-effectiveness.

If you have any questions, please feel free to contact Lon LaClaire at 604-873-7336 or lon.laclaire@vancouver.ca.

Thanks,

Donny

Donny van Dyk (he/him)

City Manager

City of Vancouver



The City of Vancouver acknowledges that it is situated on the unceded traditional territories of the xʷməθkʷəy̓əm (Musqueam), Skwxwú7mesh (Squamish), and səlilwətaʔ (Tsleil-Waututh) Nations.

MEMORANDUM

June 17, 2026

TO: Mayor and Council

CC: City Leadership Team
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FROM: Lon LaClaire
General Manager, Engineering Services

SUBJECT: **City of Vancouver Groundwater Strategy**

RTS #: N/A

The Groundwater Strategy, identified as a key deliverable under the Climate Change Adaptation Strategy and the Healthy Waters Plan – Key Directions, is now complete. It was developed through a four-phase planning process, informed by technical input from staff, advice from an expert panel and engagement with local Nations. The final strategy is appended to this memo.

Background

Groundwater has significant implications for the City, presenting both issues that must be managed and opportunities that can be leveraged. Research and engagement with staff, stakeholders and partners have identified the following four key drivers supporting the need for a coordinated and strategic approach to managing groundwater:

- **Liquid Waste Management:** In 2025, the City spent \$173 million for the treatment and disposal of wastewater, a significant amount of which is believed to be groundwater. Reducing groundwater diversions to sewer would optimize liquid waste management, generate financial savings and support the City in achieving compliance with provincial regulations.
- **Hazardous Lands and Risk Reduction:** A number of groundwater-related risks have been identified, highlighting a need to better understand vulnerabilities to inform land-use planning and avoid rehabilitation costs for land and infrastructure.
- **Water Demand Management:** Vancouver purchased \$107 million of drinking water from Metro Vancouver in 2025. Exploring the strategic and sustainable use of groundwater to

diversify non-potable sources may reduce costs while enhancing resilience to emergencies like droughts or earthquakes.

- **Protecting Nature:** Groundwater sustains ecosystems by providing a steady source of water for wetlands, streams, and vegetation – especially during dry periods. Expanding on policies that protect ecosystems such as the Groundwater Protection Area in the Rupert Renfrew Area Plan, will help protect ecosystem services and community benefits such as urban cooling, stormwater management, air and water quality improvements, recreational opportunities, and equitable access to nature.

Key Highlights

- The Groundwater Strategy responds to these drivers through a coordinated strategic framework complete with a vision, goals, objectives and an action plan.
- To respond to uncertain conditions, constraints, and evolving information, a phased, adaptive approach is proposed.
- Ten (10) Phase 1 (2026-2030) actions will fill key knowledge gaps, reduce immediate risks, build organizational capacity, and position the City for future decision-making.
- These actions are expected to yield immediate and long-range benefits, such as reductions in wastewater treatment and infrastructure costs, avoided damage to buildings and infrastructure, lower potable water demand and improved ecosystem health and resilience.
- Phase 2 actions will be considered after evaluating Phase 1 outcomes, prioritized based on core service delivery and cost-effectiveness.

Next Steps

Staff will continue to work to implement the first phase of actions, with completion targeted for 2030.

Please contact me directly if you have any questions with respect to this information.



Lon LaClaire, M.Eng., P.Eng.
General Manager, Engineering Services

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GROUNDWATER STRATEGY

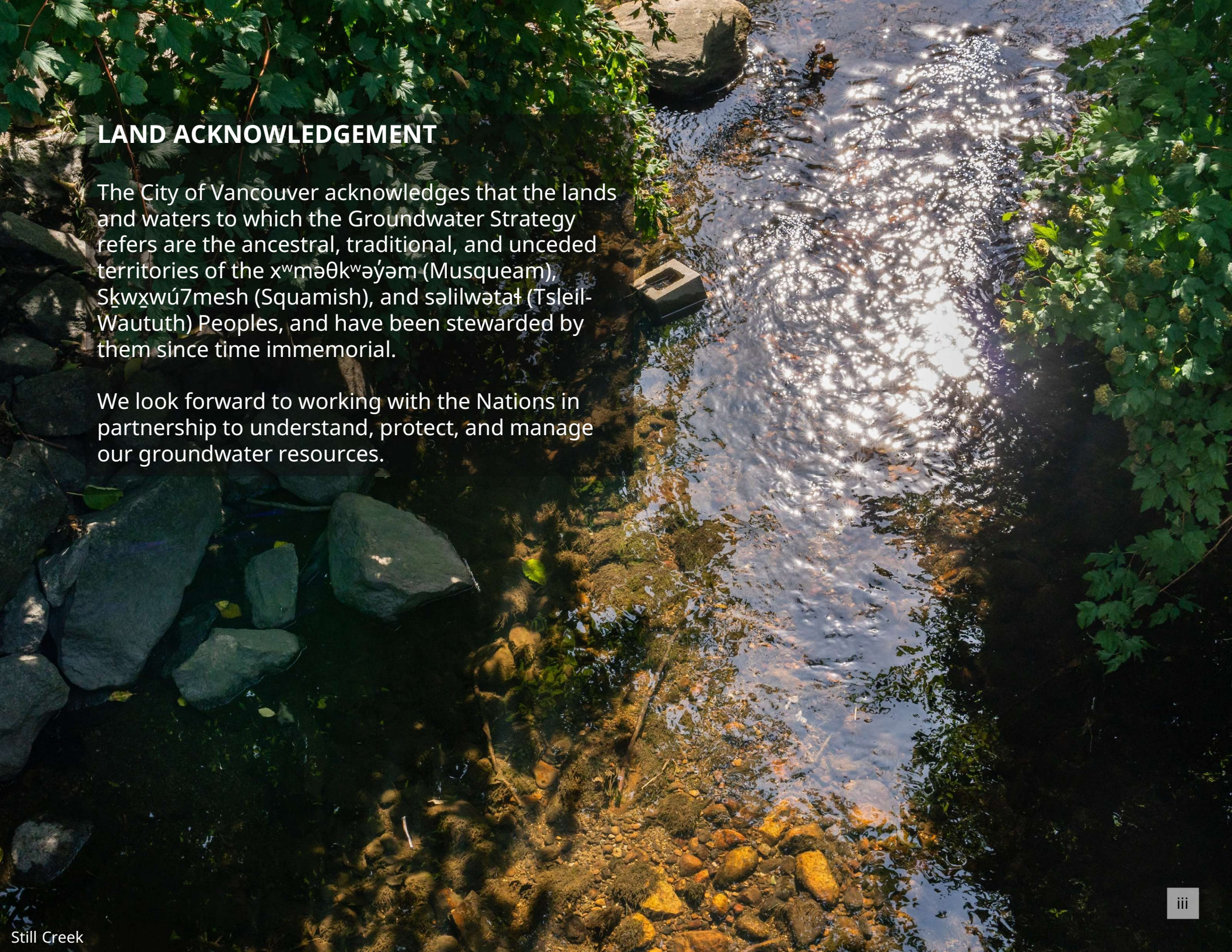
June 2026



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LAND ACKNOWLEDGEMENT

The City of Vancouver acknowledges that the lands and waters to which the Groundwater Strategy refers are the ancestral, traditional, and unceded territories of the xʷməθkʷə́yəm (Musqueam), Skwxwú7mesh (Squamish), and səliłwətał (Tseil-Waututh) Peoples, and have been stewarded by them since time immemorial.

We look forward to working with the Nations in partnership to understand, protect, and manage our groundwater resources.

ACKNOWLEDGEMENTS

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EXECUTIVE SUMMARY

The Groundwater Strategy was identified as key a deliverable under the *City's Climate Change Adaptation Strategy* and the *Healthy Waters Plan – Key Directions*. Water nourishes and sustains us; it is essential to all life and a defining element of Vancouver's identity as a city. Like many cities, however, Vancouver faces a growing set of water-related challenges. Groundwater in particular has significant implications for the City, presenting both issues that must be managed and opportunities that can be leveraged.

FRAMEWORK

Vision

Groundwater is recognized as an important resource and managed to mitigate risks, support ecosystems, and advance the City's adaptation to climate change.

Goals

- **Protect** people, infrastructure, and property from groundwater-related risks.
- **Preserve** groundwater to diversify water resources and maintain ecosystem services.
- **Adapt** to population growth, climate change, and emerging priorities with resilient groundwater management.

Objectives

- **Support Groundwater-Dependent Ecosystems** by preserving local resources and vital hydrological connections
- **Improve Water Security** and emergency preparedness through the sustainable use of groundwater
- **Reduce the impact of groundwater-related risks** by assessing vulnerabilities and developing mitigation strategies
- **Maintain groundwater levels** by enhancing infiltration and reducing waste
- **Safeguard groundwater quality** by implementing measures to prevent and mitigate aquifer contamination
- **Foster community awareness and support** for groundwater protection through education and engagement
- **Inform decision making** by increasing our understanding of local hydrogeology

Research and engagement with stakeholders and partners identified the issues and opportunities that would be addressed by the Strategy. These were subsequently organized into four key drivers: 1) Optimize liquid waste management; 2) Mitigate and adapt to risks; 3) Use groundwater strategically and sustainably; and 4) Protect ecosystems and environment.

Following additional engagement and an external assessment of costs and benefits, a consolidated list of 43 discrete actions was developed to address these drivers and achieve the Framework. This work recognized that critical knowledge gaps make a long-term plan infeasible at this time. The Groundwater Strategy therefore proposes a phased, adaptive approach, with 10 short-term actions in Phase 1. These actions will fill key knowledge gaps, reduce immediate risks, build organizational capacity, and position the City for future decision-making. They will also deliver financial savings by minimizing groundwater inflow and infiltration, avoiding land and infrastructure rehabilitation costs, and reducing purchased water costs through strategic groundwater use. After evaluating Phase 1 outcomes, a series of Phase 2 options will be considered to advance the Framework.

PHASE 1 ACTIONS (2026-2030)

1. Restrict the discharge of foundation drains into sewers
2. Develop a groundwater monitoring program
3. Assess aquifer recharge and infiltration potential
4. Quantify groundwater diversions
5. Identify groundwater-dependent ecosystems
6. Develop a groundwater data repository
7. Update the city-wide groundwater flow model
8. Assess the sustainable extraction potential of groundwater
9. Assess the potential extent and magnitude of groundwater rise
10. Engage external partners to advance objectives

INTRODUCTION: GROUNDWATER BASICS

WHAT IS GROUNDWATER?

Groundwater is the water found underground in the cracks and spaces in soil, sand and rock, shown schematically in Figure 1. It supplies water to wells, springs, and many streams and wetlands. Groundwater is a major source of drinking water supply worldwide and supports agriculture and ecosystems. Although it is out of sight, groundwater plays a critical role in the water cycle and in sustaining life on Earth.

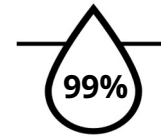
WHERE DOES GROUNDWATER COME FROM?

Groundwater typically comes from rainwater, snowmelt, or surface water bodies (e.g., rivers and lakes) where the water infiltrates into the ground. In more urbanized settings such as Vancouver, leakage from underground utilities (e.g., water pipes) can also be a source. This reliance on recharge from surface water means that groundwater can become depleted if rainfall is no longer able to infiltrate (e.g., where vegetated areas are paved over or built on).

The flow of groundwater is complex and variable; water that enters the ground as rainfall can quickly find its way back to the surface as baseflow to a watercourse, or it can move downward into deeper aquifers over thousands or even millions of years until it reaches the ocean or is extracted by a well (Figure 1).

WHAT IS AN AQUIFER?

An **aquifer** is classified as an area underground where there are significant amounts of saturated subsurface material that groundwater can move through easily (e.g., sand or gravel). The **water table** defines the water level in an aquifer, essentially a measure of how “full” the aquifer is. Where there is material that groundwater moves through much more slowly (e.g., silt, clay, or solid rock), that unit is called an **aquitard**. Underground there can be a layering of aquifers and aquitards. Where an aquitard is on top of an aquifer, it can act like a lid or cover, protecting the aquifer from contamination but also potentially causing it to become pressurized. This is referred to as a **confined aquifer**. Conversely, **unconfined aquifers** are not capped by an aquitard and are more likely to be found near the surface, are more easily contaminated from chemicals released near the surface, and often interact with and support surface water like creeks and wetlands.



Groundwater comprises 99% of all liquid fresh water on Earth^[1].



An estimated 2.5 billion people depend on groundwater for drinking, including almost 10 million Canadians^[2].



Groundwater plays a significant role in the production of food and in supporting ecosystems, such as providing base flow to streams between periods of rainfall.

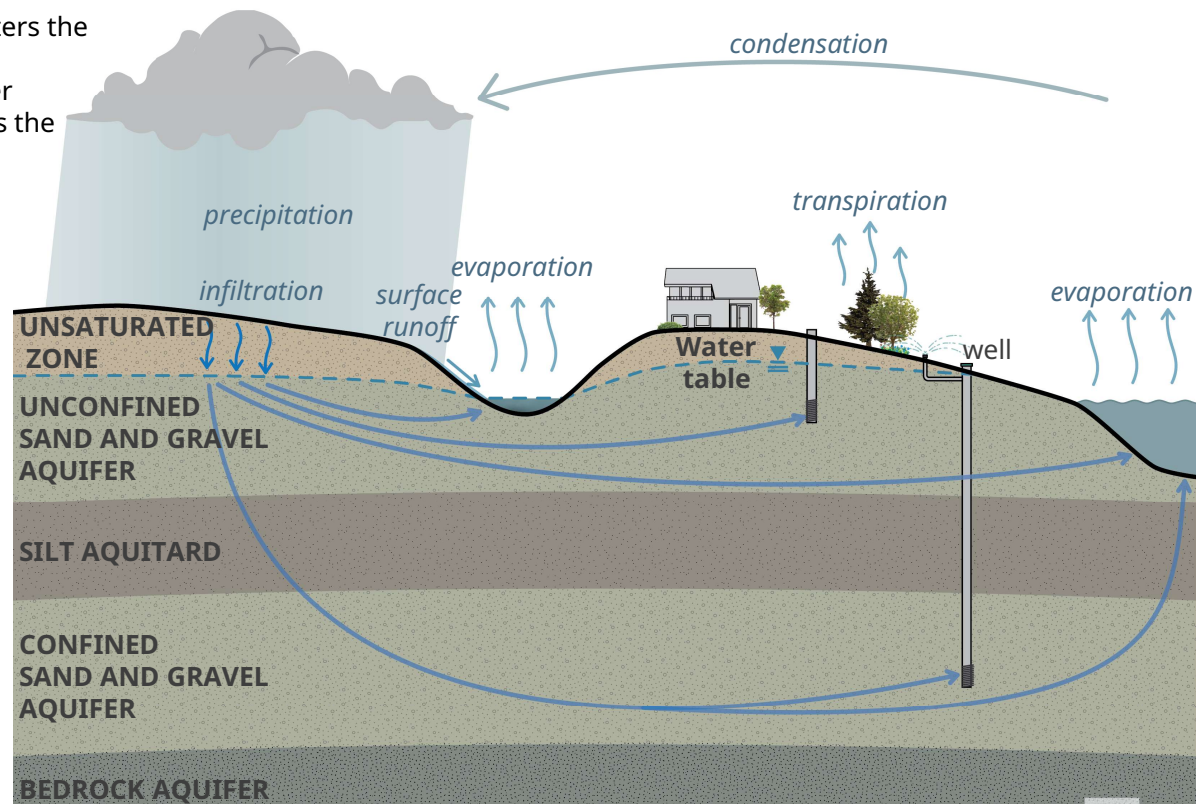


Figure 1. Groundwater cross-section.

GROUNDWATER IN VANCOUVER

AQUIFER MAPPING

Aquifers are mapped by the Province of BC^[3] to understand their extent and characteristics, using information that is available at the time. Aquifer mapping helps us understand where significant quantities of groundwater may be found, which can inform future planning initiatives. As additional studies and/or monitoring are carried out, aquifer maps may be updated, and additional aquifers may be identified. Aquifers mapped in Vancouver are shown in Map 1.

Quadra Sands Aquifer (Aquifer #49)^[4]

The Quadra Sands Aquifer is a partially confined aquifer that is understood to extend from the University of British Columbia to Port Moody and Coquitlam. The Quadra Sands Aquifer was deposited between periods of glaciation and has an age of approximately 18,000 to 26,000 years. The aquifer is known to extend farther south than is currently mapped, and is expected to underlie much of Aquifer #45 and extend south of the Fraser River. The portion of this aquifer that covers southern Vancouver, Burnaby, and New Westminster is subject to a well drilling advisory due to pressurized groundwater conditions (see Map 2 on page 15).

Fraser River Sediments Aquifer (Aquifer #45)^[5]

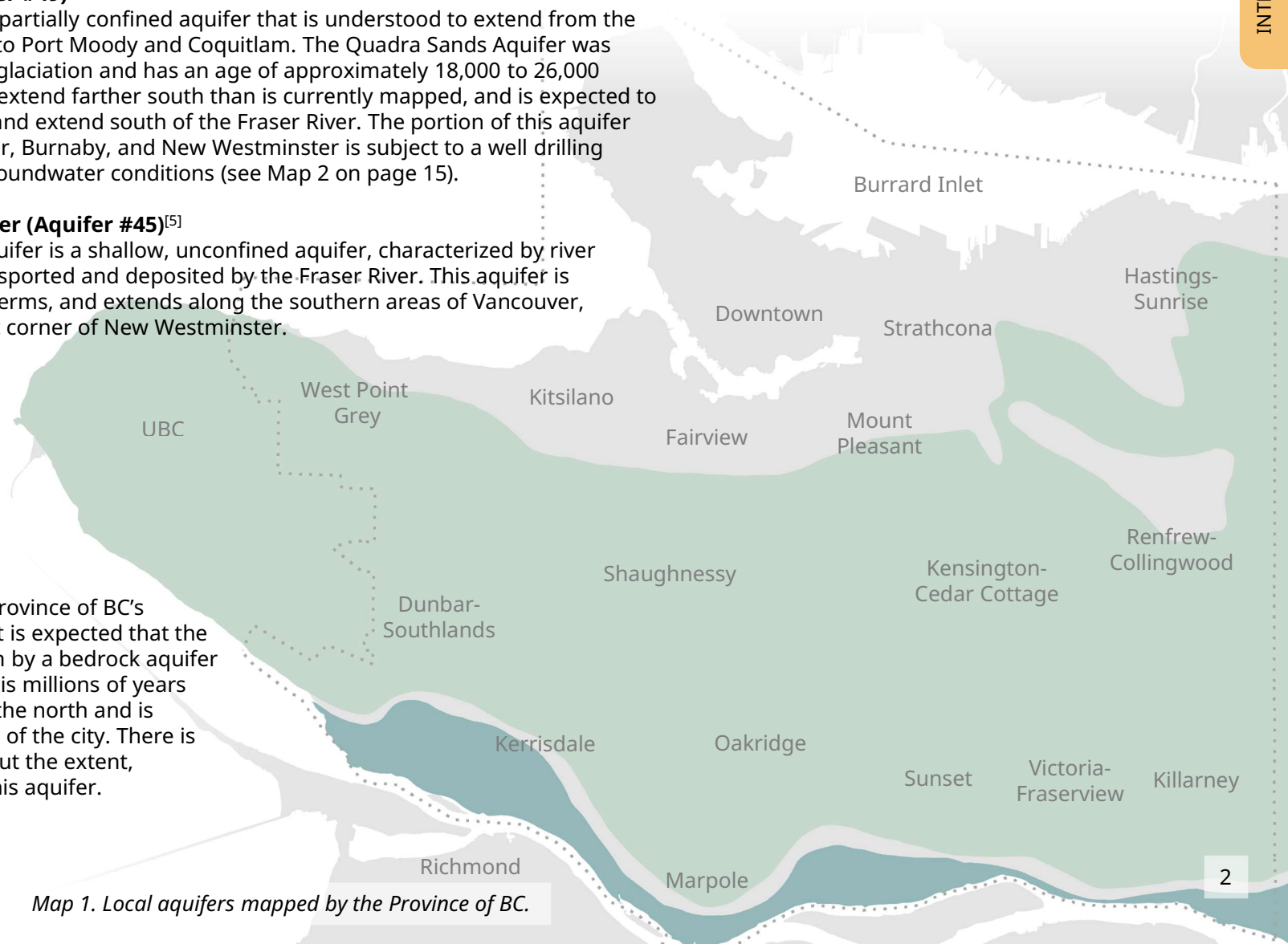
The Fraser River Sediments Aquifer is a shallow, unconfined aquifer, characterized by river sediments that have been transported and deposited by the Fraser River. This aquifer is relatively young in geological terms, and extends along the southern areas of Vancouver, Burnaby, and the westernmost corner of New Westminster.

Bedrock Aquifer (not shown)

Although not mapped by the Province of BC's Aquifer Classification System, it is expected that the majority of the City is underlain by a bedrock aquifer composed of sandstone which is millions of years old. This bedrock is shallow in the north and is deeper in the southern portion of the city. There is generally very little known about the extent, characteristics, or viability of this aquifer.

Legend

-  Aquifer #49 mapped extent
-  Aquifer #45 mapped extent
-  City of Vancouver boundary



Map 1. Local aquifers mapped by the Province of BC.

GROUNDWATER GOVERNANCE AND RATIONALE

PROVINCIAL AND LOCAL JURISDICTION

In British Columbia, the Province manages surface water and groundwater through legislation like the *Water Sustainability Act*^[6] and the *Environmental Management Act*^[7]. While this establishes the provincial framework for groundwater management, groundwater can affect local infrastructure and urban development. The Province is the primary regulator of groundwater; however, local governments also play an important influencing role through land use planning, infrastructure management, and environmental protection.

For example, the extraction and use of groundwater are regulated by the Province – yet municipal decisions related to development siting, form, or density and stormwater management largely determine the extent to which rainwater can infiltrate local aquifers. In this way, the Province manages groundwater outputs (i.e., extraction), whereas the local governments manage groundwater inputs (i.e., recharge).

In terms of water quality, the Province develops and enforces legislation to prevent and remediate groundwater contamination^[8]. Local governments also play an important role through zoning and development permitting, which often determine the likelihood of contamination occurring in a particular location.

Therefore, while groundwater jurisdiction primarily rests with the Province, local governments play a critical role in preserving both groundwater quantity and quality.

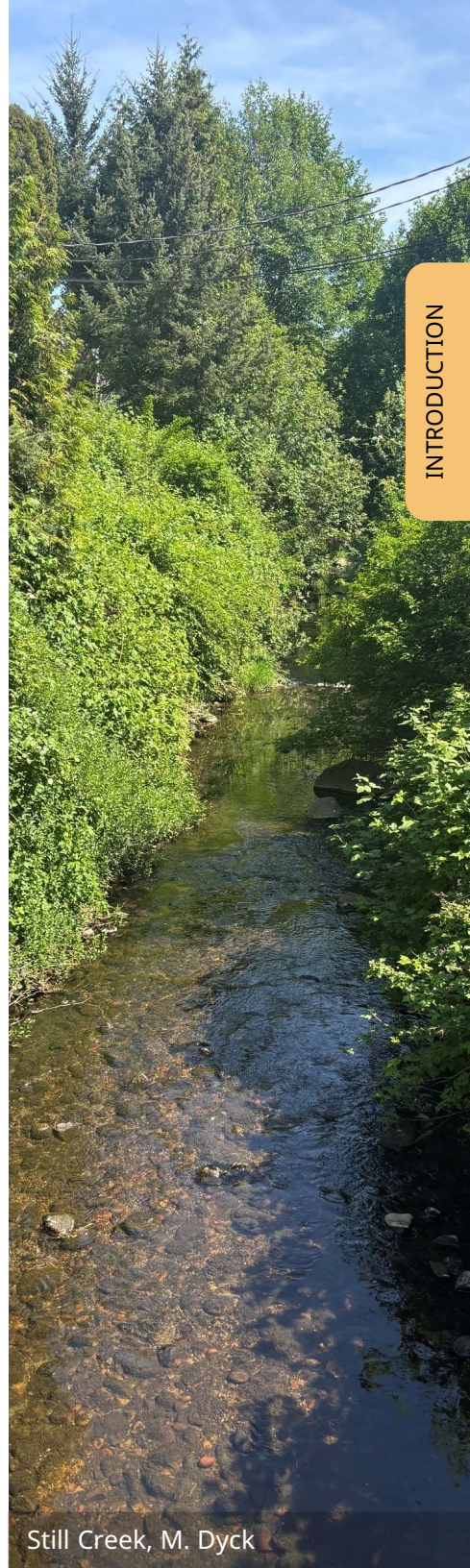
WHY WE NEED A GROUNDWATER STRATEGY

The City of Vancouver is affected by groundwater-related issues, particularly where groundwater is entering the sewer system. Vancouver has a legacy combined sewer system, where a single pipe carries both sewage and stormwater to treatment plants. Buildings constructed underground must manage groundwater both during and after construction, which often results in groundwater being diverted to sewers, with cost implications for the City on the order of tens of millions of dollars annually.

The City has responded through the development of policies/tools such as the *Groundwater Management Bulletin* to reduce the impacts of diverting groundwater to sewers, and the Groundwater Protection Area under the *Vancouver Building By-law* to maintain Still Creek groundwater baseflow. These initiatives have begun to address certain groundwater issues, but a coordinated approach is needed to understand and respond to the various ways that groundwater impacts the City, and to reduce the social, economic, and environmental costs over the long-term.

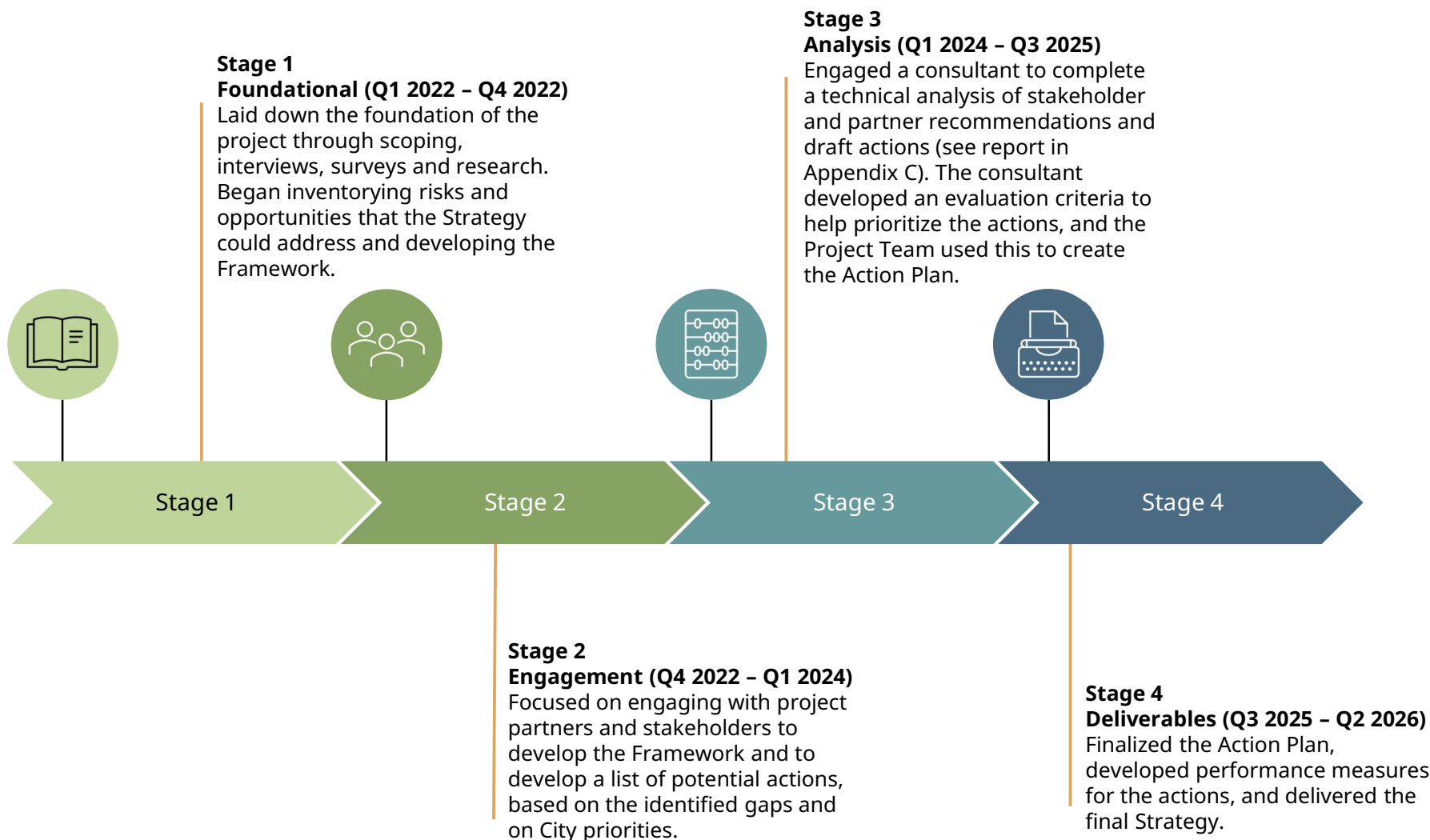
Mitigating and adapting to climate-driven threats—such as drought, sea-level rise, and extreme rainfall—presents a compelling case for action. Understanding groundwater is critical in this context, as it not only underpins effective climate adaptation but also represents a resource the City can leverage to strengthen climate resilience as it grows, supports an increasing population, and prepares for future emergencies, including droughts and earthquakes.

The Groundwater Strategy sets out a strategic, city-wide approach to characterizing and understanding Vancouver's groundwater system to provide a clearer understanding of groundwater conditions, risks, and interactions across the city. This will support more proactive planning, infrastructure management, environmental protection, and long-term decision-making, while helping the City better anticipate and respond to future pressures associated with urban growth, aging infrastructure, and climate change.



DEVELOPING THE STRATEGY: OVERVIEW

The Groundwater Strategy has been completed over four stages: completion of foundational research, engagement with stakeholders and partners, analysis of recommendations, and preparation of deliverables including an Action Plan and performance measures.



STAKEHOLDER AND PARTNER ENGAGEMENT

ENGAGEMENT OVERVIEW

The Groundwater Strategy was developed through a collaborative engagement process between City staff, local experts, and project stakeholders and partners.

STAKEHOLDERS AND PARTNERS

Staff Working Group and Expert Panel

A series of workshops were held with an internal Staff Working Group (SWG) and an Expert Panel (EP), with initial work defining the need for a groundwater strategy and identifying associated drivers. This foundational analysis informed the project's strategic direction, including the Framework (pages 12-13). Subsequent workshops produced a number of potential actions to respond to the drivers. These sessions facilitated broader engagement and helped identify insights and considerations from across the organization.

Steering Committee

Consultation with the project Steering Committee further refined and finalized the draft Framework. This helped ensure strategic alignment with other programs (i.e., One Water) and City priorities, and endorsement of the final Framework.

Local Nations

Throughout the process, the Project Team engaged with the xʷməθkʷə́yəm (Musqueam Indian Band), Skwxwú7mesh Úxwumixw (Squamish Nation), and səliłwətał (Tsleil-Waututh Nation) through a variety of mechanisms. These included regular updates through the Indigenous Referral Process, introductory and project update meetings with each of the Nations, and coordinated project and document review.

The Project Team also received learnings from the *Healthy Waters Plan* team from their ongoing engagement with the local Nations. Common themes were identified between the two projects, such as environmental protection and stewardship, cultural values and traditional knowledge, consultation and inclusion, and long-term planning. Of particular relevance to both the *Healthy Waters Plan* and the Groundwater Strategy is that each Nation linked the health of the ecosystem to their cultural identity and traditional practices. Engagement with local Nations will continue to build on these themes and they will be incorporated into the project as it moves into the implementation of Phase 1, as well as subsequent phases.

In addition, the Groundwater Strategy has considered ongoing work on the *United Nations Declaration on the Rights of Indigenous Peoples* (UNDRIP) Action Plan 2024-2028, that was approved by Vancouver City Council on June 25, 2024^[9]. The Project Team has identified potential opportunities to support the UNDRIP Action Plan during implementation of the Groundwater Strategy, and will continue to explore these in collaboration with the Nations.



STAKEHOLDER AND PARTNER ENGAGEMENT

WHAT WE HEARD

Through extensive engagement, the City gained a clearer understanding of the complex role groundwater plays in Vancouver:

1. Groundwater risks are growing and interconnected. Stakeholders and partners identified concerns about sea level rise, saltwater intrusion, subsidence, contamination, and groundwater ingress into buildings and infrastructure. Without improved monitoring and policies, these risks will continue to escalate.
2. Knowledge of Vancouver's aquifers is limited. Across all groups, there was strong consensus that Vancouver lacks baseline information on groundwater levels, recharge areas, extraction potential, contamination pathways, and how local ecosystems depend on groundwater. This limited understanding constrains planning and risk management.
3. Groundwater is an underused resource. City teams, external experts, and the local Nations emphasized opportunities for non-potable uses, emergency supply, and supporting ecological systems. However, stakeholders and partners noted that clearer policies, updated by-laws and better data are needed to unlock these opportunities safely and sustainably.
4. Groundwater is being diverted to sewers and takes up valuable capacity in the system, increasing water treatment costs, speeding up the need for replacements, and contributing to combined sewer overflows. Stakeholders shared that minimizing capacity constraints on sewer infrastructure was an immediate priority to be addressed.
5. Policy alignment is fragmented. While multiple strategies, by-laws, and provincial regulations relate to groundwater, responsibilities and expectations are not always clear. Staff identified the need for integrated guidance that supports core service delivery, simplifies development requirements, and aligns with climate resiliency goals.
6. Staff guidance reflected that implementation of Strategy actions would need to consider financial pressures, other City priorities, and evolving risks, with a focus on delivering core services.
7. The preservation of the environment, supported by groundwater, is paramount to the well-being and resilience of the City and its residents. Local Nations also emphasized this work as being of critical importance.



FRAMEWORK

The Framework sets the overall direction of the Groundwater Strategy by articulating a clear **vision**, defining priority **goals**, and establishing **objectives** and **guiding principles**. It provides a foundation for decision-making by outlining what the City aims to achieve and how the work will be carried out. The guiding principles will help to ensure that implementation of the actions is strategic, evidence-based, collaborative, equitable, and sustainable, while aligning groundwater management with broader City priorities and responsibilities.

GUIDING PRINCIPLES

Efficient

The Groundwater Strategy will prioritize cost-effective actions that are expected to have the most impact, including by avoiding significant future expenses related to groundwater risks. Emphasis will also be given to actions that address a number of concerns, have synergies with other City strategies and programs, or that produce additional co-benefits.

Sustainable

The Groundwater Strategy will aim to protect local aquifers from contamination and depletion, support ecosystems that depend on groundwater, and enable ongoing sustainable development. Emphasis will be on restoring and enhancing ecosystems and the services they perform, rather than simply limiting negative impacts.

Leadership

Within its jurisdiction, the City of Vancouver endeavours to do its part to protect and manage groundwater, including by modelling best management practices for groundwater in its own operations (e.g., at City-owned facilities), as well as through its planning and other decision-making.

Equitable

The Groundwater Strategy will be developed through the lens of equity and endeavour to fairly balance the interests of all parties that depend on or are affected by groundwater. In particular, the Groundwater Strategy will consider the potential impacts of groundwater-related decisions on marginalized groups in the city.

Integrated

Because land use, ecological health, and various forms of water (e.g., groundwater, rainwater, surface water, drinking water, and wastewater) are inextricably linked, the Groundwater Strategy will consider them holistically. As well, whenever possible, City groundwater efforts will be coordinated with its other work and incorporated into its policies, planning, and operations.

Evidence-based

Groundwater management will be informed by the best available science and emerging practices, high quality data, and traditional ecological knowledge. As such, the Groundwater Strategy will facilitate an understanding of available groundwater resources, risks and opportunities to inform future decisions.

Strategic

Wherever possible, the Groundwater Strategy will align with existing City policies and emerging priorities. It will also aim to maximize co-benefits.

Reconciliatory

Vancouver has committed to implementing the *United Nations Declaration on the Rights of Indigenous People*. Indigenous Peoples have the right to maintain and strengthen their relationship with their traditional waters. The City will engage with the local Nations during the development and implementation of its Groundwater Strategy. Moreover, shifting the City's water management paradigm towards one that respects and values water as a critical resource for people and ecosystems presents an opportunity to advance reconciliation.

Collaborative

Stakeholder involvement is a key component of successful groundwater management. The Groundwater Strategy will encourage the development of effective networks, promote the sharing of data, and improve coordination with other governments including where an action is outside of the City's jurisdiction or spans multiple jurisdictions. The City will also endeavour to conduct outreach programs in the community for businesses and residents to advance groundwater protection.

FRAMEWORK

VISION

Groundwater is recognized as an **important resource** and managed to **mitigate risks, support ecosystems, and advance the City's adaptation to climate change.**

GOALS

How we set out to achieve our vision

PROTECT

Protect people, infrastructure and property from groundwater-related risks.

PRESERVE

Preserve groundwater to diversify water resources and maintain ecosystem services.

ADAPT

Adapt to population growth, climate change and emerging priorities with resilient groundwater management.

OBJECTIVES

How we set out to achieve our goals



SUPPORT GROUNDWATER-DEPENDENT ECOSYSTEMS

by preserving local resources and vital hydrological connections



IMPROVE WATER SECURITY

and emergency preparedness through the sustainable use of groundwater



REDUCE THE IMPACT OF GROUNDWATER-RELATED RISKS

by assessing vulnerabilities and developing mitigation strategies



MAINTAIN GROUNDWATER LEVELS

by enhancing infiltration and reducing waste



SAFEGUARD GROUNDWATER QUALITY

by implementing measures to prevent and mitigate aquifer contamination



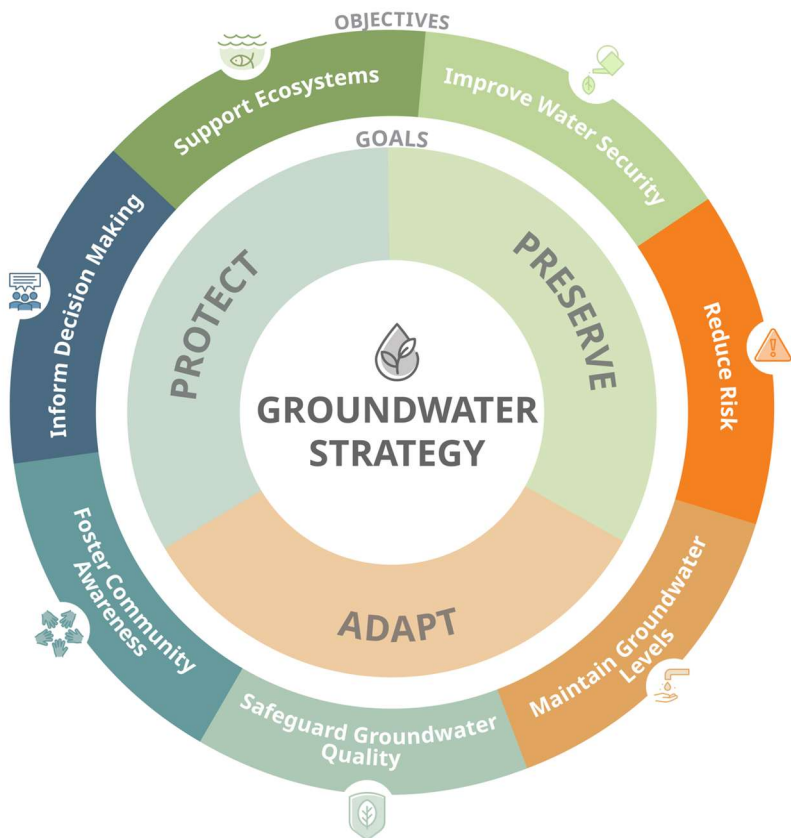
FOSTER COMMUNITY AWARENESS AND SUPPORT

for groundwater protection through education and engagement



INFORM DECISION MAKING

by increasing our understanding of local hydrogeology



Note: The Groundwater Strategy is intended as a planning and guidance document only. It does not intend to create or imply any directive, obligation or guarantee of performance by the City. The vision, goals, objectives, and actions described are aspirational and always subject to available budgetary and other resources, technical feasibility, and evolving environmental or regulatory conditions. The City may need to adjust priorities, timelines, or approaches under this Strategy, including deviating from or suspending actions, for instance, if these are not or no longer feasible or effective.

DRIVERS: OVERVIEW

Jurisdictional research, expert advice, and engagement with partners and stakeholders yielded a thorough inventory of the issues and opportunities to be addressed by the Framework. These topics are organized into four key Drivers, introduced below and discussed in more detail in the following pages.

1. OPTIMIZE LIQUID WASTE MANAGEMENT

Groundwater entering our sewers takes up valuable capacity in the system, which can increase wastewater treatment costs, contribute to combined sewer overflows, and require costly and otherwise unnecessary pipe upgrades. Some of this groundwater leaks into pipes through cracks or defects in the sewer system. Groundwater also enters the sewer via foundation drainage, which is installed to protect buildings from subsurface water. Alternatives to foundation drainage can add to the cost of new developments and impact housing delivery and affordability.

2. MITIGATE AND ADAPT TO RISKS

A number of groundwater-related hazards have been identified in Vancouver, including the potential for land subsidence due to groundwater pumping and dewatering activities, and potential flowing artesian conditions. Additional hazards are expected to be driven by climate change, including saltwater intrusion and groundwater rise. To limit the social, environmental, and financial impacts of these hazards, there is a need to better understand them, identify the City's vulnerabilities, and develop plans to proactively mitigate or adapt to them.

3. USE GROUNDWATER STRATEGICALLY AND SUSTAINABLY

A water supply gap has been predicted for the region as soon as 2030^[10], due to climate change and population growth. The use of alternative sources such as groundwater for non-potable purposes (e.g., irrigation) could provide a "potable offset," preserving potable water from the North Shore reservoirs for other uses. This practice may also have financial benefits, as locally sourced groundwater is often more cost-effective than making additional water purchases from Metro Vancouver. Diversifying the City's water resources would also make it less vulnerable to drought and may help the City respond to natural disasters like an earthquake.

4. PROTECT ECOSYSTEMS AND ENVIRONMENT

Groundwater sustains ecosystems by providing a steady source of water that supports wetlands, streams, and vegetation – especially during dry periods when surface water is scarce. The diversion of groundwater to sewer, or the reduction of rainfall infiltrating into the ground, disconnect natural systems and can limit the ability for groundwater to provide this support. Groundwater diversion to combined sewers also adds to combined sewer overflows, which can negatively impact ecosystems and deliver contaminants to receiving bodies.

DRIVER 1: OPTIMIZE LIQUID WASTE MANAGEMENT

INTRODUCTION

The City is committed to providing core services in an efficient and cost-effective manner. An opportunity to address the impacts of groundwater on the sewer system is by enhancing efforts to minimize **Inflow and Infiltration (I&I)**. **Inflow** refers to water entering sewers through direct connections (e.g., foundation drainage connections from underground parkades), while **Infiltration** refers to water that seeps into pipes through defects like cracks or leaky joints (Figure 2). I&I burdens the City's sewerage and drainage system capacity and adds to treatment costs. It also diverts groundwater baseflows away from streams and increases combined sewer overflows or introduces naturally occurring groundwater contaminants to the environment. The City addresses some groundwater inflow through development reviews; however, this can have various implications related to housing delivery timelines and costs.

KEY

- 1 Permanent Groundwater Inflow: Permanent discharge into sewers from foundation drains
- 2 Groundwater Infiltration: Leakage into sewers through cracks in pipe
- 3 Temporary Groundwater Inflow: Temporary discharge from construction site excavation

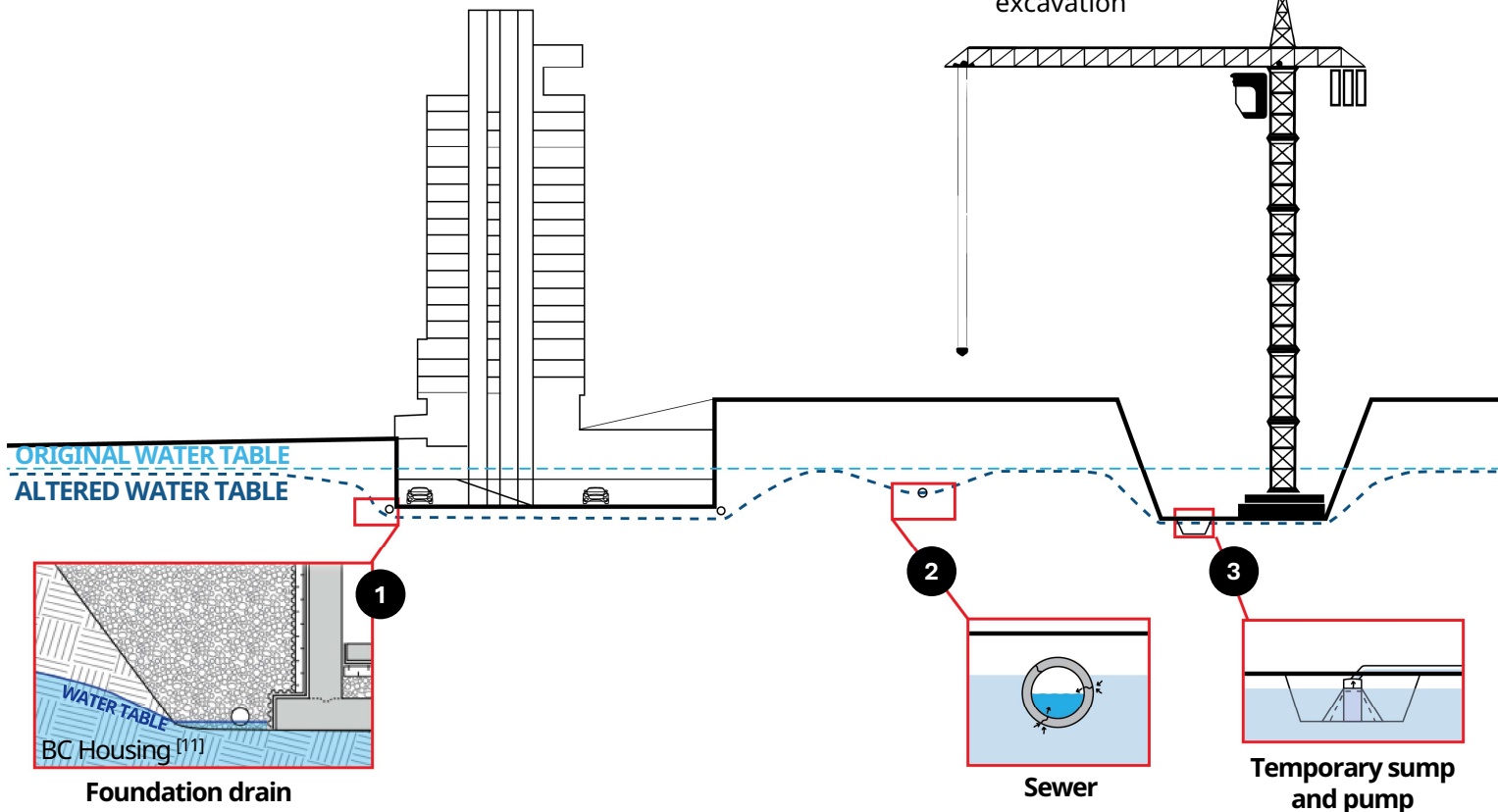


Figure 2. Groundwater inflow and infiltration.

POLICY ALIGNMENT

ENVIRONMENTAL
MANAGEMENT ACT

MUNICIPAL
WASTEWATER
REGULATION

LIQUID WASTE
MANAGEMENT PLAN

Sets requirements for the City of Vancouver to address inflow and infiltration, which Groundwater is suspected to contribute to significantly

EMERGENCY AND
DISASTER
MANAGEMENT ACT

2024 HAZARD, RISK
AND VULNERABILITY
ANALYSIS

EXTREME RAINFALL
RISK RATING: MEDIUM

By working towards reducing existing burdens on sewer system capacity, fewer upgrades may be required to manage the strain that extreme rainfall will add to the system.

INFLOW AND INFILTRATION



KEY ISSUE

Vancouver's combined sewage and drainage infrastructure was not designed to convey groundwater, however, it is often relied upon for this purpose. The intentional discharge of groundwater to sewer (i.e., inflow) stems from the construction of below ground levels, which requires foundation drainage to prevent moisture ingress into the building. Groundwater also leaks into the sewers (i.e., infiltration); however, it is often difficult to pinpoint where this is occurring, or likely to occur in the future.

Groundwater I&I increases the cost of delivering sewerage and drainage services by necessitating pre-emptive sewer pipe upgrades before they have reached the end of their expected service life. Further, the *Healthy Waters Plan* estimates that groundwater I&I contributes significantly to the volume of wastewater treated by regional treatment plants. These costs are borne by taxpayers; reducing groundwater I&I will reduce financial burden on taxpayers and extend the capacity of existing treatment plants.

Regulatory compliance

The Metro Vancouver *Liquid Waste Management Plan*^[12] prohibits groundwater discharge into sanitary sewers, and outlines requirements for the member local governments, including the City of Vancouver, to manage groundwater impacts to their sewage and drainage systems by addressing I&I management issues. Under the City's Zoning & Development by-law, a development project may be required to be designed to prevent groundwater discharge into the City collection system and to limit or reduce environmental impacts.



DESIRED FUTURE STATE

- Prioritization framework focusing efforts to limit the infiltration of groundwater to sewers, informed by relevant data on local soil and groundwater conditions and sewer infrastructure.
- A reduction in the discharge of groundwater to sewer from foundation drains (i.e., groundwater inflow).
- Compliance with regulatory obligations to not discharge groundwater into sanitary sewer systems.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Compilation of available hydrogeologic data (e.g., groundwater levels and permeability).
- ❑ Tools to cross-reference hydrogeologic data with sewer infrastructure data (e.g., pipe depth, age, material).
- ❑ A clear and transparent by-law, with requirements and incentives or penalties, that limit foundation drain discharge to the City's sewer system, developed in consultation with industry.



LEADING PRACTICE

Seattle, Washington, USA^[13]

The City of Seattle has implemented a utility fee specific to groundwater discharges to its sewer system. If estimated discharge rates are over a certain threshold, developments must install a flowmeter and pay the fee according to the measured discharge flow volumes.

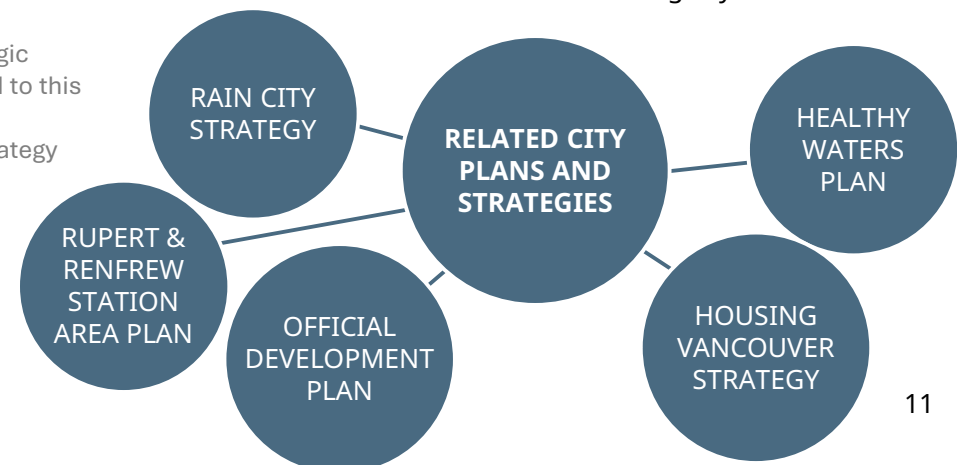


LEADING PRACTICE

San Francisco, California, USA^[14]

The City of San Francisco's public utility requires that large new developments construct an on-site water reuse system for toilet flushing and irrigation. The water sources for this system can include various stormwater sources as well as groundwater collected by foundation drainage systems.

Other City strategic initiatives related to this driver that the Groundwater Strategy builds upon:



2 UNDERGROUND PARKING



KEY ISSUE

The most cost-effective solution to reducing groundwater inflow to sewers is to reduce the depth of a building. This is most simply achieved by reducing the number of underground parking levels constructed. Although parking minimums in the City have been eliminated, the market demand for parking remains high, and there are few other incentives currently in place to reduce underground parking and associated groundwater discharge.



DESIRED FUTURE STATE

Groundwater diversions to the sewer system are minimized due to a reduction in the depth of underground parkades. Where appropriate, new developments reduce parking provisions. Above-grade parking is considered in high-risk areas where it also supports urban design objectives.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Exclude above-grade parking from floor space ratio calculations in high-risk areas where it supports groundwater objectives and achieves urban design outcomes.
- ❑ Targeted height relaxations are used, where appropriate, to enable above-grade parking solutions aligned with urban design outcomes

3 EXPEDITE AFFORDABLE HOUSING DELIVERY



KEY ISSUE

The City has the authority to limit the discharge of groundwater to sewer. However, methods to limit this discharge can add significant costs and negatively impact housing affordability (Figure 3). Reducing development review timelines has been identified as an opportunity to expedite housing supply; this can be supported by streamlining the City's groundwater requirements and clarifying groundwater management expectations.



DESIRED FUTURE STATE

- City priorities (e.g., housing) are balanced with regulatory obligations to not discharge groundwater into sanitary sewer systems.
- A reduction in development review timelines.



OPPORTUNITY FOR IMPROVEMENT

- ❑ By-law requirements that consider the cost implications of managing groundwater and are sufficiently clear and transparent that a detailed review of the project by the City is not required.

4 PROTECT AQUATIC ECOSYSTEMS



KEY ISSUE

Groundwater provides critical baseflow to aquatic ecosystems. When groundwater is diverted to the sewer, or when rain cannot infiltrate the ground, it reduces the amount of water in the ecosystem, impacting aquatic life. Groundwater may also impact habitat through alterations to water quality. For example, contaminants within groundwater may be collected and discharged to receiving bodies via I&I, and groundwater also contributes to combined sewer overflows.



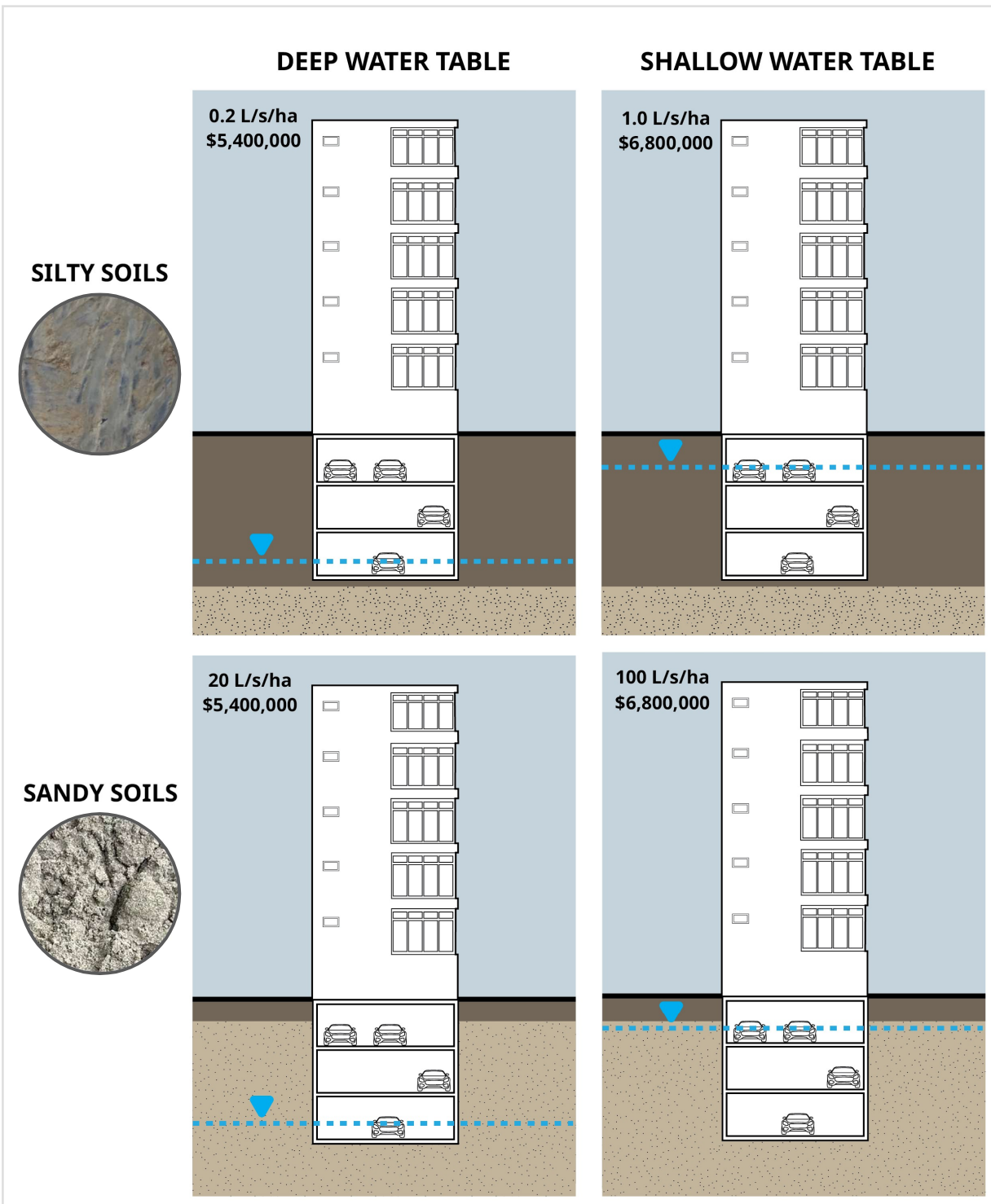
DESIRED FUTURE STATE

- Groundwater diversions to sewers are minimized, and water quality is monitored to limit impacts to receiving bodies.
- Stormwater is preferentially managed through infiltration into the ground to reduce the burden on City utilities and to enhance aquifer recharge.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Requirements or incentives for managing stormwater via infiltration.
- ❑ Requirements to monitor and report groundwater quality.



NO ONE-SIZE-FITS-ALL APPROACH

The volume of groundwater that may be collected by a building foundation drainage system can vary based on how deep the water table is, and the soil or material that surrounds the building.

Foundation "tanking" is a groundwater management solution that generally involves:

- waterproofing the underground portion of the building,
- designing the building foundation walls and slab to withstand hydrostatic pressure, and
- designing the building to resist uplift associated with buoyancy.

"Tanking" is one approach to groundwater management in areas with a high water table and relatively high estimated groundwater inflow rates (e.g., in sandy soils).

However, this approach can add millions of dollars to building construction costs. It can be difficult to justify the added expense of tanking a foundation for a new development in locations with a deeper/lower water table (left of Figure 3) or in areas where groundwater flows through the natural soil more slowly (top of Figure 3).

Estimated construction costs for a "tanked" foundation, and associated reduction in groundwater discharge to the sewer:

- Based on a 0.16 ha site area.
- Rates (L/s/ha) are groundwater discharges to sewer avoided by constructing a "tanked" foundation below the water table.
- Dollar values are estimated costs to "tank" the foundation below the water table.
- Costs are in addition to the "base case" for conventional underground construction (estimated to be \$14.9M for a 0.16 ha site).

Figure 3. Tanked foundations: construction costs and discharge reduction.

DRIVER 2: MITIGATE AND ADAPT TO RISKS

INTRODUCTION

A number of groundwater-related hazards currently exist within Vancouver, including the potential for land subsidence due to groundwater diversions and flowing artesian conditions (see case study, below). In the coming years, climate change is expected to introduce new groundwater-related hazards, including saltwater intrusion and groundwater rise, and may worsen the risks posed by existing hazards. To effectively mitigate and adapt to these hazards, additional work is needed to better understand groundwater, how it interacts with the local built environment, and how future stressors like climate change will affect this interaction.

CASE STUDY



The Beechwood Street incident

In 2015, a private contractor drilled into the Quadra Sands Aquifer and encountered groundwater under pressure, which is known as flowing artesian conditions^[15] (see Figure 4 on page 17). Millions of litres of water were brought to the surface each day, requiring significant effort to contain and divert this water to sewers. Additionally, neighbouring homes had to be evacuated temporarily because of the risk of sinkhole formation. By the time the flow was brought under control several years later, significant costs were accrued by the property owner (over \$1 million) and the City (over \$12 million). Following this incident, the Province issued an advisory for portions of Vancouver, Burnaby, and New Westminster to educate others about this risk (see Map 2).

POLICY ALIGNMENT

EMERGENCY AND DISASTER MANAGEMENT ACT

2024 HAZARD, RISK AND VULNERABILITY ANALYSIS

SEA LEVEL RISE
RISK RATING: LOW

By characterizing the scale and extent of groundwater rise, the City can proactively manage risks associated with sea level rise

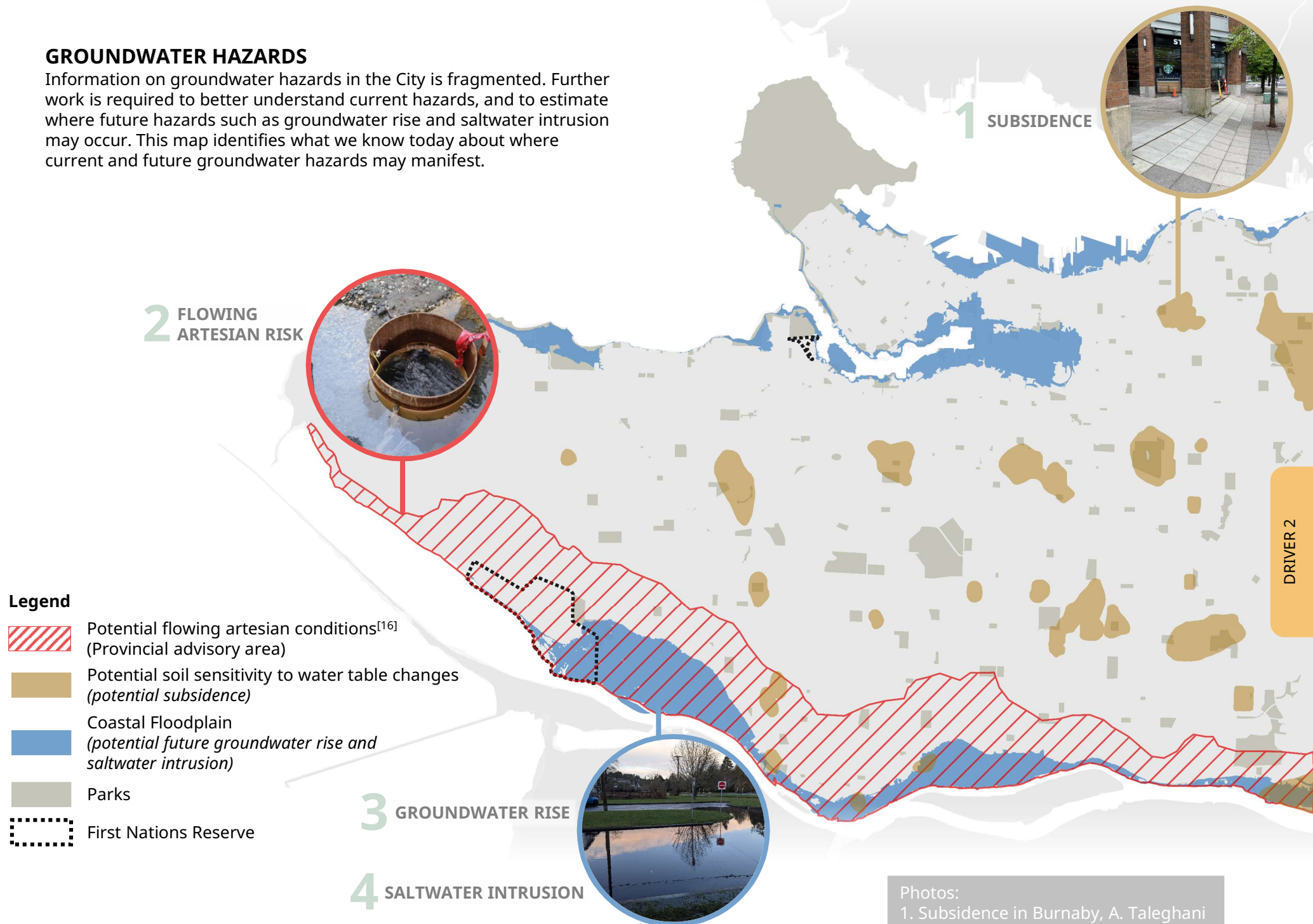
Other City strategic initiatives related to this driver that the Groundwater Strategy builds upon:



The *Climate Change Adaptation Strategy 2024-2025 Update and Action Plan* identified groundwater management as a potential means to address several risks identified by the *Hazard, Risk and Vulnerability Analysis*.

GROUNDWATER HAZARDS

Information on groundwater hazards in the City is fragmented. Further work is required to better understand current hazards, and to estimate where future hazards such as groundwater rise and saltwater intrusion may occur. This map identifies what we know today about where current and future groundwater hazards may manifest.



Map 2. Potential current and future groundwater-related hazards.

CURRENT AND FUTURE HAZARDS RELATED TO GROUNDWATER

The City is actively working to manage current groundwater-related hazards but must continue to learn about their scale and extent to proactively manage risks. As our interactions with groundwater change in the future, current hazards may evolve and risks levels change. Future hazards have also been identified by City staff as a potential threat to people, property, and/or infrastructure that should be understood and planned for.

CURRENT HAZARD: SUBSIDENCE



KEY ISSUE

Ground settlement may occur in certain areas of the city due to consolidation of certain soil types, decay of organic matter (including peat), or soil erosion (e.g., migration of soil into a void, potentially triggering sinkholes). Pumping of groundwater (i.e., dewatering) has the potential to negatively impact these mechanisms and increase the rate and amount of settlement. Where ground settlement occurs, neighbouring buildings and infrastructure may be vulnerable to damage and require costly repairs.



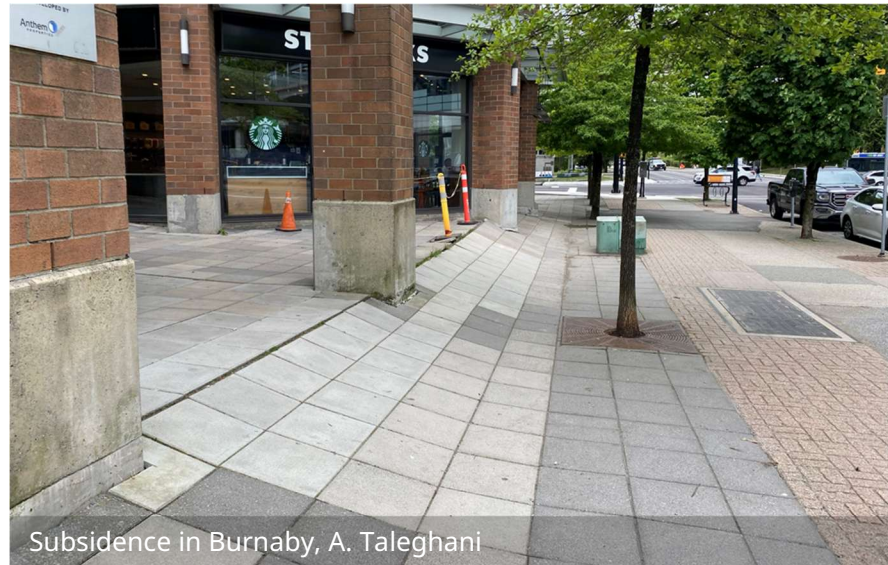
DESIRED FUTURE STATE

- The areas at risk of subsidence due to groundwater dewatering are known by the development community, and risks are managed according to best practices.
- Risks are considered during land use planning.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Increased awareness in the development community of the potential for subsidence induced by temporary and permanent groundwater diversions.
- ❑ Consideration of subsidence risk in area plan/policy documents.
- ❑ Allowance for additional above-grade density to offset loss of below-grade space, where risks exceed tolerances.

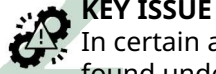


Subsidence in Burnaby, A. Taleghani



Subsidence in East Vancouver, P. Lingl

CURRENT HAZARD: FLOWING ARTESIAN GROUNDWATER



KEY ISSUE

In certain areas of the city, groundwater is naturally found under enough pressure to rise above the ground surface when disturbed by drilling or excavation. This is known as flowing artesian groundwater and can result in issues including flooding and sinkhole formation (such as occurred at Beechwood Street) and is shown schematically in Figure 4. Additional work is needed to better understand where this hazard may be present in the city and mitigate local risks.



DESIRED FUTURE STATE

➤ The extent of flowing artesian conditions is understood, and risks are communicated to relevant industries. If/where necessary, risk mitigation planning is carried out.



OPPORTUNITIES FOR IMPROVEMENT

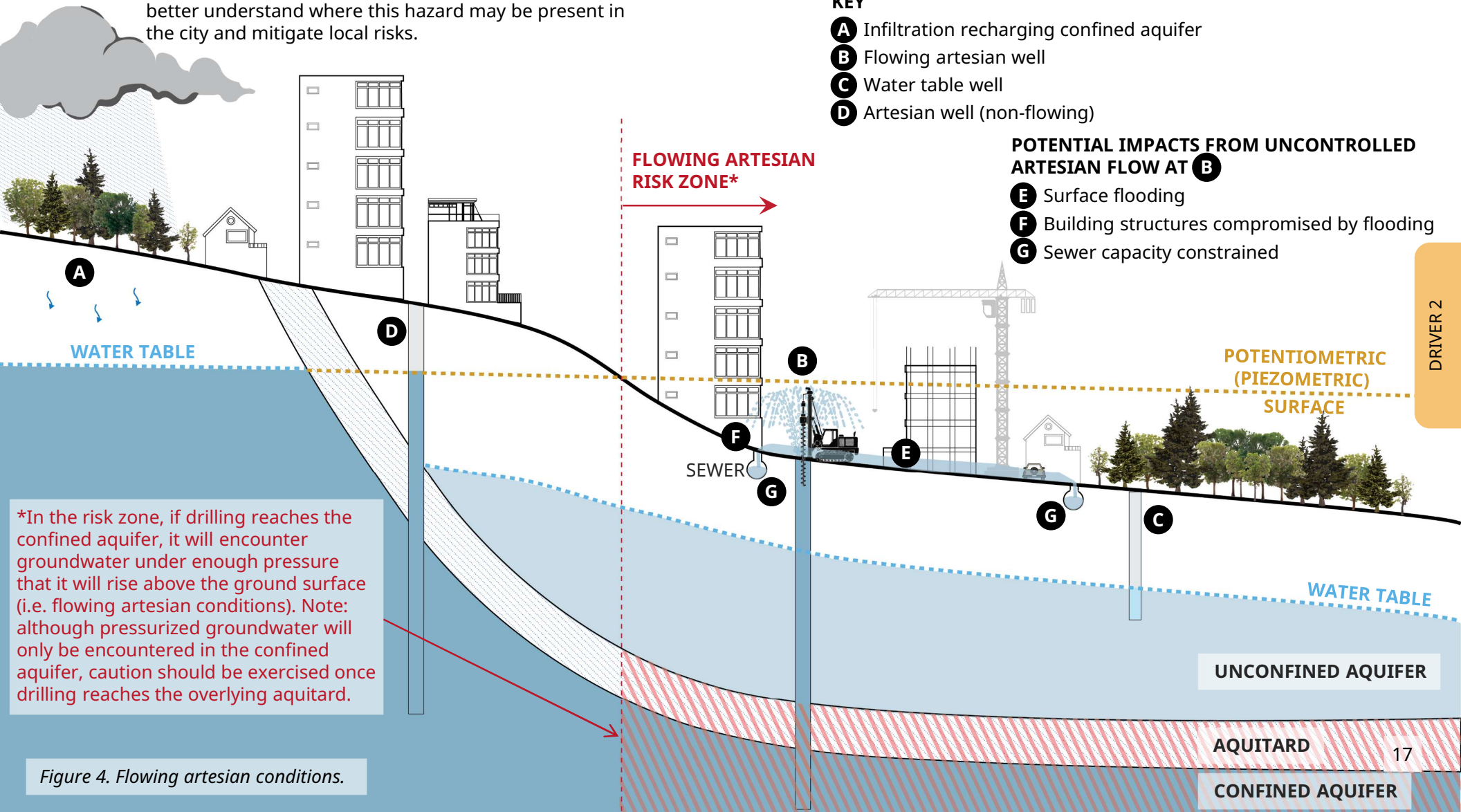
- ❑ Understanding of the aerial extent, depth, and pressure of the portions of the Quadra Sands Aquifer that exhibit flowing artesian conditions.
- ❑ Improve public, developer, and contractor awareness.

KEY

- A** Infiltration recharging confined aquifer
- B** Flowing artesian well
- C** Water table well
- D** Artesian well (non-flowing)

POTENTIAL IMPACTS FROM UNCONTROLLED ARTESIAN FLOW AT **B**

- E** Surface flooding
- F** Building structures compromised by flooding
- G** Sewer capacity constrained



DRIVER 2

*In the risk zone, if drilling reaches the confined aquifer, it will encounter groundwater under enough pressure that it will rise above the ground surface (i.e. flowing artesian conditions). Note: although pressurized groundwater will only be encountered in the confined aquifer, caution should be exercised once drilling reaches the overlying aquitard.

Figure 4. Flowing artesian conditions.

FUTURE HAZARD: GROUNDWATER RISE



KEY ISSUE

Vancouver is anticipating half a metre of sea level rise by 2050, and one metre by 2100^[17]. Groundwater levels in coastal areas are anticipated to rise as sea level rises, potentially resulting in deterioration of buried infrastructure leading to decreased service life, reduced sewer capacity, increased overland flood risk for low lying areas, below-grade flooding and moisture ingress, geotechnical impacts including increased earthquake liquefaction susceptibility, and potential contaminant mobilization/migration, shown in Figure 5.



DESIRED FUTURE STATE

➤ Buildings and infrastructure along Vancouver's coastline are protected from the impacts of groundwater rise induced by sea level rise.



LEADING PRACTICE

Oahu, Hawaii, USA^[18]

Groundwater rise induced by sea-level rise has been identified as a threat to people, property, and infrastructure throughout the island of Oahu. There are plans to map the most vulnerable areas, with mitigation strategies including raising street levels and the expansion of drainage canals.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Assessment of areas prone to groundwater rise induced by sea level rise.
- ❑ Mitigation/adaptation strategies for at-risk infrastructure.
- ❑ Policy related to new construction in high-risk areas.

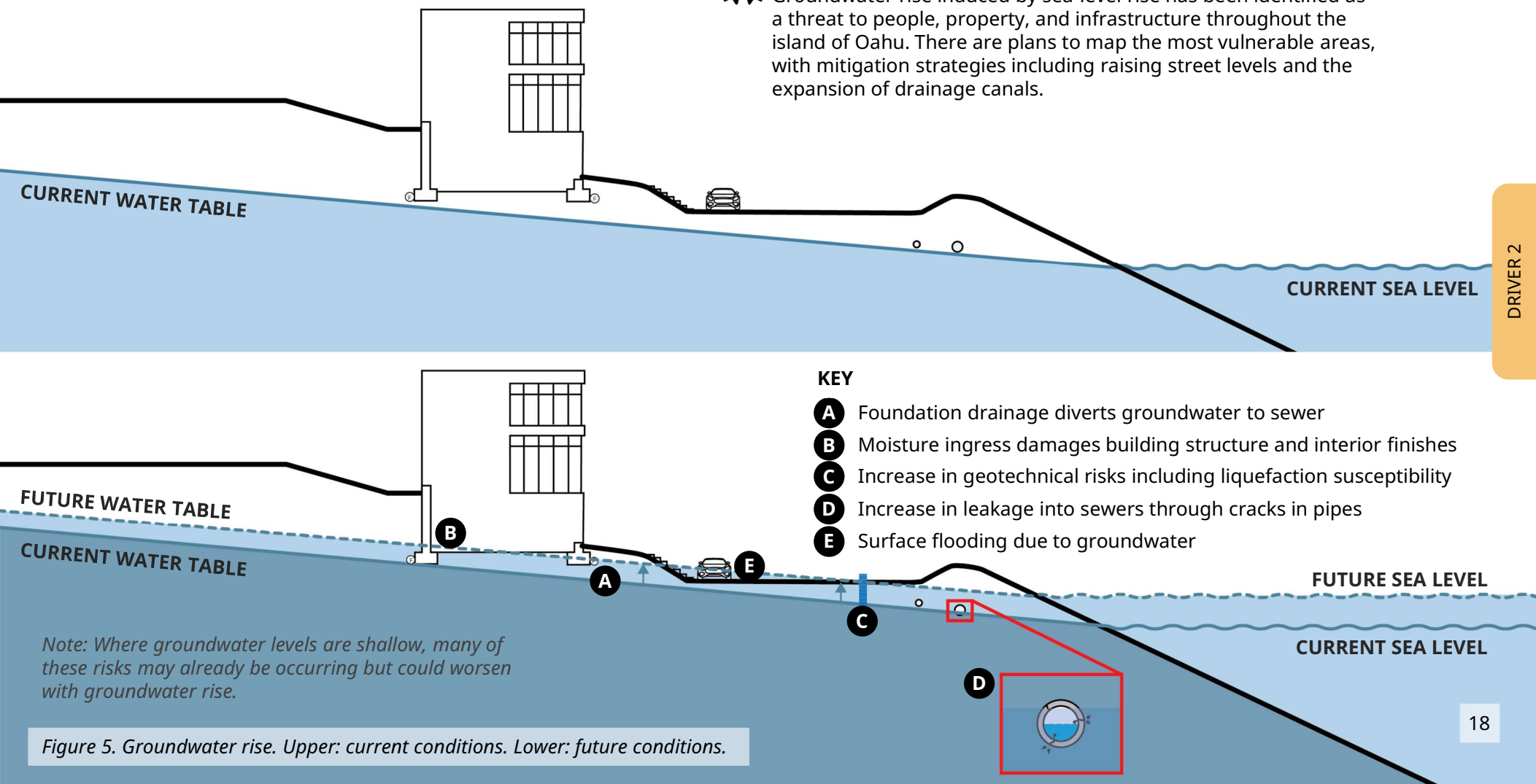
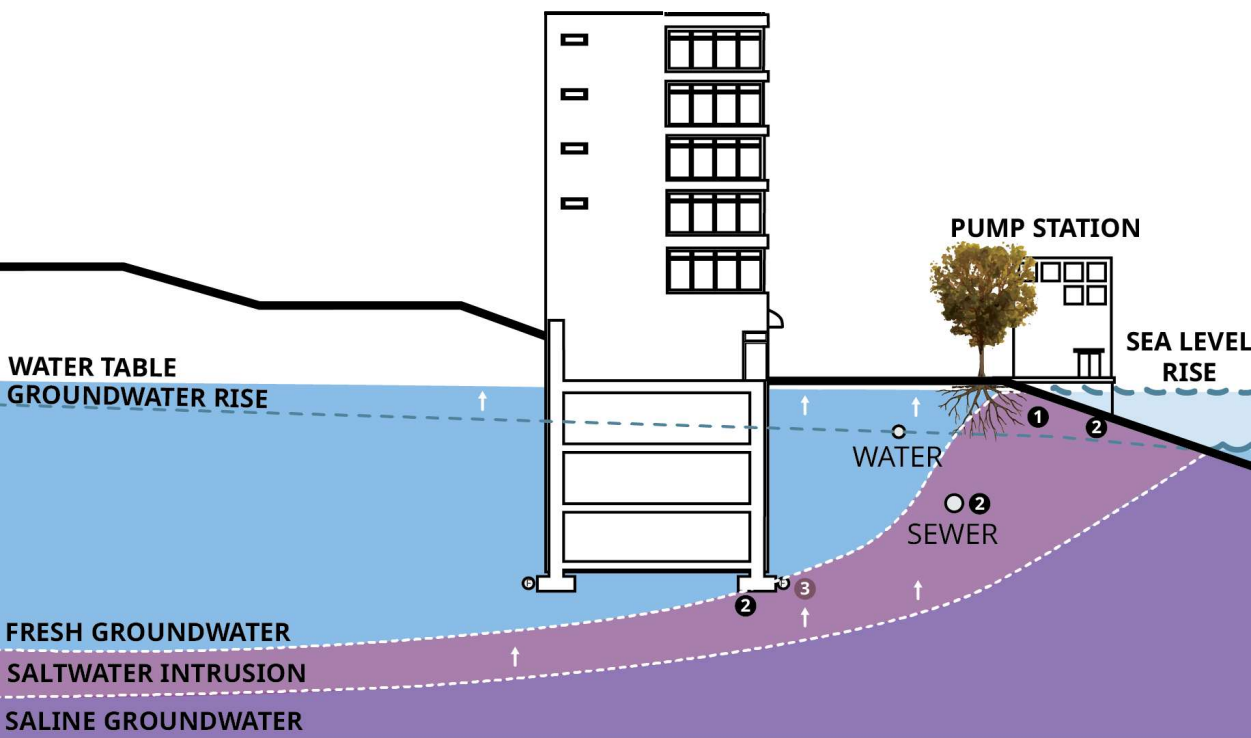
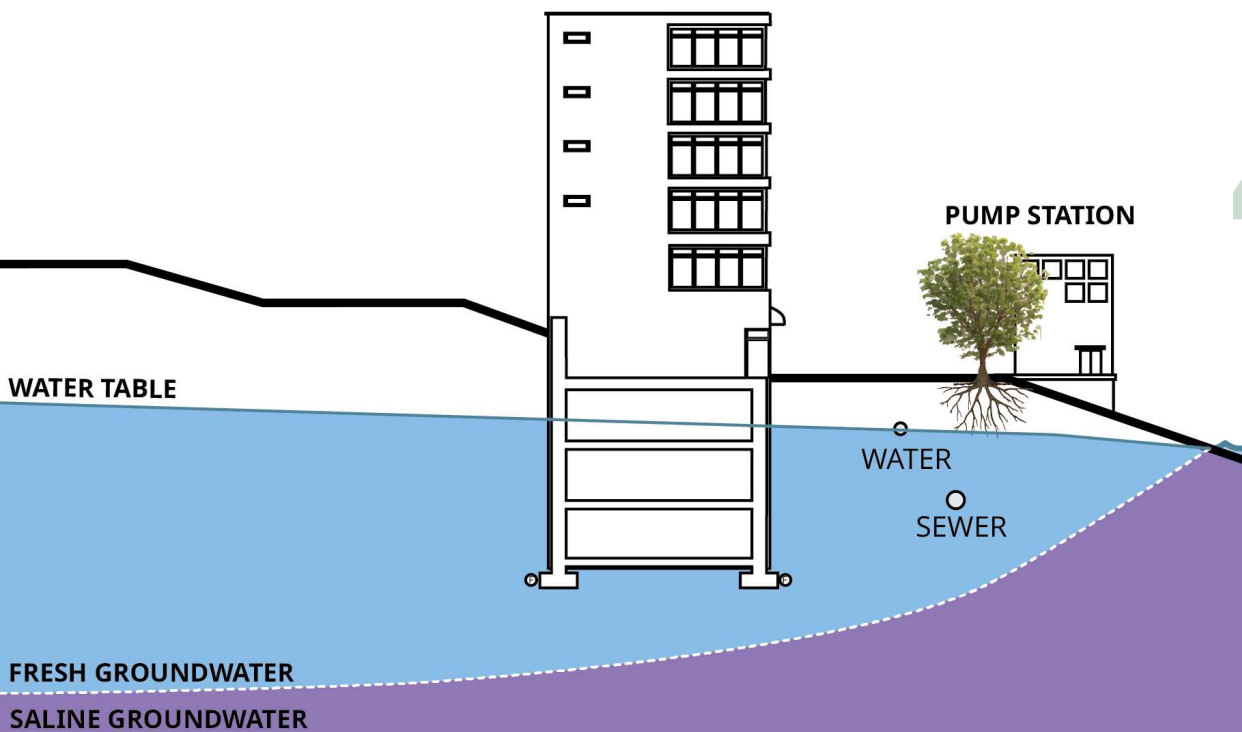


Figure 5. Groundwater rise. Upper: current conditions. Lower: future conditions.



4 FUTURE HAZARD: SALTWATER INTRUSION

KEY ISSUE

As sea level rises, or groundwater becomes depleted, salty groundwater that exists naturally beneath the coastline will move inland, shown in the lower portion of Figure 6. This issue, known as saltwater intrusion, poses a threat to critical infrastructure and buildings. Increased groundwater salinity can accelerate corrosion and deterioration of buried infrastructure and buildings, resulting in a reduced service life and costly remediation. A change in groundwater chemistry may also have negative impacts on nearby groundwater-dependent ecosystems, and will impact the potential for future groundwater use.

DESIRED FUTURE STATE

- At-risk buildings and infrastructure along Vancouver's coastline are protected from the impacts of saltwater intrusion.

OPPORTUNITIES FOR IMPROVEMENT

- ❑ Assessment of the areas prone to saltwater intrusion induced by sea level rise.
- ❑ Mitigation/adaptation strategies for at risk infrastructure.
- ❑ Policy related to new construction in high-risk areas.

KEY

- 1 Saline groundwater stresses plant health
- 2 Saline groundwater corrodes infrastructure and buildings
- 3 Foundation drainage pumps saline groundwater to sewers

Figure 6. Saltwater intrusion. Upper: current conditions. Lower: future conditions.

DRIVER 3: USE GROUNDWATER STRATEGICALLY AND SUSTAINABLY

INTRODUCTION

The City of Vancouver has piloted using groundwater for a handful of non-potable use applications such as irrigating golf courses and flushing toilets in some City facilities. As Vancouver densifies, population growth will add demand for potable water while climate change reduces the availability of drinking water sources. Exploring the potential for using groundwater for non-potable purposes to offset this growing demand, as well as a potential back-up potable water source for emergency use, may be beneficial to support water security and enhance future climate resilience. To use groundwater as an alternative water source, groundwater resources of suitable quality and quantity must be located, characterized, and protected.

CASE STUDY



Oakridge Center Redevelopment, Park Board

Due to the volume of potable water saved, Oakridge Park is a great example of using alternative sources for non-potable purposes. The site will consume approximately 40% less potable water by using groundwater and rainwater for non-potable uses. It is estimated that the development may use 300 million litres of groundwater and 50 million litres of rainwater per year for the non-potable water system^[19], which will supply water for all of the on-site toilets and urinals, cooling towers, car wash, and irrigation, as well as limited use for residential laundry.

POLICY ALIGNMENT

EMERGENCY AND DISASTER
MANAGEMENT ACT

2024 HAZARD, RISK AND
VULNERABILITY ANALYSIS

DROUGHT
RISK RATING: MEDIUM

By working towards using groundwater strategically and sustainably as an alternative resource, the City can manage water demand more cost-effectively.

Other City strategic initiatives related to this driver that the Groundwater Strategy builds upon:



STRESSED WATER SUPPLY



KEY ISSUE

Metro Vancouver is expected to face significant water supply challenges as climate change reduces snowpack by an estimated 56% by 2050^[20]. At the same time, longer and drier summers are likely to increase the frequency and severity of droughts, leading to more frequent restrictions on potable water use (Figure 7). Population growth will further intensify demand, potentially requiring costly investments in new infrastructure. Together, these pressures are expected to both increase demand for potable water and decrease availability, prompting a need to explore alternative supplies. Regional and municipal strategies already emphasize diversifying water sources, particularly for non-potable uses. Groundwater presents a viable opportunity to offset potable water demand for activities that do not require treated drinking water. Currently, substantial volumes of potable water are used for non-potable purposes. Expanding the use of groundwater for purposes like irrigation, street cleaning, toilet flushing, and certain industrial applications, would help to conserve limited potable water resources for essential uses.



DESIRED FUTURE STATE

- The City has a comprehensive understanding of local groundwater resources, including the quantity of groundwater that could be sustainably extracted.
- Rainwater infiltration is increased throughout the City (e.g., through construction of green rainwater infrastructure and/or a reduction of impervious area) which supports replenishing local aquifers and connected natural areas.
- Key groundwater recharge areas are protected to ensure adequate replenishment of the resource.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ An expanded conceptual model of Vancouver geology, monitoring of groundwater levels, and an assessment of how extraction may impact local ecosystems.
- ❑ Updated City rainwater management requirements to incentivize infiltration solutions to manage stormwater.
- ❑ Comprehensive information about infiltration potential, to help encourage and plan green rainwater infrastructure.
- ❑ Reduced setbacks requirements for infiltration features, where feasible.
- ❑ An assessment of aquifer recharge across the city.
- ❑ Land-use and development policies that encourage the preservation of absorbent landscapes in areas of significant aquifer recharge.

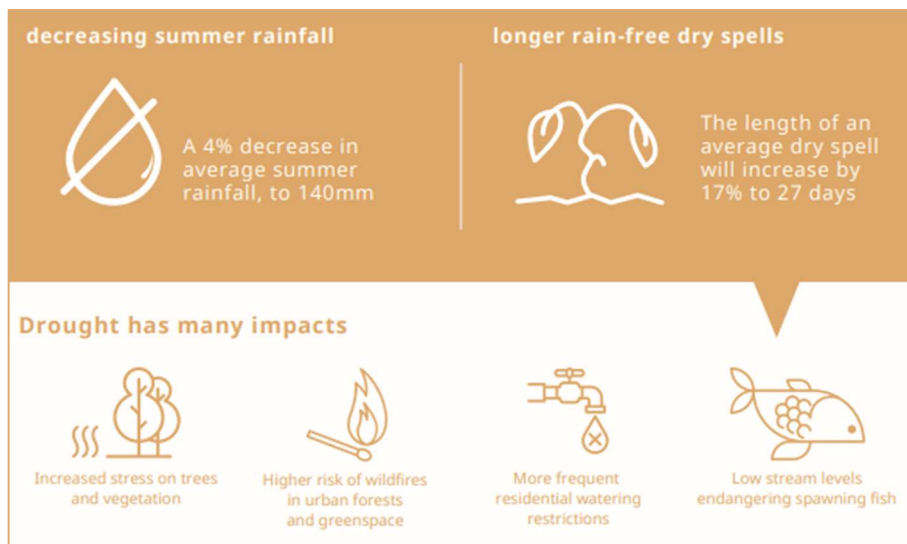


Figure 7. What to expect in Vancouver by the 2050s (Climate Change Adaptation Strategy 2024-2025 Update and Action Plan).



Capilano Lake reservoir (2015), CBC

EMERGENCY DRINKING WATER SUPPLY



KEY ISSUE

Groundwater has the potential to act as a back-up potable water source in the event of an emergency, such as an extended drought or earthquake. Local aquifers could be used to stretch our water supplies through the longer summers that are expected due to climate change (Figure 7). Emergency-use wells could access groundwater in aquifers beneath the city, which are less susceptible to damage during an earthquake. As they are local, there is a reduced need for infrastructure to convey groundwater to its destination. Several earthquake-prone jurisdictions that predominantly rely on surface water for their potable water source include groundwater as a backup supply for these reasons (e.g., Japan^[21] and California^[22]).



DESIRED FUTURE STATE

➤ Emergency supply wells are strategically located throughout the city, for use in an emergency. To ensure the wells are in good working order in the event they are needed, these wells would be used regularly in non-emergencies for non-potable purposes.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Groundwater resources are well characterized and protected (e.g., with groundwater protection zones).
- ❑ Specific facilities and/or locations that would be ideal candidates for emergency groundwater use are identified and cross-referenced with information about groundwater availability.
- ❑ Emergency supply wells are installed and equipped for emergency use and used regularly for non-potable purposes to ensure adequate maintenance and testing.



LEADING PRACTICE

San Francisco, California, USA^[23]

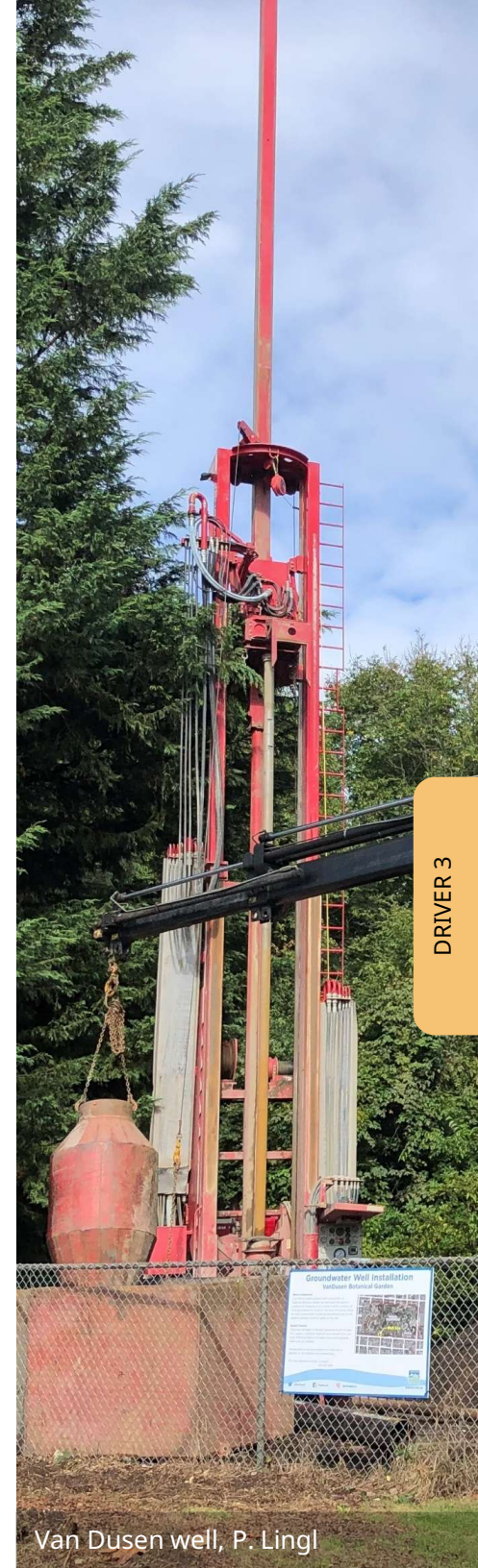
The San Francisco Public Utilities Commission has six wells where groundwater is extracted for use. One of the wells has onsite disinfection for use during an emergency. The utility intends to increase groundwater use to make their supply more diverse, and resilient to natural disasters. San Francisco is also one of the leading US cities in implementing non-potable water systems and has several district-scale projects that utilize water from foundation drainage. All new large developments must install a non-potable water system for toilet flushing and irrigation.



LEADING PRACTICE

Delta, British Columbia, Canada^{[24][25]}

The City of Delta has several wells to provide drinking water to residents and that can act as an emergency water source. These wells provide water at a lower cost than purchasing from Metro Vancouver. They are currently investigating additional areas for emergency supply.



CONTAMINATION



KEY ISSUE

Groundwater contamination can impact if and how groundwater can be used; it can also potentially migrate to sensitive habitats such as fish-bearing streams. In general, anthropogenic (human-induced) contamination in groundwater can come from point sources, such as improper management of chemicals/waste, or non-point sources, which are cumulative impacts from diffuse pollution that find their way to the aquifer. Examples of point sources of contamination are leachate from landfills, leaks of petroleum products at service stations, and legacy contamination at industrial sites. Examples of potential non-point source contamination includes urban run-off, which can contain hydrocarbons or tire compounds, or the repeated and prolonged use of fertilizers or chemical pesticides. Groundwater can also be unfit for use due to natural processes that result in elevated levels of elements such as arsenic, iron and manganese. Understanding where groundwater quality is currently not suitable, where groundwater may be more susceptible to new contamination, and how we can responsibly manage the use of potential contaminants or find alternatives, are key to protecting groundwater quality and for determining if and where groundwater may be used.

DESIRED FUTURE STATE

- Groundwater resources with adequate quality and quantity for use are protected from future contamination from widely-known and emerging contaminants.



OPPORTUNITIES FOR IMPROVEMENT

- ❑ Mapping of aquifer areas vulnerable to contamination.
- ❑ Public education on the impacts of contamination (e.g., to groundwater resources and ecosystems).
- ❑ City policies or procedures related to using the least toxic chemical available for a specific task.



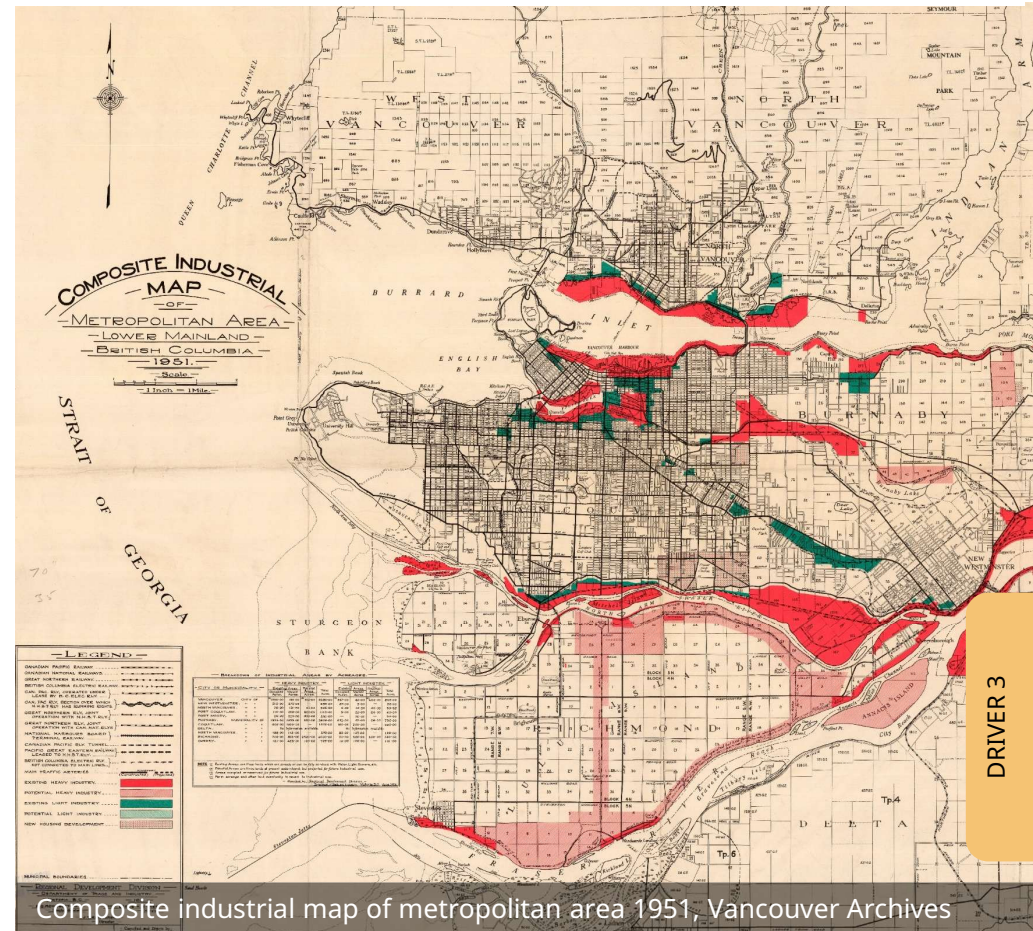
Legend



Heavy Industrial



Light Industrial



LEGACY CONTAMINATION

Chemical handling practices from historical industrial activities have left contamination in soil, sediment, and groundwater in some areas across the city. This legacy contamination limits how the land and groundwater can be used today. The protection of suitable groundwater resources is vital to ensuring they can be used, when needed, for years to come.

DRIVER 4: PROTECT ECOSYSTEMS AND ENVIRONMENT

INTRODUCTION

Historically a temperate rainforest, Vancouver was once shaped by a dense network of ravines, streams, and wetlands that were sustained by groundwater and performed critical ecological functions, including natural drainage, wildlife habitat provision, and fish spawning. Urbanization has filled in or buried most of these watercourses in pipes and has resulted in groundwater being diverted to the sewer, away from downstream ecosystems. This has disrupted natural groundwater–surface water connections and left very few streams intact. Still Creek, for example, is one of the City’s last salmon-bearing streams, and its health depends on groundwater inputs during dry periods to maintain flow and to regulate temperature. Groundwater plays a foundational role in the natural water cycle by linking surface water, soils, vegetation, and aquatic habitats, and by sustaining both terrestrial and aquatic ecosystems. Healthy ecosystems provide a suite of community benefits—including improved water quality, reduced flood and erosion risks, habitat for diverse species, access to nature and community well-being. In turn, these ecosystems help preserve groundwater by supporting infiltration and recharge processes (e.g., through vegetation, intact soils, and wetland function), which protect the long-term capacity of groundwater to support communities. Integrating ecosystem needs—including the preservation of groundwater recharge and discharge functions—into watershed-based land use planning can help protect and restore the health of ecosystems, and support mitigation and resilience to climate change.



Still Creek, C. Kimmel, Alpine Edge Photography

Other City strategic initiatives related to this driver that the Groundwater Strategy builds upon:



CLIMATE CHANGE AND GROUNDWATER-DEPENDENT ECOSYSTEMS



KEY ISSUE

Vancouver's natural assets are critical to supporting climate change mitigation and resilience. As climate projections indicate longer, hotter, and drier summers, local ecosystems such as wetlands, streams, riparian areas, are expected to experience increased reliance on groundwater to maintain ecological function. Groundwater provides a steady source of water during dry periods when surface flows decline (Map 3). Urban trees and vegetation similarly depend on shallow groundwater to support growth, health, and drought resilience. Protecting and managing groundwater resources and in turn, these natural areas is therefore essential to achieving urban forest canopy targets and maintaining ecosystem services and community benefits such as urban cooling, stormwater management, air and water quality improvements, recreational opportunities, and equitable access to nature.



DESIRED FUTURE STATE

- There is an understanding of which ecosystems across the city are reliant on groundwater, and groundwater preservation efforts are prioritized in these areas.



OPPORTUNITIES FOR IMPROVEMENT

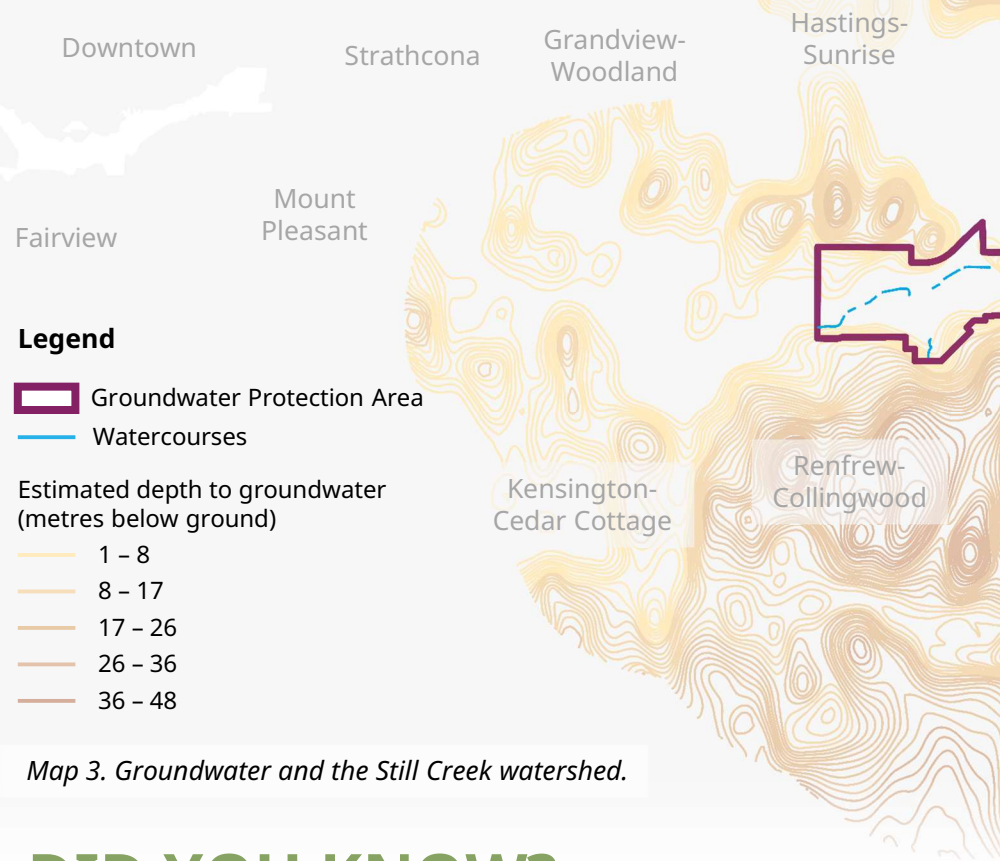
- ❑ A conceptual understanding of how groundwater interacts with specific ecosystems.
- ❑ Knowledge sharing (internally and externally) to improve the understanding of why groundwater is important to our natural systems.



LEADING PRACTICE

Vancouver Island, British Columbia, Canada^[26]

A groundwater curtailment model was developed for the Koksilah River watershed to protect aquatic life, including salmonid species. The model informed restrictions on groundwater use that had demonstrated positive impacts on streamflow.



Map 3. Groundwater and the Still Creek watershed.

DID YOU KNOW?

Through the development of the Rupert and Renfrew Station Area Plan, the City's groundwater flow model was refined for the Still Creek watershed. The model was used to estimate groundwater depth and map critical groundwater flow paths, which led to establishment of the Groundwater Protection Area (GPA).

New developments within the GPA are subject to limits on development depth, below-grade setbacks from Still Creek, and prescriptive groundwater management requirements to protect groundwater baseflow to the watercourse. A similar process could be replicated for other ecosystems that are dependent on groundwater in the City.

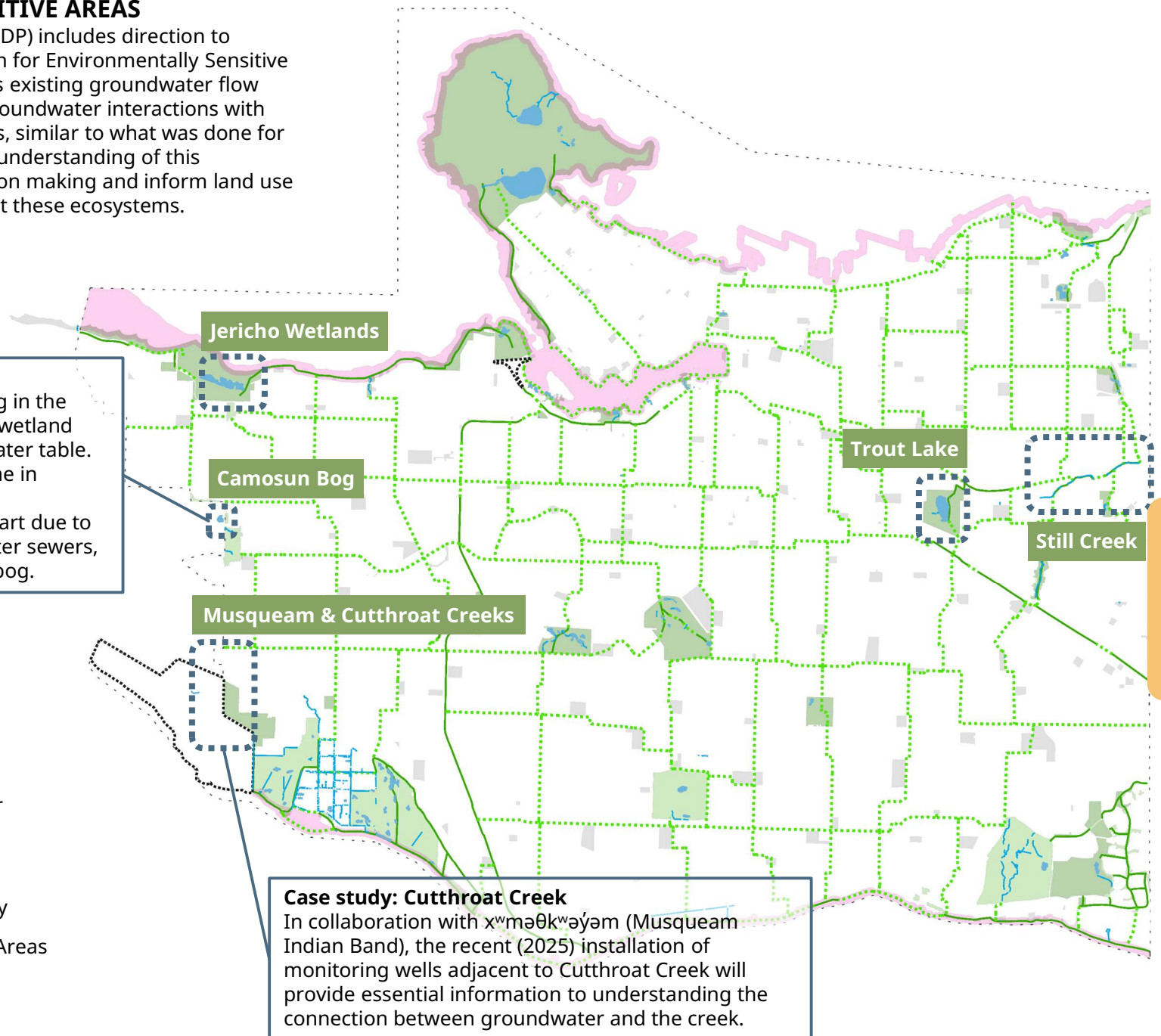
ENVIRONMENTALLY SENSITIVE AREAS

The Official Development Plan (ODP) includes direction to develop a management approach for Environmentally Sensitive Areas (ESAs). Expanding the City's existing groundwater flow model could help characterize groundwater interactions with ESAs and adjacent sensitive areas, similar to what was done for Still Creek (Map 3). An increased understanding of this connectivity could support decision making and inform land use policy or planning tools to protect these ecosystems.

Case study: Camosun Bog
Camosun Bog is the oldest bog in the Lower Mainland^[27]. A bog is a wetland formed in areas with a high water table. Monitoring has shown a decline in groundwater elevations in the surrounding area, at least in part due to diversions to nearby stormwater sewers, threatening the health of the bog.

Legend

- Aquatic
- Foreshore
- Terrestrial
- Park or Open Space
- Existing Ecological Corridor
- Watercourses
- First Nations Reserves
- City of Vancouver boundary
- Environmentally Sensitive Areas with known or suspected groundwater connectivity



LAND USE PLANNING



KEY ISSUE

The early steps of embedding ecosystem management and protection into land-use planning have been achieved through prior planning efforts (e.g., Rupert & Renfrew Area Plan) as well as the more recent adoption of the City of Vancouver's first Official Development Plan (ODP). The ODP envisions an enhanced and connected Ecological Network that includes environmentally sensitive areas and other natural areas and features that may have a range of reliance on groundwater (Map 4). Not only do some natural areas rely on groundwater, but natural areas also play an important role in protecting groundwater resources. As the degree of connectivity between natural areas and groundwater becomes better understood, appropriate measures to protect groundwater contributions to natural landscapes could be implemented. For example, policies that limit the depth of below grade structures or require infiltration to maintain groundwater recharge can help ensure that the support provided by groundwater to aquatic and terrestrial ecosystems is maintained (see Figure 8).



DESIRED FUTURE STATE

- There is a clear approach across the city for land use planning that considers the impacts of development on interactions between natural areas and groundwater.



OPPORTUNITY FOR IMPROVEMENT

- ❑ Policies and programs to protect and preserve groundwater in ecological areas that are dependent on it, which may include limits on building depth to maintain groundwater flow paths, and infiltration targets to preserve groundwater recharge.



LEADING PRACTICE

Toronto, Ontario, Canada^[28]

The Toronto and Region Conservation Authority developed the Terrestrial Natural Heritage System to establish, protect, and restore a connected network of natural cover across its jurisdiction. Supporting datasets were created to identify terrestrial, aquatic, and hydrological priorities, including mapping ecologically significant groundwater recharge areas to highlight critical linkages between terrestrial and aquatic systems.

GROUNDWATER DIVERTED TO SEWERS



KEY ISSUE

When buildings are constructed below the water table, natural groundwater flow patterns are impacted. During construction, the excavation area must be kept dry, thus groundwater is pumped from the excavation and discharged on a temporary basis to the municipal sewer system. After construction, groundwater is often collected by the building's foundation drainage systems and discharged on a permanent basis to the municipal sewer system (Figure 2). Under both scenarios, "nuisance" groundwater ends up in sewers, which diverts water away from critical downstream ecosystems such as creeks. Groundwater also contains naturally occurring dissolved minerals and constituents that can affect freshwater chemistry when discharged to surface water bodies. Additionally, groundwater can carry contaminants introduced into the ground from human activities. Together, changes to groundwater flow regimes (i.e., volumes and quality) can adversely impact natural environments.



DESIRED FUTURE STATE

- Initiatives to protect groundwater-dependent ecosystems are supported and prioritized.



OPPORTUNITY FOR IMPROVEMENT

- ❑ A regulatory Framework that aims to preserve groundwater contributions to ecosystems, which may include restrictions on groundwater diversion to sewer.



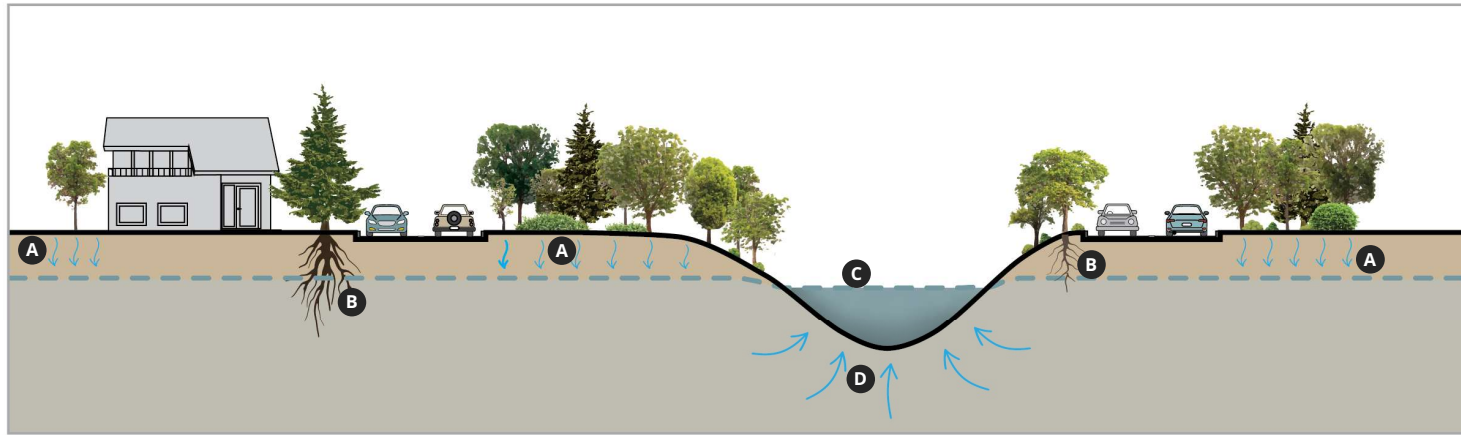
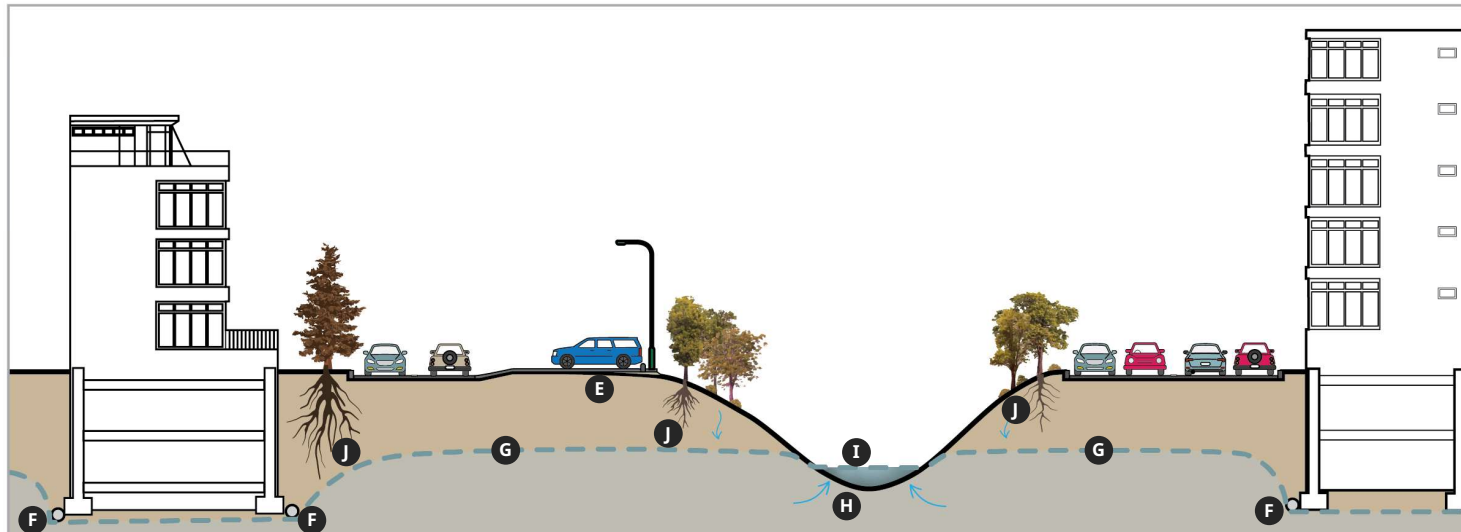
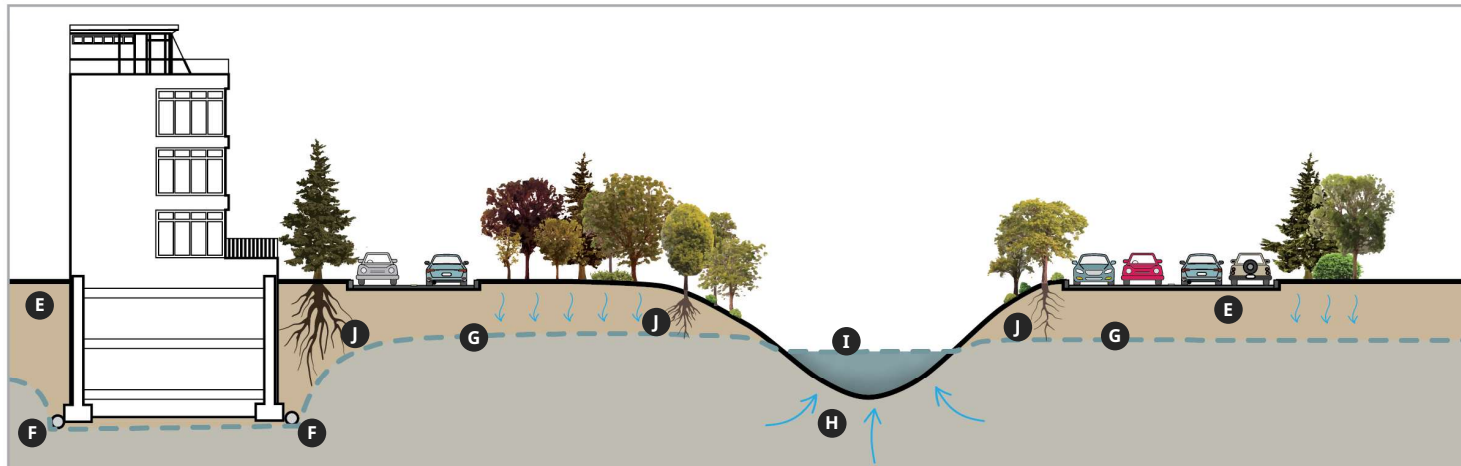


Figure 8. Reduced rainwater infiltration and increased groundwater diversions from increasing urbanization, resulting in lower water tables and various impacts to groundwater-dependent ecosystems – terrestrial and aquatic.



- A** Rainfall infiltration and groundwater recharge
- B** Uptake of groundwater by roots
- C** Gaining watercourse (receives water)
- D** Groundwater baseflow to watercourse
- E** Increased imperviousness and reduced infiltration and recharge
- F** Foundation drain diverting groundwater to sewer
- G** Lowered water table
- H** Reduced groundwater baseflow to watercourse
- I** Reduced water level in watercourse
- J** Reduced ability for roots to access groundwater

ACTION PLAN: DEVELOPING PHASE 1

DEVELOPING THE ACTION PLAN

To identify the specific steps the City will take to advance the Framework in response to the drivers, a multi-phase process was undertaken. This work integrated extensive research, broad stakeholder engagement, and technical analysis to produce a targeted, actionable, and realistic plan.

Generating a comprehensive set of actions

Engagement with the Staff Working Group (SWG) and Expert Panel (EP) resulted in significant discussion on the desired future state for a particular issue. The opportunities for improvement that were identified to reach that ideal future evolved into 300+ ideas for potential actions spanning topics from groundwater hazards, ecosystems, groundwater quality, preserving groundwater quantity, emergency use, general use (potable and non-potable applications), and sewer impacts.

Shortlisting priority actions

Refining 300+ ideas to a manageable number of actions required multiple rounds of evaluation by the Project Team, followed by additional review by the SWG and EP. To confirm the completeness and feasibility of the proposed actions and ensure that all viable options were considered, an external consultant was retained to complete jurisdictional research to explore groundwater management practices in other cities. The consultant identified redundant actions, and recommended additional actions where gaps were identified. Through this iterative process, the actions were consolidated into a set of 43 well-defined, discrete shortlisted actions that addressed the most significant and relevant risks and opportunities.

Technical analysis: deep dive on the shortlisted actions

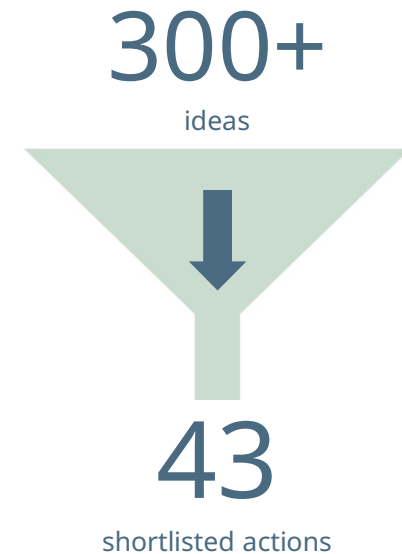
The consultant's subsequent scope of work included a cost-benefit analysis and development of high-level implementation considerations for the shortlisted actions (Appendix C).

➤ Cost-effectiveness prioritization

Benefits and indicative costs (Class D estimates) were evaluated across three categories: economic, social and environmental. Opportunities for financial savings were clearly identified in actions related to minimizing groundwater in the sewer system, avoiding rehabilitation costs for land and infrastructure, and reducing purchased water cost through strategic groundwater use. Opportunities for social and environmental benefits were highlighted in actions where limited or moderate capital investment was required and groundwater considerations could be integrated into existing City processes (e.g., engagement, partnerships, and enhancing infiltration).

➤ High-level implementation analysis

For each shortlisted action, the consultant assessed the recommended methodology or approach, expected duration and resource requirements (including costs), and key risks and dependencies in order to inform future implementation planning.



DEVELOPING PHASE 1

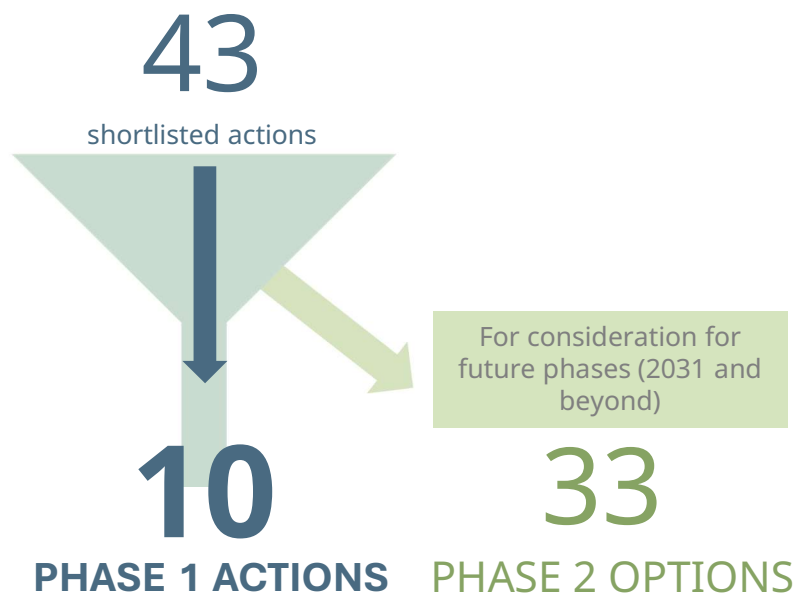
AN ADAPTIVE, PHASED APPROACH

The work to develop an extensive list of potential actions highlighted the need for work to initially focus on filling foundational gaps in our understanding about local groundwater resources. This lack of critical knowledge meant that the development of a long-term plan was not feasible or appropriate. Instead, the project transitioned to a more flexible and pragmatic planning model. The Groundwater Strategy proposes a phased, adaptive implementation approach with 10 actions prioritized for short-term implementation through 2030, which has been identified as Phase 1. These 10 actions are summarized in Tables 1 and 2 and are listed with additional context and rationale in Appendix A. The remaining 33 actions are considered options for Phase 2 and are listed in Appendix B and will be reevaluated for feasibility and suitability for implementation upon the completion of Phase 1.

PHASE 1: A FIVE-YEAR PLAN

Phase 1 brings forward a plan that:

- Spans a five-year planning horizon,
- Focuses on actions that are achievable with existing capacity,
- Establishes foundational knowledge to reduce uncertainty and support future decision-making, and
- Positions the City to reassess progress and recalibrate priorities prior to initiating subsequent phases.



2026-2030

PHASE 1

BEYOND
2030

CRITERIA FOR SELECTING PHASE 1 ACTIONS

Phase 1 actions were selected based on the following principles:

- **Foundational value**
Actions that fill critical knowledge gaps, clarify risks and opportunities, and enable future actions.
- **Support for core service delivery**
Actions that directly or indirectly support core City functions, ensuring alignment with operational priorities.
- **Cost effectiveness**
Actions identified as high-value and cost-effective.
- **Stakeholder support**
Actions that received broad support from the Staff Working Group and were informed by Expert Panel insights.

PHASE 1 ACTIONS & DELIVERABLES

 Support groundwater-dependent ecosystems	 Improve water security	 Reduce the impact of groundwater-related risks	 Maintain groundwater levels	 Safeguard groundwater quality	 Foster community awareness and support	 Inform decision making
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#	Action	Deliverable	Objectives Advanced					
								
IMMEDIATE PRIORITY								
01	Restrict the discharge of foundation drains into sewers Develop city-wide, performance-based requirements to limit the permanent diversion of groundwater into sewers from foundation drains (e.g., a maximum discharge rate).	A by-law requirement for the long-term discharge of groundwater to City sewers.						
FOUNDATIONAL KNOWLEDGE								
02	Develop a groundwater monitoring program Develop a monitoring well network throughout the city to determine seasonal and long-term groundwater elevations as well as groundwater chemistry.	Seasonal groundwater elevation data.						
		Groundwater quality data for locations with extraction potential.						
		Stratigraphy and hydraulic properties.						
03	Assess aquifer recharge and infiltration potential Undertake a city-wide assessment of infiltration potential to delineate areas where stormwater infiltration should be encouraged AND utilize this assessment to quantify aquifer recharge.	A city-wide map of infiltration potential, to inform stormwater management planning.						
		A city-wide map of groundwater recharge.						

Table 1 – Phase 1 actions, deliverables, and objectives advanced.

PHASE 1 ACTIONS & DELIVERABLES

 Support groundwater-dependent ecosystems

 Improve water security

 Reduce the impact of groundwater-related risks

 Maintain groundwater levels

 Safeguard groundwater quality

 Foster community awareness and support

 Inform decision making

#	Action	Deliverable	Objectives Advanced							
										
FOUNDATIONAL KNOWLEDGE (CONT'D)										
04	Quantify groundwater diversions Inventory and estimate all known groundwater diversions to sewers (e.g., construction dewatering, foundation drains, wells) in order to manage risks to infrastructure and development.	An inventory of suspected locations, and estimated flow volumes, of long-term groundwater diversions to sewer via foundation drainage.								
		An inventory of suspected locations, and estimated flow volumes, of short-term groundwater diversions to sewer via construction dewatering.								
05	Identify groundwater-dependent ecosystems Identify ecosystems that are reliant on groundwater and develop a water budget to support decision-making regarding how these areas should be protected.	Classification of groundwater-dependent ecosystems within ESAs.								
		A high-level water budget for all ecosystems determined to be groundwater-dependent.								
DECISION SUPPORT										
06	Develop a groundwater data repository Composite data from external sources (permit applications) and internal geotechnical data into one repository to improve decision-making for groundwater management.	A geodatabase with hydrogeological and geotechnical information, accessible by all City staff, in a spatial format.								

PHASE 1 ACTIONS & DELIVERABLES

 Support groundwater-dependent ecosystems	 Improve water security	 Reduce the impact of groundwater-related risks	 Maintain groundwater levels	 Safeguard groundwater quality	 Foster community awareness and support	 Inform decision making
--	--	--	---	---	--	--

#	Action	Deliverable	Objectives Advanced						
									
DECISION SUPPORT (CONT'D)									
07	Update the city-wide groundwater flow model Refine and expand the existing city-wide hydrogeological model with data from the monitoring program, groundwater diversion estimates, and infiltration and recharge estimates to allow for its use as a decision-support tool for risk mitigation, Area plan development, ecosystem protection, and utility and city planning.	City-wide groundwater elevation contour map.							
		A conceptual model of the city's hydrogeology.							
		A predictive tool to understand the impacts of land use changes, development projects, or other planning decisions.							
		A predictive tool to understand the impacts of climate change, and related risks.							
		A predictive tool to understand where we have areas of high I&I potential.							
08	Assess the sustainable extraction potential of groundwater Explore the potential for the future use of groundwater by completing an assessment of sustainable extraction across the city.	A heatmap of areas with a high extraction potential.							
		An estimate of extraction potential for select City parcels.							
09	Assess the potential extent and magnitude of groundwater rise Reduce risks, including surface or subsurface flooding, by completing a predictive assessment of groundwater rise induced by sea-level rise (if warranted, this will be followed by the development of mitigation strategies).	A heatmap showing the extent and magnitude of groundwater rise.							

PHASE 1 ACTIONS & DELIVERABLES



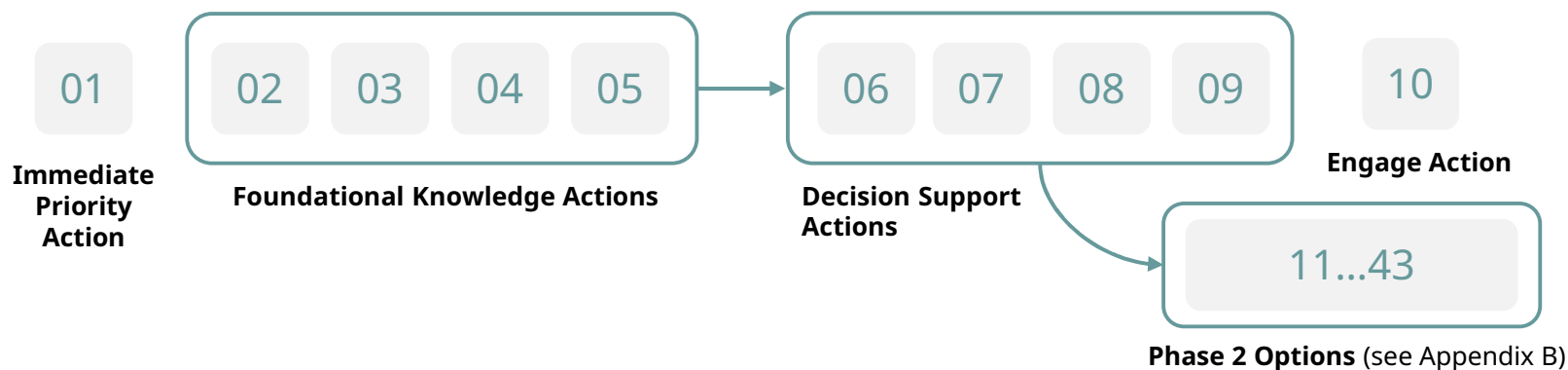
#	Action	Deliverable	Objectives Advanced						

OUTREACH

10	Engage external partners to advance objectives								
	a) Work with the Province to increase the enforcement of well decommissioning requirements	An inventory of abandoned wells to support a request to the Province to increase enforcement efforts.							
	b) Work with the Province to apply conditions to groundwater licenses that require adherence to local water conservation by-laws	Research instances of groundwater use which circumvent local water conservation efforts, in support of a request to the Province to update licensing conditions.							
	c) Work with Engineers & Geoscientists BC (EGBC) to develop a Practice Advisory for the design and construction of groundwater management structures.	Baseline prevalence and issues associated with groundwater tanking and cutoff structures to support a request to EGBC.							

Table 1 continued – Phase 1 actions, deliverables, and objectives advanced.

ACTION PLAN SUMMARY



PHASE 1 ACTIONS PROPOSED TIMELINE & TARGETS

Action	Target	2026	2027	2028	2029	2030
IMMEDIATE PRIORITY						
01	Restrict the discharge of foundation drains to sewer	Enact city-wide by-law that restricts groundwater discharge via foundation drainage by 2027				
FOUNDATIONAL KNOWLEDGE						
02	Develop a groundwater monitoring program	Install 15 wells (10 with telemetry) by 2028				
03	Assess aquifer recharge and infiltration potential	Map infiltration potential for 100% of the city by 2028				
04	Quantify groundwater diversions	Estimate groundwater diversion rates across 100% of sewer catchments by 2027				
05	Identify groundwater-dependent ecosystems	1. Identify ecosystems that are dependent on groundwater within ESAs by 2028 2. Develop water budgets for identified ecosystems by 2029				
DECISION SUPPORT						
06	Develop a groundwater data repository	Complete geodatabase for groundwater-related data by 2027				
07	Update the city-wide groundwater flow model	Update the model with data collected in Phase 1 and calibrate to steady-state conditions (calibration target: Normalized Root Mean Square Error (NRMSE) < 10%) using water levels from Action 01 by 2029				
08	Assess the sustainable extraction potential of groundwater	Complete assessment to evaluate sustainable extraction potential across the city by 2030				
09	Assess the potential extent and magnitude of groundwater rise	Complete assessment to identify areas vulnerable to groundwater rise by 2030				
OUTREACH						
10	Engage external partners to advance objectives	Complete baseline and inventory for priority areas in the city by 2030				

Table 2 – Phase 1 actions, timelines, and targets.

PHASE 1 OUTCOMES

The actions proposed in Phase 1 of the Groundwater Strategy are anticipated to deliver financial savings for the City at an order of magnitude greater than the program's cost, based on preliminary analysis by the consultant (Appendix C). While further validation would be required to confirm the exact numbers, the primary opportunities for cost savings are clear:

➤ **Inflow and infiltration into the sewer system is minimized**

In 2025, Metro Vancouver charged the City of Vancouver \$173 million for treatment and disposal; a portion of this cost reflects treatment of groundwater entering the sewer system through inflow and infiltration. By keeping groundwater out of the sewer network, the City will ease demand on wastewater treatment plants, prevent or delay costly upgrades to infrastructure, and may reduce the volume of combined sewer overflows.

➤ **Rehabilitation costs for land and infrastructure is avoided**

Proactively identifying and planning for risks is significantly more cost-effective than reacting to them as they occur. An improved understanding of groundwater rise induced by sea level rise will help the City make informed decisions about infrastructure and land-use planning, avoiding costly remediation of buildings, utilities, and public land.

➤ **Purchased water costs is reduced through strategic groundwater use**

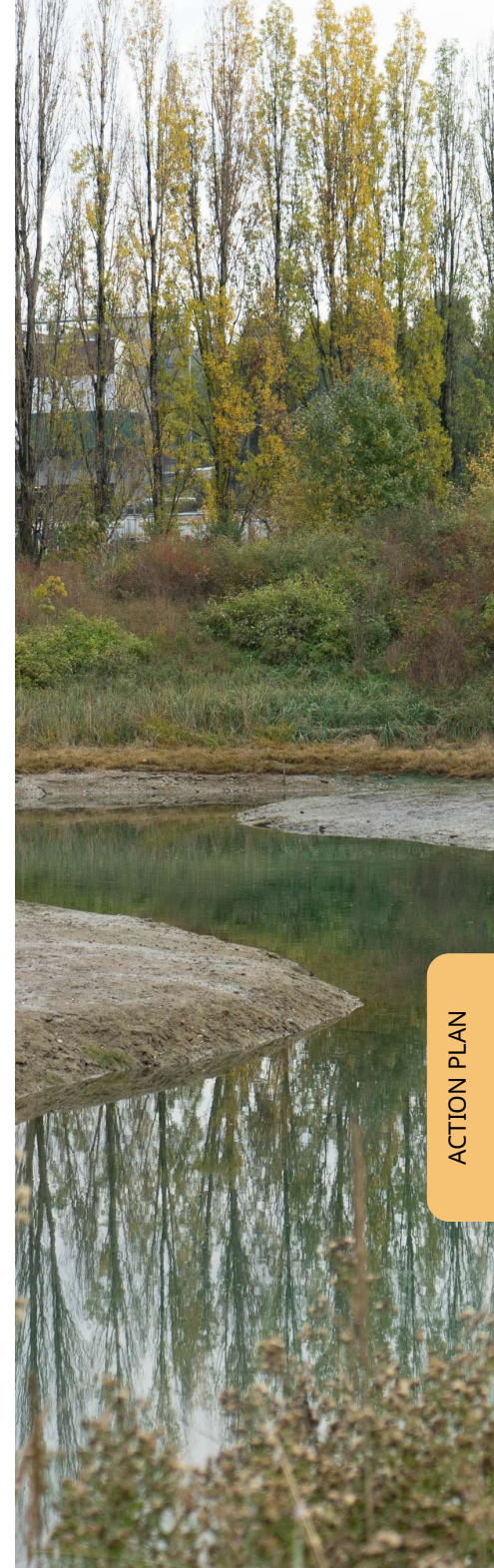
In 2025, Vancouver purchased \$107 million of drinking water from Metro Vancouver. Identifying opportunities to extract and use groundwater may lead to a decreased reliance on water purchased from Metro Vancouver, generating ongoing operational savings.

➤ **Expedited housing delivery through simplified development review processes**

As of 2024 and 2025, the Groundwater team reviewed 120 development applications per year on average. Through the development of a simplified, citywide by-law that sets clear requirements for foundation drainage, the development review processes can be accelerated for developers and will build capacity internally to focus more on value-added work.

➤ **Informed decision-making and unlocking Phase 2 Options**

20-25 monitoring wells will be added between 2026 and 2030 to help build foundational knowledge about groundwater-related risks and opportunities. Assessments on groundwater inputs and outputs will inform groundwater management as well as the cost-effective management of sewer and drainage infrastructure. This information will culminate in the refinement of the groundwater flow model, informing future decision-making related to various known and unknown risks as well as groundwater extraction potential and environmental protection. These outcomes will also help determine which Phase 2 Options should be prioritized for implementation to deliver the full value of the Strategy.



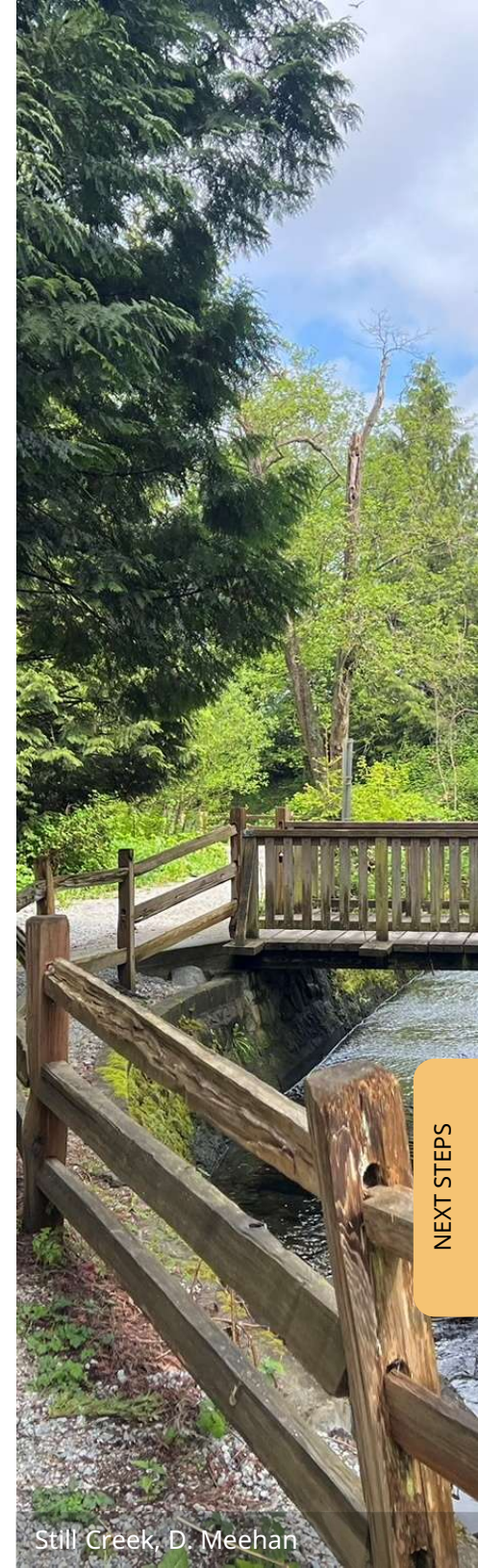
NEXT STEPS

BEYOND PHASE 1

The Groundwater Strategy sets out a vision for groundwater in Vancouver to be recognized as an important resource and managed in order to mitigate risks, support ecosystems, and advance the City's adaptation to climate change. The first phase of the Groundwater Strategy provides a strong foundation for building an understanding of the resource and sets out an Action Plan to be implemented between 2026 and 2030.

As the City moves forward with implementation of this first phase of actions, engagement with stakeholders on the details and timing of implementation will continue.

Upon completion of Phase 1, and following a review of environmental and regulatory considerations, current priorities and context, and available resources, the City will determine appropriate options for Phase 2 (see Appendix B). Financial and resource needs for this future work will be developed and brought forward through the appropriate budgeting and approval processes at that time.



GLOSSARY

Aquifer: a layer of permeable material below ground where groundwater can be transmitted and stored.

Aquitard: a layer of material that impedes the movement of groundwater (e.g., silt, clay, or solid rock).

Artesian aquifer: a permeable layer, sandwiched between two layers of impermeable material, that contains pressurized water.

Bog: A type of organic wetland whose development and persistence depends on climate, hydrology, geomorphology, and biology.

Combined sewers: a type of sewer system in which one set of pipes carries both sanitary sewage and urban rainwater runoff.

Combined sewer overflows (CSOs): events when a combined sewer is over capacity and releases a mixture of stormwater and sewage into receiving waterbodies.

Confined aquifer: an aquifer that is beneath an aquitard.

Flowing artesian well: a well that is drilled into an aquifer under enough pressure to force the water level in the well to rise above the ground surface and flow over the top of the well.

Gaining stream: a stream or river that receives water inputs from groundwater.

Green rainwater infrastructure (GRI): a suite of rainwater management tools that use both engineered and nature-based solutions to protect, restore, and mimic the natural water cycle.

Groundwater: the water found underground in the cracks and spaces in soil, sand and rock.

Groundwater recharge: the process of water entering the subsurface and reaching the water table, either as infiltration of rainfall, or losses from surface water such as rivers, creeks, ditches, lakes, ponds, and wetlands.

Groundwater rise: the upward movement of the water table due to increases in rainfall and/or nearby river, ocean or tidal levels.

Hydrologic cycle: the movement of water from precipitation, to surface water runoff, infiltration, evaporation, transpiration, and groundwater discharge. Also known as the “water cycle.”

Infiltration: the downward movement of rainwater into the soil.

Inflow and Infiltration (I&I): unwanted flows entering sewer pipes, which contribute to reduced sewer capacity, increased wastewater treatment costs, and increased combined sewer overflows. In this context:

- **I&I Inflow** refers to water entering sewers through direct connections (e.g., perimeter/foundation drainage connections), and
- **I&I Infiltration** refers to water that seeps into pipes through defects like cracks or leaky joints.

Monitoring well: a type of well used principally used for observing groundwater levels and flow conditions, obtaining samples for determining groundwater quality, and evaluating hydraulic properties of water-bearing strata.

Non-potable water: water that is not safe to drink but can still be used for other purposes including washing cars, flushing toilets, and watering plants.

Numerical model: a technique to tackle complex geological problems. Numerical modeling uses mathematical models to describe the physical conditions of geological scenarios using numbers and equations.

Potable offset: groundwater or other alternative water sources that offset or replace an equal quantity of potable water.

Potable water: water that is appropriate for drinking, cooking and bathing.

Potentiometric surface: an imaginary surface representing the total pressure of groundwater, indicating the level to which water will rise in wells drilled into a confined aquifer.

Saltwater intrusion: the movement of saline water into fresh groundwater regions in coastal aquifer settings due to pumping, reduced recharge, climate variations, or sea-level fluctuations.

Subsidence: the sinking of land. Groundwater-related subsidence occurs due to groundwater extraction.

Surface water: water bodies such as rivers, lakes, streams, and oceans which sit on the surface of the planet.

GLOSSARY

Transpiration: the process of water movement through a plant and its evaporation from aerial parts, such as leaves, stems and flowers.

Unconfined aquifer: an aquifer that is not beneath an aquitard, typically located at more shallow depths than a confined aquifer.

Water budget: an account of the water stored in a system, such as an aquifer, and the movement of water in and out of that system.

Watercourse: a river, stream, creek, waterway, lagoon, lake, spring, swamp, marsh or other natural bodies of fresh water; or a canal, ditch, reservoir or other man-made surface feature; whether it contains or conveys water continuously or intermittently

Watershed: a distinct hydrologically-defined geographic unit, within which all waterways such as creeks, streams and rivers drain to a common outlet.

Water table: the water level in an aquifer.

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- ❖ Page iv, Acknowledgements, Camosun Bog, Julie LeBlanc
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- ❖ Page 24, Driver 4: Protect ecosystems and environment, Still Creek, Christopher Kimmel, Alpine Edge Photography
- ❖ Page 27, Driver 4: Protect ecology and environment, Vanier Park, Diane Meehan
- ❖ Page 36, Phase 1 outcomes, New Brighton Park, Julia Scott Lenz
- ❖ Page 37, Next steps, Still Creek, Diane Meehan

APPENDIX A

RATIONALE FOR PHASE 1 ACTIONS

RATIONALE FOR PHASE 1 ACTIONS

Action Name	Description	Rationale
01 Restrict the discharge of foundation drains into sewers	Develop city-wide, performance-based requirements to limit the permanent diversion of groundwater into sewers from foundation drains (e.g., a maximum discharge rate).	Underground structures, including parkades, require drainage systems to protect them from water ingress and hydrostatic pressures. The groundwater collected by these systems is usually discharged to the sewer system, which not only reduces sewer system capacity, increases treatment costs, and adds to combined sewer overflow events, but can also result in other impacts such as reduced baseflow to nearby streams and geotechnical risks (e.g., subsidence). There are currently no incentives in place for developers to limit groundwater discharge. Strategies for developers to limit groundwater discharge may include constructing groundwater cut-off walls, designing building foundations to be “tanked,” reducing below-grade parking, or by re-using onsite groundwater. Currently, the requirements to limit groundwater discharge are not well defined, resulting in unforeseen costs for developers, and additional permit review time. The development of clear by-law requirements will increase transparency, reduce costs, and expedite housing delivery.
02 Develop a groundwater monitoring program	Develop a monitoring well network throughout the city to determine seasonal and long-term groundwater elevations as well as groundwater chemistry.	Little is known about groundwater elevations or water quality across the city. The data from the monitoring well network will be critical for many other actions in the Strategy as the City needs to better understand local hydrogeology to effectively protect and manage it. Data from the monitoring well network (e.g., water levels) would be made publicly available. These data will be used for various purposes, including, for example, assessing extraction potential and infiltration capacities, better understanding groundwater-ecosystem interactions, calibrating models, predicting the impacts of land-use changes, monitoring groundwater-rise, etc.
03 Assess aquifer recharge and infiltration potential	Undertake a city-wide assessment of infiltration potential to delineate areas where stormwater infiltration should be encouraged AND utilize this assessment to quantify aquifer recharge.	Protecting and enhancing recharge areas is critical to preserving aquifer resources. This action will help the City better understand our ability to manage stormwater through infiltration and potentially identify specific target areas for infiltration projects. It will also help identify areas that currently provide significant recharge to local aquifers which may inform future planning work. Assessing recharge across the City will also assist with the development of a water budget and/or refinement of the city-wide numerical model.

RATIONALE FOR PHASE 1 ACTIONS

Action Name	Description	Rationale
04 Quantify groundwater diversions	Inventory and estimate all known groundwater diversions to sewers (e.g., construction dewatering, foundation drains, wells) in order to manage risks to infrastructure and development.	The City currently has limited information about the quantity of groundwater being diverted from local aquifers; via construction dewatering, foundation drainage, and leakage into sewers. This limits our ability to properly manage and potentially use the resource, due to a fundamental gap in our understanding of its water budget. As the majority of groundwater diversions occurring today are thought to be adding that groundwater to the City's sewer and drainage system, this gap also limits our ability to properly manage our infrastructure. By inventorying groundwater diversions, we can better understand the quantity and locations of groundwater inputs to our sewer and drainage system. This will allow Staff to better focus our efforts to limit these diversions in order to preserve capacity, and will also assist with related technical work such as sewer modeling and planning. This information will also enable the development of a more complete water budget for our aquifers, allowing the City to better understand the potential for groundwater use in the future and to better understand and protect groundwater-dependent ecosystems.
05 Identify groundwater-dependent ecosystems	Identify ecosystems that are reliant on groundwater and develop a water budget to support decision-making regarding how these ecosystems should be protected.	Many natural areas, including Still Creek and Camosun Bog, are dependent on groundwater to properly function. Several others are suspected to rely on groundwater, but a city-wide inventory of groundwater-dependent ecosystems (GDEs) has not been completed. In order to protect these ecosystems, we need to first identify them and then understand how they interact with groundwater. With this information, we can predict how different stressors (e.g., increased upgradient imperviousness, new drainage systems or wells, etc) may impact these ecosystems and take steps to reduce or mitigate these impacts.
06 Develop a groundwater data repository	Composite data from external sources (permit applications) and internal geotechnical data into one repository to improve decision-making for groundwater management.	The current state of data on groundwater is uncoordinated and a patchwork, creating challenges around baselining groundwater to manage it effectively. Internal data needs to be streamlined, and barriers exist around using external data to complete information gaps. The data repository will be the first step to developing a baseline characterization of groundwater so that it can be managed to help mitigate risks, support core services, and support the 100-year ecological vision.

RATIONALE FOR PHASE 1 ACTIONS

Action Name	Description	Rationale
07 Update the city-wide groundwater flow model	Refine and expand the existing city-wide hydrogeological model with data from the monitoring program, groundwater diversion estimates, and infiltration and recharge estimates to allow for its use as a decision-support tool for risk mitigation, Area-plan development, ecosystem protection, and utility and city planning.	The City has an existing numerical model that covers the municipality (and slightly beyond). If the model can be refined to improve accuracy, it can be a powerful tool in predicting the impacts of various stressors (e.g., a changing climate, rising sea levels, groundwater extraction, increased imperviousness, additional underground infrastructure, etc.) on groundwater, connected ecosystems, and/or infrastructure. This action will allow the City to compile all the various data it has on local geology and water levels and update the existing model such that it can be used to inform decision-making.
08 Assess the sustainable extraction potential of groundwater	Explore the potential for the future use of groundwater by completing an assessment of sustainable extraction across the city.	Jurisdictions with multiple water sources that includes groundwater (e.g., San Francisco) have redundancies in terms of their water supply in the event of emergencies (e.g., after earthquakes). Other jurisdictions, including some located with Metro Vancouver, have either considered or installed wells for non-potable and potable purposes, including for emergency purposes. There is growing interest in the City to use groundwater for non-potable purposes to reduce the burden on our potable water supply. This action would determine the sustainable yield (i.e., how much groundwater can be used without depleting the aquifers or causing other adverse impacts) to determine where and how much groundwater can be used. If sufficient potential exists, this action could be followed by a demand assessment and subsequently by evaluating the feasibility of adding emergency groundwater supply to Vancouver. This could include such options as installing wells at key facilities (e.g., hospitals), adding wells to our existing water supply system as a redundancy, or installing wells in specific areas for specific purposes (e.g., for firefighting).
09 Assess the potential extent and magnitude of groundwater rise	Reduce risks, including surface or subsurface flooding, by completing a predictive assessment of groundwater rise induced by sea-level rise (if warranted, this will be followed by the development of mitigation strategies).	As sea levels rise (i.e., due to climate change) groundwater, which is hydraulically connected to the sea, will also rise. This can lead to flooding of below ground structures, geotechnical impacts, increased capture of groundwater via drainage systems, surface flooding, and other impacts. There are a number of City-owned facilities (e.g., Kitsilano Pool) and other assets (e.g., roads, sewer pipes, etc.) that may be vulnerable to groundwater rise. This action would commission a study to determine the potential future extent and magnitude of groundwater rise. Based on study findings, this action would subsequently prompt development of mitigation plans for vulnerable areas, if warranted.

RATIONALE FOR PHASE 1 ACTIONS

Action Name	Description	Rationale
10 Engage external partners to advance objectives	a) Work with the Province to increase the enforcement of well decommissioning requirements. b) Work with the Province to apply conditions to groundwater licenses that require adherence to local water conservation by-laws. c) Work with Engineers & Geoscientists BC (EGBC) to develop a Practice Advisory for the design and construction of groundwater management structures.	Despite Provincial legislation, some unused wells are not decommissioned, leading to safety concerns and potential pathways for contaminants to enter local aquifers Well closure requirements are not actively enforced by the Province. As this impacts City resources, the intention is to engage with the Province to convey our concerns and seek a commitment for additional efforts to ensure compliance. There is currently little to no design guidance available for permanent groundwater management structures (which include tanked foundations and groundwater cut-off walls). These types of structures are becoming increasingly common in Vancouver and elsewhere, and there is a level of inconsistency in the designs submitted with development applications, and the performance of these features after construction. This action would lobby EGBC to develop a Practice Advisory related to these groundwater management structures, which would simplify the development review process, improve overall performance of these structures, and protect the City, future owners, and local groundwater resources from risks.

APPENDIX B

PHASE 2 OPTIONS

PHASE 2 OPTIONS

The 2026-2030 Phase 1 Action Plan will establish the baseline information required to enable full realization of Groundwater Strategy objectives. Future phases (2031 and beyond) will implement a targeted set of additional actions summarized below. These actions were also developed in collaboration with project partners and stakeholders.

 Support groundwater-dependent ecosystems

 Improve water security

 Reduce the impact of groundwater-related risks

 Maintain groundwater levels

 Safeguard groundwater quality

 Foster community awareness and support

 Inform decision making

#	Action Name	Objectives Advanced
11	Well drilling advisory	
12	Inform neighborhood planning initiatives	
13	Discharge during construction	
14	Stormwater infiltration incentives	
15	Aquifer valuation	
16	Map groundwater I&I risks	
17	Mitigate risk of potential impacts to groundwater quality from urban runoff	
18	Aquifer vulnerability assessment	
19	Remediation for future use	
20	Reduce setbacks for infiltration features	
21	Emergency response business continuity	

#	Action Name	Objectives Advanced
22	Leverage external partners to advance our objectives	
23	Partnerships to protect groundwater ecosystems	
24	Managed aquifer recharge	
25	Reduce parkade depths	
26	Requirements for injection systems	
27	Reduce contaminants from City operations	
28	Internal education	
29	Green rainwater infrastructure at City-owned buildings	
30	Water reservation application	
31	Groundwater partnerships plan	

#	Action Name	Objectives Advanced
32	Groundwater public outreach plan	
33	Geoexchange impacts	
34	Vancouver Landfill considerations	
35	Impacts of utility trenches	
36	VBBL regulations for non-potable use	
37	Replace PFAS in firefighting foams	
38	Mitigate artificial turf	
39	Well acquisition	
40	Academic partnerships	
41	Coordinate City groundwater use	
42	Saltwater intrusion assessment	
43	Increase infiltration through parks	

PHASE 2 OPTIONS

Action Name	Description	Rationale
11 Well drilling advisory	Reduce risks related to flowing artesian conditions: a) Work with the Province and other affected local governments to refine the Well Drilling Advisory Area for flowing artesian conditions. b) Develop a plan to mitigate the risks of encountering flowing artesian conditions within the Well Drilling Advisory Area.	Flowing artesian conditions are pressurized portions of aquifers, and wells drilled in these areas can cause serious problems. For example, in 2015 a geoexchange well for a home was drilled by an inexperienced contractor, and this pierced a pressurized (artesian) portion of the underlying aquifer. It took two years and cost the City almost \$12 million to control the flow, and an estimated 3 billion gallons of groundwater were discharged to the sewer system. These pressurized areas are delineated by a Provincial Well Drilling Advisory Area map to help alert developers to the risk. The current advisory area extends from the University Endowment Lands to just west of Coquitlam. The advisory area was defined using a limited amount of available information and could be drastically improved using additional tools (e.g., geophysics). Refinement of the advisory area would improve confidence in the area boundary and would ideally reduce the size of the area itself, potentially reducing costs related to risk mitigation for municipalities and developers. This action would also help identify other requirements the City could implement to reduce the risk from these flowing artesian conditions.
12 Inform neighbourhood planning initiatives	Undertake groundwater investigations to help inform neighbourhood planning initiatives (e.g., Area Plans), related building requirements, and integrated watershed management plans in order to preserve groundwater resources and protect buildings, infrastructure, and groundwater-dependent ecosystems such as Still Creek.	These investigations will help identify areas of concern for groundwater in future neighbourhood planning initiatives and allow the City to implement targeted building requirements there. Depending on the situation, these investigations could be simple desktop exercises, or more detailed investigations (e.g., monitoring well installations) with elaborate decision support tools (i.e., numerical models).
13 Discharge during construction	Mitigate risks associated with groundwater discharged to the sewer system during construction by ensuring capacity constraints are considered as well as requirements of the City's Sewer and Watercourse By-law. This may include expanding requirements and/or establishing a monitoring and enforcement program.	Groundwater discharges from a site during construction are not currently subject to fees if entering the City's storm system or combined system. The City is paying treatment costs for discharges to the combined system and there are few disincentives for high volume discharges. In addition, the City's Erosion and Sediment Control (ESC) requirements for large lot developments are limited with respect to water quality as only TSS and pH must be monitored and treated, creating a gap in monitoring other contaminants that may pose a potential risk to receiving bodies and exposes the City to liability.

PHASE 2 OPTIONS

Action Name	Description	Rationale
14 Stormwater infiltration incentives	In line with <i>Healthy Waters Plan</i> and <i>Rain City Strategy</i> , develop options and incentives for developers to infiltrate stormwater on private property to enhance groundwater recharge, and reduce burden on sewer system capacity.	The City requires rainwater management for rezoning applications that are subject to the City's Green Buildings Policy for Rezonings, or the Rezoning Policy for Sustainable Large Developments. As of 2024, the VBBL also requires developers to require rainwater detention into tanks at minimum. However, developers have little incentive to explore options for infiltrating rainwater. Stormwater infiltration provides two purposes: it reduces the burden on the City's sewer system by reducing rainwater entering the system, and it recharges groundwater. Providing developers with options and incentives to infiltrate rainwater will reduce infrastructure and treatment costs for the City and maintain groundwater levels to support environmental benefits. By providing more options and incentives for developers to infiltrate rainwater, the City enables developers to have greater autonomy to choose retention and/or detention practices where possible. These incentives can be developed in consultation with developers.
15 Aquifer valuation	Quantify the "natural asset" value of local aquifers in terms of water storage and supply, supporting ecosystems, and other municipal services, and incorporate this information into the City's asset management system.	Traditionally, civic asset management processes have only been applied to engineered infrastructure. However, there is growing evidence that by considering natural assets (e.g., aquifers) within asset management processes, local governments can decrease capital, operations, and maintenance costs, increase levels of service, enhance their ability to adapt to climate change, and reduce the community's unfunded liabilities – all while protecting or enhancing the multitude of other benefits that natural assets bring to communities. The functions that nature provides to communities beyond core services, such as recreation, climate regulation, clean air, habitat, and biodiversity, are invaluable to the overall health and well-being of a community. Therefore, including natural assets in asset management processes provides an integrated approach to maintaining or enhancing the natural assets in a community.
16 Map groundwater I&I risks	Develop a map of groundwater elevation and cross-reference with sewer and drainage infrastructure to highlight areas where infiltration is most likely, and should be prioritized for I&I monitoring, and pipe repairs as needed.	Inflow & Infiltration (I&I) occurs when water is erroneously or unnecessarily directed to sewer pipes. One source of I&I is due to leaking sewer pipes that allow the groundwater to enter the pipe through holes or cracks in the pipe network (referred to as infiltration). This not only reduces sewer system capacity and increases treatment costs and combined sewer overflow events, but also wastes groundwater resources. A city-wide, comprehensive I&I monitoring program is very costly. However, by mapping out where City infrastructure is below the water table, it may be possible to prioritize I&I flow monitoring locations. The effectiveness of this assessment may be increased by adding available data on sewer infrastructure that may indicate the likelihood of leaks (e.g., pipe type, age, etc.).

PHASE 2 OPTIONS

Action Name	Description	Rationale
17 Mitigate risk of potential impacts to groundwater quality from urban runoff	Reduce contaminants of concern entering groundwater through urban runoff: a) Monitor and baseline groundwater quality for contaminants that may originate from urban runoff b) Collaborate with the Green Rainwater Infrastructure (GRI) branch to address contaminants of concern through GRI projects.	Urban runoff can contain contaminants which could have an adverse effect on groundwater quality. There is limited understanding of if these contaminants are present and at what magnitude in groundwater across the city. By undertaking sampling studies on on-site infiltration practices, the City will be able to characterize whether any new contaminants of concern are infiltrating into groundwater, and how to best mitigate and/or remediate them. This may include working with the Green Rainwater Infrastructure branch to develop design guidelines to treat soluble contaminants from urban runoff.
18 Aquifer vulnerability assessment	Complete an aquifer vulnerability assessment to prioritize actions related to the protection of groundwater quality.	The purpose of this action is to develop aquifer vulnerability mapping (e.g., AVI, DRASTIC) to inform land use policy and decision making. It will be an invaluable tool to help the City protect local aquifers.
19 Remediation for future use	Work with the Province to strengthen remediation requirements in areas identified for future groundwater use with consideration of the Province's <i>Considering climate change in remediation</i> guidance^[31].	Following completion of an aquifer vulnerability assessment and groundwater use potential assessment, sites suitable for future groundwater use will be identified. These sites may include private properties or City-owned properties, and they may be known to have contamination. In many situations, these sites will be remediated based on a risk assessment which often prohibits use of an underlying viable groundwater aquifer as a potable water source. This action entails working with the Province in order to protect and preserve groundwater resources for future use, in line with the Province's guidance of <i>Considering climate change in remediation</i>^[31].
20 Reduce setbacks for infiltration features	Support other City teams to work towards reducing infiltration setback requirements to meet <i>Rain City Strategy</i> objectives and enhance aquifer recharge.	Given the development pressures in the City, every inch of developable space on a property is often used, leaving limited space for infiltration features. Additionally, known setback requirements exacerbate this issue by limiting infiltration within 5 metres of Part 9 building foundations per the Vancouver Building By-law 2025 and within 3 metres of potable water pipes per Design Guidelines for Drinking Water Systems in British Columbia). This action would seek to further support ongoing work that is looking at potential options for relaxing these setbacks, to increase onsite opportunities for infiltration.

PHASE 2 OPTIONS

	Action Name	Description	Rationale
21	Emergency response business continuity	Develop a clear governance structure specific to emergency response related to groundwater risks.	In the 2015 Beechwood incident, an inexperienced contractor pierced a pressurized (flowing artesian) portion of the aquifer, leading to several billion gallons of groundwater being discharged. At the time, it was initially unclear which City business units needed to be involved, and this might have led to delays in managing the issue. This action will integrate a clear governance structure for managing these and other types of groundwater emergencies in the existing Emergency Management Plan and Incident Response Guidelines, including channels for efficient communication and data sharing, for managing groundwater-related incidents.
22	Leverage external partners to advance our objectives	Establish a forum for the Province, Metro Vancouver, and neighbouring governments including the local Nations to coordinate and collaborate to assess and mitigate groundwater-related risks (e.g., saltwater intrusion).	The Province of BC has identified two aquifers beneath Vancouver, both of which extend across multiple other municipalities. As the management of these aquifers is shared by many levels of government (including the local Nations and the Province of BC), it makes sense to have a coordinated approach. Key groundwater issues that could be addressed include drought resilience, land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets, and establishing a notification or monitoring system for large (e.g., commercial or industrial) water users.
23	Partnerships to protect groundwater ecosystems	Explore partnership opportunities with the local Nations and stewardship groups to protect groundwater-dependent ecosystems, share data and lessons learned, and collaborate on regional biodiversity goals.	Several natural areas in the city are believed to be groundwater dependent ecosystems. Many stakeholders and other governments have considerable knowledge and expertise related to the historic and present-day health and well-being of these ecosystems. To better understand and preserve these assets, the City needs to work with these partners towards a shared goal. Regional biodiversity goals could include exploring land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets. To support the UNDRIP Action Plan and better understand and preserve ecosystems, the City needs to work with these partners towards a shared goal. This might include providing support to the local Nations to facilitate participation in partnerships and to develop stewardship monitoring capacity; additionally, Indigenous vendors/consultants should be prioritized for related work. To enhance equity, this work should consider the needs of multiple species and be rooted in moving away from City control of processes.

PHASE 2 OPTIONS

Action Name	Description	Rationale
24 Managed aquifer recharge	Complete an assessment of the potential for Managed Aquifer Recharge, including the potential for aquifer storage and recovery to be used in the City as a means of storing excess rainwater for use during times of water scarcity.	Currently, the city receives too much rainfall in the winter, and not enough in the summer. This situation is likely to worsen as climate change progresses. This action will assess the potential of using local aquifers to store excess rainwater in winter months for use during times of scarcity, much like reservoirs in the North Shore do.
25 Reduce parkade depths	Explore ways to discourage below-grade parking and/or reduce overall parkade depths where groundwater may be encountered.	Parking and storage are often located in below-grade areas of the development, and depths can be significant. The deeper a development goes below ground, the greater the chances that it will impact groundwater. Groundwater is typically collected in a perimeter drainage system and discharged to the sewer as waste. Above-grade parking levels may "count against" the overall FSR (floor space ratio) of a project, resulting in a reduced allowable area for residential or commercial space. This action will explore ways to limit adverse impacts from below-grade development on groundwater. This could be achieved through allowing/encouraging above-grade parking, providing height/density bonuses to developments to make up the loss of below-grade space, and/or setting maximum allowable parkade depths.
26 Requirements for injection systems	Develop requirements, including water quality objectives and maintenance requirements, for stormwater injection systems to ensure that groundwater quality is protected.	Although relatively rare in Vancouver presently, injection wells may be used to re-inject water (or other fluid) below ground into a porous geologic formation (e.g., groundwater collected via foundation drainage, or as part of an open-loop geothermal system). It may also be used in the future to manage stormwater, in areas with limited sewer capacity. Although the Province has developed Best Management Practices related to water quality, and the <i>Environmental Management Act</i> (EMA) prohibits "pollution," limited guidance exists to ensure groundwater quality is protected. To protect groundwater quality, this action will set water quality guidelines and other requirements for any injection systems implemented in Vancouver.

PHASE 2 OPTIONS

Action Name	Description	Rationale
27 Reduce contaminants from City operations	Reduce the risks of groundwater contamination from City operations: a) Work with the City's Source Control team to inventory and assess the City's use, storage, and handling of chemicals that may impact groundwater. b) Following the development of an inventory of contaminants used by City operations, research and acquire less toxic but equally effective alternatives wherever available.	The City uses several chemicals in its daily operations, some of which may eventually make their way into local aquifers. This action will identify all contaminants of concern used by the City and Park Board and consider opportunities for less toxic but equally effective alternatives to reduce potential groundwater pollution. It may also identify additional measures that may be taken to reduce risks.
28 Internal education	Conduct regular learning sessions with key City departments about the importance of groundwater and how staff can help protect it (e.g., through process changes).	While the profile of groundwater is gradually increasing within various City departments, there is still a long way to go in terms of raising internal groundwater literacy. This action will involve hosting regular learning sessions with different City business units, particularly those whose work touches on groundwater. The goal will be to foster greater awareness and interest in protecting groundwater (and minimizing groundwater-related risks) through their work. Education should also include awareness of the liability the City carries due to wastewater and groundwater in our sewer system.
29 Green Rainwater Infrastructure at City-owned buildings	To enhance aquifer recharge, explore ways to support <i>Rain City Strategy</i> "Building and Sites Action Plan," implementing innovative Green Rainwater Infrastructure (GRI) practices at City-owned buildings.	As part of the City's efforts to show leadership on water management, this action entails developing internal policy to build and/or renovate future city buildings to manage a certain amount (e.g., 90%) of stormwater through infiltration/Green Rainwater Infrastructure (GRI). This may also include building at least one civic facility to manage all (i.e., 100%) collected stormwater through infiltration. This would demonstrate to others that infiltration is a feasible and affordable means of managing stormwater, with additional co-benefits (e.g., supporting aquifer recharge, supporting ecosystems, etc.), and help generate support for these types of actions by the public who visit the facility.

PHASE 2 OPTIONS

	Action Name	Description	Rationale
30	Water reservation application	Following an assessment of extraction potential, apply for a "water reservation" under the Province's <i>Water Sustainability Act</i> to set aside water rights for future City use.	Because the Province's approach to groundwater use is "first in time, first in right" – meaning that during times of water scarcity, licensees with earlier authorization dates are prioritized and entitled to take their full allocation of water before more recent licensees – it is important for the City to engage with the Province to determine how best to secure future water rights. This may be in the form of a water license or a water reservation. This action may also include discussions around prohibiting commercial activities that are reliant on large quantities of groundwater, or that extract and sell groundwater (e.g., water or other beverage bottlers).
31	Groundwater partnerships plan	Create outreach programs for the development community and industry/businesses on groundwater-related risks (e.g., uncertain water levels, dependent ecosystems, flowing artesian conditions, etc.) as well as best management practices.	Vancouver has unique geotechnical conditions that can impact and be impacted by development. However, developers and industry members do not always know or understand what best practices exist to manage groundwater to minimize risks, impacts, and costs to the environment and their developments. By developing digital and development-focused engagement materials, the City can equip developers and industry with the tools they need to manage groundwater effectively so as to limit impacts, risks, and costs. Potential topics include groundwater-related risks (e.g., artificially lowered water levels, dewatering-induced subsidence, flowing artesian conditions, etc.), environmental impacts (e.g., to groundwater-dependent ecosystems), as well as best management practices (e.g., site and foundation drainage).

PHASE 2 OPTIONS

Action Name	Description	Rationale
32 Groundwater public outreach plan	Engage with residents and businesses to reduce the impact of groundwater-related risks.	One of the most cost-effective means of protecting groundwater is to educate the public. Some sites in the city (e.g., civic golf courses, Hillcrest community centre) already use some groundwater (e.g., for watering lawns, flushing toilets, etc.), but the public is largely unaware of these initiatives. Public installations including signs and artwork would raise awareness of the city's groundwater resources and create interest in what the City is doing to protect it. Several potential initiatives to leverage public awareness to support groundwater management include: A) Explore targeted outreach opportunities (e.g., in schools or at public events) including by partnering with NGOs, the local Nations, and/or academic institutions on the importance of groundwater and how to protect it. B) Educate residents and businesses about the safe handling, storage, use of common chemicals, and less toxic alternatives to mitigate potential impacts on groundwater (e.g., lawn chemicals, de-icing agents, oil, paint, etc.) C) Install signage in high-traffic areas to inform the public on the importance of groundwater, what the City is doing to protect it, and how everyone can play a part. D) Engage local artists to create groundwater-themed art for public spaces to educate and inspire residents to protect local aquifers. E) Install at least one pumping well in a high-profile location to showcase opportunities related to groundwater use.
33 Geoexchange impacts	Develop requirements for geoexchange systems to limit the impact on groundwater resources and groundwater-dependent ecosystems: A) Research known impacts of geoexchange systems, and provide recommendations for potential mitigation tools (e.g., by-law requirements). B) As needed, develop and implement tools (e.g., by-laws) to mitigate impacts. May also include cross-governmental collaboration to further mitigate impacts.	While geoexchange systems are currently not very common in the city, their use could expand as developers and homeowners seek opportunities to reduce energy use and greenhouse gas emissions. However, as these systems become more common, there is a risk of thermal pollution of aquifers, which could have negative impacts (e.g., on groundwater-dependent ecosystems). There is also some concern that geothermal systems could potentially degrade groundwater quality as a result of coolant fluid leaking underground from a closed-loop system, or as a result of the water injected back into the geological formations from an open-loop system. This action will research potential impacts and mitigation strategies.

PHASE 2 OPTIONS

Action Name	Description	Rationale
34 Vancouver Landfill considerations	Work with Vancouver Landfill operations staff and their groundwater consultants to explore additional measures for the protection of the underlying aquifer and nearby ecosystems.	The Vancouver Landfill currently discharges approximately 2,000 m ³ of leachate and groundwater contaminated by leachate to the Annacis Island Wastewater Treatment Plant (WWTP) each day, resulting in significant water treatment costs. While the landfill is run exceptionally well and has engineered controls to manage leachate and groundwater that may be contaminated by leachate, there may be opportunities to strengthen groundwater protection measures. These measures could exceed Provincial requirements, but are important for the City to show leadership with all of its operations, regardless of their location. In addition, these measures can limit the cost of leachate and groundwater contaminated by leachate being sent to Annacis Island for treatment.
35 Impacts of utility trenches	Develop guidance to reduce the potential for utility trenches to act as preferential pathways that drain groundwater	Excavation backfill in utility trenches can become a preferential pathway for groundwater. In certain situations, these trenches may become unintended drainage systems that stretch over large distances. Where these trenches intercept aquifers, significant loss of groundwater may result. They could also lead to, or exacerbate, the diversion of groundwater to the sewer. This action would identify situations where additional measures may be necessary and propose solutions (e.g., require the installation of seepage collars).
36 VBBL regulations for non-potable use	Develop regulations in the Vancouver Building By-law to facilitate the sustainable use of groundwater for non-potable applications.	Groundwater in Vancouver could be used for non-potable purposes such as watering green spaces or even flushing toilets, assuming that it is used sustainably and does not deplete the aquifers. Currently, the Vancouver Building By-law (VBBL) does not include groundwater as an approved source of water, requiring that an exemption process (called an "Alternative Solution") be followed if someone wishes to use groundwater for non-potable purposes. If the VBBL could be amended to accommodate groundwater use, it may become more common. Currently, Vancouver Coastal Health and the City of Vancouver Development, Buildings & Licensing branch are exploring options, and this work could be supported by the Strategy prioritization.

PHASE 2 OPTIONS

Action Name	Description	Rationale
37 Replace PFAS in firefighting foams	Support Vancouver Fire Rescue Services in transitioning to firefighting foams that are equally effective, but do not contain toxic per- and polyfluoroalkyl substances (PFAS) or other harmful chemicals which may impact local aquifers and compromise the health of firefighters.	Many firefighting foams contain toxic per- and polyfluoroalkyl substances (PFAS). PFAS are carcinogenic and have many risks to human health. PFAS are known as “forever chemicals” and are becoming an urgent global public health issue because they do not degrade and may accumulate in groundwater. The cost of cleanup for known PFAS-contaminated sites is significant (e.g., Canadian Forces Base Comox) and can range to billions of dollars. In 2024, the Vancouver Fire Rescue Services spent \$2.8 million to purchase PFAS-free gear. The next step is to replace PFAS-containing firefighting foams. This action would reduce the potential for PFAS to impact local aquifers, protect firefighter health, and show City leadership on this important issue.
38 Mitigate artificial turf	Work with the Vancouver Park Board to explore key findings of the <i>Sport Field Strategy</i> and discuss specific applications of the synthetic turf mitigation strategies to protect groundwater as warranted.	While the use of artificial turf has expanded across the city, there are some concerns over its use. For example, runoff from artificial turf may contain microplastics and tire compounds (6PPD-quinone) that can migrate into surface waters or groundwater. This action will explore possibilities for reducing the use of artificial turf in City-owned facilities, parks, and sports fields, determining if the use of artificial turf is a threat to local groundwater quality, and developing mitigation strategies for managing potential contamination.
39 Well acquisition	Explore options for the City to acquire a well on City property once it is no longer needed by the well owner.	The City issues permits to private entities, for the use of our road right of ways, for the purpose of installing monitoring wells. These wells are often only needed temporarily and are decommissioned (ideally) when no longer needed. This action will allow the City to acquire a well when it is no longer needed by the well owner, and potentially initiate groundwater monitoring at the well.
40 Academic partnerships	Explore partnerships with academic institutions to advance the City's understanding of local aquifers and groundwater resources.	Build collaborative relationships with academic institutions to develop our understanding of local groundwater resources and groundwater quality. This may include research or studies as part of students' Capstone projects.
41 Coordinate City groundwater use	Develop a coordinated approach for City and Park Board groundwater extraction activities to ensure critical uses are prioritized, and over-extraction is avoided.	This action would facilitate a joint understanding of what activities may use groundwater in the future and establish a coordinated approach to prioritize City use and avoid over-extraction. Current consideration for uses include irrigation of park grounds, irrigation of green infrastructure assets, non-potable uses to offset drinking water uses, etc.

PHASE 2 OPTIONS

Action Name	Description	Rationale
42 Saltwater intrusion	Reduce risks related to saltwater intrusion: a) Complete an assessment of the potential extent and magnitude of saltwater intrusion, induced by sea-level rise and other factors. b) Complete an inventory of City-owned assets that may be vulnerable to saltwater intrusion and develop mitigation strategies for those assets.	Groundwater near the coast is naturally saline and the inland extent of saltwater can change over time. This process, known as saltwater intrusion, will occur in Vancouver due to a rising sea level, and may be worsened by reduced aquifer recharge and increased groundwater extraction, but the geographical extent and magnitude of this intrusion is unknown. Saltwater intrusion degrades potential groundwater resources and may impact groundwater-dependent ecosystems. It can also negatively impact infrastructure (e.g., through corrosion). There are a number of City-owned facilities (e.g., Kitsilano pool) and other assets (e.g., water and sewer pipes) that may be vulnerable to negative impacts. This action will further the City's understanding of where these types of impacts are most likely to occur. If suitable, at-risk infrastructure will be identified and mitigation strategies developed.
43 Increase infiltration through parks	Infiltrate stormwater into shallow aquifers through available large permeable spaces such as parks.	Parks currently drain excess stormwater into the sewer and drainage system, which adds burden to the sewer system and misses an opportunity for some of the City's largest permeable spaces to infiltrate and recharge groundwater. This action would explore opportunities for large permeable spaces such as turf fields and natural parks to infiltrate stormwater into the ground.

APPENDIX C

GROUNDWATER STRATEGY ACTIONS ANALYSIS REPORT

Groundwater Strategy Actions Analysis

City of Vancouver

Project number: 60737887

November 2025

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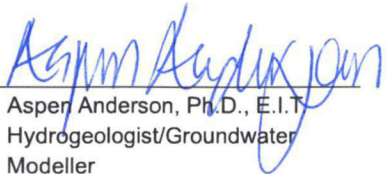
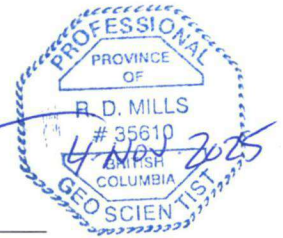
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1. Introduction

1.1 Initiation

AECOM Canada ULC (AECOM) was retained by the City of Vancouver (the City) to conduct a Groundwater Strategy Actions Analysis. In response to a Request for Proposal (RFP) PS20240856-ENG-RFP issued by the City of Vancouver, AECOM's proposal dated July 5, 2024 was submitted and accepted by the City.

1.2 Background

1.2.1 Groundwater in Vancouver

Although a regionally extensive mapped groundwater aquifer underlies the City of Vancouver, it is a poorly characterized and largely unmanaged resource. Groundwater has important implications for the City and its residents as it may affect buildings, critical infrastructure, ecosystem health, regulatory compliance, water security, emergency preparedness and may pose financial risks and opportunities. Groundwater-related risks have been identified within the City, including:

- Damage to buildings, roads, and infrastructure due to subsidence caused by lowering of the water table where sensitive soils are present
- Potential for uncontrolled flow and flooding due to flowing artesian conditions
- Rising water tables due to sea level rise, leading to potential geotechnical issues and flooding of underground structures and low-lying areas
- Groundwater entering the sewer system which can increase the risk of combined sewer overflows, sewer backups/flooding, and flows to the treatment plant.
- Aquifer depletion due to factors such as construction dewatering and the long-term diversion of groundwater via foundation drains. Aquifer depletion can negatively impact groundwater-dependent ecosystems as well as existing and future groundwater-based water supplies (e.g., golf course irrigation, emergency water supplies etc.). An inability to use groundwater may cause additional strains on Metro Vancouver's water supply.
- Pollution of aquifers with various contaminants of concern which can negatively impact groundwater-dependent ecosystems as well as existing and future groundwater-based water supplies (e.g., golf course irrigation, emergency water supplies etc.).
- Saltwater intrusion because of sea level rise or groundwater pumping which can impact aquatic and terrestrial ecosystems, lead to increased flooding and impact corrosion risks to existing buried infrastructure.
- Limiting the ability of local Nations to carry out traditional practices at surface water bodies fed by groundwater

There are also many benefits and opportunities that the City could explore through the development of a Groundwater Strategy to enable proactive management of groundwater. In addition to helping characterize and mitigate the groundwater-related risks, a robust Groundwater Strategy has the potential to increase the City's water security by providing an alternative water supply in the event of water shortages and emergencies that interrupt the existing water supply system. Groundwater from foundation dewatering systems that would otherwise be discharged into the storm sewer as waste could be used for non-potable uses such as flushing toilets or irrigation and thereby reduce the demand for, and cost of, potable water. Conservation of potable water is important to aid in closing the water supply gap that has been forecast for the region as soon as 2030 unless additional water supplies are developed. Furthermore, the British Columbia Ministry of Environment and Climate Change Strategy (MOECCS 2019) prepared the Preliminary Strategic Climate Risk Assessment for British Columbia and identified seasonal water shortage as being a high risk by 2050.

1.2.2 Current State of Knowledge

Because the City of Vancouver has been supplied by abundant high quality surface water via the Metro Vancouver drinking water network for many decades, there has been very little effort put into investigating the geology and hydrogeology underlying Vancouver. Subsurface investigations have focused on characterization of shallow soils and bedrock, groundwater levels, groundwater quality and geotechnical conditions in support of large civil infrastructure development projects (e.g. water mains, sewers, subways, buildings, etc.), contaminated site assessment and remediation activities, stormwater management planning and green infrastructure design, and in support of irrigation well development to serve City-owned parks and golf courses. Although there is abundant high quality geotechnical information that has been collected in support of residential and commercial development projects, it has not been compiled in a standardized digital format and is largely inaccessible. Other municipal and regional infrastructure projects have collected a large volume of geotechnical and hydrogeological information that also remains inaccessible. Most borehole logs and consultant reports include hard copies of borehole logs, but the information is not widely available, and a digital database has not been developed to make this information accessible. Furthermore, many of these boreholes are presumably shallow and do not extend to the top of bedrock underlying the City. However, a high-resolution map illustrating the extents of organic soils within the City that may be sensitive to changes in moisture content has been developed and maintained by the City's geotechnical engineering team.

As such, the current state of knowledge related to hydrogeology and groundwater resources is derived primarily from borehole and water well logs contained in online public databases which is very sparse, has been collected over several decades, and is of variable quality. Several high-quality data sets have been generated by subsurface investigations related to large municipal infrastructure projects (Highbury Interceptor, 7th Ave Sewer, Canada Line Subway Project and Broadway Subway Project, etc.). The City also routinely measures infiltration capacity of shallow soils to guide design of green infrastructure.

To meet the needs of the City, in 2019 the available data was utilized to develop a preliminary geological model to characterize the spatial distribution and thickness of geologic units at a coarse scale. The geological model was subsequently used to develop and calibrate a preliminary numerical groundwater model to better understand selected areas of local aquifers and guide planning decisions. The model was calibrated to average groundwater elevations for existing climatic conditions, and used to simulate groundwater levels, groundwater flow directions, baseflow discharge to streams and estimate dewatering rates for large construction projects under current and future climate conditions. However, because the model was focused on evaluating groundwater flow within a localized area of the city, it did not leverage all of the available information and could be improved by incorporating additional data, focused calibration efforts, and development of a comprehensive report to document the geological and groundwater modelling efforts.

The value of groundwater is increasingly being realized through projects that offset the use of high value treated (potable) water including irrigating municipal golf courses and parks with groundwater, filling tanker trucks with groundwater to water street trees, and using groundwater for some non-potable purposes in City-owned facilities (e.g. irrigation and flushing toilets at Hillcrest Community Centre). The City is also beginning to investigate other uses of groundwater to further reduce potable water use and increase resilience to climate change and seismic events.

1.2.3 Groundwater Strategy Development

The City is developing a Groundwater Strategy to further its efforts to become a water-sensitive city and provide a comprehensive, city-wide framework to address groundwater-related risks and opportunities. This process includes consultation with a variety of internal City departments, an external Expert Panel, and other governments including xʷməθkʷəy̓əm (Musqueam Indian Band), Skwxwú7mesh Úxwumixw (Squamish Nation), and selilwetat̓ (Tsleil-Waututh Nation).

As detailed in the Groundwater Strategy Draft Framework (City of Vancouver 2024), the vision for the Groundwater Strategy is:

“Groundwater in Vancouver is recognized and protected in order to mitigate risks, support ecosystems, and contribute to the city’s adaptation to climate change.”

The Groundwater Strategy is to establish a long-term vision for groundwater in Vancouver, and identify the suite of actions (e.g., research, regulations, policies, tools, partnerships, new infrastructure, public engagement, etc.) needed to characterize local hydrogeology, protect aquifers from contamination and depletion, sustainably manage and utilize groundwater resources, and engage relevant stakeholders.

The Groundwater Strategy identifies several goal areas:

1. Understand local hydrogeology to address Vancouver's key groundwater-related risks and opportunities.
2. Protect local aquifers from contamination and depletion, as well as the people, ecosystems, and City assets that depend on or are affected by groundwater.
3. Manage and use groundwater to enhance Vancouver's climate change adaptation and resilience in a cost-effective manner.
4. Engage with the community and other governments to develop a coordinated approach to achieving shared groundwater objectives.

The objectives of the Groundwater Strategy are to:

1. Build support for groundwater protection among City staff, businesses, and residents
2. Coordinate with other governments including local Nations on shared aquifer issues
3. Safeguard groundwater quality by preventing and remediating aquifer contamination
4. Preserve groundwater resources by enhancing infiltration and reducing waste
5. Use groundwater sustainably to advance water security and emergency preparedness
6. Support ecosystems that depend on groundwater, such as parks and streams.
7. Reduce groundwater-related risks such as flooding, as well as any subsequent social, environmental, and financial impacts

The Groundwater Strategy consists of four project stages:

Stage 1: Foundational Research

Stage 2: Engagement of Stakeholders

Stage 3: Analysis of Recommendations Received from Stakeholders

Stage 4: Development of a Final Groundwater Strategy Including an Action Plan

Stage 1 was completed by City of Vancouver staff and research partners. Stage 2 included establishment of an Expert Panel and engagement with a diverse group of stakeholders which was jointly facilitated by AECOM and the City. During Stage 2, over 300 potential actions were developed by the City and the various contributors to the initial phases of the Groundwater Strategy and subsequently distilled to 75 draft actions.

The project transitioned to Stage 3 in January 2024. AECOM joined the Project Team to objectively evaluate and refine the 75 draft actions, score them in accordance with the selected evaluation criteria, and then develop high-level implementation plans for each action to provide benefit to the community, economy, and environment. This report documents the work undertaken to complete Stage 3.

Following completion of Stage 3, the Groundwater Strategy will transition to Stage 4, when the Project Team will finalize the Groundwater Strategy. Once approved, the City will aim to begin implementing the Action Plan.

1.3 Scope of Work

The scope of work for this project was implemented in three phases, each consisting of several tasks as outlined below.

Phase 1: Background Research and Review of Project Documents

- Review Strategy-Related Documents
- Initial Review of 75 Draft Actions
- Conduct High-Level Jurisdictional Scan
- Finalize Actions
- Review Evaluation Criteria
- Trial Scoring of Five Actions
- Finalize Evaluation Criteria
- Complete Draft Phase 1 Summary Memorandum
- Initial Findings Meeting

Phase 2: High-level Implementation Plans

- Develop Sample Implementation Plan Template
- Finalize Implementation Plan Template

Develop Implementation Plan for all Actions

- City Review of Implementation Plans and Revisions
- Several workshops

Phase 3: Assess and Rank Actions

- Score and Rank Actions
- Preparation of this report

City of Vancouver staff participated in the development and implementation of the scope of work outlined above by providing ongoing feedback to the project team.

2. Phase 1: Background Research and Review of Project Documents

2.1 Strategy-Related Documents Review

The following documents were reviewed by AECOM's Project Team to enhance our historical perspective and understand the constraints and opportunities that exist:

- City of Vancouver (2018). Coastal Adaptation Plan.
- City of Vancouver (2019). Resilient Vancouver Strategy.
- City of Vancouver (2019). Rain City Strategy.
- City of Vancouver (2023). Groundwater in Vancouver: A Backgrounder.
- City of Vancouver (2024). Climate Change Adaptation Strategy.
- City of Vancouver (2024). Groundwater Management Bulletin.
- City of Vancouver (2024). Groundwater Strategy Draft Framework.
- Metro Vancouver Stormwater Interagency Liaison Group (2024). November 21 Meeting Minutes.

The content of the existing strategy-related documents was considered during completion of all subsequent tasks.

2.2 Action Items

2.2.1 Initial Draft Action Review

Appendix A.1 includes the initial Draft Actions provided to AECOM by the City's Project Team. Upon reviewing the initial Draft Actions, AECOM identified opportunities for improvement in the following areas:

- **Redundancies and Overlap:** AECOM identified action items with similarities and proposed consolidation to reduce redundancy and improve clarity. Recommendations to keep, combine, or remove actions are summarized in **Appendix A.2**, along with the City's responses and resulting adjustments. These refinements confirmed that actions could be evaluated consistently and positioned for sequencing in later stages of strategy development.
- **Action Naming:** To support future evaluation and better identify each action, AECOM also suggested assigning short-form names to each action for consistent reference during development of implementation plans, evaluation of actions, and scoring of actions.
- **Identification of All Relevant Objectives:** The initial Draft Actions provided to AECOM linked each action to a primary Strategy Objective. Recognizing that many of the Draft Actions could satisfy multiple Strategy Objectives, AECOM suggested that all relevant objectives be identified for every action. Identification of all related objectives would help demonstrate the importance of each action.

This initial Draft Action review focused on organizing actions into a coherent framework, clarifying objectives, and consolidating overlapping items. Draft Action refinement focused on identifying approaches that could strengthen Vancouver's strategy and secure alignment with best practices for groundwater management in an urban context.

2.2.2 Jurisdictional Scan

Urban groundwater management is a relatively new area of study in cities that do not rely on groundwater for potable, commercial, or industrial supply. However, there is growing recognition that healthy ecosystems and resilient communities depend on the preservation and enhancement of natural assets, including groundwater. To support the development of Vancouver's Groundwater Strategy, AECOM conducted a jurisdictional scan to identify leading practices, lessons learned, and innovative approaches from other government agencies. The findings of the Jurisdictional Scan are presented in **Appendix B**. This review was not intended to be an exhaustive global survey but rather a targeted assessment of initiatives and frameworks relevant to urban groundwater challenges. Many

jurisdictions face unique issues such as flooding, drought, saltwater intrusion, and subsidence, and no single jurisdiction is a leader in all areas.

The scan was completed through a focused literature review and internal technical consultation. Existing City-led studies and previous scans were reviewed alongside selected Groundwater Management Plans (GWMPs) and Water Management Plans (WMPs) from Canada, the United States, and international jurisdictions. GWMPs typically provide detailed frameworks for managing groundwater resources where groundwater is a primary water source, while WMPs offer broader strategies that include groundwater considerations. Both types of plans were analyzed to identify common themes, best practices, and emerging trends applicable to Vancouver.

Noteworthy initiatives were identified for each jurisdiction. In the context of this project, a noteworthy initiative refers to a priority theme or focus area identified as critical for advancing groundwater management objectives, based on technical analysis, stakeholder input, and alignment with climate resilience and urban water strategies. Noteworthy initiatives identified in this jurisdictional scan are outlined below.

1. **Aquifer Recharge:** Strategies to enhance natural or managed recharge to maintain groundwater levels and mitigate drought impacts.
2. **Drought Management:** Measures to enhance groundwater availability as an alternative supply during droughts or emergencies.
3. **Education and Outreach:** Programs to raise awareness among internal staff, development community, and the public about groundwater issues.
4. **Emergency Water Supply:** Actions to secure groundwater as a backup source during natural disasters or infrastructure failures.
5. **Financial Considerations:** Funding mechanisms and cost recovery strategies to support groundwater management initiatives.
6. **Green Rainwater Infrastructure:** Integration of infiltration-based stormwater management to improve recharge and reduce runoff.
7. **Groundwater Quality:** Protection and remediation strategies to maintain or improve groundwater quality for ecological and human uses.
8. **Monitoring, Data Management, and Data Sharing:** Development of monitoring networks and data systems to support informed decision-making.
9. **Non-Potable Groundwater Use and Conservation:** Exploration of groundwater for non-potable applications and conservation measures to reduce demand.
10. **Saltwater Intrusion and Barrier Management:** Techniques to prevent or mitigate saltwater intrusion in coastal aquifers under sea level rise scenarios.
11. **Subsidence** - Assessment and mitigation of land subsidence risks associated with groundwater extraction.
12. **Water Budgets and Modelling for Decision Analysis:** Tools and models to quantify groundwater availability and interactions for planning and policy decisions.

A summary of reviewed documents and the noteworthy initiatives covered in each document is provided in **Table 2-1:**

Table 2-1: Summary of Reviewed Water/Groundwater Management Plans and Covered Noteworthy Initiatives

Location			Level of Jurisdiction	WMP/GWMP	Noteworthy Initiatives Covered	Reference
Canada	BC	City of Abbotsford and Mission	Municipal	GWMP	7. Groundwater Quality	Golder Associates Ltd., 2012
Canada	BC	City of Kelowna	Municipal	WMP		City of Kelowna, 2023
Canada	BC	Okanagan Region	Regional	WMP		Okanagan Water Stewardship Council, 2008
Canada	OT	Oxford County	Regional	WMP		Oxford County, 2024
Canada	BC	Township of Langley	Municipal	WMP	6. Green Rainwater Infrastructure 9. Non-Potable Groundwater Use and Conservation	Inter-Agency Planning Team, 2009
United States	CA	City of San Francisco	Municipal	GWMP	4. Emergency Water Supply 9. Non-Potable Groundwater Use and Conservation	San Francisco Public Utilities Commission, 2022
United States	CA	Madera Region	Regional	GWMP	3. Education and Outreach 8. Monitoring, Data Management, and Data Sharing 9. Non-Potable Groundwater Use and Conservation 10. Saltwater Intrusion and Barrier Management 11. Subsidence	Provost & Pritchard Consulting Group, 2014
United States	CA	Santa Clara and Llagas Subbasins	Regional	GWMP	1. Aquifer Recharge 2. Drought Management 3. Education and Outreach 5. Financial Considerations 8. Monitoring, Data Management, and Data Sharing 9. Non-Potable Groundwater Use and Conservation 10. Saltwater Intrusion and Barrier Management 12. Water Budgets and Modelling for Decision Analysis	Gurdak and Cook, 2021
United States	CA	State of California	State	GWMP	1. Aquifer Recharge	California Department of Water Resources, 2024
United States	CO	State of Colorado	State	WMP	2. Drought Management 3. Education and Outreach 8. Monitoring, Data Management, and Data Sharing	Colorado Water Conservation Board and Department of Natural Resources, 2023
United States	VA			SWIFT Groundwater Initiative	1. Aquifer Recharge	Sakry, 2023
United States	NV			OneWater Nevada Groundwater Initiative	1. Aquifer Recharge	OneWater Nevada, 2023
United States	CA	Orange County Water District	Regional	GWMP	1. Aquifer Recharge 2. Drought Management 5. Financial Considerations 7. Groundwater Quality	Woodside et al., 2015

Location			Level of Jurisdiction	WMP/GWMP	Noteworthy Initiatives Covered	Reference
					8. Monitoring, Data Management, and Data Sharing 9. Non-Potable Groundwater Use and Conservation 10. Saltwater Intrusion and Barrier Management 11. Subsidence 12. Water Budgets and Modelling for Decision Analysis	
United States	CA	Yuba Subbasins	Regional	GWMP	5. Financial Considerations 11. Subsidence	Yuba Water Agency, 2019
The Netherlands		The Netherlands	Country	WMP	3. Education and Outreach 10. Saltwater Intrusion and Barrier Management	The Netherlands, 2016

The results of the jurisdictional scan highlighted several opportunities to strengthen Draft Actions in alignment with the groundwater management strategy strategic objectives. Leading practices from other jurisdictions emphasize integrated monitoring and modeling to enable data-driven decision-making, proactive recharge and infiltration strategies to mitigate drought and flooding risks, and policy frameworks that align groundwater management with climate resilience, emergency water supplies, non-emergency groundwater use and stormwater planning.

Table 2-2 lists the Draft Actions associated with each noteworthy initiative and summarizes the recommendations for modifications that were provided to the City for discussion. These recommendations reflect lessons learned from other jurisdictions, technical feasibility considerations, and alignment with Vancouver's strategic priorities. Adjustments included refining the scope of actions, consolidating overlapping items, and ensuring flexibility to accommodate future conditions such as drought, sea level rise, and regulatory changes.

Table 2-2 Draft Actions Related to Each Noteworthy Initiatives and Recommendations

Noteworthy Initiative	Related Draft Actions	AECOM Recommendations
1. Aquifer Recharge	16. Infiltration Area Assessment 19. Aquifer Valuation 52. Sea Level Rise Impact Assessment 56. Aquifer Storage and Recovery Assessment	Draft Action 56 is recommended to focus on the potential and suitability of EAR rather than ASR. If the results of an EAR assessment are promising, a MAR plan would subsequently be explored.
2. Drought Management		Incorporate Drought Management into Action 71 (Groundwater Use Potential) or establish a new action. The City could benefit from an alternative groundwater supply in the event of drought, earthquake or other natural disasters. The existing action is focused on emergency water supply, but there may also be benefits for drought management. Education of the public and collaborating with other municipalities to prepare for and manage drought may warrant a new action. Drought will become more normalized in the future. Once the groundwater resource has been characterized, use of groundwater for drought management may warrant a separate action item.
3. Education and Outreach	67. Internal Education 75. Development Community Outreach Programs 78. Public Outreach 83. Showcase Well	Be careful to avoid specificity (e.g. Showcase Well) at this early stage to allow for diverse views to be shared and incorporated into the Education and Outreach plans and actions. Showcase Well could be just one component of the overall program.
4. Emergency Water Supply	71. Groundwater Use Potential	
5. Financial Considerations	18. Stormwater Utility Fee 155. Long-term Funding Strategy	

Noteworthy Initiative	Related Draft Actions	AECOM Recommendations
6. Green Rainwater Infrastructure	15. Stormwater Infiltration Incentives 16. Infiltration Area Assessment 18. Stormwater Utility Fee 25. Evaluate Green Rainwater Infrastructure Effectiveness in Preventing Groundwater Contamination 29. Reduce Setbacks for Infiltration 60. Quality Requirements for Infiltration 68. Green Rainwater Infrastructure at City-Owned Buildings	There are a large number of actions linked to Green Rainwater Infrastructure, and there may be significant overlap between one or more actions. Consider consolidating the actions around common themes (i.e. feasibility, funding, water quality, policy, etc.).
7. Groundwater Quality	13. Water Quality Assessment Requirements as part of Erosion and Sediment Control 28. Remediate Contamination on City Properties 60. Quality Requirements for Infiltration 63. Reduce Contaminants from City Operations 85. Requirements for Developers to Remediate Contamination	Carefully consider potential conflicts between British Columbia Contaminated Site Regulation and any proposed municipal or regional bylaws that require physical remediation of contaminated sites in Actions 28 and 85. This was previously shown to impact re-development of contaminated sites within urban areas, and amendments to the Contaminated Sites Regulation were implemented. Consider a proactive approach (e.g. aquifer protection plan) that restricts certain land uses (e.g. gas stations, dry cleaners, road salt storage yards, etc.) to areas that are already impacted or where groundwater is not likely to be used now or in the future. Several water quality parameters may also naturally exceed background concentrations and remediation may be infeasible.
8. Monitoring, Data Management, and Data Sharing	3. Develop Monitoring Well Network 7. Evaluate Data Management Options 38. Collate Historical Stream Data from Development Info 41. Communication Structure Development 43. Permit Application Data Permission 54. Partnerships Local Nations & Stewardship Groups 170. Well Acquisition	Rephrase Draft Action 7 as <i>Establish Data Repository/Database for Management of Subsurface Data</i> . This should include mapping (geology, topography, historical streams, civil infrastructure, etc.), boreholes, monitoring wells, water levels, aquifer testing results, infiltration testing, and groundwater quality data. Investigate whether legal issues with Action 43 are related to 3 rd Party reliance, or disclosure of privately owned data. Seek guidance from provincial government agencies on sharing of this type of information, which is long-established (e.g. Gwells Database).
9. Non-Potable Groundwater Use and Conservation	47. Foundation Drainage Water Re-use Options 71. Groundwater Use Potential 135. Conservation Measures 146. Non-potable Groundwater Applications 174. Coordinate and Prioritize City's Uses of Groundwater	
10. Saltwater Intrusion and Barrier Management	52. Sea Level Rise Impact Assessment	MAR should be considered as a sea level rise mitigation technique.
11. Subsidence	6. Geotechnical Hazards 73. Request the Province to Consider Subsidence Risks	
12. Water Budgets and Modelling for Decision Analysis	4. Groundwater Model Refinement & Expansion 17. Water Budget for Groundwater Reliant Ecosystems 23. Quantify Groundwater Inflow & Infiltration in Sewers	

2.2.3 Finalized Actions

Appendix A.3 presents the revised Draft Actions agreed upon by AECOM and the City's Project Team. The revised Draft Actions, henceforth referred to as the Actions or Finalized Actions, represent the final list of actions that were utilized as the basis for development of High-Level Implementation Plans, Evaluation, and Scoring.

The Finalized Actions are judged to be reasonable steps toward understanding and managing groundwater in a developed urban environment and are broadly consistent with initiatives undertaken in other jurisdictions facing challenges similar to Vancouver. The issues highlighted by the Foundational Actions are critical for enabling effective groundwater management. These actions collectively address gaps in system understanding, data infrastructure, and risk mitigation. In addition to building the knowledge base, they directly support managing risks such as uncontrolled groundwater diversions (*Action 9: Inventory Groundwater Diversions*), which can lead to flooding, sewer inflow and overflows, and infrastructure damage. They also provide the basis for protecting and supporting ecosystems that depend on groundwater (*Action 17: Water Budget for Groundwater Reliant Ecosystems*), ensuring sustainable baseflow and habitat resilience under changing climate conditions. Together, these measures reduce uncertainty, enable informed decision-making, and create the conditions necessary for implementing subsequent actions that advance water security, climate adaptation, and ecological health.

Actions that are not Foundational Actions remain important because they represent practical measures to improve groundwater management and integrate it into broader City initiatives. Deferred Actions are also valuable to consider but require additional information to determine whether they should progress and to define their scope within Vancouver's integrated water management framework. Because Vancouver relies on surface water derived from snowmelt and rainfall, the City should consider and plan to manage the challenges associated with conservation of surface water and groundwater during times of shortage, when supply is low and demand is high, as the incidence of water shortage is likely to increase over time because of population growth and climate change.

The issues addressed by the Actionable Actions are complex; developing solutions will require investment and collaboration at local, regional, provincial, and federal scales. The identified actions are complementary to many existing programs focused on sustainable water management that could be expanded to consider groundwater. It is also important to recognize that these actions should continue to be revisited over time. Future conditions may reveal new priorities or emerging issues, which is why the Groundwater Strategy and associated actions should remain a living document to be updated as new information becomes available and priorities evolve. This approach ensures flexibility and responsiveness to changing circumstances while maintaining alignment with long-term objectives.

2.3 Dependencies

Some actions within the Groundwater Strategy cannot be implemented in isolation because they rely on the completion of other actions. A dependency is defined as any instance where one action depends on the implementation of another in advance. For example, *Action 4: Groundwater Model Refinement and Expansion* is required before evaluating current and future risks of *Action 176: Saltwater Intrusion*. Recognizing and mapping these dependencies is essential for effective implementation planning. It supports allocating resources strategically, prevents delays caused by missing prerequisites, and supports a phased approach where early actions build capacity for more complex initiatives.

To capture these relations, AECOM prepared an initial list of dependencies for the Draft Actions, provided in **Appendix C.1**. Based on feedback from the City's Project Team, the list was refined to produce a second draft that is documented in **Appendix C.2**.

Analysis of the Draft Actions revealed that nearly all actions rely on a select group of tasks focused on building foundational knowledge of the groundwater system. The following actions were identified as Foundational Actions that should be completed in advance of all other actions:

- *Action 3: Develop Monitoring Well Network*
- *Action 4: Groundwater Model Refinement and Expansion*
- *Action 7: Build Data Repository*
- *Action 9: Inventory Groundwater Diversions*

- *Action 16: Enhance Aquifer Recharge*
- *Action 17: Water Budget for Groundwater Reliant Ecosystems*
- *Action 27: Aquifer Vulnerability Assessment*
- *Action 43: Use of Permit Application Data*

Even within the Foundational Actions, there is a logical order of progression. However, it is important to recognize that some actions will continue to evolve over time, and there are opportunities to progress some actions in parallel with others if refinement and cross-checking process is in place as actions implemented in parallel near completion.

The remaining actions were categorized as Actionable or Deferred. Actions were considered Actionable if they could be defined, scoped and evaluated based on current information. Actions, or portions of actions, were considered Deferred if their scope could not be determined at this time because it depends on the results of one of the other actions. This categorization supports sequencing and resource planning by clearly identifying which actions can advance immediately and which require additional information or enabling conditions. The final list of dependencies is provided in **Appendix C.3**.

2.4 Evaluation Criteria

2.4.1 Development of Evaluation Criteria

Appendix D.1 outlines the initial evaluation criteria, Evaluation Criteria Option 1, provided to AECOM by the City. Upon reviewing Evaluation Criteria Option 1, AECOM proposed an alternative evaluation criteria approach based on the comparison of costs and benefits of each action. Evaluation Criteria Option 2 are provided in **Appendix D.2**.

Evaluation Criteria Option 1 and Option 2 differ in structure and approach to evaluating actions. Option 1 incorporates timing directly into the scoring through an urgency criterion, which attempts to reflect the immediacy or sequencing of actions. In contrast, Option 2 evaluates actions based on importance. Instead of scoring urgency, Option 2 allows for sequencing to be addressed through a visual mapping exercise that identifies dependencies between actions and organizes them into implementation streams. This allows the evaluation to focus solely on the relative benefits and costs of each action, while implementation planning considers when and how actions should be carried out. This approach was introduced to reduce subjectivity and improve clarity by focusing on measurable outcomes.

Both evaluation criteria options allow for weighted or unweighted scoring. In multi-criteria decision analysis, weighting is typically established through sensitivity analysis prior to final scoring, as this process evaluates how changes in criterion weights influence overall results. Sensitivity analysis should begin with an unweighted scenario as a control, providing a baseline for comparison before applying alternative weighting of criteria that may better reflect priorities of the City and stakeholders. This approach supports informed decision-making by identifying which criterion most affect outcomes and ensuring that weighing choices are transparent and defensible. Best practice is to present unweighted scoring together with the results of various weighting scenarios.

2.4.2 Trial Scoring

To assess the practicality and effectiveness of both approaches, AECOM conducted trial scoring using a subset of draft actions. This included scoring *Draft Action 18: Stormwater Utility Fee* using Evaluation Criteria Option 1 and Option 2, as well as scoring five additional actions using Option 2:

- *Draft Action 3. Develop Monitoring Well Network*
- *Draft Action 4. Groundwater Model Refinement & Expansion*
- *Draft Action 5. Well Drilling Advisory*
- *Draft Action 10. Inform Neighbourhood Planning Initiatives*
- *Draft Action 13. Water Quality Assessment Requirements as part of Erosion and Sediment Control*

Both Evaluation Criteria Option 1 and Option 2 were used with unweighted categories for the trial scoring.

Trial scoring results are shown in Table 2-3 and demonstrated that both evaluation frameworks are functional and yield comparable prioritization outcomes. Draft Action 18 scored 64% under Option 1 (Appendix D.3) and 62.5% under Option 2 (Appendix D.4), indicating consistency across approaches despite structural differences. Scores for the additional five actions under Option 2 ranged from 50% to 75% (Appendix D.5), showing the framework's ability to distinguish relative priorities. The expanded scale utilized in Option 2 offers greater granularity, which may be beneficial for evaluating diverse or complex actions. Feedback from trial scoring informed refinements to Option 2, including the addition of a fifth category for very high monetary benefits and adjustments to economic thresholds to better reflect local conditions. Further refinement, including weighted scoring and sensitivity analysis, was recommended to confirm robustness and optimize decision-making.

Table 2-3 Trial Scoring Results

Action	Evaluation Criteria	Score	Percentage
Draft Action 18: Stormwater Utility Fee	Option 1	2.55/4	64
	Option 2	15/24	62.5
Draft Action 3: Develop Monitoring Well Network	Option 2	18/24	75
Draft Action 4: Groundwater Model Refinement & Expansion	Option 2	15/24	63
Draft Action 5: Well Drilling Advisory	Option 2	18/24	75
Draft Action 10: Inform Neighbourhood Planning Initiatives	Option 2	12/24	50
Draft Action 13: Water Quality Assessment Requirements	Option 2	16/24	60

2.4.3 Finalized Evaluation Criteria

Upon review of the trial scoring, AECOM and City staff confirmed a preference for Evaluation Criteria Option 2. This framework was considered more practical and transparent because it focuses on relative benefits and costs while separating sequencing considerations, which are addressed through implementation planning rather than scoring. The final version, shown in **Table 2-4**, retains the core structure of Option 2 but incorporates refinements based on feedback from the trial scoring process.

Key adjustments included the addition of a fifth category under Benefits to capture actions with very high monetary value, providing greater differentiation for high-impact projects. Monetary thresholds for economic benefits and costs were recalibrated to better reflect local conditions and practical ranges. Furthermore, descriptions for social and environmental criteria were expanded to improve clarity and consistency, thereby reducing ambiguity during scoring. These refinements were intended to enhance transparency, support defensible decision-making, and advance the evaluation framework to reflect both technical rigor and local priorities. The finalized Evaluation Criteria Option 2 were adopted as the preferred framework for scoring actions and are henceforth referred to as the "Evaluation Criteria".

Table 2-4 Finalized Evaluation Criteria

Benefits	Highest Benefit (Score = 4)	High Benefit (Score = 3)	Medium Benefit (Score = 2)	Low Benefit (Score = 1)	No Benefit (Score = 0)
Economic - City	Will result in large (>\$10M) economic benefits to the City (e.g., reduced costs, or new revenue).	Will result in significant (\$1M-\$10M) or may lead to large (>\$10M) economic benefits to the City (e.g., reduced costs, or new revenue).	Will result in Moderate (\$500K to \$1M) or may lead to significant (\$1M-\$10M) economic benefits to the City (e.g., reduced costs, or new revenue).	Will result in minor (<\$500K) or may lead to moderate (\$500K-\$1M) economic benefits to the City (e.g., reduced costs, or new revenue).	No economic benefit to the City.
Economic - Community	Will result in large (>\$10M) economic benefits to the community (e.g., development, etc.).	Will result in significant (\$1M-\$10M) or may lead to large (>\$10M) economic benefits to the community (e.g., development, etc.).	Will result in moderate (\$500K to \$1M) or may lead to large (\$1M-\$10M) economic benefits to the community (e.g., development, etc.).	Will result in minor (<\$500K) or may lead to moderate (\$500K-\$1M) economic benefits to the community (e.g., development, etc.).	No economic benefit to the community.
Social	Large improvement to (or reduced risk to) the public's well-being, including	May lead to a large improvement to (or reduced risk to) the public's well-being,	Moderate improvement to (or reduced risk to) the public's well-being,	May lead to a moderate improvement to (or reduced risk to) the	No social benefit.

Benefits	Highest Benefit (Score = 4)	High Benefit (Score = 3)	Medium Benefit (Score = 2)	Low Benefit (Score = 1)	No Benefit (Score = 0)
	physical health, mental health, safety, equity*, reconciliation, and/or culture. Examples include providing post disaster potable water supplies or protecting housing for hundreds of people.	including physical health, mental health, safety, equity*, reconciliation, and/or culture. Examples include providing post disaster potable water supplies or protecting housing for hundreds of people.	including physical health, mental health, safety, equity, reconciliation, and/or culture. Examples include providing post disaster potable water supplies or protecting housing for multiple people or preservation of a public amenity that provides health benefits such as a wetland.	public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. Examples include providing post disaster potable water supplies or protecting housing for multiple people or preservation of a public amenity that provides health benefits such as a wetland.	
Environmental	A permanent and widespread positive environmental impact, which could include avoiding a significant negative environmental impact by completing the action.	May lead to a permanent and widespread positive environmental impact, which may include avoiding a significant negative environmental impact by completing the action.	A temporary and/or localized positive environmental impact, which may include avoiding a minor negative environmental impact if the action were not completed.	May lead to a temporary and/or localized positive environmental impact, which may include avoiding a minor negative environmental impact if the action were not completed.	No environmental benefit.
Costs		High Cost (Score = 0)	Medium Cost (Score = 1)	Low Cost (Score = 2)	No Cost (Score = 3)
Economic - City		Life cycle costs to the City >\$1M	City's life cycle costs between \$500K and \$1M	City's life cycle costs between \$100K-\$500K.	City's life cycle costs <\$100K.
Economic - Community		Life cycle costs to the community >\$1M	Community's life cycle costs between \$500K and \$1M	Community's life cycle costs between \$100K and \$500K.	Community's life cycle costs <\$100K.
Social		Major negative impacts to physical health, mental health, safety, culture, services or public confidence. Could include loss of housing, water, food, health and/or cultural services to hundreds of people.	Moderate impacts to public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. Could include loss of housing, water, food, health and/or cultural services to multiple people.	Minor negative impacts to public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. An example includes the temporary loss of a public amenity (e.g., park) during construction.	No risk to the public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture.
Environmental		A permanent and widespread negative environmental impact (e.g., permanent and widespread).	A permanent or widespread negative environmental impacts.	A temporary and localized negative environmental impacts.	No negative environmental impacts.

Evaluation of Foundational Actions

After trial scoring, it was decided that Foundational Actions should not be scored against the full set of evaluation criteria because their primary benefit is systemic: they unlock and enable all subsequent actions. These measures—such as developing the monitoring well network, refining the groundwater model, and building the data repository—provide the essential knowledge base and tools required for effective implementation of the remaining Groundwater Strategy actions. Scoring of these actions alongside others would not accurately reflect their enabling role, as their value lies in reducing uncertainty and supporting informed decision-making rather than delivering discrete, standalone benefits.

Indicative economic costs were provided for these actions to support early-stage budgetary planning and resource allocation. While these costs are important for financial planning, they do not diminish the fact that Foundational Actions are more critical than other actions in the strategy. Subsequent actions depend on the successful completion of these Foundational Actions, and they should be prioritized. Completing the Foundational Actions ensures that the City has the technical basis and confidence needed to implement the broader suite of actions effectively.

3. Phase 2: High-level Implementation Plans

3.1 Implementation Plan Template

The Implementation Plan template, provided in **Appendix E.1**, was developed to provide a structured and transparent approach for developing high-level project plans that aid in the evaluation and prioritization of actions. It was designed collaboratively to align with the adopted evaluation framework and support defensible decision-making by linking implementation details to scoring criteria. Each implementation plan captures essential information about the action, including its identification, rationale, and strategic alignment. Further, it outlines implementation details such as timeline, methodology, deliverables, draft KPIs, and assumptions. Dependencies are clearly distinguished as predecessors and successors to illustrate sequencing and interrelationships. The template also incorporates evaluation results based on the finalized Evaluation Criteria—economic, social, and environmental—along with additional considerations such as funding recommendations and alignment with other City strategies. This format is intentionally concise to allow for rapid digestion of the content relevant to each action while providing sufficient detail for planning, costing, and progress tracking.

Feedback from City staff during working sessions shaped the final design of the Implementation Plan template. Early discussions emphasized the need for clarity and usability, which led to refinements such as merging description and rationale fields, simplifying methodology guidance, and ensuring the template could accommodate the implementation plan for each action on a single page. The City requested strong alignment with the adopted evaluation criteria to maintain transparency and traceability, resulting in the inclusion of fields for benefits, costs, and dependencies. Additional adjustments, such as distinguishing predecessors from successors and adding placeholders for future updates (e.g. status tracking) were incorporated to support long-term use and maintenance of the implementation plans. These refinements reflect a collaborative approach focused on balancing technical rigor with practical application.

3.2 Implementation Plan Development

3.2.1 Implementation Methodology

As requested by the City, the implementation methodology for each of the Finalized Actions was developed using a Request for Proposal (RFP)-style task list to provide clarity, accountability, and enable status tracking. This format outlined discrete tasks, expected deliverables, and key milestones, enabling transparent communication of requirements for internal teams or external consultants. The RFP-style approach also supports future procurement processes by defining scope elements early, reducing ambiguity during later stages of contracting and execution.

3.2.2 Evaluation Criteria and Costing

Each plan was populated with evaluation details based on the adopted Evaluation Criteria covering economic, social, and environmental categories. For the economic criterion, indicative costs were prepared in 2025 dollars following Public Services and Procurement Canada (PSPC) Class D guidelines for conceptual-stage estimates. A Class D estimate provides a preliminary cost based on limited information and broad assumptions, with an accuracy range of approximately $\pm 50\%$. These estimates are intended for budgeting and prioritization rather than procurement and are appropriate for strategic planning where detailed design is not yet available. Because the Groundwater Strategy is a planning document, this approach was deemed to be suitable and defensible for this stage of evaluation and costs should be updated on a regular basis to ensure they remain relevant and suitable for use.

Costs were derived using professional judgment supported by benchmarks from similar municipal projects and historical data. Where possible, unit rates for common infrastructure elements were applied, and assumptions were documented to maintain transparency. The City of Vancouver provided key assumptions regarding whether work would be completed internally, by consultants, or other delivery mechanisms. Furthermore, the City's Project Team estimated the staffing needs in terms of Full Time Equivalents (FTE's) and provided estimated annual salaries for use in costing.

Foundational Actions were not evaluated against the full set of Evaluation Criteria because their benefits are systemic and enable all subsequent actions. For these actions, only indicative economic costs were provided using PSPC Class D guidelines to support early-stage budgeting and planning.

Actions with high uncertainty or an undefined scope of work reliant on results from other actions were labeled as Deferred and were not evaluated. Deferred actions should be revisited in the future when more information is available.

3.2.3 Additional Information and Strategic Alignment

Where information was available, Implementation Plans included potential funding sources to support implementation. The City of Vancouver also provided a list of relevant City strategies with which each action aligns, reinforcing integration across municipal initiatives and ensuring that groundwater management actions maintain synergies with existing programs.

3.3 Implementation Plans

The Implementation Plans are provided in **Appendix E.2** and serve as a bridge between the strategic vision of the Groundwater Management Strategy and the practical steps required to achieve it. The purpose of the Implementation Plans is to translate high-level actions into actionable considerations that can guide operational decision-making, resource allocation, and sequencing. By providing clarity on tasks, timelines, costs, and interdependencies, these plans enable the City of Vancouver to move from conceptual objectives to coordinated execution while maintaining flexibility for future updates as new data and priorities emerge.

Developing these plans required addressing uncertainty inherent to early-stage planning. Actions with incomplete data or multi-part scopes were documented with clear assumptions, and components with a more comprehensive understanding incorporated more detail. Subsequent phases, whose scope is dependent on the initial phase(s) were flagged for future consideration or left intentionally broad to represent the level of uncertainty in scope. This approach reflects the principle of continuous improvement that is embedded in the Groundwater Strategy and acknowledges that the actions and implementation plans will need to evolve as new information becomes available in the future based on the learnings from completion of other actions, the understanding of the system is improved, the City's prioritize change, and with the passage of time.

Foundational Actions were treated as enabling measures and were not evaluated against the full criteria because their benefits are systemic and unlock all subsequent actions. These actions establish the basic level of characterization and system understanding to complete the remaining actions.

Each Implementation Plan is designed as a practical reference tool. City staff can use them to identify required tasks, understand sequencing, and estimate resource needs. The plans also support budgeting and prioritization by providing indicative costs and benefits against defined evaluation criteria. While they offer a structured roadmap, they are not static documents. Updates should be incorporated as projects advance, and new data emerges.

4. Phase 3: Assess and Rank Actions

4.1 Methodology

In multi-criteria decision analysis, best practice is to begin with an unweighted scoring framework to establish a baseline for comparison. This ensures that all criteria are treated equally and provides a transparent and unbiased reference point for evaluating the influence of weighting. Weighting is then applied to reflect policy priorities or strategic objectives, but only after confirming that the unweighted results are reasonable and defensible. Comparing weighted and unweighted outcomes is essential to verify that weighting does not introduce unintended bias or disproportionately influence rankings.

This protocol was followed by first applying unweighted scoring across all evaluation criteria, providing a neutral baseline and allowing for the identification of actions that deliver balanced benefits relative to costs across economic, social and environmental objectives. At the City's request, two additional scenarios were explored for combining the Economic City and Economic Community categories.

The three scoring scenarios applied to evaluate the Actions included:

1. **Baseline – Unweighted Scoring:** All criteria were scored equally to establish a neutral reference point. This approach is standard in multi-criteria decision analysis and ensures transparency before introducing weighting.
2. **Averaged Economic Categories – Weighted Scoring:** The Economic City and Economic Community categories were combined by averaging their scores and applying weighting so that the combined economic criterion carried the same weight as social and environmental criteria. This scenario was intended to reduce the influence of economic considerations relative to other outcomes.
3. **Additive Economic Categories – Unweighted Scoring:** This scenario combined the Economic City and Economic Community values into a single category without applying weighting. The purpose was to reflect total economic impact while maintaining equal weight across all criteria.

4.1.1 Baseline – Unweighted Scoring

Each action was scored using the unweighted finalized Evaluation Criteria, which allow a maximum of 28 points across economic, social, and environmental benefit and cost categories as shown in (Table 4-1). The maximum number of points assigned to the benefits is higher than the maximum number of points for cost because there was a wider range in benefits which required greater gradation to prioritize between actions.

Table 4-1 Baseline - Unweighted Scenario Scoring Methodology

	Category	Weight	Maximum Points
Benefits	Economic City	1	4
Highest Benefit: 4 points	Economic Community	1	4
High Benefit: 3 points	Environmental	1	4
Medium Benefit: 2 points	Social	1	4
Low Benefit: 1 point			
No Benefit: 0 points			
Costs	Economic City	1	3
No Cost: 3 points	Economic Community	1	3
Low Cost: 2 points	Environmental	1	3
Medium Cost: 1 point	Social	1	3
High Cost: 0 points			
Total			28

The resulting unweighted score for the Baseline scenario is calculated as the sum of all category points:

$$\text{Score} = (\text{Benefits} + \text{Costs}) * \text{weights} \quad \text{Equation 1}$$

$$\begin{aligned} \text{Score} = & [\text{Economic City Benefits} + \text{Economic Community Benefits} + \text{Environmental Benefits} \\ & + \text{Social Benefits}] + [\text{Economic Costs} + \text{Economic Community Costs} \\ & + \text{Environmental Costs} + \text{Social Costs}] \end{aligned} \quad \text{Equation 2}$$

4.1.2 Averaged Economic Categories – Weighted Scoring

A combined Economic category was introduced by averaging the City and Community scores (**Table 4-2**), with the combined value weighted equally to social and environmental categories. This approach equally prioritizes Economic City and Economic Community but reduces the relative influence of economics compared to social and environmental considerations in the unweighted framework.

Table 4-2 Averaged Economic Categories – Weighted Scenario Scoring Methodology

	Category	Weight	Maximum Points
Benefits	Economic City	0.5	2
	Economic Community	0.5	2
	Environmental	1	4
	Social	1	4
Costs	Economic City	0.5	1.5
	Economic Community	0.5	1.5
	Environmental	1	3
	Social	1	3
Total			21

The resulting weighted score for the Averaged Economic Categories scenario is calculated as the sum of all category points multiplied by the weight for each category:

$$\begin{aligned} \text{Score} = & [(\text{Economic City Benefits} * 0.5) + (\text{Economic Community Benefits} * 0.5) \\ & + \text{Environmental Benefits} + \text{Social Benefits}] + [(\text{Economic Costs} * 0.5) \\ & + (\text{Economic Community Costs} * 0.5) + \text{Environmental Costs} + \text{Social Costs}] \end{aligned} \quad \text{Equation 3}$$

4.1.3 Additive Economic Categories – Unweighted Scoring

An additional scenario was developed by combining the Economic City and Economic Community categories into a single measure. Unlike the weighted scenario, this approach does not apply weighting; instead, it adds the dollar values from both categories and reclassifies the total economic costs and benefits against the existing thresholds in the evaluation criteria. This method considers the full economic impact of an action while maintaining equal weight across all criteria (**Table 4-3**). Including this scenario provides an important sensitivity check and enhances transparency by showing how merging the two economic categories—without altering their relative influence—might affect prioritization outcomes.

Table 4-3 Additive Combined Economic Categories – Unweighted Scenario Scoring Methodology

	Category	Weight	Maximum Points
Benefits	Economic City and Community	1	4
Highest Benefit: 4 points			
High Benefit: 3 points	Environmental	1	4
Medium Benefit: 2 points			
Low Benefit: 1 point	Social	1	4
No Benefit: 0 points			
Costs	Economic City and Community	1	3
No Cost: 3 points			
Low Cost: 2 points	Environmental	1	3
Medium Cost: 1 point			
High Cost: 0 points	Social	1	3
Total			21

In this scenario, the dollar values for the Economic City and Economic Community categories were added and then reclassified as High, Medium, Low, etc. using the Evaluation Criteria. The assigned monetary ranges in Evaluation Criteria were not adjusted. For example, if an action had an Economic City benefit of \$9M and an Economic Community benefit of \$1.5M, the combined Economic City and Community benefit would total \$10.5M, resulting in a classification of “Highest Benefit” and a score of 4 in the Economic City and Community category. The resulting score for the Additive Economic Categories scenario is calculated as the sum of all category points:

$$\begin{aligned} \text{Score} = & [\text{Combined Economic City and Community} + \text{Environmental Benefits} + \text{Social Benefits}] \\ & + [\text{Combined Economic City and Community Costs} + \text{Environmental Costs} \\ & + \text{Social Costs}] \end{aligned} \quad \text{Equation 4}$$

4.1.4 Example Scoring

Action 71: Groundwater Use Potential is scored herein to demonstrate the scoring calculations used for each scenario. **Table 4-4** summarizes the evaluation for *Action 71: Groundwater Use Potential* and the following calculations demonstrate the resulting scores.

Table 4-4 Example Evaluation for Action 71: Groundwater Use Potential

Benefits			Evaluation	Score
Economic (City)	High	\$5M–\$15M	Benefit is identification of alternative water source that could be developed to establish a new water supply for use during emergencies. Also may avoid the cost of mislocated or ineffective infrastructure and enabling system resilience planning. Potentially reduces cost of potable water used for non-potable uses.	3
Economic (Community)	High	\$1M–\$5M	Benefit is the avoided cost of water access during disaster scenarios. Enables planning for decentralized and redundant emergency groundwater supply (e.g. hospitals, firefighting, underserved areas). Supports equitable access to non-potable and potable alternatives during heat or drought.	3
Economic (City and Community)	Highest	\$6M – \$20M	Additive Economic Categories scenario only.	4
Social	High	-	Strengthens disaster preparedness and public confidence in City readiness. Supports vulnerable populations with improved water security in crisis.	3
Environmental	High	-	Protects aquifers by ensuring any proposed extraction is within sustainable limits. Helps preserve baseflow and ecosystem function by evaluating long-term impacts under various stress conditions.	3

Costs			Evaluation	Score
Economic (City)	Low	\$300K	Cost of consultant-led evaluation leveraging largely existing tools and may involve groundwater modeling, scenario testing, and mapping. Includes water balance development, sensitivity analysis, water quality evaluation and reporting.	2
Economic (Community)	No cost	-	No direct cost; communities benefit from future infrastructure based on the findings.	3
Economic (City and Community)	Low	\$300K	Additive Economic Categories scenario only.	2
Social	No cost	-	No direct disruption since this is a technical planning and analysis exercise.	3
Environmental	No cost	-	Action prevents over-extraction and degradation through proactive planning. No ecological disturbance occurs during modeling.	3

Baseline - Unweighted and Uncombined Economic Scoring

The Unweighted Scenario scoring for *Action 71: Groundwater Use Potential* is:

$$\text{Score} = [\text{Economic City Benefits} + \text{Economic Community Benefits} + \text{Environmental Benefits} + \text{Social Benefits}] + [\text{Economic Costs} + \text{Economic Community Costs} + \text{Environmental Costs} + \text{Social Costs}] \quad \text{Equation 2}$$

$$\text{Score} = [3 + 3 + 3 + 3] + [2 + 3 + 3 + 3]$$

$$\text{Score} = 23 \text{ out of a maximum of } 28$$

Averaged Economic Categories – Weighted

The Weighted Average Combined Economic Scenario scoring for *Action 71: Groundwater Use Potential* is:

$$\text{Score} = [(\text{Economic City Benefits} * 0.5) + (\text{Economic Community Benefits} * 0.5) + \text{Environmental Benefits} + \text{Social Benefits}] + [(\text{Economic Costs} * 0.5) + (\text{Economic Community Costs} * 0.5) + \text{Environmental Costs} + \text{Social Costs}] \quad \text{Equation 3}$$

$$\text{Score} = [(3 * 0.5) + (3 * 0.5) + 3 + 3] + [(2 * 0.5) + (3 * 0.5) + 3 + 3]$$

$$\text{Score} = 17.5 \text{ out of a maximum of } 21$$

Additive Economic Categories – Unweighted

The Unweighted Additive Combined Economic Scenario scoring for *Action 71: Groundwater Use Potential* is:

$$\text{Score} = [\text{Economic City and Community} + \text{Environmental Benefits} + \text{Social Benefits}] + [\text{Economic City and Community Costs} + \text{Environmental Costs} + \text{Social Costs}] \quad \text{Equation 4}$$

$$\text{Score} = [4 + 3 + 3] + [2 + 3 + 3]$$

$$\text{Score} = 18 \text{ out of a maximum of } 21$$

4.2 Results

The scoring results are shown in **Table 4-5** and summarize how each action performed against the Evaluation Criteria in the unweighted and combined economic categories scenario. The results highlight relative strengths in economic, environmental, and social dimensions and providing a transparent basis for prioritization. The Baseline scenario uses a scoring scale out of 28 points, while both the Averaged Economic Categories and Additive Economic Categories scenarios use a scale out of 21 points. As a result, direct comparison of absolute scores between scenarios is not appropriate. Instead, the analysis focuses on the relative placement of actions within each scenario to assess how different scoring approaches influence prioritization. The scoring results under three scenarios highlights the flexibility of the evaluation framework to reflect changing priorities and reinforces the importance of integrating cost considerations into strategic decision-making.

4.2.1 Baseline - Unweighted Scenario

Actions that achieved the highest scores in the Baseline scenario typically required limited capital investment yet delivered systemic improvements, resulting in strong cost-effectiveness. Conversely, actions with the lowest scores generally involved low capital investment but lacked significant benefits or widespread impact. Mid-range scores were typically associated with actions that had one or two categories rated low for benefits or high for costs.

Across all results in the Baseline scenario, economic factors emerged as the primary differentiator among actions with similar benefit profiles, underscoring the importance of cost-effectiveness in strategic planning. Actions that integrate groundwater considerations into existing City processes—such as *Action 15: Stormwater Infiltration Incentives*, *Action 68: GRI at City-Owned Buildings*, and *Action 22: Map Groundwater I&I Risks*—tended to score higher because they deliver broad benefits without requiring major new infrastructure, resulting in lower economic costs.

Some actions with substantial economic costs—such as *Action 176: Saltwater Intrusion*, *Action 10: Inform Neighbourhood Planning Initiatives*, and *Action 52: Groundwater Rise Management*—ranked among the highest for benefits but also require significant capital investment. For these actions, it may be advantageous to identify components that can be implemented at a lower cost to preserve some benefits if full funding is not immediately available.

4.2.2 Averaged Economic Categories – Weighted Scenario

The Averaged Economic Categories scenario generally maintained the overall prioritization structure observed in the Baseline scenario, with most actions shifting only slightly. Weighting the economic categories to reduce their influence relative to social and environmental criteria produced a clear trend: actions with balanced benefits across all dimensions tended to have increased scores, while those heavily weighted toward economic outcomes saw modest declines.

Collaboration and outreach-oriented actions—such as internal education, academic partnerships, and public engagement—rose in relative importance under this scenario. These measures scored higher because they deliver broad social and environmental benefits without significant cost, aligning well with the weighting approach. Conversely, actions that are primarily economic in nature, or that offer limited non-economic benefits, generally had reduced scores. Examples include regulatory adjustments and infrastructure-focused measures that, while valuable, do not provide the same breadth of benefits across all categories.

Overall, the weighting approach did not disrupt the strategic landscape: top-tier actions remained near the top, and changes were concentrated in mid-tier items. This reinforces that the evaluation framework is robust and that weighting primarily fine-tunes prioritization rather than driving wholesale shifts.

4.2.3 Additive Economic Categories – Unweighted Scenario

The Additive Economic Categories scenario combines City and Community economic scores into a single measure without applying weighting. The monetary brackets in the evaluation criteria were not adjusted for this scenario. As a result, actions that previously scored “Highest” in both Economic City and Economic Community received only a single “Highest” score for benefits under this scenario. Actions that moved into a higher evaluation category scored relatively higher compared to their ranking in the Baseline scenario.

This outcome reflects a limitation in the scoring because there is no differentiation between actions that barely meet the “Highest” threshold and those that far exceed the threshold across two categories. Similarly, actions with very strong economic benefits did not have any advantage. Instead, the scenario primarily benefitted actions that moved up an evaluation category when their City and Community economic values were added together.

For example, *Action 22: Map Groundwater I&I Risks* and *Action 100: Terrestrial Groundwater Thresholds* improved slightly because their combined economic benefits moved them into a higher bracket. In contrast, *Action 71: Groundwater Use Potential*, which was already “Highest” in both economic categories, saw little change because its score was already maximized and the addition of the categories was not realized. Actions with minimal economic benefits, such as *Action 67: Internal Education*, shifted downward relative to actions that moved into a higher economic category despite strong social and environmental benefits.

Adjusting the monetary ranges in the evaluation criteria (for this scenario only) should be considered to represent the broader spectrum of economic values produced by adding the Economic City and Community categories. Introducing additional brackets or finer gradation would allow greater differentiation between actions with moderate economic benefits and those with exceptionally high combined benefits. This adjustment would ensure that the scoring system better reflects the true magnitude of economic impacts.

Overall, the Additive scenario did not significantly disrupt top-tier rankings but introduced more noticeable changes in mid-tier actions. These shifts highlight how prioritization can vary when economic considerations are combined without adjusting thresholds and emphasize the importance of presenting multiple scenarios to support transparent and balanced decision-making.

4.2.4 Prioritization

The City of Vancouver should adopt a phased approach to implementing the Groundwater Strategy actions, beginning with those that establish the foundation for all subsequent work. Foundational Actions must be prioritized first because they provide critical knowledge and data infrastructure necessary to inform future decisions. These actions will deliver the greatest impact on understanding the groundwater system and managing the information required for effective planning and monitoring. As presented in **Section 2.2.3**, the Foundational Actions include:

- *Action 3: Develop Monitoring Well Network*
- *Action 4: Groundwater Model Refinement and Expansion*
- *Action 7: Build Data Repository*
- *Action 9: Inventory Groundwater Diversions*
- *Action 16: Enhance Aquifer Recharge*
- *Action 17: Water Budget for Groundwater Reliant Ecosystems*
- *Action 27: Aquifer Vulnerability Assessment*
- *Action 43: Use of Permit Application Data*

Once Foundational Actions are underway, the next priority should be Actionable Actions with identified dependencies. These actions form Actionable Streams where progress on one action enables the initiation of others. Advancing these Actionable Streams early will prevent bottlenecks and allow for progression of an entire stream supported by results of precursor actions.

The remaining Actionable Stand-Alone Actions without dependencies should be prioritized based on evaluation scores, as shown in the streaming diagram in **Figure 4-1**. Grouping of the Actionable Stand-Alone Actions into tiers based on scoring (e.g. top five or top ten scoring actions), will allow the City to progress high-value measures in parallel. This approach directs resources toward actions offering the greatest combined benefits and cost-effectiveness while maintaining flexibility to adjust as new information emerges. Actionable Stand-Alone Actions should also be opportunistically progressed to take advantage of funding programs and proceed with important items that are urgent or immediate value.

The unbiased scoring scenario should be used as the primary basis for prioritizing these Actionable Stand-Alone Actions. This scenario provides a logical ordering of actions and reflects a balanced view of benefits and costs

without introducing weighting biases. Sensitivity analysis confirmed that the overall order of high-scoring actions did not change under alternative scenarios, reinforcing the robustness of the unweighted approach. Importantly, the unbiased scoring did not demote actions with high cost and high benefits, ensuring that these measures remain visible for consideration even when resource constraints exist.

Table 4-5 provides a summary of the scoring results for all Actionable Actions using the three scoring methods. The actions are ordered based on the Baseline – Unweighted scoring methodology. By showing the scores under all three methods, one can see that the ranking would be similar under all three scoring methodologies. One can also see how some actions would move up slightly (e.g., *Action 100: Terrestrial Groundwater Thresholds*) or down slightly (e.g., *Action 74: Water Reservation Application*) if one of the other two scoring methodologies were adopted.

The Score and Priority Description column in **Table 4-5** was produced to help guide prioritization of actions based on the recommendation provided in this section. In general, the assignment of priority in the Score and Priority Description column reflects the baseline scores, where actions with higher scores are assigned a higher priority. However, actions with successors or actions where both the Economic City and Economic Community evaluations are “Highest” were also given a higher priority. Priority was assigned based on the following:

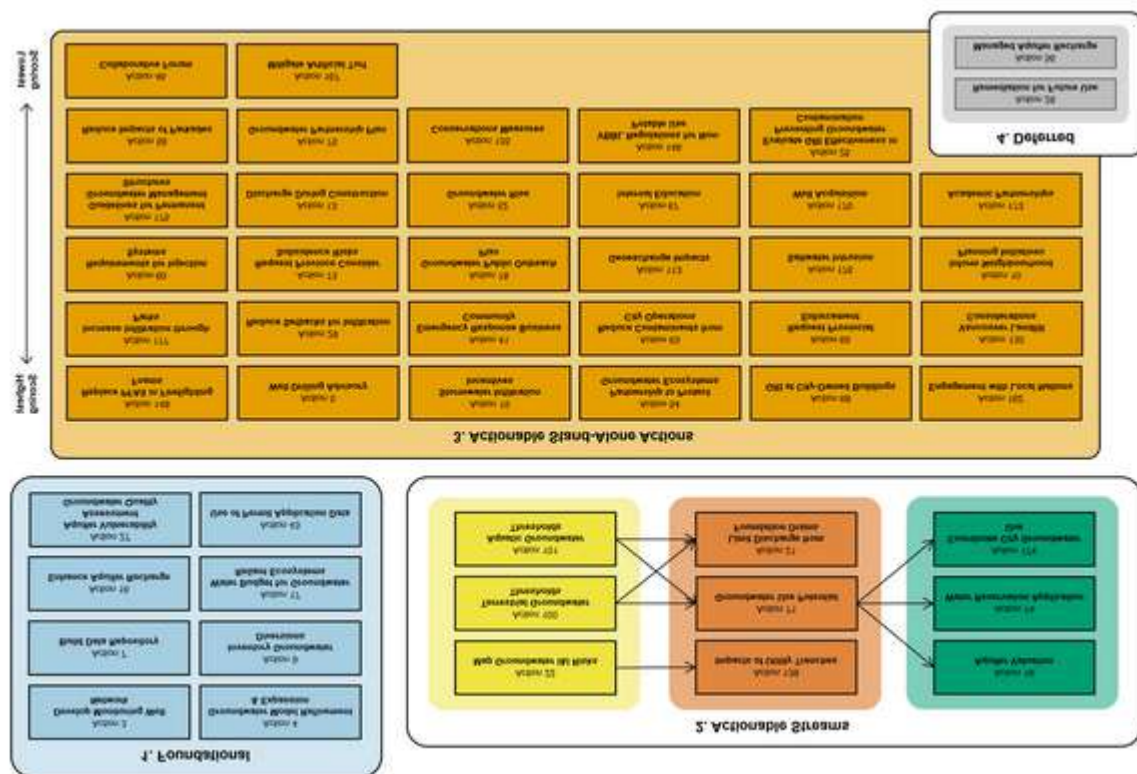
- High Priority: Scored 22 or above, had a successor, or assigned “Highest” for both Economic City and Economic Community benefits
- Medium Priority: Scored greater than 18 but less than 22
- Low Priority: Scored 18 or below

Table 4-5 Action Summary and Scoring Results

Action				Assessment and Ranking				Dependencies		Evaluation: Benefits				Evaluation: Costs			
Number	Name	Type	Timeline	Baseline – Unweighted Score	Averaged Financial Categories – Weighted Score	Additive Financial Categories – Unweighted Score	Score and Priority Descriptor	Required Predecessors	Successors	Economic (City)	Economic (Community)	Social	Environmental	Economic (City)	Economic (Community)	Social	Environmental
3	Develop Monitoring Well Network	Foundational	3 years				Foundational							Medium			
4	Groundwater Model Refinement and Expansion	Foundational	2 years				Foundational							Low			
7	Build Data Repository	Foundational	2 years				Foundational							Low			
9	Inventory Groundwater Diversions	Foundational	3 years				Foundational							Low			
16	Enhance Aquifer Recharge	A. Foundational B. Deferred	1 year				Foundational							Medium			
17	Water Budget for Groundwater Reliant Ecosystems	Foundational	1 year				Foundational							No cost			
27	Aquifer Vulnerability Assessment	Foundational	1 year				Foundational							Low			
43	Use of Permit Application Data	Foundational	6 months				Foundational							Low			
71	Groundwater Use Potential	A. Actionable B. Deferred	1 year	23	17.5	18	High		16, 74, 174	High	High	High	High	Low	No cost	No cost	No cost
148	Replace PFAS in Firefighting Foams	Actionable	2 years	23	17	18	High			High	High	High	High	No cost	No cost	Low	No cost
5	Well Drilling Advisory	A. Actionable	2 years	22	16.5	16	High			Highest	High	Medium	High	Medium	No cost	No cost	No cost
15	Stormwater Infiltration Incentives	Actionable	2 years	22	16.5	17	High	100, 101		Highest	High	High	High	Low	Low	Low	No cost
19	Aquifer Valuation	Actionable	2 years	22	17	17	High	71		High	High	High	High	Medium	No cost	No cost	No cost
54	Partnerships to Protect Groundwater Ecosystems	Actionable	1 year	22	17	18	High			Medium	Medium	High	High	No cost	No cost	No cost	No cost
68	GRI at City-owned Buildings	Actionable	2 years	22	16.5	16	High			Highest	High	Medium	High	Medium	No cost	No cost	No cost
74	Water Reservation Application	Actionable	2 years	22	15.5	16	High	71		Highest	High	Medium	Medium	No cost	No cost	Low	No cost
162	Engagement with Local Nations	Actionable	1 year	22	17	18	High			Medium	Medium	High	High	No cost	No cost	No cost	No cost
177	Increase infiltration through parks	Actionable	2 years	22	17	18	High			High	Medium	High	High	Low	No cost	No cost	No cost
22	Map Groundwater I&I Risks	Actionable	1.5 years	21	16	17	High		139	High	Medium	Medium	High	Low	No cost	No cost	No cost
29	Reduce Setbacks for Infiltration	Actionable	2 years	21	16	16	Medium			High	Medium	Medium	High	Low	No cost	No cost	No cost
41	Emergency Response Business Continuity	Actionable	1 year	21	15.5	17	Medium			High	Medium	Medium	Medium	No cost	No cost	No cost	No cost
63	Reduce Contaminants from City Operations	A. Actionable B. Deferred	1 year	21	16	16	Medium			High	Medium	Medium	High	Low	No cost	No cost	No cost
65	Request Provincial Enforcement	Actionable	1 year	21	15.5	16	Medium			High	Medium	Medium	Medium	No cost	No cost	No cost	No cost

Action				Assessment and Ranking				Dependencies		Evaluation: Benefits				Evaluation: Costs			
Number	Name	Type	Timeline	Baseline – Unweighted Score	Averaged Financial Categories – Weighted Score	Additive Financial Categories – Unweighted Score	Score and Priority Descriptor	Required Predecessors	Successors	Economic (City)	Economic (Community)	Social	Environmental	Economic (City)	Economic (Community)	Social	Environmental
100	Terrestrial Groundwater Thresholds	Actionable	1 year	21	16	17	High		21, 71	Medium	Medium	Medium	High	No cost	No cost	No cost	No cost
101	Aquatic Groundwater Thresholds	Actionable	1 year	21	16	16	High		21, 71	High	Medium	Medium	High	Low	No cost	No cost	No cost
130	Vancouver Landfill Considerations	Actionable	2 years	21	16	17	Medium			High	Low	Medium	High	No cost	No cost	No cost	No cost
21	Limit Discharge from Foundation Drains	Actionable	3 years	20	15	16	High	100, 101		High	High	Medium	High	Low	Low	Low	No cost
60	Requirements for Injection Systems	Actionable	2 years	20	15.5	16	Medium			Medium	Medium	Medium	High	Low	No cost	No cost	No cost
73	Request Province Consider Subsidence Risks	Actionable	2 years	20	14.5	15	Medium			High	Medium	Medium	Low	No cost	No cost	No cost	No cost
78	Groundwater Public Outreach Plan	Actionable	1 year	20	16	16	Medium			Medium	Low	High	High	Low	No cost	No cost	No cost
113	Geoexchange Impacts	A. Actionable B. Deferred	1 year	20	15.5	16	Medium			High	Low	Medium	High	Low	No cost	No cost	No cost
176	Saltwater Intrusion	A. Actionable B. Deferred	1 year	20	14.5	13	High			Highest	Highest	Low	Medium	High	No cost	No cost	No cost
10	Inform Neighbourhood Planning Initiatives	Actionable	Ongoing	19	15	14	Medium			High	Medium	Medium	High	High	No cost	No cost	No cost
139	Impacts of Utility Trenches	Actionable	1 year	19	14	14	Medium	22		High	Medium	Low	Medium	Low	No cost	No cost	No cost
174	Coordinate City Groundwater Use	Actionable	1 year	19	15	16	Medium	71		High	None	Medium	High	Low	No cost	No cost	No cost
175	Guidelines for Permanent Groundwater Management Structures	Actionable	3 years	19	15	16	Medium			High	Medium	High	Medium	Low	Medium	No cost	No cost
13	Discharge During Construction	Actionable	2 years	18	14.5	14	Low			High	Medium	Medium	High	Low	High	No cost	No cost
52	Groundwater Rise	A. Actionable B. Deferred	1 year	18	14	14	High			Highest	Highest	Medium	Medium	High	High	No cost	No cost
67	Internal Education	Actionable	6 months	18	14.5	15	Low			Medium	None	Medium	High	Low	No cost	No cost	No cost
170	Well Acquisition	Actionable	1 year	18	13.5	14	Low			Medium	Low	Medium	Medium	No cost	No cost	Low	No cost
173	Academic Partnerships	Actionable	1 year	18	14.5	14	Low			Low	Low	High	Medium	Low	No cost	No cost	No cost
58	Reduce Impacts of Parkades	Actionable	1 year	17	12.5	12	Low			High	High	Low	Medium	Low	Medium	Low	No cost
75	Groundwater Partnerships Plan	Actionable	1 year	17	13	13	Low			Medium	Low	Medium	Low	Low	No cost	No cost	No cost
135	Conservation Measures	Actionable	3 years	17	13	14	Low			High	None	Medium	Medium	Low	No cost	Low	No cost
146	VBBL Regulations for Non-Potable Use	Actionable	3 years	17	12.5	13	Low			High	Low	Low	Low	Low	No cost	No cost	No cost
25	Evaluate GRI Effectiveness in Preventing Groundwater Contamination	Actionable	5 years	15	12	12	Low			Low	None	Low	Medium	Low	No cost	No cost	No cost
46	Collaborative Forum	Actionable	1 year	15	11.5	12	Low			Low	None	Low	Low	No cost	No cost	No cost	No cost

Action				Assessment and Ranking				Dependencies		Evaluation: Benefits				Evaluation: Costs			
Number	Name	Type	Timeline	Baseline – Unweighted Score	Averaged Financial Categories – Weighted Score	Additive Financial Categories – Unweighted Score	Score and Priority Descriptor	Required Predecessors	Successors	Economic (City)	Economic (Community)	Social	Environmental	Economic (City)	Economic (Community)	Social	Environmental
167	Mitigate Artificial Turf	Actionable	5 years	15	12	12	Low			Low	None	Low	Medium	Low	No cost	No cost	No cost
28	Remediation for Future Use	Deferred															
56	Managed Aquifer Recharge	Deferred															



number: 60737887

5. Conclusions

Groundwater is a critical natural resource within the City of Vancouver. The Groundwater Strategy represents an important step toward proactive management of this resource to support water conscious infrastructure design, minimize costly infrastructure upgrades and support thriving resilient communities and ecosystems. The Groundwater Strategy Actions Analysis presented herein followed a structured approach to identify, evaluate, prioritize, and implement actions in a transparent, traceable and adaptable manner. Based on the evaluation, we conclude the following:

1. **Finalized Actions:** A comprehensive review of 75 Draft Actions developed by the City of Vancouver and their Expert Panel was completed. These draft actions were refined to produce a shortened list of 50 Finalized Actions that are unique, clear, comprehensive and aligned with the strategic objectives of the Groundwater Strategy. The actions clearly identify and communicate actions that are valuable and worth pursuing to improve the understanding and management of groundwater in the City of Vancouver. No redundant actions were identified. The Finalized Actions included the following:
 - a. **Foundational Actions:** Eight (8) Foundational Actions (Actions 3, 4, 7, 9, 16, 17, 27, and 43) that are required to provide the technical basis for all subsequent actions by establishing data management infrastructure, characterizing the subsurface and achieving a basic understanding of the groundwater system. Their completion is required to provide the factual basis and understanding that many subsequent actions rely upon. Due to their importance, these actions were not scored.
 - b. **Actionable Stand-Alone Actions:** Thirty-one (31) Actionable Actions (5, 10, 13, 15, 25, 29, 41, 46, 52, 54, 58, 60, 63, 65, 67, 68, 73, 75, 78, 113, 130, 135, 146, 148, 162, 167, 170, 173, 175, 176, and 177) that can be actioned in a prioritized manner following completion of the Foundational Actions.
 - c. **Actionable Streams:** Mapping dependencies highlighted the need for phased execution of some actions. Nine (9) Actionable Actions (Actions 19, 21, 22, 71, 74, 100, 101, 139, and 174) that can only be completed as Actionable Streams in concert with other actions. These actions require careful sequencing amongst the precursors and successors.
 - d. **Deferred Actions:** Two (2) Deferred Actions (Actions 28 and 56) that require additional information to determine whether they should progress and to define their scope within the City of Vancouver's integrated water management framework. In addition to these actions, portions of some Actionable Actions were deferred until the precursor(s) are completed.
2. **Jurisdictional Scan:** The jurisdictional scan confirmed that the actions identified in the Groundwater Management Strategy reflect leading practices in urban groundwater management. Key themes appearing in the Finalized Actions of the City of Vancouver Groundwater Strategy were validated as essential components of a resilient groundwater management. Many actions were captured in one or more groundwater strategy documents developed by other leaders in municipal and regional groundwater and surface water management. The Finalized Actions are reasonable steps toward understanding and managing groundwater in a developed urban environment and are broadly consistent with initiatives undertaken in other jurisdictions in similar settings, including growing coastal communities managing sea level rise and the impacts of climate change.
3. **Assessment and Ranking of Finalized Actions:** Finalized Evaluation Criteria were utilized to objectively score all 40 Actionable Actions following a transparent and defensible process. The criteria were found to adequately differentiate scores for each of the actions to support objective prioritization. A comprehensive digital tool was developed by AECOM to host implementation plans and score Actionable Actions in MS Excel™ format. When scoring was completed using unweighted criteria, the actions were ranked based on their resultant scores and importance as follows:
 - a. **Foundational Actions:** Eight (8) Foundational Actions (Actions 3, 4, 7, 9, 16, 17, 27, and 43) have the highest priority due to their importance to the fundamental understanding of the system and future value to the Groundwater Strategy, but they were not scored.

- b. High Priority Actions: Sixteen (16) Finalized Actions were assigned a High Priority because they had a score of 22 or above, had a successor, or were evaluated as “Highest” for both Economic City and Economic Community benefits.
- c. Medium Priority Actions: Thirteen (13) Finalized Actions were assigned a Medium Priority because they had a score greater than 18 but less than 22.
- d. Low Priority Actions: Eleven (11) Finalized Actions were assigned a Low Priority because they had a score of 18 or below.

Prioritization should begin with Foundational Actions, followed by Actionable Streams, and then Actionable Stand-Alone Actions guided by scoring results.

Actions that scored highest across all scenarios were those delivering broad social and environmental benefits with minimal cost, such as *Action 71: Groundwater Use Potential*. These measures offer systemic improvements and strong alignment with strategic objectives.

Actions with high costs but significant benefits, such as *Action 176: Saltwater Intrusion* and *Action 52: Groundwater Rise*, scored lower overall but remain strategically important for long-term resilience.

4. **Scoring Sensitivity Analysis**: Consistent with industry best practice, a sensitivity analysis was conducted to determine whether the approach to scoring was inherently biased. Three (3) alternatives for weighting of criteria: 1) Unweighted Criteria; 2) Averaged Financial Criteria; and 3) Additive Financial Criteria. The evaluation criteria developed during this project are suitable for use to evaluate the current Actionable Actions and others that may be developed in the future. Sensitivity analysis showed:
- a. Weighting and combining economic categories influenced mid-tier rankings but did not change the overall order of high-scoring actions. This confirms that the unbiased scoring scenario is a robust method for prioritization and reinforces the credibility of the overall approach.
 - b. For Actionable Stand-Alone Actions, the unbiased scoring scenario provides a logical basis for prioritization because it reflects balanced benefits and costs without introducing weighting biases. Importantly, this scenario did not de-prioritize actions with high cost and high benefits, ensuring these remain visible for consideration.

6. Recommendations

To advance the Groundwater Strategy effectively, the City of Vancouver should adopt a structured and adaptive approach to implementation. The following recommendations are provided to guide prioritization and resource allocation and direct the implementation to proceed in a logical, efficient, and adaptable manner:

1. **Implement Foundational Actions First:** Foundational actions should be initiated first because they establish the knowledge base and data infrastructure required to unlock and implement all subsequent actions. While many of these actions have a high cost, these measures will deliver the greatest impact with respect to understanding the groundwater system and managing groundwater-related risks. Completing these actions early is required to enable informed decision-making and reduce uncertainty in later phases.
2. **Follow the Streaming Diagram for Sequencing of Actionable Streams:** Actions with defined dependencies (Actionable Streams) should be advanced in accordance with the streaming diagram developed during implementation planning. Advancing these streams early will prevent bottlenecks and allow for rapid progression of a stream of actions to arrive at a clear decision supported by the results of precursor actions.
3. **Use Scoring to Prioritize Actionable Stand-Alone Actions:** Actionable Stand-Alone Actions without dependencies should be prioritized based on evaluation scores. Grouping these actions into tiers, such as the top five or ten, will allow the City to progress high-value measures in parallel. This binning approach directs resources toward actions offering the greatest combined benefits and cost-effectiveness.

The unbiased scoring scenario should be used as the primary basis for prioritizing Actionable Stand-Alone Actions because it reflects balanced benefits and costs without introducing weighting biases. Sensitivity analysis confirmed that this approach is robust and does not demote actions with high cost and high benefits.

4. **Refine Cost Estimates and Explore Phased Delivery:** Indicative costs provided in the Implementation Plans should be refined as more detailed information becomes available. For actions with high capital requirements, consider phased implementation or alternative delivery approaches to preserve benefits while reducing upfront costs. For example, having groundwater specialists attend neighbourhood planning meetings may help achieve some objectives at minimal cost compared to full-scale modeling for neighbourhood plan assessments. When funding becomes available, more robust technical assessments can be completed with the benefit of input from the neighbourhood planning meetings.
5. **Leverage Funding Opportunities:** The City should actively pursue external funding programs to accelerate implementation of the Groundwater Strategy, particularly for actions that do not have precursors. Opportunistic implementation can reduce financial burden and advance strategic objectives ahead of schedule.
6. **Maintain and Continuously Improve the Actions:** Because groundwater is not presently well understood, the understanding of the system will rapidly improve, allowing for better decisions to be made with respect to the prioritization of future actions. The Groundwater Strategy and associated actions should be treated as living documents. Updates and refinements should be incorporated periodically as new data becomes available, priorities shift, or emerging challenges arise. This should include actioning the Deferred Actions or developing new actions over time.

This adaptive approach will ensure the Groundwater Strategy benefits from the best and latest information, remains relevant in the context of City priorities, and can be implemented effectively in the future. We recommend the plan include provision for ongoing maintenance of information combined with a more fulsome review and update of the document every five years, similar to other planning documents.

7. **Future Adaption:** The Groundwater Strategy and associated actions should remain a living document. Future conditions may reveal new priorities or emerging issues, and updates will be required as new information becomes available, and City priorities evolve. This adaptive approach will allow the strategy to remain relevant and effective over time.

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Appendix **A**

Draft and Finalized Actions

- A.1 Initial Draft Action Provided to AECOM
- A.2 Proposed Combinations
- A.3 Finalized Actions

Appendix A Draft and Finalized Actions

A.1 Initial Draft Action Provided to AECOM

Unique Action ID Number	Objective(s) this action relates to (primarily)	Draft Action	Rationale, Description, Background, Context and Any Support for Action
3	Cross-cutting	Develop a monitoring well network throughout the city to determine seasonal and long-term groundwater elevations as well as groundwater chemistry.	Very little is known about groundwater elevations or water quality across the city. The data from the monitoring well network will be critical for many other actions in the strategy as the City needs to better understand local hydrogeology in order to effectively protect and manage it. Data from the monitoring well network (e.g. water levels) would be made publicly available. These data will be used for various purposes, including for example, assessing extraction potential and infiltration capacities, better understanding groundwater-ecosystem interactions, calibrating models, predicting the impacts of land-use changes, monitoring groundwater-rise, etc.
4	Cross-cutting	Refine and expand the existing city-wide hydrogeological model to allow for its use as a decision-support tool for risk mitigation, Area-plan development, ecosystem protection, and utility and city planning.	The city has an existing numerical model that covers the municipality (and slightly beyond). If it can be refined to improve accuracy, it can be a powerful tool in predicting the impacts of various stressors (e.g. a changing climate, rising sea levels, groundwater extraction, increased imperviousness, additional underground infrastructure, etc.) on groundwater, connected ecosystems, and/or infrastructure. This action will allow the City to compile all of the various data it has on local geology and water levels, and update the existing model such that it can be used to inform decision-making.
5	Mitigate risks	Work with the Province and other affected local governments to refine the Well Drilling Advisory Area for flowing artesian conditions and share with the development community.	The current well drilling advisory area extends from the University Endowment Lands to just west of Coquitlam. The advisory is a useful means of improving general understanding among the public and contractors of the risks related to flowing artesian conditions. This should help reduce the potential for more incidents like the one that occurred at Beechwood Street in 2015, when an inexperienced contractor drilled a geoexchange well for a home and pierced a pressurized (flowing artesian) portion of the aquifer. It took two years and cost the City almost \$12 million to control the flow, and an estimated 3 billion gallons of groundwater were discharged to the sewer system. However, the advisory area was defined using a limited amount of available information and could be drastically improved using additional tools (e.g. geophysics). A refinement of this nature would improve confidence in the area boundary, and would ideally reduce the size of the area itself, potentially reducing costs related to risk mitigation for municipalities and developers. Through the use of more advanced tools, it may also be possible to define the area vertically, which could provide a depth that is "safe to dig". This would further reduce uncertainty and costs.
6	Mitigate risks	Support the City's Geotechnical team in their effort to develop studies related to understanding and mitigating groundwater-related geotechnical hazards.	This study will help the City to identify geotechnical hazards related to groundwater (e.g. slope stability), and minimize the risks to new developments and infrastructure.
7	Cross-cutting	Evaluate data management options to improve quality, accessibility and usability of the City's hydrogeologic data.	The City's hydrogeological data is currently stored across various City departments in different formats (including paper, PDFs, and various databases). Consolidating this data into one database would make it much easier to analyze, use, and share. In addition, look for ways to further develop internal communication to improve accessibility and use this data to inform decision-making.
9	Preserve resources	Inventory all known activities or infrastructure that are capturing	A first step towards reducing groundwater waste is to identify dewatering activities across the city. This is also a necessary step in developing a comprehensive understanding of our urban hydrogeology (i.e. developing an

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		groundwater (e.g. construction dewatering, foundation drains, wells).	accurate water budget). Collecting and sharing data on where the water table is being artificially lowered, will also be beneficial for others, including the development community. As an extreme example of this, the Oakridge Centre re-development has brought to light the fact that portions of the Canada Line Skytrain and possibly some neighbouring developments were built below the natural water table. Oakridge has been pumping groundwater since the 1950s (originally for a geoexchange cooling system for the mall), and as a result the water table has been artificially lowered by approximately six metres. Therefore, any below-ground structures built near Oakridge since this time could be impacted if groundwater pumping at the mall ceases and the water table rises once again.
10	Preserve resources	Undertake groundwater investigations to help inform neighbourhood planning initiatives (e.g. Area Plans) and related building requirements in order to preserve groundwater resources, and also protect buildings, infrastructure, and dependent ecosystems.	These investigations will help identify areas of concern for groundwater in future neighbourhood planning initiatives, and allow the City to implement targeted building requirements there. Depending on the situation, these investigations could be simple desktop exercises, or more detailed investigations (e.g. monitoring well installations) with elaborate decision support tools (i.e. numerical models).
13	Support ecosystems	Expand the City's Erosion and Sediment Control requirements to include an assessment of water quality to ensure any groundwater discharged to the sewer system is meeting the requirements of the City's Sewer and Watercourse By-law. Establish a process to monitor and enforce these requirements during construction.	Currently, the Sewer and Watercourse by-law stipulates water quality standards for discharge to the storm sewer. However, outside of the City's ESC (Erosion and Sediment Control) requirements, there does not appear to be any mechanism that requires a project proponent to monitor or otherwise provide proof that these standards are being met. Due to the existing ESC requirements during construction, this may be a convenient project phase to require additional monitoring and reporting to ensure S&WC by-law compliance. As any long-term diversion of groundwater from the site (post-construction) into the sewer would also be of concern due to liability that the City carries, any requirements being considered for the construction phase would need to consider how/if the water quality at construction can be considered a proxy for the water quality after construction. The goal for this action is to ensure that discharges to the storm system meet strict water quality requirements, in order to protect receiving bodies such as English Bay.
15	Preserve resources	In line with Healthy Waters Plan and Rain City Strategy, develop requirements or incentives for stormwater infiltration on private property in order to enhance groundwater recharge.	Paved and built surfaces limit rainwater infiltration. While there are requirements for stormwater infiltration on public property in Vancouver, currently there are none for developments on private property. This action will address that, and help ensure that less rainwater ends up in the sewer system where feasible/practicable, and more can infiltrate and replenish local aquifers. For example, the City could charge landowners for the volume of stormwater that enters City infrastructure, or develop rainwater management requirements that require a certain level of infiltration.
16	Preserve resources	Undertake a detailed, city-wide infiltration assessment in order to delineate areas where stormwater infiltration should be encouraged/(or discouraged due to increased risk), and to identify areas that are currently providing significant groundwater recharge.	Currently, infiltration potential is assessed prior to the design of individual Green Rainwater Infrastructure (GRI), however little work has been completed to date to assess infiltration potential across the City as a whole. Besides the physical ability of soils to accommodate infiltration, other factors may need to be considered when assessing infiltration potential. These include the existence of contaminants that may be mobilized through infiltration, or the potential for infiltration to cause geotechnical issues (e.g. slope failures). This action will help the City to better target specific areas for infiltration to manage rainwater. It will also help identify areas that are likely to be important recharges areas, that must be protected in order to sustain our aquifers
17	Support ecosystems	Identify ecosystems that are reliant on groundwater and develop a water budget model for them to help determine where and how, these ecosystems should be protected.	Many ecosystems, such as Still Creek and Camosun Bog are dependent on groundwater to properly function. Several others are suspected to rely on groundwater, but a city-wide inventory of groundwater-dependent ecosystems (GDE's) has not been completed. In order to protect these ecosystems, we need to first identify them and then understand how they interact with groundwater. With this information, we can predict how different stressors

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			(e.g. increased upgradient imperviousness, new drainage systems or wells, etc.) may impact these ecosystems, and take steps to reduce or mitigate these impacts.
18	Preserve resources	Implement a stormwater utility fee with equity considerations to recoup treatment costs, discourage groundwater discharges, and encourage stormwater infiltration.	Currently, uncontaminated groundwater discharges to the sewer system are free, so there is very little incentive for developers to change this practice. Charging a stormwater utility fee based on the volume of groundwater discharged would encourage developers to reduce these discharges, such as by using Green Rainwater Infrastructure (GRI), tanking their foundations, or by re-using onsite groundwater or rainwater. It would also generate funds that could be used to install more GRI assets, or make other needed improvements to the sewer system. The stormwater utility fee could include equity considerations, such as lower rates for certain types of developments.
19	Cross-cutting	Quantify the "natural asset" value of local aquifers in terms of water storage and supply, supporting ecosystems, and other municipal services, and incorporate this information into the City's asset management system.	Traditionally, civic asset management processes have only been applied to engineered infrastructure. However, there is growing evidence that by considering natural assets (e.g. aquifers) within asset management processes, local governments can decrease capital, operations, and maintenance costs; increase levels of service; enhance their ability to adapt to climate change; and reduce the community's unfunded liabilities – all while protecting or enhancing the multitude of other benefits that natural assets bring to communities. The functions that nature provides to communities beyond core services, such as recreation, climate regulation, clean air, habitat, and biodiversity, are invaluable to the overall health and well-being of a community. Therefore, including natural assets in asset management processes provides an integrated approach to maintaining or enhancing the natural assets in a community.
21	Preserve resources	Develop city-wide sustainable performance-based requirements for the to limit the permanent diversion of groundwater into sewers from foundation drains (e.g. a maximum discharge rate).	Underground structures, including parkades, require drainage systems to protect them from water ingress and hydrostatic pressures. The groundwater collected by these systems is usually discharged to the sewer system, which not only reduces sewer system capacity, increases treatment costs, and adds to combined sewer overflow (CSO) volumes but can result in other impacts (e.g. reduced baseflow to nearby streams, increased geotechnical risk like subsidence). This action will help to mitigate these and other impacts, by requiring developers to limit the amount of groundwater diverted to sewer, through the use of cut-off walls, tanked building foundations, and above-grade parking.
22	Preserve resources	Develop a map of groundwater elevation and cross-reference with sewer and drainage infrastructure to highlight areas where I&I is most likely, and should be prioritized for I&I monitoring, and pipe repairs as needed.	Leaking sewer pipes allow the infiltration of groundwater. This not only reduces sewer system capacity, adds to treatment costs and CSO volumes, but also wastes the resource. A city-wide, comprehensive I&I monitoring program is very costly. By mapping out the where the city's infrastructure is below the water table, it may be possible to prioritize where I&I flow monitoring should occur. The effectiveness of this assessment may be increased by adding available data on sewer infrastructure that may indicate the likelihood of leaks (e.g. pipe type, age, etc.).
23	Preserve resources	Calculate the average volume of groundwater entering the City's sewer system via inflow and infiltration for each sewer catchment area	It is currently unknown what percentage of the City's sewer pipes are occupied by groundwater in each sewer catchment area. Yet this information would help the City understand how dewatering by developments impacts sewer capacity, and whether stronger policies to discourage these discharges are warranted. It would also allow the City to better understand how much groundwater enters the sewer system through infiltration of leaky pipes.
25	Safeguard quality	Work with GRI team to increase water quality monitoring to evaluate the long-term effectiveness of Green Rainwater Infrastructure assets in preventing contaminants (including dissolved phase constituents) from entering groundwater.	Green rainwater infrastructure (GRI) promotes sustainable urban rainwater management by slowing down and providing retention to rainwater, allowing it to soak into the ground. This helps reduce the volume of water entering our sewer system and increases groundwater recharge. However, stormwater can be contaminated (e.g. on roads, where vehicle tire particles, oil, and metals from brake pads mix with rain). While GRI assets often filter out many suspended contaminants, it is unclear which types and percentages of dissolved contaminants are removed. The goal of this action is to develop a comprehensive assessment, potentially including temporary or semi-permanent

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			water quality monitoring, to better understand where treatment effectiveness could be increased via GRI design improvements.
27	Safeguard quality	Complete an aquifer vulnerability assessment to prioritize actions related to the protection of groundwater quality.	The purpose of this action is to develop aquifer vulnerability mapping (e.g. AVI, DRASTIC) to inform land use policy and decision making. It will be an invaluable tool to help the City protect local aquifers.
28	Safeguard quality	In line with Provincial direction for climate adaption, physically remediate any contamination found in viable groundwater aquifer on City-owned properties to drinking water standards.	Several City-owned properties are known to have contamination and are currently undergoing remediation. In many situations, these sites will be remediated based on risk assessment which often prohibits the use of underlying viable groundwater aquifer as a potable water source as an institutional control. This action will help identify where the City may be able to commit to physical remediation of contamination and protect and preserve the groundwater resources for the possibility of future use. This would be line with current Provincial directions: https://engage.gov.bc.ca/govtogetherbc/engagement/making-contaminated-sites-climate-ready/
29	Preserve resources	Explore and work towards reducing setback requirements related to infiltration to meet Rain City Strategy objectives and enhance aquifer recharge.	Given the development pressures in the City, every inch of developable space on a property is often used, leaving limited space for infiltration features (e.g. GRI). Additionally, two known setbacks exacerbate this issue by precluding the act of infiltration within a set distance of building foundations (5m) and potable water pipes (distance??). This action would seek to further support ongoing work (e.g. RainCity strategy - Pathways Study) that is looking at potential options for relaxing these setbacks, in order to increase onsite opportunities for rainwater infiltration.
36	Mitigate risks	Develop a plan to mitigate the risks of encountering flowing artesian conditions within the Well Drilling Advisory Area.	Flowing artesian conditions are pressurized portions of aquifers, and wells drilled in these areas can cause serious problems. For example, in 2015 a geoechange well for a home was drilled by an inexperienced contractor, and this pierced a pressurized portion of the aquifer. It took two years and cost the City almost \$12 million to control the flow, and an estimated 3 billion gallons of groundwater were discharged to the sewer system. These pressurized areas are roughly delineated by a Provincial Well Drilling Advisory Area map to help alert developers to the risk. But this action would help identify other requirements the City could implement to reduce the risk from these flowing artesian conditions.
38	Support ecosystems	As part of the development review process, collate any relevant hydrogeological data related to historical streams that could be useful for future daylighting initiatives.	Most of Vancouver's streams were lost over the previous century of development, often either put into pipes that became our modern day sewers, or filled in with material and built on top of. While a map of these streams was published several decades ago, the accuracy of the map (and location of some of the streams) could be refined, as additional data becomes available. Identifying and collating hydrogeological data that indicates the presence of a historic stream will help fill gaps in this history, and could be beneficial for projects that seek to daylight these creeks in the future. Historic streams can be found beneath the surface throughout the city, and pose some challenges to new developments. While a map of these streams was published several decades ago, the accuracy of the map (and location of some of the streams) could be refined, ground-truthed and where possible. As well, it may be possible to digitize historic maps and aerial photos. Flagging and collating hydrogeological data will assist with this initiative.
41	Mitigate risks	Develop a clear governance structure, including channels for efficient communication and data sharing, for managing groundwater-related emergencies incidents (e.g. flooding from flowing artesian conditions).	In the 2015 Beechwood incident, an inexperienced contractor pierced a pressurized (flowing artesian) portion of the aquifer, leading to several billion gallons of groundwater being discharged. At the time, it was initially unclear which City business units needed to be involved, and this might have led to delays in managing the issue. This action will develop a clear governance structure for managing these and other types of groundwater emergencies.

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43	Cross-cutting	Explore options for the City to gain permission to use environmental, geotechnical and hydrogeological data received as part of permit applications, to support City initiatives.	When developers conduct a hydrogeological study, they often install monitoring wells and submit the data to the City. This action would give the City permission to use this data in order to protect and manage local groundwater resources. Options could include working with the City's Legal Services to identify a solution, or lobbying the Province to amend the Groundwater Protection Regulation to require the submission of borehole data and monitoring wells, and add them to its GWELLS database.
46	Collaborate	Work with other interested parties to establish a forum for the Province, Metro Vancouver, and neighbouring governments including local Nations to share knowledge on key groundwater issues (e.g. aquifer contamination), and to collaborate on solutions.	The Province of BC has identified two aquifers beneath Vancouver, both of which extend across multiple other municipalities. As the management of these aquifers are shared by many levels of government (including local Nations and the Province of BC), it makes sense to have a coordinated approach. Key groundwater issues could include drought resilience, land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets, and establishing a notification or monitoring system for large (e.g. commercial or industrial) water users. Related to #74.
47	Use sustainably	Conduct a jurisdictional scan to determine potential options for the re-use of foundation drainage water.	Foundation drainage water from developments is typically discharged to the sewer system. This action would identify what other jurisdictions are doing with this groundwater (such as using it for non-potable purposes) and identify possible steps the City can take.
52	Mitigate risks	Complete an assessment of the potential extent and magnitude of groundwater rise and saltwater intrusion; induced by sea-level rise.	"Groundwater rise" occurs when sea levels rise (primarily due to climate change) and the water table also rises as a result. This can lead to flooding of below ground structures, geotechnical impacts, increased capture of groundwater via drainage systems, surface flooding, and other impacts. Additionally, this rise will be accompanied by a landward migration of the saltwater interface, potentially impacting infrastructure (e.g. corrosion) and other receptors (e.g. wells, ecosystems). This action will further the City's understanding of where these types of impacts are most likely, and will be subsequently used to inventory susceptible infrastructure and other receptors, and to develop a mitigation strategy related to these impacts. To maximize cost-effectiveness, this assessment may also include an assessment of saltwater intrusion induced by reduced aquifer recharge and increased groundwater extraction.
54	Support ecosystems	Explore partnership opportunities with local Nations and stewardship groups to protect groundwater-dependent ecosystems, share data and lessons learned, and collaborate on regional biodiversity goals.	Several ecosystems in the city are believed to be groundwater dependent (GDE's). Many stakeholders and other governments have considerable knowledge and expertise related to the historic and present-day health and well-being of these ecosystems. In order to better understand and preserve these assets, the City needs to work with these partners towards a shared goal. Regional biodiversity goals could include exploring land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets.
56	Use sustainably	Complete an assessment of the potential for an aquifer storage and recovery system to be used in the City as a means of storing excess rainwater for use during times of water scarcity.	Currently, the city receives too much rainfall in the winter, and not enough in the summer. And this is likely to worsen as climate change progresses. This action will assess the potential of using local aquifers to store excess rainwater in winter months for use during times of scarcity, much like reservoirs in the North Shore do.
58	Preserve resources	Explore way to encourage at or above-grade parking (e.g. height or density bonuses).	The deeper a development goes below ground, the greater the chances that it will impact groundwater -- for example, through the use of perimeter drainage systems that drain groundwater into the sewer system. One potential solution is to encourage the use of multi-level above grade parking within the building envelope. Currently, this practice is rarely used in Vancouver, in part due to the fact that such above-grade parking levels would 'count against' the overall FSR (floor space ratio) of the project, resulting in a reduce allowable area for residential or commercial space. Providing density bonuses or other incentives could help reduce the volume of groundwater going into the sewer system, by encouraging alternatives to below grade parkades.

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59	Support ecosystems	Support the development of the Rupert and Renfrew Station Area Plan as it pertains to the protection of groundwater and the Still Creek watershed.	The Rupert and Renfrew Station Area Plan is an important opportunity to implement progressive development policies to protect groundwater, as well as the Still Creek ecosystem which depends on groundwater for base flow. This Area Plan also has the potential to be a template for other Area Plans in the future.
60	Safeguard quality	Develop requirements, including water quality objectives and maintenance requirements, for stormwater infiltration or injection systems to ensure that groundwater quality is protected.	Although relatively rare currently, injections wells have been used in Vancouver to re-inject GW collected via foundation drainage, or as part of an open-loop geothermal system. It may also be used in the future to manage stormwater, in areas with limited sewer capacity. Although the Province has developed BMP's related to water quality, and the Environmental Management Act (EMA) prohibits "pollution", limited guidance exists to ensure groundwater quality is protected. This action will seek to develop procedures and/or guidelines for injection systems implemented in Vancouver. An injection well is used to place water (or other fluid) below ground into a porous geologic formation, such as sandstone or limestone. To protect groundwater quality, this action will set water quality guidelines and other requirements for any injection systems implemented in Vancouver.
63	Safeguard quality	Develop an inventory of contaminants of concern that are either stored at city facilities or released to the environment by City operations, and that could contaminate aquifers.	A variety of chemicals are used by the City of Vancouver in its own operations and facilities, and some of these may be leaching into the soil and subsequently contaminating groundwater. This action will identify all contaminants of concern used by the City and Park Board.
65	Safeguard quality	Request that the Provincial government increase their enforcement efforts with regards to laws related to well decommissioning and temporary construction dewatering authorizations.	Despite Provincial legislation, some unused wells are not decommissioned, leading to safety concerns and also the potential for contaminants to enter local aquifers via these wells. In addition, the Water Sustainability Act requires that Provincial approval be granted for construction dewatering. The intention of this requirement is to ensure the impacts of these activities on the environment and other water rights holders are assessed. Neither the well closure requirements, nor the requirements for approval to dewater (referred to as Use Approvals), are actively enforced by the Province. As both impact city resources, the intention is to engage with the Province to convey our concerns and seek a commitment for additional efforts to ensure compliance with these requirements.
67	Build support	Conduct regular learning sessions with key City departments about the importance of groundwater and how staff can help protect it (e.g. through process changes).	While the profile of groundwater is gradually increasing within various City departments, there is still a long way to go in terms of raising internal groundwater literacy. This action will involve hosting regular learning sessions with different City business units, particularly those whose work touches on groundwater. The goal will be to foster greater awareness and interest in protecting groundwater (and minimizing groundwater-related risks) through their work. Education should also include awareness of the liability the city carries due to wastewater and groundwater in our sewer system.
68	Preserve resources	In order to enhance aquifer recharge, explore ways to support Rain City Strategy actions related to implementing innovative Green Rainwater Infrastructure practices at city-owned buildings.	As part of the City's efforts to show leadership on water management, this action entails developing internal policy to build and/or renovate future city buildings to manage a certain amount (e.g. 90%) of stormwater through infiltration. This may also include building at least one civic facility to manage all (i.e. 100%) collected stormwater through infiltration. This would demonstrate to others that infiltration is a feasible and affordable means of managing stormwater, with additional co-benefits (e.g. supporting aquifer recharge, supporting ecosystems, etc.), and also help generate support for these types of actions by the public who visits the facility.
71	Use sustainably	Evaluate the feasibility of using groundwater as an emergency water source.	Jurisdictions with multiple water sources that includes groundwater (e.g. San Francisco) have redundancies in terms of their water supply in the event of emergencies (e.g. after earthquakes). Other jurisdictions, including some located with Metro Vancouver, have either considered or installed wells solely for emergency purposes. This action would include a demand assessment followed by evaluating the feasibility of adding emergency groundwater supply to

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			Vancouver. This could include such options as installing wells at key facilities (e.g. hospitals), adding wells to our existing water supply system as a redundancy, or installing wells in specific areas for specific purposes (e.g. for fire-fighting). Several scenarios should be considered, such as major disasters (e.g. earthquakes) or more frequent emergencies (e.g. drought or extreme heat). Considerations should include prioritizing new water sources in under-served or otherwise vulnerable areas. The action would also include recommendations related to effective operation and maintenance of these wells when not in use (if used solely for emergencies).
73	Mitigate risks	Request that the Province consider the potential for offsite subsidence in geotechnically problematic areas when adjudicating water licenses and use approvals for groundwater extraction.	Currently, the Province does not consider offsite subsidence when adjudicating water licenses and use approvals, yet groundwater extraction (including for perimeter drainage) can cause subsidence at neighbouring properties as well as City roads and underground utilities. This action will involve lobbying the Province so that they consider these potential offsite impacts.
74	Use sustainably	Following an assessment of extraction potential, apply for a "water reservation" under the Province's <i>Water Sustainability Act</i> to set aside water rights for future City use.	Because the Province's approach to groundwater use is "first in time, first in right" – meaning that during times of water scarcity, licensees with earlier authorization dates are prioritized and entitled to take their full allocation of water before more recent licensees -- it is important for the City to engage with the Province to determine how best to secure future water rights. This may in the form of a water license or a water reservation. This action may also include discussions around prohibiting commercial activities that are reliant on large quantities of groundwater, or that extract and sell groundwater (e.g. water or other beverage bottlers). Related to #46.
75	Build support	Create outreach programs for the development community on groundwater-related risks (e.g. uncertain water levels, dependent ecosystems, flowing artesian conditions, etc.) as well as best management practices.	New developments can have a number of significant groundwater-related impacts, and conversely groundwater may impact developments. Therefore, outreach to the development community is needed to improve understanding and to achieve compliance with the City's current and future requirements related to groundwater management. Potential topics include groundwater-related risks (e.g. artificially lowered water levels, drainage-induced subsidence, flowing artesian conditions, etc.), environmental impacts (e.g. to groundwater-dependent ecosystems), as well as best management practices (e.g. site and foundation drainage).
78	Build support	Explore targeted outreach opportunities (e.g. in schools or at public events) including by partnering with NGOs, local Nations, and/or academic institutions on the importance of groundwater and how to protect it.	One of the most cost-effective means of protecting groundwater, is to educate the public, especially school-aged children. The City may wish to develop educational materials, with particular venues or target audiences in mind (e.g. schools, public events), to raise the profile of groundwater issues.
82	Build support	Install signage in high-traffic areas to inform the public on the importance of groundwater, what the City is doing to protect it, and how everyone can play a part.	Some sites in the city (e.g. civic golf courses, Hillcrest community centre) already use some groundwater (e.g. for watering lawns, flushing toilets, etc.), but the public is largely unaware of these initiatives. Additionally, there are a number of ecosystems throughout the city that are either known, or suspected, to be significantly supported by groundwater. Installing signage in these locations will provide an educational opportunity to raise awareness about groundwater.
83	Use sustainably	Install at least one pumping well in a high profile location to showcase opportunities related to groundwater use.	This water well would demonstrate the feasibility of using groundwater in emergencies such as earthquakes, and at all other times it would be used for non-potable purposes such as watering parks.
85	Safeguard quality	Explore options to set new requirements for developers to	When developers remediate their sites (e.g. clean-ups after a gas station closes), it is an opportunity to require any contamination found in the viable groundwater aquifer be remediated to numerical standards. This will prohibit the

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		physically remediate contamination found in viable groundwater aquifer to drinking water standards.	use of risk assessment, and also allow the aquifer to be physically remediated to drinking water standards and be climate ready for future potable uses.
88	Safeguard quality	Educate residents and businesses about the safe handling, storage, use of common chemicals, and less toxic alternatives to mitigate potential impacts on groundwater (e.g. lawn chemicals, de-icing agents, oil, paint, etc.)	This outreach campaign will help educate businesses and residents about actions they can take to reduce the contamination of groundwater with commonly used chemicals. It would be run by the City's communications team.
90	Use sustainably	As necessary, assist the Waterworks team in continually updating the Waterworks Emergency Response Plan with details related to new wells that may be used during an emergency.	The City's Waterworks Utility has an Emergency Response Plan (ERP) that provides a structured method of responding to an emergency within the City of Vancouver's water system. This plan will need to be updated as new groundwater wells are developed that can provide a source of emergency water.
92	Mitigate risks	Complete an inventory of City-owned assets that may be vulnerable to groundwater rise or saltwater intrusion, and develop mitigation strategies for those assets.	This action would follow action # (safety row 52). There are a number of City-owned facilities (e.g. Kits pool) and other assets (e.g. roads, sewer pipes, etc.) that may be vulnerable to groundwater rise and saltwater intrusion. This action would identify those assets, and propose a mitigation strategy for each.
98	Safeguard quality	Following the development of an inventory of contaminants used by City operations, research and acquire less toxic but equally effective alternatives wherever available.	The City uses a number of chemicals (e.g. pesticides) and other contaminants (e.g. road salt) in its daily operations, some of which may eventually make their way into local aquifers. This action will identify opportunities for less toxic but equally effective alternatives to minimize groundwater pollution. It may also identify additional measures that may be taken to reduce risks (e.g. secondary containment, education regarding proper use)
100	Support ecosystems	Define minimum groundwater elevations for the protection of terrestrial groundwater-dependent ecosystems.	A number of terrestrial ecosystems in Vancouver (including parks, street trees, and vegetation on private property) are believed to be dependent on shallow groundwater to survive. This action will help determine the minimum local groundwater elevation that is needed to support these ecosystems, thereby helping to protect them. This action will also support the Urban Forest Strategy.
101	Support ecosystems	Define thresholds for aquatic groundwater-dependent ecosystems that define the minimum acceptable water level (e.g. for wetlands and bogs) and/or flow volumes (e.g. for streams) for the protection of ecosystem health.	A number of aquatic ecosystems in Vancouver (including wetlands, bogs, and streams) depend on groundwater. This action will help determine the minimum local groundwater elevation that is needed to support these ecosystems, thereby helping to protect them.
104	Preserve resources	Following an assessment to define key aquifer recharge areas, explore options to protect or enhance infiltration in these areas.	Protecting recharge areas is critical to preserving aquifer resources. This action will define the key recharge areas in the city, and explore options for protecting or enhancing infiltration in them. Protection could include establishing land use restrictions that limit or prohibit the production, use, storage (e.g. underground fuel tanks) and/or disposal of high risk or other selected contaminants in aquifer recharge areas, municipal well capture zones, or other sensitive groundwater areas.

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109	Use sustainably	Assess if and where groundwater can be used to augment our potable water system (e.g. in times of drought).	In the Lower Mainland, several local governments use groundwater for a large portion (and in some cases 100%) of their water needs, including White Rock, Abbotsford, and Chilliwack. Even urban centres such as San Francisco utilize some groundwater for drinking, non-potable uses, and during emergencies. This action will help determine if and where in Vancouver groundwater can be used for potable purposes (e.g. in times of drought).
113	Safeguard quality	Research the potential impacts of geoexchange systems on groundwater resources and groundwater-dependent ecosystems. As needed, develop tools (e.g. by-laws) and cross-governmental collaboration to mitigate the potential impacts.	While geoexchange systems are currently not very common in the city, their use could expand as developers and homeowners seek opportunities to reduce energy use and greenhouse gas emissions. However, as these systems become more common, there is a risk of thermal pollution of the aquifers, which could have some negative effects (e.g. on groundwater-dependent ecosystems). There is also some concern that geothermal systems can potentially degrade groundwater quality as a result of coolant fluid leaking underground from a closed-loop system, or as a result of the water injected back into the geological formations from an open-loop system. This action will research those potential impacts, and ways to possibly mitigate them.
130	Safeguard quality	Working with Vancouver landfill operations staff, and their groundwater consultants, explore additional measures for the protection of the underlying aquifer, and nearby ecosystems (e.g. Burns Bog).	While the City's landfill in Delta is run exceptionally well, there may be opportunities to strengthen groundwater protection measures, which could also help support the neighbouring Burns Bog ecosystem. These measures could exceed Provincial requirements, but are important for the City to show leadership with all of its operations, regardless of their location.
135	Use sustainably	Build on existing civic water initiatives and apply conservation measures (e.g. water meters, watering restrictions, internal pricing) to all groundwater use.	The City has a number of strong conservation programs to reduce water use in City and Park Board operations. However, groundwater is often seen as a free resource, and conservation initiatives do not typically apply to groundwater. For example, if a civic golf course reduces potable water use by substituting it with groundwater, it is still considered to have reduced (potable) water use. Further, the water license issued by the Province for this extraction would not likely include conditions related to following local water use restrictions (e.g. outdoor watering restrictions in the summer). This can act as a perverse incentive to use groundwater wastefully. This action seeks to make sure that all internal conservation measures and targets that apply to potable water from Metro Vancouver also apply to groundwater.
139	Preserve resources	Where warranted to reduce impacts, consider approaches that reduce the potential for utility trenches to act as preferential pathways that drain groundwater (e.g. seepage collars on utility trenches)	Excavation backfill in utility trenches can become a preferential pathway for groundwater. In certain situation, these trenches may become unintended drainage systems that stretch over large distances. Where these trenches intercept aquifers, significant loss of groundwater may result. They could also lead to, or exacerbate, the diversion of groundwater to the sewer. This action would identify situations where additional measures may be necessary, and propose solutions (e.g. require the installation of seepage collars).
146	Use sustainably	Develop regulations in the Vancouver Building By-law to facilitate the sustainable use of groundwater for non-potable applications.	Groundwater in Vancouver could be used for non-potable purposes such as watering green spaces or even flushing toilets, assuming that it is used sustainably and does not deplete the aquifers. Currently, the Vancouver Building By-law (VBBL) does not include groundwater as an approved source of water, requiring that an exemption process (called a "Alternative Solution") be followed if someone wishes to use groundwater for non-potable purposes. If the VBBL could be amended to accommodate groundwater use, it may become more common. Currently, Vancouver Coastal Health and Development, Buildings & Licensing are exploring ways to do this, and the Groundwater Team could assist with this work.
148	Safeguard quality	Identify and transition to firefighting foams that are equally effective, but that do not contain toxic per- and polyfluorinated substances (PFAS) or	Many firefighting foams in use today contain toxic per- and polyfluorinated substances (PFAS). PFAS are known as "forever chemicals" because they don't degrade, are known to accumulate in groundwater where they can cost billions of dollars to remediate, and are becoming an urgent public health issue. In April 2024, the Vancouver Fire Rescue Services spent \$2.8 million to purchase PFAS-free gear. [See: https://vancouver.ca/news-

Unique Action ID Number	Objective(s) this action relates to (primarily)	Draft Action	Rationale, Description, Background, Context and Any Support for Action
		other harmful chemicals which can accumulate in local aquifers and compromise the health of firefighters.	calendar/vancouver-protecting-firefighters-with-new-pfas-free-gear-april-2024.aspx] The next logical step is to replace PFAS-containing firefighting foams. This action would reduce PFAS contamination of local aquifers, protect firefighter health, and show City leadership on this important issue.
150	Build support	Engage local artists to create groundwater-themed art for public spaces to educate and inspire residents to protect local aquifers.	The City often installs art in public spaces to inspire residents. The Rain City Strategy and other City initiatives have utilized art in creative ways to highlight water-related issues. There are currently two known groundwater-related art pieces in the city, and this action would facilitate additional installations.
151	Build support	Create and maintain a groundwater website outlining what Vancouver is doing to protect local aquifers, minimize groundwater-related risks, and use groundwater resources, and as well as how businesses and residents can do their part.	Currently there is almost no information on the City's website about groundwater, and none that is of much interest to the general public. This action would create a basic webpage (including other digital content as needed) to provide an introduction to how groundwater works and how it benefits us all, to summarize what the City is doing on groundwater, and how residents and businesses can do their part. It would also provide an overview of the groundwater strategy.
152	Use sustainably	Complete an assessment of sustainable extraction potential across the City.	Because there is growing interest in the city to use groundwater for non-potable and even potable purposes, it is important to determine the sustainable yield -- i.e. how much groundwater can be used without depleting the aquifers or causing other adverse impacts. This assessment will be the first step to determine where, how much, and for what purposes groundwater can be used.
154	Support ecosystems	Work with other interested parties to ensure that Camosun Bog has adequate groundwater to thrive.	Camosun Bog is believed to be a groundwater-dependent ecosystem (GDE). The water level in the bog has been artificially lowered, due to the installation of two large drains that were designed to reduce flooding in nearby underground structures. These drains are slated for replacement, giving the City an opportunity to reassess their usefulness and impacts. This action would include developing an understanding of how the bog functions, what groundwater's role is, and looking at opportunities to enhance the ecosystem. These enhancements may include changes to city infrastructure (i.e. nearby drains), or other changes.
155	Cross-cutting	Explore a dedicated long-term funding strategy for City projects that protect and utilize groundwater, and/or minimize groundwater-related risks.	Implementing many of the actions in the groundwater strategy will require additional funding. This action will explore options for obtaining that funding. For example, there may be opportunities to work with UBCM or the FCM to seek funding from other levels of government. Similarly, there may be opportunities for funding by collaborating with the Province and local Nations through the Watershed Security Strategy. Moreover, the Province's "Compendium of Provincial Groundwater Science and Monitoring Projects" states that they sometimes partners with local governments to "fund groundwater-related studies."
162	Collaborate	Continue to engage with xʷməθkʷəy̓əm (Musqueam), Skwxwú7mesh (Squamish) and səllwətał (Tsleil-Waututh) to support local Nations' priorities throughout the implementation of the strategy's actions.	Reconciliation is one of the Guiding Principles of the Groundwater Strategy. While the City has made regular efforts to meet with and engage with local Nations on groundwater issues during the consultation phase of the Groundwater Strategy, this action will ensure that engagement continues during the implementation phase of the strategy.
167	Safeguard quality	Explore possibilities for reducing the use of artificial turf in city-owned facilities, parks, and sports fields where microplastics from the turf can leach into aquifers.	While the use of artificial turf has expanded in the city (likely based on the assumption that it requires less water and maintenance), it has a number of problems. For example, runoff from artificial turf may contain pollutants like microplastics, heavy metals, and chemicals that can migrate into surface water or groundwater. Moreover, with a short lifespan of 10-20 years, the turf typically ends up in landfills where it can further break down and contaminate

Unique Action ID Number	Objective(s) this action relates to (primarily)	Draft Action	Rationale, Description, Background, Context and Any Support for Action
			aquifers. This action will explore possibilities for reducing the use of artificial turf in city-owned facilities, parks, and sports fields.
170	Safeguard quality	Explore options for the City to acquire a well on City property once it is no longer needed by the well owner.	The city issues permits to private entities, for the use of our road right of ways, for the purpose of installing monitoring wells. These wells are often only needed temporarily and are decommissioned (ideally) when no longer needed. This action will allow the City to acquire a well when it is no longer needed by the well owner, and potentially initiate groundwater monitoring at the well.
173	Build support	Explore partnerships with academic institutions to advance the City's understanding of local aquifers and groundwater resources.	Build collaborative relationships with academic institutions to develop our understanding of groundwater resources. This may include research or studies as part of students' Capstone projects.
174	Use sustainably	Develop a coordinated approach for the City's and Park Board's groundwater extraction activities to ensure critical uses are prioritized, and over-extraction is avoided.	This action would help facilitate discussions to reach a consensus and have a joint understanding of what activities may use groundwater in the future and establish a coordinated approach to prioritize use and avoid over-extraction. Current consideration for uses include irrigation of park grounds, irrigation of green infrastructure assets, non-potable uses to offset drinking water uses, etc.
175	Cross-cutting	Explore options to clarify design requirements for tanked foundations, foundation drainage systems, groundwater cutoff walls/structures, or performance-based measures (e.g. through the VBBL, EGBC practice advisory, etc.).	This action would address the lack of performance-based measures to limit or prevent the discharge of groundwater to the City's sewer system.

A.2 Proposed Action Combinations

Unique Action ID number	Draft action	AECOM Proposed Status	CoV Response to Proposed Change	Decision and Updated Status Accepted by CoV
3	Develop a monitoring well network throughout the city to determine seasonal and long-term groundwater elevations as well as groundwater chemistry.	Keep.		Keep, no change.
4	Refine and expand the existing city-wide hydrogeological model to allow for its use as a decision-support tool for risk mitigation, Area-plan development, ecosystem protection, and utility and city planning.	Keep.		Keep, no change.
5	Work with the Province and other affected local governments to refine the Well Drilling Advisory Area for flowing artesian conditions and share with the development community.	Combine actions 5 and 36.	5 + 36 to be grouped. These actions are dependent. Remove "and share with the development community" from #5.	Combined with Draft Action 36. Text changed as suggested.
6	Support the City's Geotechnical team in their effort to develop studies related to understanding and mitigating groundwater-related geotechnical hazards.	Combine actions 6 and 73.	Keep 6 and 73 as standalone actions.	Combined with Draft Action 73.
7	Evaluate data management options to improve quality, accessibility and usability of the City's hydrogeologic data.	Keep.		Kept, no change.
9	Inventory all known activities or infrastructure that are capturing groundwater (e.g. construction dewatering, foundation drains, wells).	Combine actions 9, 10, 47, and 59.	10 + 59 to be combined into one action. Keep other actions standalone.	Kept as stand-alone action, no change.
10	Undertake hydrogeological groundwater investigations to help inform neighbourhood planning initiatives (e.g. Area Plans) and related building requirements in order to preserve groundwater resources, and also protect buildings, infrastructure, and dependent ecosystems. that include building requirements that help preserve sensitive groundwater flow regimes (e.g. Still Creek base flows)	Combine actions 9, 10, 47, and 59.	10 + 59 to be combined into one action. Keep other actions standalone.	Combined with Draft Action 59.
13	Expand the City's Erosion and Sediment Control requirements to include an assessment of water quality to ensure any groundwater discharged to the sewer system is meeting the requirements of the City's Sewer and Watercourse By-law. Establish a process to monitor and enforce these requirements during construction.	Keep.		Kept, no change.
15	In line with Healthy Waters Plan and Rain City Strategy, develop requirements or incentives for stormwater infiltration on private property in order to enhance groundwater recharge.	Combine actions 15, 18, and 29.	Keep 15, 18 and 29 as standalone actions.	Kept as stand-alone action, no change.
16	Undertake a detailed, city-wide infiltration assessment in order to delineate areas where stormwater infiltration should be encouraged/(or discouraged due to increased risk), and to identify areas that are currently providing significant groundwater recharge.	Combine actions 16 and 104.	16 + 104 to be grouped.	Combined with Draft Action 104.

Unique Action ID number	Draft action	AECOM Proposed Status	CoV Response to Proposed Change	Decision and Updated Status Accepted by CoV
17	Identify ecosystems that are reliant on groundwater and develop a water budget model for them to help determine where and how, these ecosystems should be protected.	Keep.		Kept, no change.
18	Implement a stormwater utility fee with equity considerations to recoup treatment costs, discourage groundwater discharges, and encourage stormwater infiltration.	Combine actions 15, 18, and 29.	Keep 15, 18 and 29 as standalone actions.	Kept as stand-alone action, no change.
19	Quantify the "natural asset" value of local aquifers in terms of water storage and supply, supporting ecosystems, and other municipal services, and incorporate this information into the City's asset management system.	Keep.		Kept, no change.
21	Develop city-wide sustainable performance-based requirements for the to limit the permanent diversion of groundwater into sewers from foundation drains (e.g. a maximum discharge rate of 5 L/min/ha).	Keep.		Kept, no change.
22	Develop a map of groundwater elevation and cross-reference with sewer and drainage infrastructure to highlight areas where I&I is most likely, and should be prioritized for I&I monitoring, and pipe repairs as needed.	Keep.		Kept, no change.
23	Calculate the average volume of groundwater entering the City's sewer system via inflow and infiltration for each sewer catchment area	Keep.		Kept, no change.
25	Work with GRI team to increase water quality monitoring to evaluate the long-term effectiveness of Green Rainwater Infrastructure assets in preventing contaminants (including dissolved phase constituents) from entering groundwater.	Keep.		Kept, no change.
27	Complete an aquifer vulnerability assessment to prioritize actions related to the protection of groundwater quality.	Keep.		Kept, no change.
28	In line with Provincial direction for climate adaption, physically remediate any contamination found in viable groundwater aquifer on City-owned properties to drinking water standards.	Keep.		Kept, no change.
29	Explore and work towards reducing setback requirements related to infiltration to meet Rain City Strategy objectives and enhance aquifer recharge.	Combine actions 15, 18, and 29.	Keep 15, 18 and 29 as standalone actions.	Kept as stand-alone action, no change.
36	Develop a plan to mitigate the risks of encountering flowing artesian conditions within the Well Drilling Advisory Area.	Combine actions 5 and 36.	5 + 36 to be grouped. These actions are dependent.	Combined with Draft Action 5.
38	As part of the development review process, collate any relevant hydrogeological data related to historical streams that could be useful for future daylighting initiatives.	Keep.		Kept, no change.

Unique Action ID number	Draft action	AECOM Proposed Status	CoV Response to Proposed Change	Decision and Updated Status Accepted by CoV
41	Develop a clear governance structure, including channels for efficient communication and data sharing, for managing groundwater-related emergencies incidents (e.g. flooding from flowing artesian conditions).	Keep.		Kept, no change.
43	Explore options for the City to gain permission to use environmental, geotechnical and hydrogeological data received as part of permit applications, to support City initiatives.	Keep.		Kept, no change.
46	Work with other interested parties to establish a forum for the Province, Metro Vancouver, and neighbouring governments including local Nations to share knowledge on key groundwater issues (e.g. aquifer contamination), and to collaborate on solutions.	Combine actions 46 and 54.	Keep 46 and 54 as standalone actions.	Kept as stand-alone action, no change.
47	Conduct a jurisdictional scan to determine potential options for the re-use of foundation drainage water.	Combine actions 9, 10, 47, and 59.	10 + 59 to be combined into one action. Keep other actions standalone.	Kept as stand-alone action, no change.
52	Complete an assessment of the potential extent and magnitude of groundwater rise and saltwater intrusion, induced by sea-level rise.	Combine actions 52 and 92.	52 + 92 to be grouped.	Combined with Draft Action 92.
54	Explore partnership opportunities with local Nations and stewardship groups to protect groundwater-dependent ecosystems, share data and lessons learned, and collaborate on regional biodiversity goals.	Combine actions 46 and 54.	Keep 46 and 54 as standalone actions.	Kept as stand-alone action, no change.
56	Complete an assessment of the potential for an aquifer storage and recovery system to be used in the City as a means of storing excess rainwater for use during times of water scarcity.	Combine actions 56, 71, 109, and 152.	Keep 56 as a standalone action.	Kept as stand-alone action, no change.
58	Explore way to encourage at or above-grade parking (e.g. height or density bonuses).	Keep.		Kept, no change.
59	Support the development of the Rupert and Renfrew Station Area Plan as it pertains to the protection of groundwater and the Still Creek watershed.	Combine actions 9, 10, 47, and 59.	10 + 59 to be combined into one action. Keep other actions standalone.	Combined with Draft Action 10.
60	Develop requirements, including water quality objectives and maintenance requirements, for stormwater infiltration or injection systems to ensure that groundwater quality is protected.	Keep.		Kept, no change.
63	Develop an inventory of contaminants of concern that are either stored at city facilities or released to the environment by City operations, and that could contaminate aquifers.	Combine actions 63, 88, and 98.	63 + 98 to be grouped.	Combined with Draft Action 98.
65	Request that the Provincial government increase their enforcement efforts with regards to laws related to well decommissioning and temporary construction dewatering authorizations.	Keep.		Kept, no change.

Unique Action ID number	Draft action	AECOM Proposed Status	CoV Response to Proposed Change	Decision and Updated Status Accepted by CoV
67	Conduct regular learning sessions with key City departments about the importance of groundwater and how staff can help protect it (e.g. through process changes).	Keep.		Kept, no change.
68	In order to enhance aquifer recharge, explore ways to support Rain City Strategy actions related to implementing innovative Green Rainwater Infrastructure practices at city-owned buildings.	Keep.		Kept, no change.
71	Evaluate the feasibility of using groundwater as an emergency water source.	Combine actions 56, 71, 109, and 152.	71 + 152 to be grouped.	Combined with Draft Action 152.
73	Request that the Province consider the potential for offsite subsidence in geotechnically problematic areas when adjudicating water licenses and use approvals for groundwater extraction.	Combine actions 6 and 73.	Keep 6 and 73 as standalone actions.	Kept as stand-alone action, no change.
74	Following an assessment of extraction potential, apply for a "water reservation" under the Province's Water Sustainability Act to set aside water rights for future City use.	Keep.		Kept, no change.
75	Create outreach programs for the development community on groundwater-related risks (e.g. uncertain water levels, dependent ecosystems, flowing artesian conditions, etc.) as well as best management practices.	Combine actions 75, 78, 82, 150, and 151.	75 should be a standalone action (75 is outreach to developers, whereas the other 5 actions have a more general/public audience.)	Kept as stand-alone action, no change.
78	Explore targeted outreach opportunities (e.g. in schools or at public events) including by partnering with NGOs, local Nations, and/or academic institutions on the importance of groundwater and how to protect it.	Combine actions 75, 78, 82, 150, and 151.	78 + 82 + 150 + 151 + 88 to be grouped.	Combined with Draft Actions 82, 88, 150, and 151.
82	Install signage in high-traffic areas to inform the public on the importance of groundwater, what the City is doing to protect it, and how everyone can play a part.	Combine actions 75, 78, 82, 150, and 151.	78 + 82 + 150 + 151 + 88 to be grouped.	Combined with Draft Actions 78, 88, 150, and 151.
83	Install at least one pumping well in a high profile location to showcase opportunities related to groundwater use.	Keep.		Kept, no change.
85	Explore options to set new requirements for developers to physically remediate contamination found in viable groundwater aquifer to drinking water standards.	Keep.		Kept, no change.
88	Educate residents and businesses about the safe handling, storage, use of common chemicals, and less toxic alternatives to mitigate potential impacts on groundwater (e.g. lawn chemicals, de-icing agents, oil, paint, etc.)	Combine actions 63, 88, and 98.	88 to be grouped with other outreach actions (78, 82, 150, 151).	Combined with Draft Actions 78, 82, 150, and 151.
90	As necessary, assist the Waterworks team in continually updating the Waterworks Emergency Response Plan with details related to new wells that may be used during an emergency.	Keep.	The CoV team has decided that action #90 should simply be deleted, as it is not significant	Removed.

Unique Action ID number	Draft action	AECOM Proposed Status	CoV Response to Proposed Change	Decision and Updated Status Accepted by CoV
			enough to include in the Strategy.	
92	Complete an inventory of City-owned assets that may be vulnerable to groundwater rise or saltwater intrusion, and develop mitigation strategies for those assets.	Combine actions 52 and 92.	52 + 92 to be grouped.	Combined with Draft Action 92.
98	Following the development of an inventory of contaminants used by City operations, research and acquire less toxic but equally effective alternatives wherever available.	Combine actions 63, 88, and 98.	63 + 98 to be grouped.	Combined with Draft Action 62.
100	Define minimum groundwater elevations for the protection of terrestrial groundwater-dependent ecosystems.	Keep.		Kept, no change.
101	Define thresholds for aquatic groundwater-dependent ecosystems that define the minimum acceptable water level (e.g. for wetlands and bogs) and/or flow volumes (e.g. for streams) for the protection of ecosystem health.	Keep.		Kept, no change.
104	Following an assessment to define key aquifer recharge areas, explore options to protect or enhance infiltration in these areas.	Combine actions 16 and 104.	16 + 104 to be grouped.	Combined with Draft Action 16.
109	Assess if and where groundwater can be used to augment our potable water system (e.g. in times of drought).	Combine actions 56, 71, 109, and 152.	This is a duplicate and was supposed to be deleted.	Removed Action.
113	Research the potential impacts of geoexchange systems on groundwater resources and groundwater-dependent ecosystems. As needed, develop tools (e.g. by-laws) and cross-governmental collaboration to mitigate the potential impacts.	Keep.		Kept, no change.
130	Working with Vancouver landfill operations staff, and their groundwater consultants, explore additional measures for the protection of the underlying aquifer, and nearby ecosystems (e.g. Burns Bog).	Keep.		Kept, no change.
135	Build on existing civic water initiatives and apply conservation measures (e.g. water meters, watering restrictions, internal pricing) to all groundwater use.	Keep.		Kept, no change.
139	Where warranted to reduce impacts, consider approaches that reduce the potential for utility trenches to act as preferential pathways that drain groundwater (e.g. seepage collars on utility trenches)	Keep.		Kept, no change.
146	Develop regulations in the Vancouver Building By-law to facilitate the sustainable use of groundwater for non-potable applications.	Keep.		Kept, no change.
148	Identify and transition to firefighting foams that are equally effective, but that do not contain toxic per- and polyfluorinated substances (PFAS) or other harmful chemicals which can accumulate in local aquifers and compromise the health of firefighters.	Keep.		Kept, no change.

Unique Action ID number	Draft action	AECOM Proposed Status	CoV Response to Proposed Change	Decision and Updated Status Accepted by CoV
150	Engage local artists to create groundwater-themed art for public spaces to educate and inspire residents to protect local aquifers.	Combine actions 75, 78, 82, 150, and 151.	78 + 82 + 150 + 151 + 88 to be grouped.	Combined with Draft Actions 78, 82, 88, and 151.
151	Create and maintain a groundwater website outlining what Vancouver is doing to protect local aquifers, minimize groundwater-related risks, and use groundwater resources, and as well as how businesses and residents can do their part.	Combine actions 75, 78, 82, 150, and 151.	78 + 82 + 150 + 151 + 88 to be grouped.	Combined with Draft Actions 78, 82, 88, and 150.
152	Complete an assessment of sustainable extraction potential across the City.	Combine actions 56, 71, 109, and 152.	71 + 152 to be grouped.	Combined with Draft Action 71.
154	Work with other interested parties to ensure that Camosun Bog has adequate groundwater to thrive.	Keep.		Kept, no change.
155	Explore a dedicated long-term funding strategy for City projects that protect and utilize groundwater, and/or minimize groundwater-related risks.	Keep.		Kept, no change.
162	Continue to engage with xʷməθkʷəy̓əm (Musqueam), Skwxwú7mesh (Squamish) and səliwətał (Tsleil-Waututh) to support local Nations' priorities throughout the implementation of the strategy's actions.	Keep.		Kept, no change.
167	Explore possibilities for reducing the use of artificial turf in city-owned facilities, parks, and sports fields where microplastics from the turf can leach into aquifers.	Keep.		Kept, no change.
170	Explore options for the City to acquire a well on City property once it is no longer needed by the well owner.	Keep.		Kept, no change.
173	Explore partnerships with academic institutions to advance the City's understanding of local aquifers and groundwater resources.	Keep.		Kept, no change.
174	Develop a coordinated approach for the City's and Park Board's groundwater extraction activities to ensure critical uses are prioritized, and over-extraction is avoided.	Keep.		Kept, no change.
175	Explore options to clarify design requirements for tanked foundations, foundation drainage systems, groundwater cutoff walls/structures, or performance-based measures (e.g. through the VBBL, EGBC practice advisory, etc.).	Keep.		Kept, no change.

A.3 Finalized Actions

Number	Name	Description	Rationale	Strategy Objective(s)	Type
3	Develop Monitoring Well Network	Develop a monitoring well network throughout the city to determine seasonal and long-term groundwater elevations as well as groundwater chemistry.	Little is known about groundwater elevations or water quality across the city. The data from the monitoring well network will be critical for many other actions in the strategy as the City needs to better understand local hydrogeology to effectively protect and manage it. Data from the monitoring well network (e.g. water levels) would be made publicly available. These data will be used for various purposes, including, for example, assessing extraction potential and infiltration capacities, better understanding groundwater-ecosystem interactions, calibrating models, predicting the impacts of land-use changes, monitoring groundwater-rise, etc.		Foundational
4	Groundwater Model Refinement and Expansion	Refine and expand the existing city-wide hydrogeological model to allow for its use as a decision-support tool for risk mitigation, Area-plan development, ecosystem protection, and utility and city planning.	The City has an existing numerical model that covers the municipality (and slightly beyond). If the model can be refined to improve accuracy, it can be a powerful tool in predicting the impacts of various stressors (e.g. a changing climate, rising sea levels, groundwater extraction, increased imperviousness, additional underground infrastructure, etc.) on groundwater, connected ecosystems, and/or infrastructure. This action will allow the City to compile all the various data it has on local geology and water levels and update the existing model such that it can be used to inform decision-making.	3. Safeguard quality 4. Preserve resources 5. Use sustainably 6. Support ecosystems 7. Reduce risks	Foundational
5	Well Drilling Advisory	Reduce risks related to flowing artesian conditions: A. Work with the Province and other affected local governments to refine the Well Drilling Advisory Area for flowing artesian conditions. B. Develop a plan to mitigate the risks of encountering flowing artesian conditions within the Well Drilling Advisory Area.	Flowing artesian conditions are pressurized portions of aquifers, and wells drilled in these areas can cause serious problems. For example, in 2015 a geoexchange well for a home was drilled by an inexperienced contractor, and this pierced a pressurized (artesian) portion of the underlying aquifer. It took two years and cost the City almost \$12 million to control the flow, and an estimated 3 billion gallons of groundwater were discharged to the sewer system. These pressurized areas are delineated by a Provincial Well Drilling Advisory Area map to help alert developers to the risk. The current advisory area extends from the University Endowment Lands to just west of Coquitlam. The advisory area was defined using a limited amount of available information and could be drastically improved using additional tools (e.g. geophysics). Refinement of the advisory area would improve confidence in the area boundary and would ideally reduce the size of the area itself, potentially reducing costs related to risk mitigation for municipalities and developers. This action would also help identify other requirements the City could implement to reduce the risk from these flowing artesian conditions.	2. Collaborate 4. Preserve resources 7. Reduce risks	A. Actionable B. Actionable
7	Build Data Repository	Composite data from external sources (permit applications) and internal geotechnical data into one repository to improve decision-making for groundwater management.	Current State: The current state of data on groundwater is uncoordinated and patchworked, creating challenges around baselining groundwater to manage it effectively. Internal data needs to be streamlined, and barriers exist around using external data to complete information gaps. Desired Future State: To manage groundwater effectively with sufficient information and clear decision-making tools.	1. Build support 3. Safeguard quality 4. Preserve resources 5. Use sustainably 6. Support	Foundational

Number	Name	Description	Rationale	Strategy Objective(s)	Type
			Gap addressed by action: The data repository will be the first step to developing a baseline characterization of groundwater so that it can be managed to help mitigate risks (such as Beechwood), support core services (such as reducing burdens on sewer system capacity to accommodate growth); and support Vancouver Plan's 100 year ecological vision.	ecosystems 7. Reduce risks	
9	Inventory Groundwater Diversions	Inventory and estimate all known groundwater diversions (e.g. construction dewatering, foundation drains, wells, inflow and infiltration, etc.) to manage risks for existing urban infrastructure and development.	Current State: The City currently has limited information about the quantity of groundwater being diverted from local aquifers, via construction dewatering, foundation drainage, and leakage into sewers. This limits our ability to properly manage and potentially use the resource, due to a fundamental gap in our understanding of its water budget. As most groundwater diversions occurring today are thought to be adding groundwater to the City's sewer and drainage system, this gap also limits our ability to properly manage our infrastructure. Desired Future State: By inventorying groundwater diversions, we can better understand the quantity and locations of groundwater inputs to our sewer and drainage system. This will allow staff to better focus our efforts on limiting these diversions to preserve capacity and will also assist with related technical work such as sewer modeling and planning. This information will also enable the development of a more complete water budget for our aquifers, allowing the City to better understand the potential for groundwater use in the future and to better understand and protect groundwater dependent ecosystems.	1. Build support 4. Preserve resources 7. Reduce risks	Foundational
10	Inform Neighbourhood Planning Initiatives	Undertake groundwater investigations to help inform neighbourhood planning initiatives (e.g. Area Plans) and related building requirements in order to preserve groundwater resources and protect buildings, infrastructure, and groundwater-dependent ecosystems such as Still Creek.	These investigations will help identify areas of concern for groundwater in future neighbourhood planning initiatives and allow the City to implement targeted building requirements there. Depending on the situation, these investigations could be simple desktop exercises, or more detailed investigations (e.g. monitoring well installations) with elaborate decision support tools (i.e. numerical models).	4. Preserve resources 6. Support ecosystems 7. Reduce risks	Actionable
13	Discharge During Construction	Mitigate risks associated with groundwater discharged to the sewer system during construction by ensuring capacity constraints are considered as well as requirements of the City's Sewer and Watercourse By-law. This may include expanding requirements and/or establishing a monitoring and enforcement program.	Groundwater discharges from a site during construction are not currently subject to fees if entering the City's storm system or combined system. The City is paying treatment costs for discharges to the combined system and there are no disincentives against high volume discharges. In addition, the City's Erosion and Sediment Control (ESC) requirements for large lot developments are limited with respect to water quality as only TSS and pH must be monitored and treated, creating a gap in monitoring other contaminants that may pose a potential risk to receiving bodies and exposes the City to liability.	6. Support ecosystems 7. Reduce risks	Actionable
15	Stormwater Infiltration Incentives	In line with Healthy Waters Plan and Rain City Strategy, develop options and incentives for developers to infiltrate stormwater into retention systems on private property to enhance groundwater recharge, and	Current state: The City requires rainwater management for rezoning applications that are subject to the City's Green Buildings Policy for Rezoning, or the Rezoning Policy for Sustainable Large Developments. As of 2024, the VBL requires developers to require rainwater detention into tanks at minimum. Developers have little incentive to explore options for infiltrating rainwater, which is preferable for recharging groundwater. Future State: In line	4. Preserve resources 6. Support ecosystems	Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
		reduce burden on sewer system capacity.	with the Healthy Waters Plan, by 2075, non-sanitary flows (a bulk of which includes groundwater) will only be conveyed in separated storm mains. Until then, if left unchecked, groundwater will continue to burden the City's sewer and drainage system significantly. Stormwater infiltration provides two purposes: it reduces the burden on the City's sewer system by reducing rainwater entering the system, and it recharges groundwater. Providing developers with options and incentives to infiltrate rainwater will reduce treatment costs for the City significantly and maintain groundwater levels to support environmental benefits. Gap addressed: By providing more options and incentives for developers to infiltrate rainwater, such as net zero dedications, the City enables developers to have greater autonomy to choose retention and/or detention practices where possible. These incentives can be developed in consultation with developers.		
16	Enhance Aquifer Recharge	Safeguard groundwater resources by protecting and enhancing aquifer recharge: A. Undertake a detailed, city-wide assessment of infiltration potential to delineate areas where stormwater infiltration should be encouraged and utilize this assessment to quantify (present-day) aquifer recharge for use in developing a water budget and/or numerical model B. Following an assessment to define key aquifer recharge areas, explore options to protect or enhance infiltration in these areas.	Protecting and enhancing recharge areas is critical to preserving aquifer resources. This action will help the City to better understand our ability to manage stormwater through infiltration and potentially identify specific target areas for significant infiltration projects. It will also help identify areas that currently provide significant recharge to local aquifers, possibly resulting in restrictions on development that increases imperviousness in these areas. Assessing recharge across the City will also assist with the development of a water budget and/or refinement of the city-wide numerical model. Current State: Infiltration assessments are completed on a one-off basis, to assess the feasibility for GRI in a particular area. However, this work has not been completed on a city-wide basis. In terms of aquifer recharge, an estimate was developed for the city-wide numerical model that current exists, but presumably this information could be refined with additional detailed work. Desired Future State: A readily available assessment of infiltration potential, in a GIS format, that would allow for a high-level feasibility assessment for GRI projects that include infiltration. Similarly, a GIS layer of present-day groundwater recharge, to be used in developing a water budget and/or refining the existing numerical model.	4. Preserve resources 6. Support ecosystems 7. Reduce risks	A. Foundational B. Deferred - Scope dependent on the results from part A
17	Water Budget for Groundwater Reliant Ecosystems	Identify ecosystems that are reliant on groundwater and develop a water budget model for them to help determine where and how these ecosystems should be protected.	Many ecosystems, such as Still Creek and Camosun Bog are dependent on groundwater to properly function. Several others are suspected of relying on groundwater, but a city-wide inventory of groundwater-dependent ecosystems (GDEs) has not been completed. To protect these ecosystems, we need to first identify them and then understand how they interact with groundwater. With this information, we can predict how different stressors (e.g. increased upgradient imperviousness, new drainage systems or wells, etc.) may impact these ecosystems and take steps to reduce or mitigate these impacts.	6. Support ecosystems	Foundational
19	Aquifer Valuation	Quantify the "natural asset" value of local aquifers in terms of water storage and supply, supporting ecosystems, and other municipal services, and	Traditionally, civic asset management processes have only been applied to engineered infrastructure. However, there is growing evidence that by considering natural assets (e.g. aquifers) within asset management processes, local governments can decrease capital, operations, and maintenance costs,	1. Build Support 3. Safeguard quality 4. Preserve	Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
		incorporate this information into the City's asset management system.	increase levels of service, enhance their ability to adapt to climate change, and reduce the community's unfunded liabilities – all while protecting or enhancing the multitude of other benefits that natural assets bring to communities. The functions that nature provides to communities beyond core services, such as recreation, climate regulation, clean air, habitat, and biodiversity, are invaluable to the overall health and well-being of a community. Therefore, including natural assets in asset management processes provides an integrated approach to maintaining or enhancing the natural assets in a community. Desired Future State: Understand value of aquifers to guide decision-making around infrastructural options.	resources 5. Use sustainably 6. Support ecosystems 7. Reduce risks	
21	Limit Discharge from Foundation Drains	Develop city-wide sustainable performance-based requirements to limit the permanent diversion of groundwater into sewers from foundation drains (e.g. a maximum discharge rate).	Current State: Underground structures, including parkades, require drainage systems to protect them from water ingress and hydrostatic pressures. The groundwater collected by these systems is usually discharged to the sewer system, which not only reduces sewer system capacity, increases treatment costs, and adds to combined sewer overflow (CSO) events, but can also result in other impacts such as reduced baseflow to nearby streams and geotechnical risks (e.g. subsidence). There are currently no incentives in place for developers to limit groundwater discharge. Desired Future State: Incentivize developers and contractors to prevent the loss of groundwater through dewatering. Strategies for developers may include the use of groundwater cut-off walls, tanked building foundations, groundwater discharge fee and reduce below-grade parking. Gap Addressed: This action will help mitigate impacts to the sewer and drainage system by incentivizing developers to limit the amount of groundwater diverted to sewer.	4. Preserve resources 6. Support ecosystems 7. Reduce risks	Actionable
22	Map Groundwater I&I Risks	Develop a map of groundwater elevation and cross-reference with sewer and drainage infrastructure to highlight areas where I&I is most likely, and should be prioritized for I&I monitoring, and pipe repairs as needed.	Inflow & Infiltration (I&I) occurs when rainwater and groundwater are erroneously or unnecessarily directed to sewer pipes. One source of I&I is due to leaking sewer pipes that allow the groundwater to enter the pipe through holes or cracks in the pipe network. This not only reduces sewer system capacity and increases treatment costs and Combined Sewer Overflow (CSO) events but also wastes the groundwater resources. A city-wide, comprehensive I&I monitoring program is very costly. However, by mapping out where City infrastructure is below the water table, it may be possible to prioritize I&I flow monitoring locations. The effectiveness of this assessment may be increased by adding available data on sewer infrastructure that may indicate the likelihood of leaks (e.g. pipe type, age, etc.).	4. Preserve resources 7. Reduce risks	Actionable
25	Evaluate GRI Effectiveness in Preventing Groundwater Contamination	Work with GI team to increase water quality monitoring to evaluate the long-term effectiveness of Green Rainwater Infrastructure assets in preventing contaminants (including dissolved	Green Rainwater Infrastructure (GRI) promotes sustainable urban rainwater management by slowing down and providing retention to rainwater, allowing it to soak into the ground. This helps reduce the volume of water entering our sewer system and increases groundwater recharge. However, stormwater can be contaminated (e.g. on roads, where particles, oil, and metals from brake		Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
		phase constituents) from entering groundwater.	pads mix with rain). While GRI assets often filter out many suspended contaminants, it is unclear which types and percentages of dissolved contaminants are removed. The goal of this action is to develop a comprehensive assessment, potentially including temporary or semi-permanent water quality monitoring, to better understand where treatment effectiveness could be increased via GRI design improvements.		
27	Aquifer Vulnerability Assessment	Complete an aquifer vulnerability assessment to prioritize actions related to the protection of groundwater quality.	The purpose of this action is to develop aquifer vulnerability mapping to inform land use policy and decision making. It will be an invaluable tool to help the City protect local aquifers.	3. Safeguard quality	Foundational
28	Remediation for Future Use	Work with the Province to remediate legacy contamination in areas identified for future use following Provincial direction on making contaminated sites climate ready.	Following completion of an aquifer vulnerability assessment and groundwater use potential assessment, sites suitable for future use will be identified. These sites may include private properties or City-owned properties, and they may be known to have contamination. In many situations, these sites will be remediated based on a risk assessment which often prohibits use of an underlying viable groundwater aquifer as a potable water source. This action entails working with the Province to protect and preserve groundwater resources for future use, in line with current Provincial direction of Making Contaminated Sites Climate Ready: https://engage.gov.bc.ca/govtogetherbc/engagement/making-contaminated-sites-climate-ready/	3. Safeguard quality	Deferred - Scope of remediation is site specific. Type, location, and degree of contamination needs to be determined prior to scoping.
29	Reduce Setbacks for Infiltration	Support other City teams to work towards reducing setback requirements related to infiltration to meet Rain City Strategy objectives and explore enhancing aquifer recharge.	Given the development pressures in the City, every inch of developable space on a property is often used, leaving limited space for infiltration features (e.g. GRI). Additionally, two known setbacks exacerbate this issue by precluding the act of infiltration within a set distance of building foundations (5m for Part 9 Buildings per VBBL 2019) and potable water pipes (3m per Design Guidelines for Drinking Water Systems in British Columbia). This action would seek to further support ongoing work (e.g. Rain City strategy - Pathways Study) that is looking at potential options for relaxing these setbacks, to increase onsite opportunities for infiltration.	4. Preserve resources	Actionable
41	Emergency Response Business Continuity	Develop a clear governance structure specific to emergency response related to groundwater risks.	Current State: In the 2015 Beechwood incident, an inexperienced contractor pierced a pressurized (flowing artesian) portion of the aquifer, leading to several billion gallons of groundwater being discharged. At the time, it was initially unclear which City business units needed to be involved, and this might have led to delays in managing the issue. Desired Future State: Residents, businesses and the general public can rely on the City to coordinate emergency response to groundwater risks efficiently. Gap addressed by action: This action will integrate a clear governance structure for managing these and other types of groundwater emergencies in the existing Emergency Management Plan and Incident Response Guidelines, including channels for efficient communication and data sharing, for managing groundwater-related incidents (e.g. flooding from flowing artesian conditions).	1. Build support 7. Reduce risks	Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
43	Use of Permit Application Data	Explore options for the City to gain permission to use environmental, geotechnical, and hydrogeological data received as part of permit applications, to support City initiatives.	When developers conduct hydrogeological studies, they often install monitoring wells and submit the data to the City. This action would give the City permission to use this data to protect and manage local groundwater resources. Options could include working with the City's Legal Services to identify a solution or lobbying the Province to amend the Groundwater Protection Regulation to require the submission of borehole data and monitoring wells and add them to its GWELLS database.	3. Safeguard quality ⁴ . Preserve resources ⁵ . Use sustainably ⁶ . Support ecosystems ⁷ . Reduce risks	Foundational
46	Collaborative Forum	Establish a forum for the Province, Metro Vancouver, and neighbouring governments including local Nations to coordinate and collaborate to assess and mitigate groundwater-related risks (e.g. saltwater intrusion).	The Province of BC has identified two aquifers beneath Vancouver, both of which extend across multiple other municipalities. As the management of these aquifers are shared by many levels of government (including local Nations and the Province of BC), it makes sense to have a coordinated approach. Key groundwater issues could include drought resilience, land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets and establishing a notification or monitoring system for large (e.g. commercial or industrial) water users. Related to #74 (Water Reservation Application). Desired Future State: This is about bringing stakeholders together to share knowledge and expertise and work together on shared issues.	2. Collaborate 3. Safeguard quality 4. Preserve resources 5. Use sustainably 6. Support ecosystems 7. Reduce risks	Actionable
52	Groundwater Rise	Reduce risks related to groundwater rise, including surface or subsurface flooding: A. Complete an assessment of potential extent and magnitude of groundwater rise. B. Complete an inventory of areas in the City that may be vulnerable to groundwater rise and develop mitigation strategies.	Future State: "Groundwater rise" resulting from increasing sea levels (i.e. due to climate change) can lead to flooding of below ground structures, geotechnical impacts, increased capture of groundwater via drainage systems, surface flooding, and other impacts. There are a number of City-owned facilities (e.g. Kits pool) and other assets (e.g. roads, sewer pipes, etc.) that may be vulnerable to groundwater rise. Desired Future State: Develop mitigation plans for areas vulnerable to 0.5 m and 1.0m sea level rise by the Year 2050 and 2100 (based on Provincial Guidelines) and resulting groundwater rise to provide input into the Fraser River Flood Management Plan by 2030.	7. Reduce risks	A. Actionable B. Deferred - Scope will be dependent on the area of land at risk to saltwater intrusion
54	Partnerships to Protect Groundwater Ecosystems	Explore partnership opportunities with local Nations and stewardship groups to protect groundwater-dependent ecosystems, share data and lessons learned, and collaborate on regional biodiversity goals.	Several ecosystems in the city are believed to be groundwater dependent (GDEs). Many stakeholders and other governments have considerable knowledge and expertise related to the historic and present-day health and well-being of these ecosystems. To better understand and preserve these assets, the City needs to work with these partners towards a shared goal. Regional biodiversity goals could include exploring land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets. Current State: Several ecosystems in the city are believed to be groundwater dependent (GDEs). Many stakeholders and other governments have considerable knowledge and expertise related to the historic and present-day health and well-being of these ecosystems.	1. Build support 2. Collaborate 6. Support ecosystems	Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
			Desired Future State: To support the UNDRIP Action Plan and better understand and preserve natural assets, the City needs to work with these partners towards a shared goal. This might include providing support to local Nations to facilitate participation in partnerships and to develop stewardship monitoring capacity; additionally, indigenous vendors/consultants should be prioritized for related work. To enhance equity, this work should consider the needs of multiple species and be rooted in moving away from City-control of processes.		
56	Managed Aquifer Recharge	Complete an assessment of the potential for Managed Aquifer Recharge, including the potential for aquifer storage and recovery to be used in the city as a means of storing excess rainwater for use during times of water scarcity.	Currently, the city receives too much rainfall in the winter, and not enough in the summer. This situation is likely to worsen as climate change progresses. This action will assess the potential of using local aquifers to store excess rainwater in winter months for use during times of scarcity, much like reservoirs in the North Shore do.	4. Preserve resources 5. Use sustainably 7. Reduce risks	Deferred - Scope and applicability of this action is dependent on the groundwater modeling and identified recharge/discharge zones
58	Reduce Impacts of Parkades	Explore ways to discourage below-grade parking and/or reduce overall impacts of parkades by reducing parkade depths or tanking foundations where groundwater may be encountered.	Current State: Parking and storage is often located in below-grade areas of the development, and depths can be significant. The deeper a development goes below ground, the greater the chances that it will impact groundwater. Groundwater is typically collected in a perimeter drainage system and discharged as waste. Above-grade parking levels may 'count against' the overall FSR (floor space ratio) of a project, resulting in a reduced allowable area for residential or commercial space. Desired Future State: Limit adverse impacts from below-grade development on groundwater. This could be achieved through allowing/encouraging above-grade parking, providing height/density bonuses to developments to make up the loss of below-grade space, and/or setting maximum allowable parkades depths.	1. Build support 4. Preserve resources 6. Support ecosystems 7. Reduce risks	Actionable
60	Requirements for Injection Systems	Develop requirements, including water quality objectives and maintenance requirements, for stormwater infiltration or injection systems to ensure that groundwater quality is protected.	Although relatively rare in Vancouver presently, injections wells may be used to re-inject water (or other fluid) below ground into a porous geologic formation (e.g., groundwater collected via foundation drainage, or as part of an open-loop geothermal system). It may also be used in the future to manage stormwater, in areas with limited sewer capacity. Although the Province has developed BMPs related to water quality, and the Environmental Management Act (EMA) prohibits "pollution," limited guidance exists to ensure groundwater quality is protected. To protect groundwater quality, this action will set water quality guidelines and other requirements for any injection systems implemented in Vancouver.	3. Safeguard quality	Actionable
63	Reduce Contaminants from City Operations	Reduce the risks of groundwater contamination from City operations: A. Develop an inventory of contaminants of concern that are either stored at city facilities or	The City uses several chemicals (e.g. pesticides) and other contaminants (e.g. road salt) in its daily operations, some of which may eventually make their way into local aquifers. This action will identify all contaminants of concern used by the City and Park Board and consider opportunities for less toxic but equally effective alternatives to minimize groundwater pollution. It may also identify	1. Build support 3. Safeguard quality	A. Actionable B. Deferred - Costing will be dependent on the number of identified

Number	Name	Description	Rationale	Strategy Objective(s)	Type
		released to the environment by City operations, and that could contaminate aquifers. B. Following the development of an inventory of contaminants used by City operations, research and acquire less toxic but equally effective alternatives wherever available.	additional measures that may be taken to reduce risks (e.g. secondary containment, education regarding proper use).		contaminants of concern
65	Request Provincial Enforcement	Request that the Provincial government increase their enforcement efforts with regards to laws related to well decommissioning and temporary construction dewatering authorizations.	Despite Provincial legislation, some unused wells are not decommissioned, leading to safety concerns and the potential for contaminants to enter local aquifers via these wells. In addition, the Water Sustainability Act requires that Provincial approval be granted for construction dewatering. The intention of this requirement is to ensure the impacts of these activities on the environment and other water rights holders are assessed. Neither the well closure requirements, nor the requirements for approval to dewater (referred to as Use Approvals), are actively enforced by the Province. As both impact City resources, the intention is to engage with the Province to convey our concerns and seek a commitment for additional efforts to ensure compliance with these requirements.	2. Collaborate3. Safeguard quality	Actionable
67	Internal Education	Conduct regular learning sessions with key City departments about the importance of groundwater and how staff can help protect it (e.g. through process changes).	While the profile of groundwater is gradually increasing within various City departments, there is still a long way to go in terms of raising internal groundwater literacy. This action will involve hosting regular learning sessions with different City business units, particularly those whose work touches on groundwater. The goal will be to foster greater awareness and interest in protecting groundwater (and minimizing groundwater-related risks) through their work. Education should also include awareness of the liability the city carries due to wastewater and groundwater in our sewer system.	1. Build support 7. Reduce risks	Actionable
68	GRI at City-owned Buildings	To enhance aquifer recharge, explore ways to support Rain City Strategy actions related to implementing innovative Green Rainwater Infrastructure practices at City-owned buildings.	As part of the City's efforts to show leadership on water management, this action entails developing internal policy to build and/or renovate future city buildings to manage a certain amount (e.g. 90%) of stormwater through infiltration / Green Rainwater Infrastructure (GRI). This may also include building at least one civic facility to manage all (i.e. 100%) stormwater collected through infiltration. This would demonstrate to others that infiltration is a feasible and affordable means of managing stormwater, with additional co-benefits (e.g. supporting aquifer recharge, supporting ecosystems, etc.), and help generate support for these types of actions by the public who visits the facility.	1. Build support 4. Preserve resources	Actionable
71	Groundwater Use Potential	Explore the potential for the City to use groundwater:A. Complete an assessment of sustainable extraction potential across the City.B. Evaluate the feasibility of using groundwater in the future for non-potable, emergencies, and/or potable use (i.e.	Jurisdictions with multiple water sources that includes groundwater (e.g. San Francisco) have redundancies in terms of their water supply in the event of emergencies (e.g. after earthquakes). Other jurisdictions, including some located with Metro Vancouver, have either considered or installed wells solely for emergency purposes, and there is growing interest in the City to use groundwater for non-potable and even potable purposes. This action would determine the sustainable yield (i.e. how much groundwater can be used	5. Use sustainably7. Reduce risks	A. Actionable B. Deferred - Scope and applicability dependent on results from part A.

Number	Name	Description	Rationale	Strategy Objective(s)	Type
		determine demand and infrastructure requirements).	without depleting the aquifers or causing other adverse impacts) to determine where, how much, and for what purposes groundwater can be used. This would be followed by a demand assessment and subsequently by evaluating the feasibility of adding emergency groundwater supply to Vancouver. This could include such options as installing wells at key facilities (e.g. hospitals), adding wells to our existing water supply system as redundancy, or installing wells in specific areas for specific purposes (e.g. for firefighting). Several scenarios should be considered, such as major disasters (e.g. earthquakes) or more frequent emergencies (e.g. drought or extreme heat). Considerations should include prioritizing new water sources in under-served or otherwise vulnerable areas. The action would also include recommendations related to effective operation and maintenance of these wells when not in use (if used solely for emergencies).		
73	Request Province Consider Subsidence Risks	Request that the Province consider the potential for offsite subsidence in geotechnically problematic areas when adjudicating water licenses and use approvals for groundwater extraction.	Currently, the Province does not consider offsite subsidence when adjudicating water licenses and use approvals, yet groundwater extraction (including for perimeter drainage) can cause subsidence at neighbouring properties as well as City roads and underground utilities. This action will involve lobbying the Province so that they consider these potential offsite impacts.	2. Collaborate 7. Reduce risks	Actionable
74	Water Reservation Application	Following an assessment of extraction potential, apply for a "water reservation" under the Province's Water Sustainability Act to set aside water rights for future City use.	Because the Province's approach to groundwater use is "first in time, first in right" – meaning that during times of water scarcity, licensees with earlier authorization dates are prioritized and entitled to take their full allocation of water before more recent licensees – it is important for the City to engage with the Province to determine how best to secure future water rights. This may be in the form of a water license or a water reservation. This action may also include discussions around prohibiting commercial activities that are reliant on large quantities of groundwater, or that extract and sell groundwater (e.g. water or other beverage bottles). Related to #46 (Collaborative Forum).	5. Use sustainably 7. Reduce risks	Actionable
75	Groundwater Partnerships Plan	Create outreach programs for the development community and industry/businesses on groundwater-related risks (e.g. uncertain water levels, dependent ecosystems, flowing artesian conditions, etc.) as well as best management practices.	Desired Future State: Developers navigate managing groundwater during and post construction with clarity. Background Current State: Vancouver has unique geotechnical conditions that vary between sites that can impact developments, and that developments can impact as well. However, developers and industry members do not always know or understand what best practices exist to manage groundwater to minimize risks, impacts and costs to the environment and their developments. Gap Addressed by Action: By developing digital and development-focused engagement materials, the City can equip developers and industry with the tools they need to manage groundwater effectively so as to minimize impacts, risks and costs. Potential topics include groundwater-related risks (e.g. artificially lowered water levels, drainage-induced subsidence, flowing artesian conditions, etc.), environmental impacts (e.g. to groundwater-dependent ecosystems), as well as best management practices (e.g. site and foundation		Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
			drainage). Desired Outcome: Developers understand the risks, costs and impacts that come with managing groundwater during and post construction and achieve compliance with clarity. Related Actions: Predecessors Successors		
78	Groundwater Public Outreach Plan	Engage with residents and businesses to reduce the impact of groundwater-related risks to the public.	One of the most cost-effective means of protecting groundwater is to educate the public. Currently there is almost no information on the City's website about groundwater, and none that is of much interest to the public. Additionally, there are several ecosystems throughout the city that are either known, or suspected, to be significantly supported by groundwater. The City may also develop educational materials with particular venues or target audiences in mind (e.g. schools, public events), and educate businesses and residents about actions they can take to reduce the contamination of groundwater with commonly used chemicals. Some sites in the city (e.g. civic golf courses, Hillcrest community center) already use some groundwater (e.g. for watering lawns, flushing toilets, etc.), but the public is largely unaware of these initiatives. Public installations including signs and artwork would raise awareness of the city's groundwater resources and create interest in what the City is doing to protect it. A water well would demonstrate the feasibility of using groundwater in emergencies such as earthquakes, and at all other times it would be used for non-potable purposes such as watering parks. Examples may include: A. Explore targeted outreach opportunities (e.g. in schools or at public events) including by partnering with NGOs, local Nations, and/or academic institutions on the importance of groundwater and how to protect it. B. Educate residents and businesses about the safe handling, storage, use of common chemicals, and less toxic alternatives to mitigate potential impacts on groundwater (e.g. lawn chemicals, de-icing agents, oil, paint, etc.). C. Install signage in high-traffic areas to inform the public on the importance of groundwater, what the City is doing to protect it, and how everyone can play a part. D. Engage local artists to create groundwater-themed art for public spaces to educate and inspire residents to protect local aquifers. E. Install at least one pumping well in a high profile location to showcase opportunities related to groundwater use.	1. Build support3. Safeguard quality	Actionable
100	Terrestrial Groundwater Thresholds	Define minimum groundwater elevations for the protection of terrestrial groundwater-dependent ecosystems.	Several terrestrial ecosystems in Vancouver (including parks, street trees, and vegetation on private property) are believed to be dependent on shallow groundwater to survive. This action will help determine the minimum local groundwater elevation that is needed to support these ecosystems, thereby helping to protect them. This action will also support the Urban Forest Strategy.	6. Support ecosystems	Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
			Desired Future State: Provide guidance to developers or staff on groundwater elevations to minimize risk to environment and financial		
101	Aquatic Groundwater Thresholds	Define thresholds for aquatic groundwater-dependent ecosystems that define the minimum acceptable water level (e.g. for wetlands and bogs) and/or flow volumes (e.g. for streams) for the protection of ecosystem health.	Several aquatic ecosystems in Vancouver (including wetlands, bogs, and streams) depend on groundwater. This action will help determine the minimum local groundwater elevation that is needed to support these ecosystems, thereby helping to protect them. Desired Future State: Provide guidance to developers or staff on groundwater elevations to minimize risk to environment and financial	6. Support ecosystems	Actionable
113	Geoexchange Impacts	Develop requirements for geoexchange systems to limit the impact on groundwater resources and groundwater-dependent ecosystems. A. Research and assess known impacts of geoexchange systems and provide recommendations for potential mitigation tools (e.g. by-law requirements). B. As needed, develop and implement tools (e.g. by-laws) to mitigate impacts. May also include cross-governmental collaboration to further mitigate impacts.	Desired Future State: Determine magnitude of risk for thermal pollution and develop plans to mitigate impacts (to aquifers and groundwater dependent ecosystems). While geoexchange systems are currently not very common in the city, their use could expand as developers and homeowners seek opportunities to reduce energy use and greenhouse gas emissions. However, as these systems become more common, there is a risk of thermal pollution of the aquifers, which could have some negative effects (e.g. on groundwater-dependent ecosystems). There is also some concern that geothermal systems can potentially degrade groundwater quality because of coolant fluid leaking underground from a closed-loop system, or because of the water injected back into the geological formations from an open-loop system. This action will research those potential impacts, and ways to possibly mitigate them.	3. Safeguard quality	A. Actionable B. Deferred
130	Vancouver Landfill Considerations	Working with Vancouver Landfill operations staff, and their groundwater consultants, explore additional measures for the protection of the underlying aquifer and nearby ecosystems.	Current State: The City's landfill in Delta currently discharges approximately 2,000 m3 of contaminated groundwater to Annacis Island per day, resulting in significant water treatment costs. Current practical measures to prevent further contamination include a two-ditch system that separates contaminated runoff, as well as a demolition debris land clearing process to prevent contaminated water from infiltrating into the peat area. Desired Future State: While the City's landfill in Delta is run exceptionally well, there may be opportunities to strengthen groundwater protection measures. These measures could exceed Provincial requirements but are important for the City to show leadership with all of its operations, regardless of their location. In addition, these measures can result in minimizing the cost of contaminated groundwater (also known as 'leachate') being sent to Annacis Island for treatment (e.g. options to manage groundwater on-site).	3. Safeguard quality 6. Support ecosystems	Actionable
135	Conservation Measures	Explore opportunities to apply conservation measures to groundwater use	The City has several strong conservation programs to reduce water use in City and Park Board operations; however, given that groundwater use is regulated by the Province, City/Metro Vancouver conservation measures are not applicable to it. To protect the potential for groundwater to provide emergency water supply and/or offset potable water demand, per the City's Drinking Water Demand Strategy, this action will seek a range of tools (e.g. requirements to adhere to summertime watering restriction) to ensure groundwater is available for both human needs and ecological health. These	4. Preserve resources 5. Use sustainably	Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
			measures would also ensure that groundwater-dependent ecosystems are not impacted by unsustainable groundwater extraction. These measures may first be applied to high volume users or high priority areas.		
139	Impacts of Utility Trenches	Develop a BMP to reduce the potential for utility trenches to act as preferential pathways that drain groundwater (e.g. seepage collars on utility trenches).	Excavation backfill in utility trenches can become a preferential pathway for groundwater. In certain situations, these trenches may become unintended drainage systems that stretch over large distances. Where these trenches intercept aquifers, significant loss of groundwater may result. They could also lead to, or exacerbate, the diversion of groundwater to the sewer. This action would identify situations where additional measures may be necessary and propose solutions (e.g. require the installation of seepage collars).	4. Preserve Resources	Actionable
146	VBBL Regulations for Non-Potable Use	Develop regulations in the Vancouver Building By-law to facilitate the sustainable use of groundwater for non-potable applications.	Groundwater in Vancouver could be used for non-potable purposes such as watering green spaces or even flushing toilets, assuming that it is used sustainably and does not deplete the aquifers. Currently, the Vancouver Building By-law (VBBL) does not include groundwater as an approved source of water, requiring that an exemption process (called an "Alternative Solution") be followed if someone wishes to use groundwater for non-potable purposes. If the VBBL could be amended to accommodate groundwater use, it may become more common. Currently, Vancouver Coastal Health and Development, Buildings & Licensing are exploring ways to do this, and the Groundwater Team could assist with this work.	1. Build support 3. Safeguard quality 7. Reduce risks	Actionable
148	Replace PFAS in Firefighting Foams	Support the Vancouver Fire Rescue Services (VFRS) in transitioning to firefighting foams that are equally effective, but do not contain toxic per- and polyfluoroalkyl substances (PFAS) or other harmful chemicals which can accumulate in local aquifers and compromise the health of firefighters.	Many firefighting foams in use today contain toxic per- and polyfluoroalkyl substances (PFAS). PFAS are known as "forever chemicals" and are becoming an urgent global public health issue because they do not degrade and may accumulate in groundwater. The cost of cleanup for known PFAS-contaminated sites is significant (e.g. CFB Comox) and can range to billions of dollars. PFAS are carcinogenic and have many risks to human health. In 2024, the Vancouver Fire Rescue Services (VFRS) spent \$2.8 million to purchase PFAS-free gear [See: https://vancouver.ca/news-calendar/vancouver-protecting-firefighters-with-new-pfas-free-gear-april-2024.aspx]. The next logical step is to replace PFAS-containing firefighting foams. This action would reduce PFAS contamination of local aquifers, protect firefighter health, and show City leadership on this important issue.	1. Build support 3. Safeguard quality 7. Reduce risks	Actionable
162	Engagement with Local Nations	Continue to engage with xʷməθkʷəy̓əm (Musqueam), Skwxwú7mesh (Squamish) and səliłwətaʔ (Tseil-Waututh) to support local Nations' priorities throughout the implementation of the strategy's actions.	Reconciliation is one of the Guiding Principles of the Groundwater Strategy. While the City has made regular efforts to meet with and engage with local Nations on groundwater issues during the consultation phase of the Groundwater Strategy, this action will ensure that engagement continues during the implementation phase of the strategy.	2. Collaborate	Actionable
167	Mitigate Artificial Turf	Work with the Vancouver Park Board to explore opportunities for using alternatives to, or developing mitigation strategies for, artificial turf in	While the use of artificial turf has expanded across the city, there are some concerns over its use. For example, runoff from artificial turf may contain harmful substances such as microplastics, 6PPD, and heavy metals that can migrate into surface waters or groundwater. Moreover, with a short lifespan of		Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
		City-owned facilities, parks, and sports fields where microplastics and 6PPD from the turf can be released to groundwater and surface water.	10-20 years, the turf typically ends up in landfills where it can further break down and can lead to more serious groundwater contamination. This action will explore possibilities for reducing the use of artificial turf in city-owned facilities, parks, and sports fields, or otherwise developing mitigation strategies for managing potential contamination.		
170	Well Acquisition	Explore options for the City to acquire a well on City property once it is no longer needed by the well owner.	The City issues permit to private entities for the use of our road right of ways, for the purpose of installing monitoring wells. These wells are often only needed temporarily and are decommissioned (ideally) when no longer needed. This action will allow the City to acquire a well when it is no longer needed by the well owner, and potentially initiate groundwater monitoring at the well.	1. Build support	Actionable
173	Academic Partnerships	Explore partnerships with academic institutions to advance the City's understanding of local aquifers and groundwater resources.	Build collaborative relationships with academic institutions to develop our understanding of groundwater resources. This may include research or studies as part of students' Capstone projects.	1. Build support	Actionable
174	Coordinate City Groundwater Use	Develop a coordinated approach and decision-making forum between the City and Park Board to manage groundwater extraction activities, ensuring critical uses are prioritized and over-extraction is avoided. Develop decision-making forums to coordinate groundwater use to ensure critical uses are prioritized and over-extraction is avoided.	This action would help facilitate discussions to reach a consensus and have a joint understanding of what activities may use groundwater in the future and establish a coordinated approach to prioritize use and avoid over-extraction. Current consideration for uses include irrigation of park grounds, irrigation of green infrastructure assets, non-potable uses to offset drinking water uses, etc. An example approach would be a decision-making body similar to PIAC (Policy Implementation Advisory Committee). Desired Future State: Using a water budget balance, groundwater use is managed sustainably to ensure availability of groundwater in emergency use cases. An example approach would be a decision-making body similar to PIAC (Policy Implementation Advisory Committee).	1. Build support 5. Use sustainably	Actionable
175	Guidelines for Permanent Groundwater Management Structures	Support development of design guidelines for permanent groundwater management structures with the Province.	The City currently does not have guidelines or set minimum design requirements for permanent groundwater management structures (which include tanked foundations and groundwater cut-off walls). These types of structures are becoming increasingly common in new developments, and there is a level of inconsistency in the designs submitted with development applications and the performance of these features after construction. There is also relatively little guidance available through regulatory authorities (i.e., EGBC) that outlines typical professional responsibilities and sign-off requirements for these types of structures. This action would aim to clarify submission requirements, simplify development review process and improve overall performance of these structures to protect the City from future risks, protect future owners from building enclosure failures, and protect groundwater resources from depletion. This action may include working with EGBC to develop a Professional Practice Advisory related to permanent groundwater management structures, developing minimum submission requirements for development applications	1. Build support 4. Preserve resources 7. Reduce risks	Actionable

Number	Name	Description	Rationale	Strategy Objective(s)	Type
			proposing these features, and/or developing requirements to be included in the Vancouver Building Bylaw (VBBL).		
176	Saltwater Intrusion	Reduce risks related to saltwater intrusion: A. Complete an assessment of the potential extent and magnitude of saltwater intrusion, induced by sea-level rise and other factors. B. Complete an inventory of City-owned assets that may be vulnerable to saltwater intrusion and develop mitigation strategies for those assets.	Groundwater near the coast is naturally saline and the inland extent of saltwater can change over time. This process, known as saltwater intrusion, will occur in Vancouver due to a rising sea level, but the geographical extent and magnitude of intrusion is unknown. Saltwater Intrusion degrades potential groundwater resources and other receptors such as groundwater dependent ecosystems. It can also impact infrastructure, through the process of corrosion. There are several City-owned facilities (e.g. Kits pool) and other assets (e.g. water & sewer pipes, etc.) that may be vulnerable to this increased corrosion. This action will further the City's understanding of where these types of impacts are most likely and will be subsequently used to inventory susceptible infrastructure and other receptors, and to develop a mitigation strategy related to these impacts. To maximize cost-effectiveness, this assessment may also include an assessment of saltwater intrusion induced by reduced aquifer recharge and increased groundwater extraction.	7. Reduce risks	A. Actionable B. Deferred - scope dependent on size of vulnerability area and number of overlapping City assets.
177	Increase Infiltration Through Parks	Infiltrate stormwater into shallow aquifers through available large permeable spaces such as parks.	Current State: Parks currently drain stormwater into the sewer and drainage system. Gap: Draining stormwater from parks into the sewer and drainage systems adds burden to the sewer system capacity, and also misses an opportunity for some of the City's largest permeable spaces to recharge groundwater. Desired Future State: Large permeable spaces such as turf and natural parks are infiltrating into the underlying aquifers.	4. Preserve resources 6. Support ecosystems	Actionable

Appendix **B**

Jurisdictional Scan

Appendix B Jurisdictional Scan

Urban groundwater management is a relatively new area of study in locations that are not dependent on groundwater resources to meet potable, commercial, or industrial needs. However, there is increasing recognition that functional ecosystems and vibrant communities require the preservation and enhancement of natural assets, including groundwater.

AECOM conducted a brief literature review and internal staff poll to identify and summarize initiatives that are being undertaken by other government agencies that could inform the Draft Actions developed for the City of Vancouver. This effort was not intended to be an exhaustive description of global trends, but rather a summary of a range of issues with a broad geographic scope for consideration as the City of Vancouver Groundwater Management Strategy is developed. Many jurisdictions have historically faced different issues (e.g. flooding, drought, etc.), and it is not necessarily the case that one jurisdiction is a leader in all areas covered by a groundwater management strategy and supporting actions.

1. Methodology

1.1 Background Document Review

During the Kickoff Meeting, AECOM was informed that the City of Vancouver had completed or directed other studies with similar focus and provided the results of those assessments for review and consideration. The following studies were reviewed to enhance our understanding of previous jurisdictional scans completed by City of Vancouver, their consultants, or other agencies:

- Gomes, Nathalie F. (2019). Groundwater for Non-Potable Use in Vancouver, BC.
- Dyck, Michaela (2021). Groundwater Management in Vancouver: A Review of Leading Practices for Local Governments
- GHD (2024). Groundwater Discharge Management Review

Gomes (2019), Dyck (2021), and GHD (2024) collectively reviewed the following jurisdictions:

- City of Burnaby, BC, Canada
- City of Chilliwack, BC, Canada
- City of Richmond, BC, Canada
- District of North Vancouver, BC, Canada
- Regional District of Nanaimo, BC, Canada
- Assiniboine Delta Natural Area, MB, Canada
- City of Toronto, ON, Canada
- Region of Waterloo, ON, Canada
- City of Los Angeles, CA, United States of America
- City of San Francisco, CA, United States of America
- City of Portland, OR, United States of America
- City of Seattle, WA, United States of America
- Redmond-Bear Creek Valley (King County), WA, United States of America
- Borough of Islington, England
- London Basin Chalk Aquifer, England

- City of Perth, WA, Australia
- Cockburn, WA, Australia

1.1.1 Water/Groundwater Management Plan Review

AECOM reviewed several Water Management Plans (WMPs) to represent a range of jurisdiction levels, groundwater issues, groundwater uses, and locations. Plans were selected for review based on report comprehensiveness, including whether they included action items, whether they included detailed solutions and mitigation measures, whether the jurisdiction is a known leader in water/groundwater management, and overall readability of the plan. Furthermore, AECOM's Technical Practice Groups involved in hydrogeology, groundwater management, stormwater management and groundwater modelling were polled to identify plans that may be of relevance to City of Vancouver.

Some jurisdictions have a mature framework for the management of groundwater outlined in a Groundwater Management Plan (GWMP) due to reliance on the resource to meet community needs, while other jurisdictions include groundwater considerations in a more generalized WMP. Both GWMPs and general WMPs were considered in this jurisdictional scan. Most jurisdictions already covered by Gomes (2019), Dyck (2021), and GHD (2024) were not reviewed a second time as many are familiar to the Project Team except for the City of San Francisco documents, which were reviewed again.

Canadian GWMPs, WMPs, strategies, and/or policies from the following jurisdictions were selected for review:

- City of Abbotsford and Mission, BC (Golder Associates Ltd., 2012)
- City of Kelowna, BC (City of Kelowna, 2023)
- Okanagan Region, BC (Okanagan Water Stewardship Council, 2008)
- Oxford County, ON (Oxford County, 2024)
- Township of Langley, BC (Inter-Agency Planning Team, 2009)

In the USA, the management of groundwater primarily falls under state jurisdiction. In some states, there is a top-down approach to groundwater management where a state-level agency is responsible for the development of GWMPs; these are often not mandatory unless dictated by the state itself. A bottom-up approach is where legislative or administrative laws designate regional or local-level agencies to be responsible for the formation of groundwater management agencies and GWMPs. In bottom-up mandatory reporting states, it may be legally required for agencies to produce GWMPs. In bottom-up voluntary states, the state may provide an enabling framework that encourages and incentivizes, but does not require, those agencies develop GWMPs. Error! Reference source not found. provides an overview of GWMP reporting requirements across the USA. Even where a GWMP is not required, many states consider groundwater within a WMP. States are not required by the United States Government to produce a WMP.

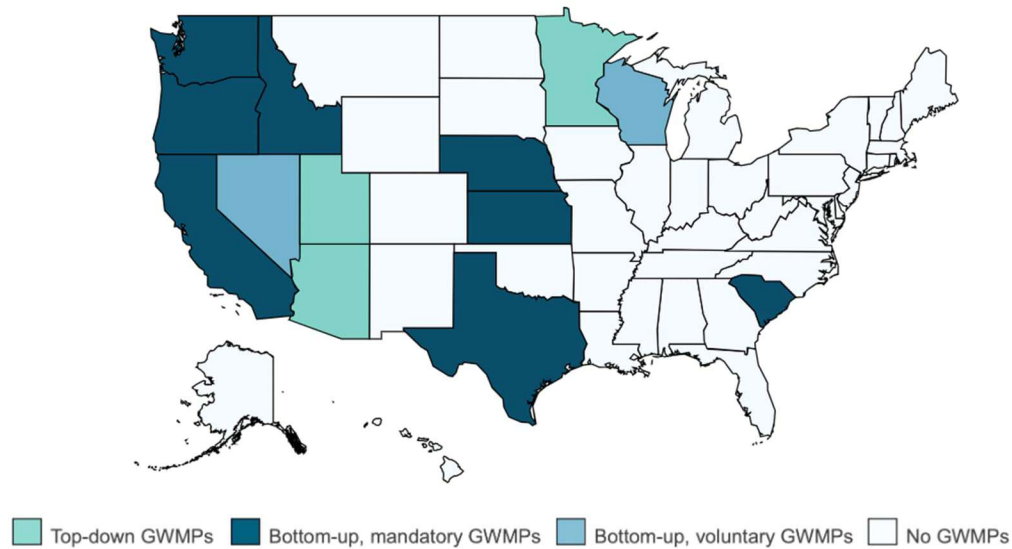


Figure 1.1 Groundwater Management Plan Reporting Within the United States (Milman, 2024).

Reviewed GWMPs and WMPs within the USA included:

- City of San Francisco, CA (San Francisco Public Utilities Commission, 2022)
- Madera Region, CA (Provost & Pritchard Consulting Group, 2014)
- Santa Clara and Llagas Subbasins, CA (Gurdak and Cook, 2021)
- State of California (California Department of Water Resources, 2024)
- State of Colorado (Colorado Water Conservation Board and Department of Natural Resources, 2023)
- Orange County Water District, CA (Woodside et al., 2015)
- Yuba Subbasins, CA (Yuba Water Agency, 2019)

Additionally, the OneWater Nevada and Sustainable Water Initiative for Tomorrow (SWIFT) projects were reviewed as they were suggested as notable water initiatives. The Netherlands WMP (2016) was reviewed due to the country's long history of coastal groundwater resource management and engineering.

The majority of GWMPs and WMPs reviewed from jurisdictions in the USA are in California. California has become a leader in groundwater management practices out of necessity. Even though the City of Vancouver may not be experiencing the same level of groundwater dependence as some of the reviewed jurisdictions, lesson learned from groundwater dependant communities can be used as cautionary tales of inaction and serve as a road map for preventative measures.

1.1.2 Results

1.1.2.1 Commonalities

Many of the jurisdictions and documents reviewed as part of this scan shared the following commonalities:

- 1. Reliance on Groundwater Resources:** Most plans reviewed were produced by/for jurisdictions reliant on groundwater to meet municipal or agricultural water demands.

The City of Vancouver can learn best practices and consequences of inaction from jurisdictions that are groundwater dependant. Developing a groundwater strategy pre-emptively and voluntarily will allow the City to plan for sustainable future groundwater management and avoiding the cost of inaction or mismanagement.

- 2. Clear Rationale for GWMP/WMP:** Many of the reviewed jurisdictions have developed GWMPs/WMPs to manage a multitude of groundwater related risks, protect their natural resources, and mitigate unintended consequences of historic groundwater mismanagement. Jurisdictions with more developed/detailed GWMPs have a long history of groundwater use and mitigating groundwater-related conflicts and risks.

Jurisdictions in California are mandated to have a GWMP by the state of California due to severe groundwater-related risks including water shortage, drought, subsidence, sea level rise, and saltwater intrusion. The City of Vancouver has an opportunity to pre-emptively and voluntarily plan for management of groundwater prior to experiencing costly and severe consequences of inaction that is increasing likely considering future climate and population change.

The State of Colorado cites the complex transboundary water agreements and the substantial population reliant on the Colorado River Basin as primary reasons for developing a WMP to guide water resource management in the future.

- 3. Location Specific Action Items and Mitigation Measures:** Plans are tailored to the specific issues that each jurisdiction faces. Recognizing the key issues addressed in each plan may be useful in identifying the information that is the most relevant to the City of Vancouver as it develops the Groundwater Strategy.

The Colorado Water Plan shares similar action items to the 69 Draft Actions proposed by the City of Vancouver. This plan communicates the action items well and may be looked to as a model when documenting the City's Groundwater Strategy.

- 4. Recognized Need for System Understanding:** Many jurisdictions highlighted the need for deep understanding of hydrologic and hydrogeologic systems prior to engaging in solutions/mitigation measures. It is difficult to manage a system that has not been characterized and may not be monitored as there is no baseline reference condition, and the impact of actions cannot be gauged.

- 5. Plan Tailored to Target Audience:** Identification of the target audience can guide the content and detail that is included in a GWMP/WMP. Most of the reviewed plans were developed for the jurisdictions own use and future guidance. These plans often included action items or recommendations.

Plans developed for regulators were primarily produced by municipalities or regional water authorities where there is a bottom-up mandatory approach to groundwater management. These plans were commonly formatted in a report style and included more technical information. Examples of plans developed for regulators include the Orange County Water District plan and the Yuba Subbasins Water Management Plan.

The Colorado Water Plan and The Netherlands National Water Plan had additional documents tailored to lay audiences. These documents were generally a few pages in length and provided clear graphics for communication. The Colorado Water Plan also outlined specific actions that the public can take to support water resource management.

1.1.2.2 Noteworthy Initiatives

During the literature review, noteworthy initiatives or findings from other jurisdictions were identified to support/guide the Draft Actions and the Implementation Plans that will be developed during Phase 2. Select notable initiatives and guidance documents identified in previous jurisdictional scans (Gomes, 2019; Dyck, 2021; and GHD, 2024) are also reiterated here where appropriate. All initiatives in this section are discussed according to the status (proposed, active, etc.) at the time of the plan publication.

- 1. Aquifer Recharge:** Aquifer recharge initiatives can be classified under several names with nuanced definitions including:

- Managed Aquifer Recharge (MAR): MAR is the purposeful recharge of water to an aquifer for subsequent recovery or environmental benefits. The primary goal of MAR initiatives is to manage groundwater levels, which can include storing water for future use or replenishing an aquifer without necessarily intending to extract it later.

Types of MAR include dry well, percolation tank, rainwater harvesting, filtration, infiltration gallery, dune filtration, infiltration pond, soil aquifer treatment, and recharge release.

- Aquifer Storage and Recovery (ASR): ASR is a type of MAR initiative that uses a well to inject water into an aquifer and subsequently recovery the water from the same well. The primary goal of ASR is to maintain water levels

- Aquifer storage, Transfer, and Recovery (ASTR): ASTR is a type of MAR initiative that injection water into a well for storage in an aquifer and recovery from a different well. This is generally used to provide additional water treatment.
- Enhanced Aquifer Recharge (EAR): EAR and MAR are often used interchangeably. However, EAR is a more generally used term to describe any method of boosting natural aquifer recharge with MAR typically indicates a planned and monitored water management approach. EAR is used more commonly in specific context of utilizing stormwater runoff to recharge aquifers whereas MAR utilizes a wide range of water sources like treated wastewater and agricultural runoff.

Compared to Green Rainwater Infiltration (GRI), EAR is a broader term encompassing various methods to intentionally increase aquifer recharge through human intervention, including specialized infrastructure like injection wells. GRI primarily focuses on plant-based systems that mimic the natural infiltration process.

In 2021, the US Environmental Protection Agency (EPA) published a review of Enhanced Aquifer Recharge (EAR) using stormwater (US EPA, 2021). Although this report summarizes the current state-of-the-science of information leading to best practices for EAR using stormwater, it also recognizes that EAR using stormwater is still relatively uncommon. To our knowledge, EAR and MAR have not been used as a mechanism for stormwater disposal without the fundamental and primary purpose of maintaining groundwater levels. Common reasons for using MAR to support sustainable urban water management include:

- Enhancing urban economies (e.g., via horticultural production)
- Enhancing urban water supply security
- Preventing saltwater intrusion in coastal aquifers
- Providing storage without loss of valuable land surface area
- Reducing evaporation of stored water
- Maintaining Environmental Flows and groundwater-dependant ecosystems, which improve local amenity, land value, and biodiversity

Many of the jurisdictions reviewed in this scan are groundwater-reliant for potable and non-potable water and have undergone or are preparing for water scarcity. As such, the reviewed MAR initiatives primarily use highly treated wastewater for recharge rather than stormwater since these initiatives are typically taking place in water-scarce regions.

- The Sustainable Water Initiative for Tomorrow (SWIFT): The Sustainable Water Initiative for Tomorrow (SWIFT) takes highly treated wastewater (blackwater) that would otherwise be discharged into rivers and puts it through additional rounds of advanced water treatment to meet drinking water quality standards. This water is then added to the Potomac Aquifer, a coastal plains aquifer experiencing land subsidence, sea level rise, and saltwater intrusion that is the primary source of groundwater throughout eastern Virginia. Recharge into the Potomac Aquifer through the SWIFT program is currently set at one million gallons per day. This is a multiyear, \$2 billion initiative.
- OneWater Nevada: Recycled water from the Reno-Stead Water Reclamation Facility goes through multiple, additional treatment steps for further purification to meet or exceed Federal and State drinking water standards. The purified water is used to replenish the underlying aquifer and maintain groundwater levels.

OneWater Nevada is testing an Advanced Purified Water Facility at American Flat. Initially, the extracted water will be used for irrigating the American Flat alfalfa fields and later will be used to augment regional drinking water supplies. The 2023 cost estimate for the Advanced Purified Water Facility at American Flat is approximately \$125 million. It will be funded by the OneWater Nevada partners, who have been pursuing State and Federal grants and low-interest loans to help offset costs.
- Orange County Water District: The Groundwater Replenishment System is a recycled water purification system in operation since 2008. Wastewater that would otherwise be discharged to the Pacific Ocean is purified using a three-step process (microfiltration, reverse osmosis, and advanced oxidation/disinfection) to produce high-quality water used to recharge the groundwater basin and for injection into the Talbert Seawater Intrusion Barrier with the primary goal of reducing saltwater incursion. When first completed, the plant produced up to 70 million gallons per day of product water.

- Santa Clara and Llagas Subbasins: The Los Gatos Recharge System (LGRS) is planned to generate up to 14,000 AF/year (17 million m³/year) of potable water reuse (blackwater) for recharge using advanced water purification processes, including microfiltration, reverse osmosis, and advanced oxidation (ultraviolet light-peroxide). The project would provide a locally controlled, drought-resilient source of purified water for the Santa Clara Subbasin. Two-thirds of the managed recharge occurs through in-stream recharge facilities along more than 91 miles of stream channel. Over 60,000 AF (740 million m³) is recharged from releases into creeks in most years. Valley Water, the state-appointed water authority for this redoing, has allocated funding for additional fish barrier removal projects and has been collecting habitat and fish data to further support fish and aquatic habitat restoration in Coyote Creek, Guadalupe River, and Stevens Creek watersheds.
- State of California: Flood-managed aquifer recharge (MAR) uses flood water resulting from rainfall or snow melt for MAR on agricultural lands and working landscapes. The Department of Water Resources encourages Flood-MAR practices at multiple scales, from individual landowners diverting flood water with existing infrastructure, to using extensive detention/recharge areas.

2. Drought Management: Drought management initiatives are important in the context of groundwater supply considering previous local droughts and Vancouver's reliance on regional surface water reservoirs that require replenishment by snowmelt during spring and summer months. Changing snowfall patterns in response to climate change combined with population growth may increase pressure on existing surface water resources. Although seismic upgrades to water conveyance systems are underway, it is also possible that the drinking water supply would be impacted during an earthquake. On the Sunshine Coast, groundwater resources extracted from the Church Road Well Field were relied upon to supplement surface water supply during the severe drought causing Stage 4 water conservation efforts in the fall of 2022. The Chapman Water System, which supplies water to 90% of the Sunshine coast population, is now supplemented by groundwater from the Church Road Well Field for drought management. Many of the reviewed jurisdictions are in drought prone areas that necessitate advanced drought management plans.

- Orange County Water District: Groundwater production and pumping rates are set annually to increase or decrease groundwater storage levels as needed in response to hydrological conditions. The primary mechanism used to manage pumping is the Basin Production Percentage, a percentage of each Producer's water supply that comes from groundwater pumped from the basin. The Basin Production Percentage is set on an annual basis and is uniform for all producers. Groundwater pumping above this percentage is assessed and an additional charge is applied that creates a disincentive for over-producing.
- Santa Clara and Llagas Subbasins: Since 1996, imported water is stored and used for in-lieu and managed recharge in the Semitropic Groundwater Bank (Semitropic Bank) for withdrawal when needed. The Semitropic Bank provides a place to store surplus water supplies that may be inexpensively secured in wet years for later withdrawal and use in dry years. Water may also be stored and retrieved in the same year depending on operational needs.

Storage in the bank occurs when water is physically delivered to recharge ponds in the Semitropic Bank service area, or when surface water deliveries are used by landowners overlying Semitropic's service area in-lieu of local groundwater pumping. Therefore, return of stored water is accomplished by exchanging water rights or by Semitropic physically pumping groundwater into the California Aqueduct conveyance system for use by contractors downstream.

In the critically dry year of 2021, for instance, the regional water authority, Valley Water, purchased 58,000 AF (71.5 million m³) to maintain treatment plant deliveries and recharge to protect groundwater levels and reduce the risk of land subsidence.

- State of Colorado: A drought resiliency toolkit and a drought-ready community framework is planned to support local planning and to guide local community discussions on water security, drought planning, and risk-mitigation projects. The framework will outline best practices for drought planning and recovery.

3. Education and Outreach: Education is an important part of making stakeholders and the public aware of groundwater and its relevance to urban areas. Several jurisdictions invest heavily in education and outreach, with some notable examples provided below.

- State of Colorado: 50 Partner Actions were identified as examples of opportunities for individuals and communities to help achieve the overall vision set out in the Colorado water plan (a WMP). The Partner Actions are communicated in the form of a pamphlet which outlines how each action will be funded.

Intermittent surveys gauge public understanding and help guide education/outreach needs around water issues. These surveys started in 2013. In the fall of 2021, a new survey was released to help gauge change in perceptions over time.

The Water Plan Grant Program supports a holistic view of watershed health in terms of recognizing and funding environmental, watershed, and recreational projects. A capacity-building hub will be created to provide accessible educational opportunities. An interactive online education resource can help reduce access barriers to water education. The hub will reinforce topics that are foundational to the Water Plan. The hub will provide training modules and resources that can be expanded over time. A statewide education and outreach campaign will be developed and branded to help reinforce the critical issues and opportunities that the Colorado Water Plan brings to light.

An interagency environmental justice and equity working group focused on identifying tools to support disproportionately impacted communities. One example of this type of mapping tool is the Colorado EnviroScreen tool, which is an interactive environmental justice mapping tool that identifies communities with the greatest environmental health risks statewide.

A series of contests or "innovation challenges" will be convened for each of the four action areas of the Water Plan: Thriving Watersheds, Robust Agriculture, Vibrant Communities, and Resilient Planning. The goals of these challenges will be to mobilize local partners, inspire and elevate innovative approaches, encourage use of grant programs, and foster implementation of Water Plan actions. Coalitions for each innovation challenge will be strategically built to identify partners, designate appropriate funding, leverage grant funding, or otherwise support and develop the contest scope.

- Madera Region: Public education will be provided to raise awareness of groundwater conditions, preparation for the next drought, better understanding of water resources, and causes and impacts of subsidence. A major focus of outreach programs will be on K-12 education.
- Santa Clara and Llagas Subbasins: A full range of educational programs is offered for both teachers and students. From puppet plays for kindergarteners to workshops for educators, school outreach projects provide effective, hands-on learning experiences. Through educational programs, students can tour a groundwater recharge facility, create a simulated pond or explore the plant and animal life in a creek. All activities are geared for specific grade levels, from pre-kindergarten to college. Groundwater Awareness Week is celebrated as an annual observation of the importance of groundwater. Pamphlets, fact sheets, and summary reports are prepared to help transmit key messages related to groundwater.

The Groundwater Guardian Program is sponsored by the Groundwater Foundation, a not-for-profit education organization that strives to increase groundwater awareness. Groundwater Guardian is an annually earned designation for communities and affiliates that take voluntary, proactive steps toward groundwater protection.

- The Netherlands: The 'Our Water' public awareness campaign (www.onswater.nl) is a publicity campaign designed to increase water awareness among the Dutch population, explain the need for new investment, and increase the involvement of people and their ability to cope. Using the "am I being flooded" app, people can discover the water levels around them and the action that should be taken. Encouraging schools to pay extra attention to water in a water education program helps bring awareness at an early age.

4. Emergency Water Supply: Meeting community water supply needs in response to an emergency is detailed for one community. Several local initiatives in British Columbia are actively pursuing, or have pursued, groundwater to meet post-disaster potable water needs; these initiatives include emergency water for the University of British Columbia, the City of Surrey, and the University Endowment Lands administered by the provincial government.

- City of San Francisco: The Groundwater Supply Project has six wells where groundwater is/can be extracted, disinfected with chlorine, and pumped to be blended with surface water in a reservoir. One of the wells has onsite disinfection and is connected to a hydrant to fill water trucks in case of an emergency.

5. Financial Considerations: Groundwater management actions can be costly to implement. To ensure the strategy is appropriately funded, the following communities have made noteworthy efforts to fund groundwater management initiatives.

- Orange County Water District: The annual operating budget and expected revenues for FY 2014-15 were approximately \$134.4 million. This includes a budget of \$26 million to purchase imported water for recharge. Revenue sources include assessments to groundwater producers, property taxes, grants, and low-interest

loans. A comprehensive long-range debt program provides funding for projects necessary to increase basin production and protect water quality.

The District holds very high credit ratings of AAA from Standard & Poor's, AAA from Fitch, along with an Aa1 rating from Moody's. Because of these excellent credit ratings, the District can borrow money at a substantially reduced cost. The District has over \$908 million in existing assets. The Replacement and Refurbishment Fund was established to ensure that sufficient funds are available to repair and replace existing District infrastructure, such as pumps, heavy equipment, wells and water recycling facilities.

The District receives a small percentage of property taxes, also referred to as ad valorem taxes, collected in the service area. Orange County assesses and collects these taxes and transmits them to the District at various times during the year. This revenue source has been dedicated to the District's annual debt service expense.

Cash reserves generate interest revenues. Most cash reserves are invested in short term securities. Miscellaneous revenues are primarily comprised of water sales from the Green Acres Project and loan repayments. The loan repayments originate from the Conjunctive Use Well Program in which the District loaned Producers money at low interest rates for construction of new production wells and related facilities. In addition, numerous small items such as rents, subsidies and minor fees are grouped in this account.

- Santa Clara and Llagas Subbasins: Under the pooling approach, water is considered a single commodity irrespective of the water's source or costs since all users benefit from the availability of multiple sources of water. The costs of the treated water facilities are pooled with all other costs within the zone of benefit and recouped primarily through the basic charge assessed on all groundwater pumped from the Santa Clara and Llagas subbasins. Treated water retail customers who receive treated imported surface water pay the same charge that municipal and industrial groundwater pumpers pay per unit volume of water extracted as well as an additional treated water surcharge.
- Yuba Subbasins: Agency estimates a cost of \$1 million to \$1.5 million per year to implement their Groundwater Strategy Plan (rough costs estimates of approximately 25 actions are provided in Table 6-1 in the Yuba Subbasins Groundwater Strategy Plan). Some of these costs are already being incurred through existing groundwater management. The implementation of the plan, including projects and management actions, will be funded through available grant funding as well as existing revenue streams.

6. Green Rainwater Infrastructure: Some systems have the objective of reducing combined sewer overflows (CSOs) and the other objectives are focused on maintaining the function of the natural hydrologic system. Many communities are requiring new developments no increase to pre-development peak discharge rate across the Lower Mainland, British Columbia and elsewhere. The goal of maintaining the function of natural hydrologic system is to maintain recharge to the underlying aquifers, reduce runoff flows to sewer infrastructure and improve water quality.

- Township of Langley: Proposed to mandate new developments to maintain their pre-development infiltration rates.

7. Groundwater Quality: Several initiatives are focused on preserving or enhancing the quality of groundwater in the aquifers. This is particularly challenging in urban or developing areas, where potential sources of contaminants are abundant and include hydrocarbons, chlorinated solvents, road salt, metals, nutrients, bacteria and others.

- City of Abbotsford and City of Mission: Development of a contaminant inventory is recommended before decision concerning groundwater quality protection can be made. Inventories should be conducted at a regional scale, within individual capture zones, and at wellheads to identify potential threats. Preliminary capture zone analysis was conducted for municipal water wells using analytical methods in 2010.
- Orange County Water District: The Orange County Water District lacks the regulatory authority to require responsible parties or potentially responsible parties to clean up pollutants that have contaminated groundwater. In some cases, financial incentives are used to encourage pumping and treatment of groundwater that does not meet drinking water standards to protect water quality by reducing the spread of poor-quality groundwater.

8. Monitoring, Data Management, and Data Sharing: Monitoring programs are required to monitor groundwater conditions and make sound decisions regarding groundwater resource management. These programs generate large volumes of data that must be preserved for future review and use. A centralized database offers the opportunity to enforce quality control in a consistent manner.

- Madera Region: The Indian Wells Valley Cooperative Groundwater Management Group is a public water data-sharing group that was formed to coordinate efforts, share data, and avoid redundant efforts. The group consists of most of the major water producers, other government agencies, and concerned citizens.
- Orange County Water District: Annual samples are collected from approximately 400 District-owned monitoring wells and 220 privately and publicly owned drinking water wells. These samples were analyzed for groundwater elevation and water quality. All data pertaining to well information, sub-surface geology, water levels, and water quality is stored within a database managed by the District.

Continual monitoring of groundwater near the coast is done to assess the effectiveness of the Alamitos and Talbert Barriers and track salinity levels in the Bolsa and Sunset Gaps (see the Saltwater Intrusion and Barrier Management Noteworthy Initiatives for additional context). Over 425 monitoring and production wells are sampled semi-annually to assess water quality conditions during periods of lowest (winter) and peak production (summer).

- Santa Clara and Llagas Subbasins: Pressure transducers and data loggers in 87 wells throughout the Santa Clara and Llagas subbasins measure water levels daily and electric sounder readings are taken monthly. Telemetry equipment has been installed at 23 of these locations, covering 34 wells since some locations have multiple wells, allowing remote data retrieval over the cellular phone network. The groundwater quality monitoring network in the Santa Clara Subbasin comprises 52 wells with samples from all groundwater quality monitoring wells collected annually in the fall. Groundwater level data collected in the field is validated prior to database upload. New measurements are compared to historic water levels as an initial screening criterion. The database is an industry standard enterprise system with limited write access and uses standard data validation and integrity protocols.
- State of California: The Groundwater Ambient Monitoring and Assessment (GAMA) program consists of a spatially distributed network to produce data sets that address basin scale objectives and assessments. GAMA networks rely primarily on existing public supply wells, with other types of wells (irrigation, domestic supply, or monitoring wells) sampled as necessary to achieve the required spatial distribution.

The Domestic Well Project collects samples from private wells on a county level. This program is offered free to well owners who volunteer and the water quality data is placed on GeoTracker GAMA without well owner identification. Geo Tracker GAMA is an on-line database providing water quality data from various sources on an interactive Google-based map. The goal of this system is to provide a centralized system that is available to the public and decision makers. The Priority Basin Project initially focused on assessing the deep groundwater resource that accounts for over 95 percent of all groundwater used for public drinking.

- State of Colorado: Reviews were conducted of the reporting database, key data sets that are most critical, and ways that data can be more seamlessly integrated into updates for both water efficiency plans and drought plans. Guidance documents were evaluated to streamline information in ways that increase utility participation and allow for better coordination of grant and outreach opportunities.

9. Non-Potable Groundwater Use and Conservation: The following initiatives outline how other jurisdictions have conserved potable water resources. Because many of these jurisdictions are reliant on groundwater as a primary water source, general water conservation methods are beneficial for reducing groundwater use.

In the City's case, it has been suggested that potable water conservation initiatives do not necessarily reduce groundwater consumption since non-potable groundwater is often seen as a free resource and used as a direct substitute for potable water. In line with the City's One Water strategy, it is suggested that messaging surrounding conservation efforts should focus on reducing overall water consumption rather than only reducing potable-water consumption. This may provide an opportunity for focused education and outreach. For reference, the William J. Worthen Foundation published an Onsite Non-potable water Reuse Guide for how to incorporate non-potable water into design, operations and maintenance of projects (William J. Worthen Foundation, 2018).

- City of San Francisco: Non-potable groundwater is used for filling lakes in parks, golf clubs, cemeteries, and the zoo.

- Madera Region: A conservation voucher/rebate program will be implemented for low flow plumbing fixtures, smart irrigation controllers, turf removal, and replacement with drought tolerant vegetation.
- Orange County Water District: The Green Acres Project has been operational since 1991. This is a non-potable recycled water supply project that utilizes a dedicated set of pipelines to deliver irrigation and industrial water to users. The secondary wastewater effluent is filtered and disinfected with chlorine to produce irrigation and industrial water. Most of the recycled water is used on golf courses, greenbelts, cemeteries, and nurseries.

A restaurant water conservation program offered free laminated cards for restaurants to place on their tables. The cards inform patrons that water will be served only upon request. This encourages environmental awareness and water and energy conservation.

- Santa Clara and Llagas Subbasins: Approximately 33,000 AF/year (40 million m³/year) of demands are projected to be met with non-potable recycled water by 2040. The Silicon Valley Advanced Water Purification Center will produce up to 8 million gallons of purified recycled water a day through microfiltration, reverse osmosis, and ultraviolet disinfection. Water from this facility is blended into existing recycled water provided by South Bay Water Recycling to improve overall recycled water quality for irrigation and industrial purposes.

Nearly 20 different water conservation programs have been implemented using a mix of incentives and rebates, free device installation, home visits, site surveys, and educational outreach to reduce water consumption in homes, businesses, and agriculture. Recent program expansion includes a new gray water system rebate program and increased rebates for turf removal. These programs are designed to achieve sustainable, long-term water savings and are implemented regardless of water supply conditions. Valley Water's conservation program saved an estimated 76,000 AF (94 million m³/year) of water in 2019.

- Township of Langley: The Township of Langley proposed to expand xeriscaping using a variety of indigenous and drought-tolerant plants, shrubs, and groundcover.

10. Saltwater Intrusion and Barrier Management: The aquifers underlying Vancouver are bounded to the north, west and south by the Pacific Ocean and saline portion of the Fraser River, making coastal groundwater resources susceptible to sea level rise and saltwater intrusion.

- Madera Region: The Madera Region currently does not have any saltwater intrusion measures but plans to require, through the well permitting process, the use of geophysical surveys in all new boreholes that have the potential to encounter saline water. This will enhance groundwater protection by identifying the aquifer zone(s) with elevated concentrations of specific conductance, as well as the depths of confining layers, to design adequate sanitary/annular seals.
- Orange County Water District: Monitoring initiatives are in place to detect the encroachment of seawater into fresh groundwater zones along the coast spurred by overdraft, which has lowered the water table up to 12 m (40 ft) below sea level. The Alamitos Seawater Intrusion Barrier includes 43 injection wells and 177 active monitoring well sites. The Talbert Seawater Barrier is composed of a series of 36 well sites that are used to inject an average of 36,000 AF/year (44 million m³/year) of water into four aquifer zones to halt seawater intrusion through the Talbert Gap, a 2.5 mile geological feature between the Newport and Huntington Mesas.

Because Santa Ana River water is a major source of recharge for the basin, salt management programs in the upper watershed are vital to protect the water quality in Orange County. Recharging the Orange County Groundwater Basin with recycled water produced is expected to reduce salinity levels over the long-term. To reduce the level of nitrate in Santa Ana River water, an extensive system of wetlands in the Prado Basin is operated. Approximately half of the non-storm flows of the Santa Ana River are diverted through the wetland ponds that remove approximately 15 to 40 tons of nitrates a month, depending on the season.

- Santa Clara and Llagas Subbasins: The managed recharge program is critical to maintaining adequate artesian pressure in the principal aquifer zone underlying the southern portions of the Bay, which helps prevent seawater intrusion. Historically, an extensive program of locating and properly destroying old and abandoned wells in the northern Santa Clara Subbasin along the Bay was conducted so that these wells would not act as conduits for seawater intrusion from the shallow groundwater down to the principal aquifer. The Subbasins have the authority to require owners of wells determined to be "public nuisances" to seal and destroy the wells or upgrade them to active or standby status.

- The Netherlands: There are several sand-nourishment initiatives throughout the Netherlands to counteract flooding due to sea level rise. The Sand Engine was a large-scale sand nourishment pilot project located along the Dutch coastline to reinforce local coastal defence structures. Model simulations completed in Huizer et al. (2016) showed that the Sand Engine would result in substantial growth of fresh groundwater reserves through building sand dunes along the coastline. The model also showed increased groundwater head within these dunes were effective at reducing saltwater intrusion.

11. Subsidence: Land subsidence occurs naturally and in response to groundwater abstraction or changes in water levels within loose, unconsolidated or compressible soils.

- Madera Region: The Region has had significant subsidence issues due to groundwater withdrawals since 1926. The subsidence impacts groundwater storage capacity, water-delivery canals, and flood control. The overarching and highest-priority goal is to stabilize the groundwater levels by 2024, by approximately 250,000 AF/year (308 million m³/year). Currently, subsidence data is obtained twice yearly in December and June. Maps of the results are published in January and July as part of the San Joaquin River Restoration Project. Subsidence data is collected from surveying, extensometers, continuous global positioning satellites, interferometric synthetic aperture radar (InSAR), and LiDAR. Policies for new well permits in the proximity of the subsidence area will require wells to be constructed so they extract from the upper aquifer only and limit the deep well extractions.
- Orange County Water District: Subsidence in this area occurs in swampy low-lying coastal areas due to changes in groundwater conditions. InSAR data collected from satellites and data collected by the Orange County Surveyor show that ground surface elevations in Orange County both rise and fall in response to groundwater recharge and withdrawals. The subsidence is variable and does not show a pattern of widespread irreversible permanent lowering of the ground surface. There is little potential for future widespread permanent, irreversible subsidence due to sustainable groundwater management and policy of maintaining groundwater storage levels within a specified operating range. Nevertheless, the District annually reviews survey data to evaluate ground surface fluctuations within the District's service area.
- Yuba Subbasins: Land subsidence monitoring is conducted through surveying of a network of monuments. The surveying process allows for demonstration of the rate and extent of land subsidence. Available data shows that inelastic land subsidence due to groundwater withdrawal is not an issue in the Yuba Subbasins.

12. Water Budgets and Modelling for Decision Analysis: Many communities have developed water budgets and completed groundwater modelling to support management of groundwater. Evaluations range from scoping level to detailed assessments.

- Orange County Water District: The District has a regional scale, transient MODFLOW model with solute transport (MT3DMS) that is used to perform various basin production, recharge, and saltwater intrusion scenarios. There are also smaller models made for the Talbert Gap and Alamitos Barrier.
- Santa Clara and Llagas Subbasins: A periodic water balance is performed to reconcile all measured imported water, reservoir inflows and releases, and changes in surface water storage. The results of this balance become the final accounting for distribution and facility processing. The data is used for water rights reporting, accounting for usage of federal water, for facility performance measurement purposes, and for the groundwater subbasin water budget.

Three numerical models are maintained to support operational decisions and long-term water supply planning: two for the Santa Clara Subbasin (one for the Santa Clara Plain and one for Coyote Valley) and a separate model for the Llagas Subbasin. These models are used to evaluate and forecast groundwater storage and water levels under various operational and hydrologic conditions. Maintaining calibrated models that can reasonably forecast groundwater conditions is an important part of the comprehensive Groundwater Management Strategy.

Appendix **C**

Dependencies

- C.1 Draft Action Dependencies First Draft and Provided Feedback
 - C.2 Draft Action Dependencies Second Draft and Provided Feedback
 - C.3 Finalized Action Dependencies
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Appendix C Dependencies

C.1 Draft Action Dependencies First Draft and and Provided Feedback

Draft Action	Dependency 1	Dependency 2	Dependency 3	Feedback from the City on Proposed Dependencies
3. Develop Monitoring Well Network	155. Long-term Funding Strategy			No - short-term funding is already available for this project
4. Groundwater Model Refinement & Expansion	3. Develop Monitoring Well Network	7. Evaluate Data Management Options	43. Permit Application Data Permission	3 - Yes 7 - No, nice to have but not critical. Subject action could proceed w/o this action. 43 - No, nice to have but not critical. Subject action could proceed w/o this action.
6. Geotechnical Hazards	4. Groundwater Model Refinement & Expansion			No - not necessary as team is already supporting this project
10. Inform Neighbourhood Planning Initiatives	4. Groundwater Model Refinement & Expansion			Yes
15. Stormwater Infiltration Incentives	16. Infiltration Area Assessment	29. Reduce Setbacks for Infiltration		16 - No, nice to have but not critical. Subject action could proceed w/o this action. 29 - No, nice to have but not critical. Subject action could proceed w/o this action.
16. Infiltration Area Assessment	4. Groundwater Model Refinement & Expansion	6. Geotechnical Hazards		4 - No, nice to have but not critical. Subject action could proceed w/o this action. 6 - No, nice to have but not critical. Subject action could proceed w/o this action.
19. Aquifer Valuation	4. Groundwater Model Refinement & Expansion	71. Groundwater Use Potential		4 - Yes 71 - Yes NOTE TO AECOM: the team is not super familiar with the procedures for natural asset management, but we feel that there are likely a number of assessments that would be required to precede this action, including #4 and #71. However, we suspect there would be a number of others as well.
22. Map Inflow & Infiltration Risks	4. Groundwater Model Refinement & Expansion			No, nice to have but not critical. Subject action could proceed w/o this action.
28. Remediate Contamination on City Properties	155. Long-term Funding Strategy			No, nice to have but not critical. Subject action could proceed w/o this action.
52. Sea Level Rise Impact Assessment	4. Groundwater Model Refinement & Expansion			Yes

Draft Action	Dependency 1	Dependency 2	Dependency 3	Feedback from the City on Proposed Dependencies
54. Partnerships Local Nations & Stewardship Groups	100. Terrestrial Ecosystem Groundwater Elevation Thresholds	101. Aquatic Ecosystem Thresholds		100 - No, nice to have but not critical. Subject action could proceed w/o this action. 101 - No, nice to have but not critical. Subject action could proceed w/o this action.
56. Aquifer Storage and Recovery Assessment	4. Groundwater Model Refinement & Expansion			Not sure. It seems as though the model would be a useful tool for this assessment, but the City team is unsure if it is absolutely critical, or if there would be another way.
67. Internal Education	63. Reduce Contaminants from City Operations			No, nice to have but not critical. Subject action could proceed w/o this action.
68. Green Rainwater Infrastructure at City-Owned Buildings	67. Internal Education	60. Quality Requirements for Infiltration	16. Infiltration Area Assessment	All - No, nice to have but not critical. Subject action could proceed w/o this action.
71. Groundwater Use Potential	4. Groundwater Model Refinement & Expansion	56. Aquifer Storage and Recovery Assessment	47. Foundation Drainage Water Re-use Options	All - No, nice to have but not critical. Subject action could proceed w/o this action. NOTE TO AECOM: we should discuss if action 56 should be modified so it is not specific to "use during times of water scarcity".
73. Request the Province to Consider Subsidence Risks	6. Geotechnical Hazards			No, nice to have but not critical. Subject action could proceed w/o this action.
75. Development Community Outreach Programs	3. Develop Monitoring Well Network	6. Geotechnical Hazards	85. Requirements for Developers to Remediate Contamination	No to all 3. We could do this action now, with the information we currently have.
109. Augmenting Potable Water System	3. Develop Monitoring Well Network			Yes. NOTE to AECOM: what about other actions, like #152 which relates to completing an assessment of sustainable extraction potential?

C.2 Draft Action Dependencies Second Draft and and Provided Feedback

Draft Action	Dependency 1	Dependency 2	Dependency 3	Feedback from the City on Proposed Dependencies
4. Groundwater Model Refinement & Expansion	3. Develop Monitoring Well Network			
10. Inform Neighbourhood Planning Initiatives	4. Groundwater Model Refinement & Expansion			These are nice to have but not dependencies
18. Stormwater Utility Fee	15. Stormwater Infiltration Incentives	16. Infiltration Area Assessment		No to both, not dependencies
19. Aquifer Valuation	4. Groundwater Model Refinement & Expansion	71. Groundwater Use Potential	109. Augmenting Potable Water System	Delete 109 (duplicate of 71)
23. Quantify Groundwater Inflow & Infiltration in Sewers	4. Groundwater Model Refinement & Expansion			No
47. Foundation Drainage Water Re-use Options	9. Groundwater Capture Inventory			No
52. Sea Level Rise Impact Assessment	4. Groundwater Model Refinement & Expansion			
56. Aquifer Storage and Recovery Assessment	4. Groundwater Model Refinement & Expansion			No
60. Quality Requirements for Infiltration	4. Groundwater Model Refinement & Expansion			No to 4. Add 25. <i>Evaluate Green Rainwater Infrastructure Effectiveness in Preventing Groundwater Contamination</i>
74. Water Reservation Application	71. Groundwater Use Potential			Yes, part A of 71
83. Showcase Well	3. Develop Monitoring Well Network			Yes to 3, no to 71
85. Requirements for Developers to Remediate Contamination	71. Groundwater Use Potential			Yes to 71, 13 is nice to have but not dependent
109. Augmenting Potable Water System	3. Develop Monitoring Well Network	71. Groundwater Use Potential		71 + 109 have been combined
139. Reduce Potential for Utility Trenches as Pathways	4. Groundwater Model Refinement & Expansion	71. Groundwater Use Potential		Add 22. <i>Map Inflow & Infiltration Risks</i> only.
174. Coordinate and Prioritize City's Uses of Groundwater	71. Groundwater Use Potential	74. Water Reservation Application		Yes, to both

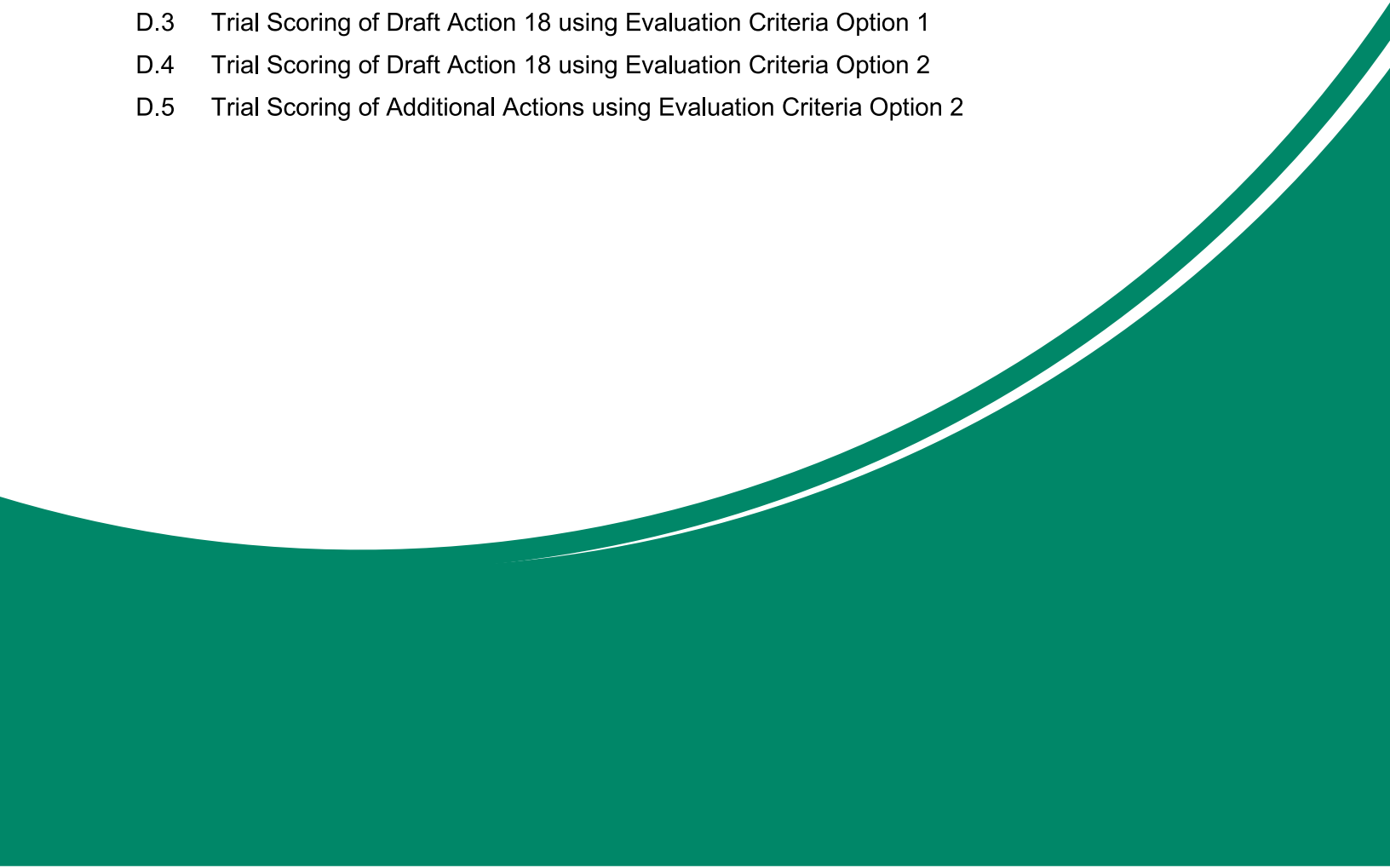
Draft Action	Dependency 1	Dependency 2	Dependency 3	Feedback from the City on Proposed Dependencies
Other dependencies for consideration				
17. Water Budget for Groundwater Reliant Ecosystems	3. Develop Monitoring Well Network			
22. Map Inflow & Infiltration Risks	3. Develop Monitoring Well Network	9. Groundwater Capture Inventory	7. Evaluate Data Management Options	
27. Vulnerability Assessment	7. Evaluate Data Management Options	3. Develop Monitoring Well Network		
38. Collate Historical Stream Data from Development Info	7. Evaluate Data Management Options			
100. Terrestrial Ecosystem Groundwater Elevation Thresholds	17. Water Budget for Groundwater Reliant Ecosystems			
101. Aquatic Ecosystem Thresholds	17. Water Budget for Groundwater Reliant Ecosystems			
16. Infiltration Area Assessment	60. Quality Requirements for Infiltration			16 > 60

C.3 Finalized Action Dependencies

Action Number	Direct Predecessor(s)	Direct Successor(s)
19	71	
21	100, 101	
22		139
71		19, 74, 174
74	71	
100		21, 71
101		21, 71
139	22	
174	71	

Appendix **D**

Evaluation Criteria and Trial Scoring

- D.1 Draft Evaluation Criteria Option 1
 - D.2 Draft Evaluation Criteria Option 2
 - D.3 Trial Scoring of Draft Action 18 using Evaluation Criteria Option 1
 - D.4 Trial Scoring of Draft Action 18 using Evaluation Criteria Option 2
 - D.5 Trial Scoring of Additional Actions using Evaluation Criteria Option 2
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Appendix D Evaluation Criteria and Trial Scoring

D.1 Draft Evaluation Criteria Option 1

Criterion (Consultant or City)	Weight	Scoring			
		1	2	3	4
Urgency Is there reason to prioritize this action? (e.g. imminent risk, foundational to other actions, public safety, quick win, low chances of unintended consequences, etc.)	25%	Action is not urgent			Action is very urgent
Effectiveness How effective will the action be in supporting one or more of the Strategy objectives?	25%	Action is expected to provide minor positive impacts			Action is expected to provide significant positive impacts
Financial Implications What are the financial implications of the action for the City? (Overall Cost = Cost to Implement and support + Cost of inaction* – any expected cost savings) Note: "Cost of inaction" refers to likely costs borne by the City due to not implementing the action (e.g. from risks the City is exposed to)	20%	Action is expected to have negative financial implications (e.g. very expensive to implement and/or high cost of inaction)			Action is expected to have positive financial implications (e.g. relatively inexpensive to implement, generate revenue, save City money (e.g. on water costs), or mitigate potentially costly risks)
Level of Effort What is the level of effort by City staff required to implement the action? (e.g. is significant work required, are major process or policy changes required, is it within existing municipal toolkit, etc.).	15%	Significant effort required to implement action (e.g. multiple policy updates, major changes to processes)			Very little effort needed to implement action (e.g. no additional tools, policy updates, or consultants required, etc.)
Alignment & Co-Benefits How well does the action support or align with other City projects or priorities? Does it produce additional co-benefits?	15%	Action is not aligned with existing policy priorities or work, and/or does not have significant co-benefits.			Aligns closely with existing policies or work, and/or produces co-benefits related to other City priorities

D.2 Draft Evaluation Criteria Option 2

Benefits	High Benefit Score = 3	Medium Benefit Score = 2	Low Benefit Score = 1	No Benefit Score = 0
Economic - City	Significant (>\$1M) economic benefits to the City (e.g., reduced costs, or new revenue).	Moderate (\$500k to \$1M) economic benefits to the City (e.g., reduced costs, or new revenue).	Minor (<\$500k) economic benefits to the City (e.g., reduced costs, or new revenue).	No economic benefit to the City.
Economic - Community	Significant (>\$1M) economic benefits to the community (e.g., development, etc.).	Moderate (\$500k to \$1M) economic benefits to the community (e.g., development, etc.).	Minor (<\$500k) economic benefits to the community (e.g., development, etc.).	No economic benefit to the community.
Social	Significant improvement to (or reduced risk to) the public's well-being, including physical health, mental health, safety, equity*, reconciliation, and/or culture. Examples include providing post disaster potable water supplies or protecting housing for hundreds of people.	Moderate improvement to (or reduced risk to) the public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. Examples include providing post disaster potable water supplies or protecting housing for multiple people.	Minor improvement to (or reduced risk to) the public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. An example includes contributing to the preservation of a public amenities that provide health benefits such as a wetland.	No social benefit.
Environmental	A permanent and widespread positive environmental impact, which may include avoiding a significant negative environmental impact by completing the action.	A permanent or widespread positive environmental impact, which may include avoiding a moderate negative environmental impact if the action were not completed.	A temporary and localized positive environmental impact, which may include avoiding a minor negative environmental impact if the action were not completed.	No environmental benefit.
Costs	No Cost Score = 3	Low Cost Score = 2	Medium Cost Score = 1	High Cost Score = 0
Economic - City	City's life cycle costs <\$100,000.	City's life cycle costs between \$100k and \$500k.	City's life cycle costs between \$500k and \$1M.	Life cycle costs to the City >\$1M.
Economic - Community	Community's life cycle costs <\$100,000.	Community's life cycle costs between \$100k and \$500k.	Community's life cycle costs between \$500k and \$1M.	Life cycle costs to the community >\$1M.
Social	No risk to the public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture.	Minor negative impacts to public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. An example includes the temporary loss of a public amenity (e.g., park) during construction.	Moderate impacts to public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. Could include loss of housing, water, food, health and/or cultural services to multiple people.	Major negative impacts to physical health, mental health, safety, culture, services or public confidence. Could include loss of housing, water, food, health and/or cultural services to hundreds of people.
Environmental	No negative environmental impacts.	Temporary and localized negative environmental impacts.	A permanent or widespread negative environmental impacts.	A permanent and widespread negative environmental impact (e.g., permanent and widespread).

D.3 Trial Scoring of Draft Action 18 using Draft Evaluation Criteria Option 1

Criterion (Consultant or City)	Weight	Scoring			
		1	2	3	4
Urgency Is there reason to prioritize this action? (e.g. imminent risk, foundational to other actions, public safety, quick win, low chances of unintended consequences, etc.)	-	Action is not urgent			Action is very urgent
Effectiveness How effective will the action be in supporting one or more of the Strategy objectives?	-	Action is expected to provide minor positive impacts			Action is expected to provide significant positive impacts
Financial Implications What are the financial implications of the action for the City? (Overall Cost = Cost to Implement and support + Cost of inaction* – any expected cost savings) Note: "Cost of inaction" refers to likely costs borne by the City due to not implementing the action (e.g. from risks the City is exposed to)	-	Action is expected to have negative financial implications (e.g. very expensive to implement and/or high cost of inaction)			Action is expected to have positive financial implications (e.g. relatively inexpensive to implement, generate revenue, save City money (e.g. on water costs), or mitigate potentially costly risks)
Level of Effort What is the level of effort by City staff required to implement the action? (e.g. is significant work required, are major process or policy changes required, is it within existing municipal toolkit, etc.).	-	Significant effort required to implement action (e.g. multiple policy updates, major changes to processes)			Very little effort needed to implement action (e.g. no additional tools, policy updates, or consultants required, etc.)
Alignment & Co-Benefits How well does the action support or align with other City projects or priorities? Does it produce additional co-benefits?	-	Action is not aligned with existing policy priorities or work, and/or does not have significant co-benefits.			Aligns closely with existing policies or work, and/or produces co-benefits related to other City priorities

D.4 Trial Scoring of Draft Action 18 using Draft Evaluation Criteria Option 2

Benefits	High Benefit; Score = 3	Medium Benefit; Score = 2	Low Benefit; Score = 1	No Benefit; Score = 0
Economic - City	Significant (>\$1M) economic benefits to the City (e.g., reduced costs, or new revenue)	Moderate (\$500k to \$1M) economic benefits to the City (e.g., reduced costs, or new revenue)	Minor (<\$500k) economic benefits to the City (e.g., reduced costs, or new revenue)	No economic benefit to the City.
Economic - Community	Significant (>\$1M) economic benefits to the community (e.g., development etc.)	Moderate (\$500 to \$1M) economic benefits to the community (e.g., development etc.)	Minor (<\$500k) economic benefits to the community (e.g., development etc.)	No economic benefit to the community.
Social	Significant improvement to (or reduced risk to) the public's well-being, including physical health, mental health, safety, equity*, reconciliation, and/or culture. Examples include providing post disaster potable water supplies or protecting housing for hundreds of people.	Moderate improvement to (or reduced risk to) the public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. Examples include providing post disaster potable water supplies or protecting housing for multiple people.	Minor improvement to (or reduced risk to) the public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. An example includes contributing to the preservation of a public amenity that provides health benefits such as a wetland.	No social benefit
Environmental	A permanent and widespread positive environmental impact, which may include avoiding a significant negative environmental impact by completing the action	A permanent or widespread positive environmental impact, which may include avoiding a moderate negative environmental impact if the action were not completed	A temporary and localized positive environmental impact, which may include avoiding a minor negative environmental impact if the action were not completed	No environmental benefit

Costs	No Cost; Score = 3	Low Cost; Score = 2	Medium Cost; Score = 1	High Cost; Score = 0
Economic - City	City's life cycle costs < \$100,000	City's life cycle costs between \$100k and \$500k	City's life cycle costs between \$500k and \$1M	Life cycle costs to the City > \$1M
Economic - Community	Community's life cycle costs < \$100,000	Community's life cycle costs between \$100k and \$500k	Community's life cycle costs between \$500k and \$1M	Life cycle costs to the community >\$1M
Social	No risk to the public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture.	Minor negative impacts to public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. An example includes the temporary loss of a public amenity (e.g., park) during construction.	Moderate impacts to public's well-being, including physical health, mental health, safety, equity, reconciliation, and/or culture. Could include loss of housing, water, food, health and/or cultural services to multiple people.	Major negative impacts to physical health, mental health, safety, culture, services or public confidence. Could include loss of housing, water, food, health and/or cultural services to hundreds of people.
Environmental	No negative environmental impacts	A temporary and localized negative environmental impacts.	A permanent or widespread negative environmental impacts	A permanent and widespread negative environmental impact (e.g., permanent and widespread)

D.5 Trial Scoring of Additional Actions using Draft Evaluation Criteria Option 2

Action	Benefits			Costs					Total
	Economic (City)	Economic (Community)	Social	Environmental	Economic (City)	Economic (Community)	Social	Environmental	
3. Develop Monitoring Well Network	Could lead to work that helps reduce I&I, CSO's, treatment levies, pump station run times, and infrastructure upgrades. (Score = 3)	>\$500k value to the community since they will have access to the information and save costs in hydrogeological/geotechnical work. Assume > 20 developments save > \$25k in hydrogeological studies. (Score = 2)	May lead to the protection of groundwater resources that protect and/or provide public amenities (e.g., emergency water source or wetlands). (Score = 2)	Inform policies and projects that will protect critical groundwater-ecosystem interactions. (Score = 2)	~\$1M (Score = 0)	None. (Score = 3)	Possible minor disruption during well drilling. (Score = 3)	Possible minor disruption during well drilling. (Score = 3)	18/24
4. Groundwater Model Refinement & Expansion	Could lead to work that helps reduce I&I, CSO's, treatment levies, pump station run times, and infrastructure upgrades. (Score = 3)	Could lead to work that reduces the need for developer funding downstream infrastructure upgrades (Score = 1)	May lead to the protection of groundwater resources that protect and/or provide public amenities (e.g., emergency water source or wetlands). (Score = 2)	Inform policies and projects that will protect critical groundwater-ecosystem interactions. (Score = 2)	\$100k-\$500k (Score = 2)	None. (Score = 3)	None. (Score = 3)	None. (Score = 3)	15/24
5. Well Drilling Advisory	Could save hundreds of thousands in City costs by avoiding another Beechwood type incident. Could open additional development potential. (Score = 2)	Could save hundreds of thousands in developer/homeowner costs by avoiding another Beechwood type incident. Could open additional development potential. (Score = 2)	Could reduce the size of the Advisory Area, allowing wells/heat pumps in safe areas that currently fall under the Advisory Area. This would increase dependence on gas/hydro systems. (Score = 1)	Could increase the number of heat pumps, reducing environmental impacts from gas/electrical heating/cooling. (Score = 1)	~\$100k (Score = 3)	None. (Score = 3)	None. (Score = 3)	None. (Score = 3)	18/24
10. Inform Neighbourhood Planning Initiatives	Minimal. (Score = 0)	Potentially some economic benefit in that groundwater requirements are limited to specific areas of greatest impact. (Score = 1)	Help support community amenities such as Still Creek. (Score = 1)	Help preserve environmental resources such as Still Creek. (Score = 2)	Huge range; depends. (Score = 1)	Huge range; depends. (Score = 1)	None. (Score = 3)	None. (Score = 3)	12/24
13. Water Quality Assessment Requirements as part of Erosion and Sediment Control	Reduce City liability for 'contaminated' water entering the sewer system and receiving waters. (Score = 1)	None. (Score = 0)	Improve quality of recreational areas (e.g., English Bay) (2)	Reduce contaminated water entering natural receiving bodies (Score = 2)	<\$100k, mostly staff time. (Score = 3)	May cost developers ~\$5k-\$25k per development in sampling costs (Score = 2)	None. (Score = 3)	None. (Score = 3)	16/24

Appendix **E**

Implementation Plans

- E.1 Implementation Plan Template
- E.2 Finalized Implementation Plans

Appendix E Implementation

E.1 Implementation Plan Template

Action					
Number					
Name					
Description					
Rationale					
Strategy Objectives					
Action Type					
Score					
Implementation					
Timeline					
Methodology					
Deliverables					
Draft KPIs					
Assumptions					
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies					
Funding Recommendations					
Other considerations					

E.2 Finalized Implementation Plans

Action					
Number	3				
Name	Develop Monitoring Well Network				
Description	Develop a monitoring well network throughout the city to determine seasonal and long-term groundwater elevations as well as groundwater chemistry.				
Rationale	Little is known about groundwater elevations or water quality across the city. The data from the monitoring well network will be critical for many other actions in the strategy as the City needs to better understand local hydrogeology to effectively protect and manage it. Data from the monitoring well network (e.g. water levels) would be made publicly available. These data will be used for various purposes, including, for example, assessing extraction potential and infiltration capacities, better understanding groundwater-ecosystem interactions, calibrating models, predicting the impacts of land-use changes, monitoring groundwater-rise, etc.				
Strategy Objectives					
Action Type	Foundational				
Score					
Implementation					
Timeline	3 years				
Methodology	1. Determine water quality vs quantity monitoring needs 2. Determine data frequency and telemetry needs 3. Select well location(s) 4. Drill well(s) 5. Monitor on an ongoing basis 6. Review and report data 7. Maintain and repair wells as needed				
Deliverables					
Draft KPIs	Number of well-years of data (1 well-year is 1 year of data for 1 well) for quantity Number of well-years of data (1 well-year is 1 year of data for 1 well) for quality Number of wells providing quantity and quality data Frequency of quality data Number of wells per square km				
Assumptions	Implementation to be completed by a consultant. On-going O&M to be provided by City staff. 15 monitoring wells to be established				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)		\$625K	Install approximately 15 wells (15 x \$35,000 + \$100,000 initial assessment/PM etc.). Staff time (97.5 hours) for annual monitoring & maintenance, data assessment, reporting and PM.		
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies	Resilient Vancouver, Rain City Strategy, ISMP Guidelines, Water Sustainability Act, Groundwater Protection Regulation, Groundwater Management Bulletin				
Funding Recommendations	Government grants that focus on water sustainability and climate change resiliency (e.g., Intact Climate Resiliency Grants, FCM, etc.)				
Other considerations	This action will support City's efforts to incorporate hydrogeological considerations into neighbourhood planning, protect groundwater resources, increase the potential for aquifer use during water scarcity, reduce I&I and CSOs.				

Action					
Number	4				
Name	Groundwater Model Refinement and Expansion				
Description	Refine and expand the existing city-wide hydrogeological model to allow for its use as a decision-support tool for risk mitigation, Area-plan development, ecosystem protection, and utility and city planning.				
Rationale	The City has an existing numerical model that covers the municipality (and slightly beyond). If the model can be refined to improve accuracy, it can be a powerful tool in predicting the impacts of various stressors (e.g. a changing climate, rising sea levels, groundwater extraction, increased imperviousness, additional underground infrastructure, etc.) on groundwater, connected ecosystems, and/or infrastructure. This action will allow the City to compile all the various data it has on local geology and water levels and update the existing model such that it can be used to inform decision-making.				
Strategy Objectives	3. Safeguard quality 4. Preserve resources 5. Use sustainably 6. Support ecosystems 7. Reduce risks				
Action Type	Foundational				
Score					
Implementation					
Timeline	2 years				
Methodology	1. Establish objectives and end uses for geological and numerical groundwater models. 2. Update geologic model, including ground surface topography, with additional borehole and satellite data published since model development. 3. Develop the conceptual hydrologic and hydrogeologic model by identifying sources and sinks, boundary conditions, ecosystems, and infrastructure interacting with the groundwater system. 4. Update groundwater model mesh and structure to include higher resolution where additional detail is needed for calibration and analysis (e.g. civil infrastructure, pumping, groundwater surface water interaction, inflow and infiltration, etc.) 5. Develop annual and seasonal calibration targets (e.g. groundwater elevations, flows, etc.) and parameterize boundary conditions (e.g. recharge, tidal, etc.) and aquifer properties. 6. Calibrate numerical groundwater model to steady-state and/or transient data to satisfy modelling objectives. 7. Conduct sensitivity analysis on the calibrated model to understand influence of uncertain parameters and help focus future data collection efforts. 8. Report model performance and sensitivity for calibrated model. 9. Run the model using future climate projections to understand future baseline conditions. 10. Produce comprehensive report documenting construction, calibration of geological model and numerical groundwater model as well as simulation results for existing and future baseline conditions.				
Deliverables	Updated geologic model Updated conceptual hydrogeologic model Updated and re-calibrated numerical groundwater model Technical modeling report				
Draft KPIs	Percent of new borehole, satellite, and monitoring data successfully incorporated into geologic model Calibration statistics for groundwater model including mass balance, normalized root mean squared error (NRMSE), percent bias, etc. for groundwater level and flux calibration targets Number of parameters tested and documented in the sensitivity analysis Number of outputs that can be utilized for water balance development				
Assumptions	Completed by an external consultant. Include 250 hr of city staff time to prepare the RFP, select the consultant, collate and provide data to a consultant, track project progress and review deliverables. Costing assumes that borehole logs and calibration data are available in digital format (database) prior to model commencement.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)		\$125K	Update to conceptual model and numerical groundwater model completed by external consultant (\$100K). If transient calibration included, add \$25K. City Staff time (250 hours).		
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies					
Funding Recommendations					
Other considerations					

Action					
Number	5				
Name	Well Drilling Advisory				
Description	Reduce risks related to flowing artesian conditions: A. Work with the Province and other affected local governments to refine the Well Drilling Advisory Area for flowing artesian conditions. B. Develop a plan to mitigate the risks of encountering flowing artesian conditions within the Well Drilling Advisory Area.				
Rationale	Flowing artesian conditions are pressurized portions of aquifers, and wells drilled in these areas can cause serious problems. For example, in 2015 a geoexchange well for a home was drilled by an inexperienced contractor, and this pierced a pressurized (artesian) portion of the underlying aquifer. It took two years and cost the City almost \$12 million to control the flow, and an estimated 3 billion gallons of groundwater were discharged to the sewer system. These pressurized areas are delineated by a Provincial Well Drilling Advisory Area map to help alert developers to the risk. The current advisory area extends from the University Endowment Lands to just west of Coquitlam. The advisory area was defined using a limited amount of available information and could be drastically improved using additional tools (e.g. geophysics). Refinement of the advisory area would improve confidence in the area boundary and would ideally reduce the size of the area itself, potentially reducing costs related to risk mitigation for municipalities and developers. This action would also help identify other requirements the City could implement to reduce the risk from these flowing artesian conditions.				
Strategy Objectives	2. Collaborate 4. Preserve resources 7. Reduce risks				
Action Type	A. Actionable B. Actionable				
Score	22				
Implementation					
Timeline	2 years				
Methodology	A1. Engage with the Province and local governments to define roles, responsibilities, and shared objectives. Establish a working group or task force. A2. Compile hydrogeological reports, borehole/test well logs, well records, and past artesian flow events. Review the current advisory area boundaries and identify data gaps. A3. Acquire additional data to address uncertainties. A4. Use updated groundwater model to develop groundwater level maps for each aquifer to determine where artesian conditions may be present and apply appropriate factor of safety. A5. Use future climate and development modeling to assess potential changes to artesian conditions. A6. Re-delineate the well drilling advisory area using compiled and new data. Apply GIS tools to update maps with new metadata and justification. A7. Work with Province of British Columbia to publish updated advisory maps through provincial and municipal platforms and update permitting and advisory protocols. B1. Use the updated geologic model to determine thickness of aquitard units overlying artesian aquifers to establish maximum depth of excavation without risk of breaching the aquitard. B2. Develop a risk matrix. Classify risk zones within the updated advisory area and work to allow for flexibility on subsurface parking, etc. to avoid or mitigate risks of encountering flowing artesian conditions. B3. Require mandatory risk mitigation measures be included in development permit applications. Develop regulatory checklists and submission requirements. B4. Develop a rapid response plan for uncontrolled artesian flows, coordinating with municipal emergency services and environmental regulators. Include protocols for environmental containment and monitoring.				
Deliverables	A1. Map of simulated groundwater elevations in each identified aquifer showing areas with potential flowing artesian conditions. A2. Map of updated Advisory Area. B1. Map of interpreted depth to top of the aquifer. May be used as a guide for excavation depth. B3. Risk mitigation plan, which could include education & outreach, permit requirements (etc.).				
Draft KPIs	Number of stakeholder meetings Number artesian events per year Advisory area completion Risk matrix classification Mitigation plan completion Contractor training Emergency response readiness				
Assumptions	A. Developed by an external consultant, potentially with the use of geophysical techniques. B. Developed by City staff.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Highest	\$10M–15M	Avoids extreme costs of uncontrolled artesian flow incidents (e.g., Beechwood St, which cost ~\$12M). Improves permitting clarity, reducing delays and risk of litigation.	4	
Economic (Community)	High	\$1M–2M	Reduces risk of costly well control incidents for developers and homeowners. Updated boundaries may reduce the size of the advisory area, lowering regulatory burdens and unnecessary costs.	3	
Social	Medium		Improves public safety and builds trust in land-use planning and well management. Increases awareness among well drillers and property owners. Fact-based planning approach allows investment and development community to make informed decisions.	2	
Environmental	High		Prevents uncontrolled discharge of groundwater (e.g., billions of litres wasted in prior events). Helps protect aquifers from depressurization and contamination.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Medium	\$600K–750K	A. \$500K. B. \$180K for 2,340 staff hours.	1	
Economic (Community)	No cost		No direct financial impact on residents. May result in clearer and possibly less restrictive boundaries, reducing unnecessary mitigation costs for private developers. Will also provide greater clarity to investment and development community at time of purchase.	3	
Social	No cost		No disruption to communities; only administrative and technical planning activities.	3	
Environmental	No cost		No environmental disturbance. Project is based on data analysis, mapping, and coordination.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	BC Ministry of Environment – Water and Watershed Security Fund Union of BC Municipalities (UBCM) – Community Emergency Preparedness Fund Natural Resources Canada (NRCan) – Climate Change Adaptation Program				
Other considerations					

Action					
Number	7				
Name	Build Data Repository				
Description	Composite data from external sources (permit applications) and internal geotechnical data into one repository to improve decision-making for groundwater management.				
Rationale	Current State: The current state of data on groundwater is uncoordinated and patchworked, creating challenges around baselining groundwater to manage it effectively. Internal data needs to be streamlined, and barriers exist around using external data to complete information gaps. Desired Future State: To manage groundwater effectively with sufficient information and clear decision-making tools. Gap addressed by action: The data repository will be the first step to developing a baseline characterization of groundwater so that it can be managed to help mitigate risks (such as Beechwood), support core services (such as reducing burdens on sewer system capacity to accommodate growth); and support Vancouver Plan's100 year ecological vision.				
Strategy Objectives	1. Build support 3. Safeguard quality 4. Preserve resources 5. Use sustainably 6. Support ecosystems 7. Reduce risks				
Action Type	Foundational				
Score					
Implementation					
Timeline	2 years				
Methodology	1. Identify and establish data access agreements, including retroactive arrangements where needed. Define licensing terms, data sharing permissions, and update protocols such as publication frequency and versioning. 2. Define data requirements by identifying specific data needs. 3. Create a metadata scheme to ensure consistent documentation. 4. Inventory existing internal and external data sources (e.g. engineering, planning, environment) and data types (geology, well locations, groundwater elevations, infiltration testing results, hydraulic conductivity measurements, groundwater quality, etc.). 5. Identify and list potential external data sources that could be linked to the repository. 6. Develop a centralized repository structure by choosing a platform or tool for hosting data and developing folder structures, data naming conventions, and version control protocols. 7. Develop and implement a QA/QC protocol for data validation, completeness, and relevance that considers how existing data, and new data will be vetted as it is incorporated into the data repository. Flag and document limitations or uncertainties. 8. Compile data, standardize data formats and projects, upload QAed and standardized data into the repository. 9. Develop a digital workflow for new data collection that integrates with existing programs and uploads data directly to the repository. 10. Develop a data toolkit, including a web map (similar to iMapBC) to allow internal and external users to access and explore the data repository to recognize full value of data repository and encourage broader use. 11. Develop a schedule to maintain and regularly update repository. Include change logs to track modifications.				
Deliverables	A centralized data repository that contains subsurface data that can be continually updated as new data is collected. QA/QC protocols and documentation Data toolkit featuring a web map.				
Draft KPIs	Percent of targeted datasets uploaded Percent of QA/QC issues per dataset or percent datasets passing QC Number of times repository accessed or referenced Time between data collection and entry				
Assumptions					
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)		\$300K	Consulting time (\$150K) plus staff time (1,950 hours).		
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	CleanBC – Climate Preparedness and Adaptation Strategy Funding, data infrastructure for groundwater modeling fits within eligible categories (e.g., planning, monitoring, data systems).				
Other considerations	There is a risk of duplicated efforts if departments maintain separate data silos. Co-benefit of enhancing transparency and supporting cross-departmental collaboration Should comply with BC Data Catalogue specifications				

Action						
Number	9					
Name	Inventory Groundwater Diversions					
Description	Inventory and estimate all known groundwater diversions (e.g. construction dewatering, foundation drains, wells, inflow and infiltration, etc.) to manage risks for existing urban infrastructure and development.					
Rationale	Current State: The City currently has limited information about the quantity of groundwater being diverted from local aquifers, via construction dewatering, foundation drainage, and leakage into sewers. This limits our ability to properly manage and potentially use the resource, due to a fundamental gap in our understanding of its water budget. As the majority of groundwater diversions occurring today are thought to be adding that groundwater to the City's sewer and drainage system, this gap also limits our ability to properly manage our infrastructure. Desired Future State: By inventorying groundwater diversions, we can better understand the quantity and locations of groundwater inputs to our sewer and drainage system. This will allow staff to better focus our efforts to limit these diversions in order to preserve capacity, and will also assist with related technical work such as sewer modeling and planning. This information will also enable the development of a more complete water budget for our aquifers, allowing the City to better understand the potential for groundwater use in the future and to better understand and protect groundwater dependent ecosystems.					
Strategy Objectives	1. Build support 4. Preserve resources 7. Reduce risks					
Action Type	Foundational					
Score						
Implementation						
Timeline	3 years					
Methodology	1. Identify types of structures, activities and natural features that may divert groundwater. 2. Use the water table elevation in the groundwater model to identify specific areas where structures, activities and natural features extend below the water table and may capture groundwater. This may include traditional foundation drainage systems for buildings and subsurface infrastructure, wells, dewatering systems, leaky sewers, groundwater discharge areas, historical streams, etc. 3. Identify where the groundwater ends up for each location/activity (e.g., consumed, combined sewer, storm sewer, sanitary sewer etc.) and whether it likely remains within the surface water catchment or is exported to a waste water treatment plant via sanitary or combined sewer. 4. Where available, use measured data such as pumping records to quantify any metered diversions for wells, drainage systems, pump stations, etc. that are interpreted to be primarily groundwater. 5. Use the city-wide groundwater model to quantify the amount of groundwater diverted to subsurface infrastructure (e.g., storm sewer, combined sewer, irrigation, etc.) and determine where it is discharged. Ensure evaluation is sufficiently refined to establish localized water budgets, identify target areas where groundwater diversion is significant and identify opportunities for enhanced conservation measures.					
Deliverables	Map and database that includes locations and quantities of groundwater diverted from aquifers. Local scale estimates of quantity of all significant sources of groundwater being diverted into the sewer system. Identified opportunities for improvement to better protect groundwater resource and minimize inflow and infiltration to sewer network.					
Draft KPIs	Number of identified activities or infrastructure that are capturing groundwater					
Assumptions	This would be completed by City hydrogeological staff. May expand upon the work completed for previous evaluations of the Oakridge development, which included a numerical groundwater model that incorporated deep parkades in the Cambie Corridor.					
Dependencies						
Required Predecessors						
Successor(s)						
Benefits				Unweighted Score	Weighted Score	
Economic (City)						
Economic (Community)						
Social						
Environmental						
Costs				Unweighted Score	Weighted Score	
Economic (City)		\$150K	Staff time (1,950 hours) with some consultant support for additional modelling analysis if required.			
Economic (Community)						
Social						
Environmental						
Additional Details						
Alignment with other City Strategies						
Funding Recommendations	Government grants that focus on water sustainability and climate change resiliency (e.g., Intact Climate Resiliency Grants, FCM, etc.)					
Other considerations	The results would identify the location and estimated quantity of all groundwater discharges and could inform future groundwater modelling and water balance assessments. May help determine potential options for the re-use of foundation drainage water.					

Action					
Number	10				
Name	Inform Neighbourhood Planning Initiatives				
Description	Undertake groundwater investigations to help inform neighbourhood planning initiatives (e.g. Area Plans) and related building requirements in order to preserve groundwater resources and protect buildings, infrastructure, and groundwater-dependent ecosystems such as Still Creek.				
Rationale	These investigations will help identify areas of concern for groundwater in future neighbourhood planning initiatives and allow the City to implement targeted building requirements there. Depending on the situation, these investigations could be simple desktop exercises, or more detailed investigations (e.g. monitoring well installations) with elaborate decision support tools (i.e. numerical models).				
Strategy Objectives	4. Preserve resources 6. Support ecosystems 7. Reduce risks				
Action Type	Actionable				
Score	19				
Implementation					
Timeline	Ongoing				
Methodology	For each neighbourhood where an area plan has been or will be developed: 1. Develop a risk framework for identifying high risk development zones. This may include shallow groundwater areas, presence of organic soils, known artesian conditions, groundwater dependent ecosystems, and recharge zones sensitive to land cover change. Identify gaps in geological and numerical groundwater model and consider filling them to meet the objectives of the study. 2. Use the results from the existing numerical groundwater model (e.g. depth to water table, recharge zones, flow directions) and aquifer vulnerability mapping in the risk framework to identify areas of high risk 3. Evaluate the compatibility of proposed development with identified groundwater conditions and risks. This may consider suitability of deep excavations, conventional foundation designs vs alternative water-sensitive methods, proximity to recharge zones, presence of contamination, sensitive soils, flooding and seepage risks, impervious area coverage, and suitability of green rainwater infiltration strategies. Potential use of predictive groundwater modeling scenarios to explore how high risk areas may change in the future under various development scenarios and ensure long-term resilience. 4. Develop a GIS-based dashboard/layer package for planners and permitting staff.				
Deliverables	Baseline groundwater characteristics for each Area Plan Risk framework Simulated change in groundwater elevations, flow directions and fluxes for recommended development scenario. Groundwater risk map and recommended strategies. GIS-based dashboard/layer package.				
Draft KPIs	Number of neighbourhoods assessed Number and coverage area (in km²) of groundwater risk maps completed Number of area plans or development guidelines that incorporate groundwater and surface water sensitive design elements Number of groundwater ecosystems (terrestrial or aquatic), or recharge zones protected through area plans Number of groundwater issues encountered that could have been avoided through groundwater sensitive area plans Percent of developments that incorporate groundwater sensitive design				
Assumptions	Assume 1 area plan/year. Assume investigations are completed by an external consultant - reasonable to assume a similar cost (per year) as the budget for AECOM's work on Still Creek, for the Rupert & Renfrew Area Plan Also assume 390 hours/year of city groundwater staff time to assist with consultant management, data collation, reviews and facilitating area-specific development requirements.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$2M–5M	Avoids long-term infrastructure and permitting costs over design life of infrastructure by adopting water-sensitive design. Enables identification of groundwater risks before development occurs, avoiding unintended impacts to the natural and built environment, future repairs, mitigation, or litigation costs. Improves permitting efficiency and reduces reactive interventions. Reduces costs of water treatment for clean groundwater entrained in combined sewer network.	3	
Economic (Community)	Medium	\$500K-1M	Reduces risk of flooding, basement seepage, or costly waterproofing measures due to shallow water tables or artesian conditions. Preserves aquatic and terrestrial ecosystems dependent on groundwater.	2	
Social	Medium		Improves development safety and transparency; supports proactive planning. Benefits communities near sensitive ecosystems, organic soils or where the water table is high.	2	
Environmental	High		Informs protection of groundwater-dependent ecosystems, recharge zones, and aquifer health. Conserves groundwater for other purposes. Enables adaptive land use under climate change.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	High	\$1.5M	\$90K per area plan for consultant investigations (Still Creek/Rupert & Renfrew benchmark) and \$30K for 390 hours of groundwater staff time per area plan.	0	
Economic (Community)	No cost		No out-of-pocket cost to residents; future requirements may arise from planning outcomes, but the investigations do not impose direct financial burden.	3	
Social	No cost		No displacement or disruption; potential minor concerns from identification of high-risk areas.	3	
Environmental	No cost		Limited to desktop assessments and localized fieldwork (e.g., monitoring wells, flow monitoring, site visits, etc.) with minimal disturbance.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Developer contributions in high-risk areas Canada Infrastructure Program BC Community Resilience Investment Program				
Other considerations	Incorporate infiltration design within broader flood and drought adaptation planning				

Action					
Number	13				
Name	Discharge During Construction				
Description	Mitigate risks associated with groundwater discharged to the sewer system during construction by ensuring capacity constraints are considered as well as requirements of the City's Sewer and Watercourse By-law. This may include expanding requirements and/or establishing a monitoring and enforcement program.				
Rationale	Groundwater discharges from a site during construction are not currently subject to fees if entering the City's storm system or combined system. The City is paying treatment costs for discharges to the combined system and there are no disincentives against high volume discharges. In addition, the City's Erosion and Sediment Control (ESC) requirements for large lot developments are limited with respect to water quality as only TSS and pH must be monitored and treated, creating a gap in monitoring other contaminants that may pose a potential risk to receiving bodies and exposes the City to liability.				
Strategy Objectives	6. Support ecosystems 7. Reduce risks				
Action Type	Actionable				
Score	18				
Implementation					
Timeline	2 years				
Methodology	1. Review current ESC requirements and the Sewer and Watercourse By-law to identify gaps and the need for additional requirements for groundwater discharges during construction. Review may include a jurisdictional scan. 2. Consult with internal departments (e.g. Sewer Operations, Legal, Engineering, Permitting etc.) to identify known groundwater discharge quality issues, confirm regulatory authority, risk exposure, monitoring/enforcement capacity for managing groundwater discharges and ability to charge developers for discharges. 3. Define appropriate water quality/quantity parameters, testing methods, sampling frequency and reporting protocols that will be required/allowed during construction to assess compliance with existing/new sewer discharge standards. 4. Assess whether construction-phase water quality can be used as a proxy for long-term discharge quality and identify cases where post-construction follow-up may be needed. 5. Update ESC documentation and inspection procedures to include groundwater quality review and define enforcement triggers if standards are not met. 6. Develop guidance for ESC inspectors and permit reviewers, including checklists, enforcement triggers, payment terms and escalation protocols.				
Deliverables	Updated ESC requirements for construction site discharges (including water quality criteria and monitoring requirements). Development of construction discharge fee (if approved) Guidance for ESC inspectors and permit reviewers outlining enforcement triggers, payment terms and escalation steps.				
Draft KPIs	Number or percent of construction sites reviewed for compliance Number or percent of non-compliant developments Financial contributions from construction sites for discharges (total, per site, per site*month, per volume discharged)				
Assumptions	Assumes - Initial 3,900 staff hours. Ongoing 975 staff hours to administer				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$2M–\$6M	Immediate and sustained reduction in hydraulic and pollutant loading to sewer system (\$1M–\$2.5M), potential reduction in sanitary/combined flow to Metro Van treatment plant resulting in treatment savings (\$500K–\$2M), and potential reduction in overflows and/or associated contaminants from construction site discharges. (\$500K–\$1.5M).	3	
Economic (Community)	Medium	\$250K–\$1M	Reduced risk of contractors having to clean-up or mitigate impacts from discharging contaminated groundwater into the sewer system (\$250K–\$1M).	2	
Social	Medium		Increases public trust in construction oversight and groundwater protection. Reducing/managing construction related discharges may reduce CSO's and/or contaminants in stormwater discharges which can negatively impact community amenities such as urban streams, beaches, False Creek and English Bay.	2	
Environmental	High		Reduces risk of groundwater-borne pollutants (e.g., hydrocarbons, metals, turbidity) entering streams, False Creek, English Bay, Burrard Inlet, Fraser River, etc. Supports water quality objectives in both sewered and natural systems.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$150K	\$150K for 1,950 staff hours to develop by-law revisions, enforcement process, technical criteria, training, inspection protocol, and monitoring/reporting tools.	2	
Economic (Community)	High	\$2M	Developers may require additional quality testing and treatment to ensure compliance (e.g., lab analysis, pre-treatment systems). The City may decide to apply an additional fee to cover staffing inspection/enforcement costs and/or discharge fee. Assume 200 sites per year x \$10k per site	0	
Social	No cost		No disruption to residents or the general public.	3	
Environmental	No cost		Non-invasive, regulatory action with net-positive impacts.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	UBCM – Asset Management Planning Program CleanBC – Climate Preparedness and Adaptation Strategy BC Infrastructure Planning Grant Excavation Permit Fees				
Other considerations	Focus on protecting public receiving waters (e.g. English Bay) and minimizing City liability, not just on builder compliance. Initial rollout should be targeted to higher-risk projects to reduce administrative burden and ensure practical adoption. Consider Burrard Inlet Water Quality Objectives for Freshwater Tributaries.				

Action					
Number	15				
Name	Stormwater Infiltration Incentives				
Description	In line with Healthy Waters Plan and Rain City Strategy, develop options and incentives for developers to infiltrate stormwater into retention systems on private property to enhance groundwater recharge, and reduce burden on sewer system capacity.				
Rationale	Current state: The City requires rainwater management for rezoning applications that are subject to the City’s Green Buildings Policy for Rezoning, or the Rezoning Policy for Sustainable Large Developments. As of 2024, the VBBL requires developers to require rainwater detention into tanks at minimum. Developers have little incentive to explore options for infiltrating rainwater, which is preferable for recharging groundwater. Future State: In line with the Healthy Waters Plan, by 2075, non-sanitary flows (a bulk of which includes groundwater) will only be conveyed in separated storm mains. Until then, if left unchecked, groundwater will continue to burden the City’s sewer and drainage system significantly. Stormwater infiltration provides two purposes: it reduces the burden on the City’s sewer system by reducing rainwater entering the system, and it recharges groundwater. Providing developers with options and incentives to infiltrate rainwater will reduce treatment costs for the City significantly and maintain groundwater levels to support environmental benefits. Gap addressed: By providing more options and incentives for developers to infiltrate rainwater, such as net zero dedications, the City enables developers to have greater autonomy to choose retention and/or detention practices where possible. These incentives can be developed in consultation with developers.				
Strategy Objectives	4. Preserve resources 6. Support ecosystems				
Action Type	Actionable				
Score	22				
Implementation					
Timeline	2 years				
Methodology	1. Conduct a jurisdictional scan to identify successful stormwater infiltration incentive programs in other cities with similar groundwater and sewer system challenges. 2. Engage with developers and internal City staff to identify technical, financial, and regulatory barriers to infiltration and gather input on the types of incentives that would be attractive to the development community and most likely to have high uptake. 3. Analyze infiltration mapping results from Action 16 (Enhance Aquifer Recharge) and water balance data to establish clear technical criteria and site selection guidelines for where and how infiltration systems should be implemented on private property, ensuring systems are designed to manage risks such as moisture ingress. 4. Define minimum performance criteria for infiltration systems to qualify for incentives (without prescribing specific design approaches). 5. Develop a range of incentives (e.g., net-zero dedications, expedited permitting, or utility fee reductions) tailored to different development types and site conditions. 6. Identify how incentives and requirements can be integrated into rezoning, permitting, or development review processes, ensuring alignment with the Vancouver Building By-law and Rain City Strategy.				
Deliverables	A citywide incentive program for stormwater infiltration on private property Technical guidance outlining acceptable infiltration practices and performance criteria. Revised bylaws or policy documents (e.g., rezoning policy, groundwater bulletin)				
Draft KPIs	Number of developments implementing infiltration systems through the incentive program. Volume of stormwater infiltrated annually (m³/year), estimated or measured. Reduction in stormwater volume discharged to sewers from participating developments. Percentage of eligible developments in high-priority recharge zones implementing infiltration.				
Assumptions	Suggest incentives for retention/detention (include stormwater utility fee for example), cost out what benefits could be captured by 2075.				
Dependencies					
Required Predecessors	100, 101				
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Highest	\$10M–\$30M	Avoided sewer infrastructure upgrades (\$5M–\$15M), lowered combined pumping and treatment costs (\$2M–\$5M), reduced flooding and avoided sewer backup claims (\$3M–\$10M)	4	
Economic (Community)	High	\$5M–\$13M	Reduced localized flooding and property damage (e.g., basement back-ups), \$5M–\$10M. Incentive-driven savings for developers/homeowners (e.g., faster permitting, reduced utility fees), \$500K–\$3M.	3	
Social	High		Enhanced green infrastructure and reduced nuisance flooding makes city more livable. Enhances community participation in sustainability goals and increases support for water-sensitive development practices.	3	
Environmental	High		Restores natural function of hydrologic cycle by increasing groundwater recharge, sustaining shallow aquifers, supporting stream baseflow, and mitigating urban runoff pollution. Contributes to long-term ecological health of groundwater-dependent ecosystems.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$300K	Staff time (3,900 hours).	2	
Economic (Community)	Low	<\$25K	Voluntary costs to developers/homeowners for installation of infiltration systems. Can be offset with incentives. Insurance claim costs where ingress is a risk.	2	
Social	Low		Minimal disruption. Concerns may arise around permitting timelines or site suitability, but voluntary incentives reduce resistance.	2	
Environmental	No cost		No adverse impacts.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Development contributions or cost-sharing with developers (e.g. through Development Cost Levies) CleanBC – Climate Preparedness and Adaptation Strategy for infrastructure and planning support. BC Infrastructure Planning Grant				
Other considerations	Incorporate infiltration design within broader flood and drought adaptation planning				

Action					
Number	16				
Name	Enhance Aquifer Recharge				
Description	Safeguard groundwater resources by protecting and enhancing aquifer recharge: A. Undertake a detailed, city-wide assessment of infiltration potential to delineate areas where stormwater infiltration should be encouraged and utilize this assessment to quantify (present-day) aquifer recharge for use in developing a water budget and/or numerical model B. Following an assessment to define key aquifer recharge areas, explore options to protect or enhance infiltration in these areas.				
Rationale	Protecting and enhancing recharge areas is critical to preserving aquifer resources. This action will help the City to better understand our ability to manage stormwater through infiltration and potentially identify specific target areas for significant infiltration projects. It will also help identify areas that currently provide significant recharge to local aquifers, possibly resulting in restrictions on development that increases imperviousness in these areas. Assessing recharge across the City will also assist with the development of a water budget and/or refinement of the city-wide numerical model. Current State: Infiltration assessments are completed on a one-off basis, to assess the feasibility for GRI in a particular area. However, this work has not been completed on a city-wide basis. In terms of aquifer recharge, an estimate was developed for the city-wide numerical model that current exists, but presumably this information could be refined with additional detailed work. Desired Future State: A readily available assessment of infiltration potential, in a GIS format, that would allow for a high level feasibility assessment for GRI projects that include infiltration. Similarly, a GIS layer of present-day groundwater recharge, to be used in developing a water budget and/or refining the existing numerical model.				
Strategy Objectives	4. Preserve resources 6. Support ecosystems 7. Reduce risks				
Action Type	A. Foundational B. Deferred - Scope dependent on the results from part A				
Score					
Implementation					
Timeline	1 year				
Methodology	A1. Identify and map depth to groundwater across the City to determine groundwater recharge and discharge areas. Identify areas where the water table is estimated to be within 1.5 m of ground surface to and likely to have a lower infiltration potential. A2. Develop and implement a field program to create a coarsely gridded data set, much like the monitoring well network but aimed at characterizing infiltration potential. The field program should include: 1) multiple infiltration tests at multiple depths using a standardized methodology (e.g. Guelph Permeameter or equivalent), 2) logged overburden geology (up to approximately 2m depth, where infiltration tests are occurring) at the same time as the infiltration testing, and 3) soil samples for particle size distribution analysis. A3. Analyze data and classify recharge potential into high, moderate, and low for each geologic unit, soil texture, depth, land use. A4. Overlay land use and zoning maps with recharge areas. Interpolate results onto existing 2D geological maps together with topography, stormwater catchments and drainage infrastructure to visualize infiltration potential across the City. A5. Assess areas of known contamination, land use threats, and focused development within recharge areas. Identify the risk associated with each recharge area. Additional Task (Optional): A6. For areas identified as having high recharge potential and slated for enhanced infiltration methods, consider analyzing isotopes for relative age dating and completing tracer tests for detailed pathway analysis.				
Deliverables	GIS-based map of recharge areas categorized by recharge potential (low, medium, and high). Identifies areas of contamination and/or sensitive soils where enhanced recharge measures should be carefully evaluated and/or avoided.				
Draft KPIs	Number of infiltration tests completed per square kilometer Percent of land area analyzed for recharge potential and presented on maps Percent of area with high recharge potential under protective land use designations Number of identified areas of increased risk where enhanced recharge should be avoided Number of planning documents updated to reflect recharge considerations				
Assumptions	A. Completed by an external consultant. Include 975 hours of city staff time to collate and provide data to a consultant. B. Completed by city-staff. Assume 3,900 hours. Ongoing: Assume 390 hours/year (City staff time)				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)		\$500K	25 x \$10K permeability tests and \$250K analysis, modeling and reporting.		
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Natural Resources Canada – Climate Change Adaptation Program UBCM – Community Emergency Preparedness Fund: Risk Mapping, Assessment & Planning stream CleanBC – Climate Preparedness and Adaptation Strategy				
Other considerations	Reference leading jurisdictions' approaches (e.g., California, Ontario Source Water Protection) Risk of low uptake or implementation delays if policies are not well integrated into existing planning tools				

Action					
Number	17				
Name	Water Budget for Groundwater Reliant Ecosystems				
Description	Identify ecosystems that are reliant on groundwater and develop a water budget model for them to help determine where and how these ecosystems should be protected.				
Rationale	Many ecosystems, such as Still Creek and Camosun Bog are dependent on groundwater to properly function. Several others are suspected to rely on groundwater, but a city-wide inventory of groundwater-dependent ecosystems (GDEs) has not been completed. To protect these ecosystems, we need to first identify them and then understand how they interact with groundwater. With this information, we can predict how different stressors (e.g. increased upgradient imperviousness, new drainage systems or wells, etc.) may impact these ecosystems, and take steps to reduce or mitigate these impacts.				
Strategy Objectives	6. Support ecosystems				
Action Type	Foundational				
Score					
Implementation					
Timeline	1 year				
Methodology	1. Use the city-wide groundwater model in addition to local knowledge to identify GDEs. Use mapping tools, geospatial data, and existing ecological inventories to delineate the areal extent for each GDE. This should consider recent daylighting initiatives and features that drain the aquifer beyond City of Vancouver boundaries. It may also be useful to calculate groundwater discharge to historical streams to identify future opportunities for GDE enhancement. 2. Develop a conceptual model/understanding (including local topographic, geologic, hydrogeologic, and hydrologic characteristics) for each GDE. 3. Use the city-wide groundwater model, with local refinements (if necessary), to simulate groundwater heads, flow, and discharge for each GDE. 4. Develop an annual and monthly water balance for each GDE under current climate conditions. 5. Apply climate projections to the model to estimate impacts of future climate change on groundwater discharge to each GDE.				
Deliverables	Map illustrating GDEs within and surrounding the City of Vancouver. Monthly water budget for each GDE under current and future climatic conditions.				
Draft KPIs	Number of GDEs identified Percent of GDEs with monthly water budget				
Assumptions	Completed by an external consultant. Include 975 hours of city staff time to collate and provide data to a consultant.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)		\$60K	20 GDEs x \$3K per water balance = \$60K		
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Environment and Climate Change Canada – EcoAction or Habitat Stewardship Program				
Other considerations	May build off work from Australia and California Land use constraints near sensitive GDEs may generate opposition				

Action					
Number	19				
Name	Aquifer Valuation				
Description	Quantify the "natural asset" value of local aquifers in terms of water storage and supply, supporting ecosystems, and other municipal services, and incorporate this information into the City's asset management system.				
Rationale	Traditionally, civic asset management processes have only been applied to engineered infrastructure. However, there is growing evidence that by considering natural assets (e.g. aquifers) within asset management processes, local governments can decrease capital, operations, and maintenance costs, increase levels of service, enhance their ability to adapt to climate change, and reduce the community's unfunded liabilities – all while protecting or enhancing the multitude of other benefits that natural assets bring to communities. The functions that nature provides to communities beyond core services, such as recreation, climate regulation, clean air, habitat, and biodiversity, are invaluable to the overall health and well-being of a community. Therefore, including natural assets in asset management processes provides an integrated approach to maintaining or enhancing the natural assets in a community. Desired Future State: Understand value of aquifers to guide decision-making around infrastructural options.				
Strategy Objectives	1. Build Support 3. Safeguard quality 4. Preserve resources 5. Use sustainably 6. Support ecosystems 7. Reduce risks				
Action Type	Actionable				
Score	22				
Implementation					
Timeline	2 years				
Methodology	1. Complete a jurisdictional scan to review methodologies for natural asset valuation 2. Define which aquifer services to quantify (e.g., emergency water supply, baseflow to GDEs during summer months, etc.) 3. Use results from the calibrated groundwater model and water balance to quantify each aquifer service (e.g., ML of water supply, L/s of baseflow, etc.). 4. Define the methodology used for valuing services (e.g., standard industry rates vs cost of replacing services with engineered systems, etc.) 5. Estimate the value of the services the aquifer(s) provide(s) 6. Consult with internal departments to integrate aquifers within existing asset management efforts and system(s) 7. Build out asset attributes for each aquifer (e.g., condition, value, owner and risks) to populate existing asset information systems 8. Prepare a summary report outlining methodology, aquifer service values, integration steps, and recommendations for updating asset management practices, asset management plans and decision making processes to account for natural groundwater assets.				
Deliverables	An assessment of the natural asset value of local aquifers and GDEs Integration of aquifers into the City's asset management system(s) Ongoing management of groundwater resources as a city asset				
Draft KPIs	Number of aquifer services quantified Total value of aquifer(s) and GDEs Percent integration of aquifers and GDEs into the City's asset management system(s)				
Assumptions	Onetime: Completed by an external consultant. Assume 2,925 hours of city staff time to supply data, and to integrate the result into the City's asset management system. Ongoing: Assume 195 hours of additional city staff per year to administer.				
Dependencies					
Required Predecessors	71				
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$5M–\$15M	Benefits in the form of reduced infrastructure costs and optimized investment decisions (e.g., baseflow augmentation, stormwater storage, backup supply systems). Asset integration supports funding access, prioritization, and service delivery at lower lifecycle cost	3	
Economic (Community)	High	\$1M–\$5M	Avoided costs from service disruption or replacement of natural infrastructure (\$500K–\$2M), sustained access to ecosystem services (\$250K–\$1M), improved decision-making leading to long-term protection of aquifer-supported amenities including green spaces, street trees, GDEs, etc. (\$250K–\$2M).	3	
Social	High		Protects natural assets such as green spaces, GDEs and street trees that supports community well-being. Builds awareness of the role of aquifers in daily life, equity in environmental services, and transparency in municipal decision-making. Reinforces sustainability values.	3	
Environmental	High		Treating aquifers as an asset helps develop the case for their protection.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Medium	\$800K	Consultant support for modeling, valuation, and integration (\$500K over 2 years). Staff time (2,925 hours for 1 year + ongoing administration cost 195 hours/year)	1	
Economic (Community)	No cost		No direct cost.	3	
Social	No cost		No adverse social effects.	3	
Environmental	No cost		No disturbance.	3	
Additional Details					
Alignment with other City Strategies	City's Asset Management Policy				
Funding Recommendations	UBCM – Asset Management Planning Program Real Estate Foundation of BC Municipal Natural Assets Initiative Federation of Canadian Municipalities – Municipal Asset Management Program				
Other considerations	Assume COV obtains rights to use from province.				

Action					
Number	21				
Name	Limit Discharge from Foundation Drains				
Description	Develop city-wide sustainable performance-based requirements to limit the permanent diversion of groundwater into sewers from foundation drains (e.g. a maximum discharge rate).				
Rationale	Current State: Underground structures, including parkades, require drainage systems to protect them from water ingress and hydrostatic pressures. The groundwater collected by these systems is usually discharged to the sewer system, which not only reduces sewer system capacity, increases treatment costs, and adds to combined sewer overflow (CSO) events, but can also result in other impacts such as reduced baseflow to nearby streams and geotechnical risks (e.g. subsidence). There are currently no incentives in place for developers to limit groundwater discharge. Desired Future State: Incentivize developers and contractors to prevent the loss of groundwater through dewatering. Strategies for developers may include the use of groundwater cut-off walls, tanked building foundations, groundwater discharge fee and reduce below-grade parking. Gap Addressed: This action will help mitigate impacts to the sewer and drainage system by incentivizing developers to limit the amount of groundwater diverted to sewer.				
Strategy Objectives	4. Preserve resources 6. Support ecosystems 7. Reduce risks				
Action Type	Actionable				
Score	20				
Implementation					
Timeline	3 years				
Methodology	1. Determine maximum I&I values that would not result in CSO events under a common storm (e.g., I&I allowance under a 2 year storm). 2. Use results from the groundwater model and groundwater diversion action items to identify areas where the water table is above typical foundation drain depths and discharge ends up in a combined sewer. 3. Use results from the city-wide groundwater model to estimate cumulative discharge volumes and identify potential environmental impacts (loss of baseflow, reduced recharge) leveraging EFN action item. 4. Estimate the flows from foundation drains and compare it to the maximum I&I values determined in Step 1. If the estimated flows are significant (e.g. exceed CSO objectives or reduce flows below EFN thresholds) then proceed to the next step. 5. Based on the steps above, develop requirements to limit the permanent diversion of groundwater into sewers from foundation drains (e.g., a maximum discharge rate). 6. Meet with the development community to discuss the proposed requirements and gather their feedback on engineering design options and evaluation effectiveness, cost, constructability, and lifecycle impacts. 7. Finalize, get approval and implement performance-based requirements, which may involve revision of the Groundwater Management Bulletin and/or new groundwater and building bylaws. 8. Implement performance-based requirements, similar to RWM requirements.				
Deliverables	Baseline assessment report Jurisdictional Review Draft performance-based criteria New Groundwater Bylaw				
Draft KPIs	Estimated flow from foundation drains vs allowable capacity within combined sewer system Measured change in baseflows Number of jurisdictions reviewed Number of pilot projects completed				
Assumptions	Assume 5,850 staff hours in AECOM costing (no external)				
Dependencies					
Required Predecessors	100, 101				
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$5M–\$15M	Long-term sewer infrastructure and treatment cost savings. Reducing permanent groundwater discharge into the sewer system lowers the load on sanitary infrastructure, reducing pumping, conveyance, and treatment costs.	3	
Economic (Community)	High	\$1M–\$3M	Reduces flooding risk in basements by reducing the likelihood of surcharging combined sewers. Reducing City infrastructure costs will translate into lower wastewater rates for property owners/tenants.	3	
Social	Medium		By reducing CSO's, water quality in False Creek/English Bay where people recreate (e.g., kayak and swim). Reduces service disruptions caused by sewer surcharges. Improves transparency and fairness by applying consistent city-wide discharge limits.	2	
Environmental	High		Prevents excessive aquifer drawdown and protects groundwater-dependent streams by avoiding unnecessary groundwater discharge. Reduces the probability of combined sewer overflows.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$450K	Staff time (5,850 hours)	2	
Economic (Community)	Low	\$10K–\$50K/property (developer costs)	New standards may require improved foundation drainage designs (e.g. tanked systems or on-site infiltration), increasing capital costs for some developments, especially in high groundwater areas.	2	
Social	Low		Some social resistance expected. Developers may seek clarity on compliance pathways and allowable alternatives. May reduce availability of parking in dense neighbourhoods.	2	
Environmental	No cost		No environmental harm from this policy initiative.	3	
Additional Details					
Alignment with other City Strategies	Healthy Waters Plan Vancouver Plan Ecological Vision				
Funding Recommendations	Infrastructure Canada – Green Infrastructure Fund UBCM – Asset Management Planning Program Development contributions				
Other considerations	Assuming this is a scoping level assessment (limitations for detailed assessment) using the groundwater model for development scenarios. Risk of non-compliance if enforcement or guidance is unclear				

Action					
Number	22				
Name	Map Groundwater I&I Risks				
Description	Develop a map of groundwater elevation and cross-reference with sewer and drainage infrastructure to highlight areas where I&I is most likely, and should be prioritized for I&I monitoring, and pipe repairs as needed.				
Rationale	Inflow & Infiltration (I&I) occurs when rainwater and groundwater are erroneously or unnecessarily directed to sewer pipes. One source of I&I is due to leaking sewer pipes that allow the groundwater to enter the pipe through holes or cracks in the pipe network. This not only reduces sewer system capacity and increases treatment costs and Combined Sewer Overflow (CSO) events but also wastes the groundwater resources. A city-wide, comprehensive I&I monitoring program is very costly. However, by mapping out where City infrastructure is below the water table, it may be possible to prioritize I&I flow monitoring locations. The effectiveness of this assessment may be increased by adding available data on sewer infrastructure that may indicate the likelihood of leaks (e.g. pipe type, age, etc.).				
Strategy Objectives	4. Preserve resources 7. Reduce risks				
Action Type	Actionable				
Score	21				
Implementation					
Timeline	1 - 1.5 years.				
Methodology	1. Use the simulated groundwater elevation results from the city-wide numerical model (Action 4) and generate a raster of groundwater levels under average annual and seasonal conditions. 2. Join groundwater elevation data to sewer infrastructure GIS layers, including sanitary, storm, and combined sewers, using common spatial references and segment geometry. 3. Identify pipe segments located below the water table and calculate a depth below water table for each segment in the GIS layer. 4. Incorporate additional sewer system attributes, such as pipe/joint material and age, that may indicate leak potential to enhance prioritization. 5. Generate a composite I&I risk map highlighting pipe segments where groundwater elevations exceed pipe inverts, and where material or age suggest higher vulnerability to leakage. 6. Consult with sewer operations and capital planning teams to confirm data assumptions and discuss how this map can inform I&I monitoring, inspections, and rehabilitation/renewal prioritization.				
Deliverables	GIS layer of all city sewer pipe segments (sanitary, storm, and combined). The layer will include a field for depth below water table and the associated I&I risk rating				
Draft KPIs	Length and/or percent of sanitary/combined and storm sewer system flagged as high-risk for I&I Number of areas identified for targeted I&I monitoring				
Assumptions	Completed by city staff. Assume 3,900 staff hours.				
Dependencies					
Required Predecessors					
Successor(s)	139				
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$5M–\$12M	Immediate and sustained reduction in sewer system infiltration and treatment costs (\$2M–\$5M), deferral or downsizing of capital infrastructure upgrades (\$2M–\$5M), savings from proactive asset management and reduced emergency responses (\$1M–\$2M).	3	
Economic (Community)	Medium	\$250K–\$1M	Reduced private sewer backup incidents and localized flooding (\$250K–\$1M)	2	
Social	Medium		Reduced CSO's may result in fewer beach closures and water quality advisories.	2	
Environmental	High		Reduced sewer overflows and groundwater infiltration into sewers leads to improved water quality and energy efficiency, while preserving groundwater to support ecosystems.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$300K	Staff time (3,900 hours)	2	
Economic (Community)	No cost		No direct cost to third-party stakeholders.	3	
Social	No cost		No disruption to residents or businesses	3	
Environmental	No cost		Non-invasive, no environmental costs	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	UBCM – Asset Management Planning Program Federation of Canadian Municipalities – Green Municipal Fund BC Infrastructure Planning Grant Internal utility capital budgets (could support GIS work and risk analysis as part of broader sewer separation and renewal efforts)				
Other considerations	Wet-season groundwater conditions would represent conservative (risk-averse) conditions. Future monitoring should follow this action for flagged high-risk zones.				

Action					
Number	25				
Name	Evaluate GRI Effectiveness in Preventing Groundwater Contamination				
Description	Work with GI team to increase water quality monitoring to evaluate the long-term effectiveness of Green Rainwater Infrastructure assets in preventing contaminants (including dissolved phase constituents) from entering groundwater.				
Rationale	Green Rainwater Infrastructure (GRI) promotes sustainable urban rainwater management by slowing down and providing retention to rainwater, allowing it to soak into the ground. This helps reduce the volume of water entering our sewer system and increases groundwater recharge. However, stormwater can be contaminated (e.g. on roads, where vehicle tire particles, oil, and metals from brake pads mix with rain). While GRI assets often filter out many suspended contaminants, it is unclear which types and percentages of dissolved contaminants are removed. The goal of this action is to develop a comprehensive assessment, potentially including temporary or semi-permanent water quality monitoring, to better understand where treatment effectiveness could be increased via GRI design improvements.				
Strategy Objectives					
Action Type	Actionable				
Score	15				
Implementation					
Timeline	5 years				
Methodology	1. Select sites for monitoring 2. Determine parameters to measure and the method/frequency for monitoring. Assuming primary interests are monitoring the impacts of road runoff (metals, hydrocarbons, road salt), recommend monitoring may include physical parameters, anions, dissolved metals, and hydrocarbons. 3. Complete monitoring/collect data 4. Analyze resulting data 5. Use results to inform design, maintenance, and monitoring of future GRI installations				
Deliverables					
Draft KPIs	Number of GRI sites monitored Percent of GRI sites monitored Percent TSS removed Percent of sites with Coliform > CCME/BCWQ/CDWQ/BC CSR criteria Percent of sites with metals > CCME/BCWQ/CDWQ/BC CSR criteria Percent of sites with polycyclic aromatics > CCME/BCWQ/CDWQ/BC CSR criteria Percent of sites with concentrations > CCME/BCWQ/CDWQ/BC CSR criteria				
Assumptions	The City may choose to have a consultant to collect and interpret the data				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Low	<\$500K	May reduce water treatment costs for future groundwater uses.	1	
Economic (Community)	None		None	0	
Social	Low		May improve groundwater quality that could become a potable or protect existing water for non-potable water use	1	
Environmental	Medium		Will likely lead to improved GRI that better addresses groundwater quality and preserves quality of discharge to groundwater-dependent ecosystems	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$500K	Assume monitoring of 10 sites at \$20K per site for data collection and laboratory analysis. Analysis and interpretation of data estimated at \$50K depending on scope and duration of monitoring. Assumes one upgradient and one downgradient well installation per site to an assumed depth of 5 m (\$10K per site).	2	
Economic (Community)	No cost		None	3	
Social	No cost		None	3	
Environmental	No cost		Yes	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Government grants that focus on water sustainability and climate change resiliency (e.g., Intact Climate Resiliency Grants, FCM, etc.)				
Other considerations	It will be important to determine if study is to consider impacts of road de-icing salt.				

Action					
Number	27				
Name	Aquifer Vulnerability Assessment				
Description	Complete an aquifer vulnerability assessment to prioritize actions related to the protection of groundwater quality.				
Rationale	The purpose of this action is to develop aquifer vulnerability mapping to inform land use policy and decision making. It will be an invaluable tool to help the City protect local aquifers.				
Strategy Objectives	3. Safeguard quality				
Action Type	Foundational				
Score					
Implementation					
Timeline	1 year				
Methodology	1. Select appropriate vulnerability assessment method 2. Define parameters and data inputs depending on selected method 3. Generate or refine spatial datasets with special consideration to desired spatial resolution. This may include spatial interpolation where only point data is available 4. Perform a sensitivity analysis on the individual parameters, considering weighting of parameters, and possible region-specific adjustments. 5. Calculate the composite vulnerability score spatially. Consider normalization of the vulnerability scale. 6. Classify vulnerability zones (low, moderate, high). 7. Compile information into a map/tool (e.g., GIS layer) that can be easily used by City planning and permitting staff. Develop instructions/guidance for staff.				
Deliverables	City-wide GIS layers for inputs to vulnerability assessment City-wide GIS layer of aquifer vulnerability Methodology report and guidance on how to use map layers				
Draft KPIs	Percentage of city land area mapped and classified according to vulnerability Number of plans, policies, or permits that reference or use the aquifer vulnerability assessment once completed Percent of vulnerability assessment action items completed. Number of incidences of aquifer contamination, remediation, groundwater related property devaluation or groundwater related health concerns pre and post aquifer vulnerability mapping.				
Assumptions	Completed by an external consultant. Assume 250 hours of city staff to develop RFP, manage the consultant, provide data and review deliverables.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)		\$60K–140K	\$60K–120K for external consultant. Staff time (260 hours). Additional budget for data refinement and sensitivity analysis tools.		
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Natural Resources Canada – Climate Change Adaptation Program Provincial ministries (e.g., BC Ministry of Environment & Climate Change Strategy)				
Other considerations	Consider results in zoning updates				

Action					
Number	28				
Name	Remediation for Future Use				
Description	Work with the Province to remediate legacy contamination in areas identified for future use following Provincial direction on making contaminated sites climate ready.				
Rationale	Following completion of an aquifer vulnerability assessment and groundwater use potential assessment, sites suitable for future use will be identified. These sites may include private properties or City-owned properties, and they may be known to have contamination. In many situations, these sites will be remediated based on a risk assessment which often prohibits use of an underlying viable groundwater aquifer as a potable water source. This action entails working with the Province in order to protect and preserve groundwater resources for future use, in line with current Provincial direction of Making Contaminated Sites Climate Ready: https://engage.gov.bc.ca/govtogetherbc/engagement/making-contaminated-sites-climate-ready/				
Strategy Objectives	3. Safeguard quality				
Action Type	Deferred - Scope of remediation is site specific. Type, location, and degree of contamination needs to be determined prior to scoping.				
Score					
Implementation					
Timeline					
Methodology					
Deliverables					
Draft KPIs					
Assumptions					
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies					
Funding Recommendations					
Other considerations					

Action					
Number	29				
Name	Reduce Setbacks for Infiltration				
Description	Support other City teams to work towards reducing setback requirements related to infiltration to meet Rain City Strategy objectives and explore enhancing aquifer recharge.				
Rationale	Given the development pressures in the City, every inch of developable space on a property is often used, leaving limited space for infiltration features (e.g. GRI). Additionally, two known setbacks exacerbate this issue by precluding the act of infiltration within a set distance of building foundations (5m for Part 9 Buildings per VBBL 2019) and potable water pipes (3m per Design Guidelines for Drinking Water Systems in British Columbia). This action would seek to further support ongoing work (e.g. Rain City strategy - Pathways Study) that is looking at potential options for relaxing these setbacks, to increase onsite opportunities for infiltration.				
Strategy Objectives	4. Preserve resources				
Action Type	Actionable				
Score	21				
Implementation					
Timeline	2 years				
Methodology	1. Compile existing setback regulations and identify underlying rationale for each. 2. Complete a jurisdictional scan to identify setback regulations in similar urban and climatic settings and whether any additional measures are engaged (e.g., impermeable liners, tanked foundations, limiting building/drain tile depths etc.). 3. Use 2D or 3D numerical groundwater models to simulate infiltration near structures and other infrastructure under different scenarios (soil types and permeability, foundation and pipe depth, seasonal groundwater levels). 4. Evaluate risks to existing structures including structural damage, water level rise/fall, settlement, basement flooding, etc. 5. Identify scenarios or conditions where reduced setback may be safe (specific soil or aquifer types, depths to groundwater, controlled volumes and rates of infiltration, use of engineered systems). 6. Coordinate with other City teams to support development of technical guidance and criteria for implementation of systems. 7. Identify and support pilot studies. Evaluate results from pilot studies and refine setback guidelines. 8. Integrate reduced setback criteria into city policy and planning processes. 9. Communicate results to development community and City engineering staff.				
Deliverables	Bylaw update to reduce setback or exemption for reduced setback. Pilot study design and results. Map of areas where green infrastructure has or will be opportunistically implemented to determine the impact of increased infiltration on the city-wide water balance and groundwater transport.				
Draft KPIs	Number of pilot studies initiated per year Increase in area of infiltration-based green infrastructure projects after the policy update Impact of increased infiltration on volume of groundwater available for consumption Volume of stormwater diverted from combined sewer network and treated at WWTPs. Reduction in volume of CSOs.				
Assumptions	Completed by city staff - assume 1200 hr of staff time				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1M–2M	Cost savings through deferred, avoided or reduced stormwater infrastructure expansion, reduced load on sewer system, and potential to reduce wastewater treatment costs (from runoff in combined sewer catchment areas) and/or fines associated with CSOs.	3	
Economic (Community)	Medium	\$500K–1M	Increases developable space. Enables more efficient site layouts by reclaiming land near structures for infiltration.	2	
Social	Medium		Improves community acceptance of Rain City goals by making compliance more feasible. Increased awareness of groundwater recharge importance. Reduction in beach closures and increased use of water for recreational purposes.	2	
Environmental	High		Enhances aquifer recharge and baseflow support. Reduces urban runoff and potential pollutant transport to receiving waters. Strengthens resilience under climate change. If done in combined sewer catchment areas then could reduce the risk of combined sewer overflows.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$120K	\$100K for external consultant to conduct modelling study. Staff time (260 hours). Additional budget for data refinement and sensitivity analysis tools.	2	
Economic (Community)	No cost		No cost burden for landowners.	3	
Social	No cost		Minimal risk of resistance if public safety is prioritized. Developers may balk at need to install additional measures such as impermeable membranes.	3	
Environmental	No cost		None	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Green Infrastructure Grant Programs Partnerships with developers as part of stormwater or green infrastructure offset programs				
Other considerations	Could lead to unintended consequences such as basement flooding or structural damage from shallow groundwater rise				

Action					
Number	41				
Name	Emergency Response Business Continuity				
Description	Develop a clear governance structure specific to emergency response related to groundwater risks.				
Rationale	Current State: In the 2015 Beechwood incident, an inexperienced contractor pierced a pressurized (flowing artesian) portion of the aquifer, leading to several billion gallons of groundwater being discharged. At the time, it was initially unclear which City business units needed to be involved, and this might have led to delays in managing the issue. Desired Future State: Residents, businesses and the general public can rely on the City to coordinate emergency response to groundwater risks efficiently. Gap addressed by action: This action will integrate a clear governance structure for managing these and other types of groundwater emergencies in the existing Emergency Management Plan and Incident Response Guidelines, including channels for efficient communication and data sharing, for managing groundwater-related incidents (e.g. flooding from flowing artesian conditions).				
Strategy Objectives	1. Build support 7. Reduce risks				
Action Type	Actionable				
Score	21				
Implementation					
Timeline	1 year				
Methodology	1. Define the purpose of the Groundwater Emergency Management Plan (GEMP), including its role in responding to groundwater-related emergencies such as unsustainable drawdown, flooding, excessive flows, ecosystem degradation, slope failure, and water quality threats. 2. Develop a draft outline of the major components of the GEMP, including emergency scenarios covered by the plan, monitoring and detection protocols, decision thresholds and triggers, response levels, mitigation actions, enforcement procedures, communication strategies, and coordination mechanisms. 3. Align the proposed GEMP structure with existing City emergency response and climate adaptation frameworks to ensure integration and consistency. 4. Identify internal and external partners required for each component of the GEMP and distinguish between those who will be directly responsible for implementation and those who are stakeholders or advisory participants by establishing a RACI matrix. 5. Conduct preliminary outreach to key partners and stakeholders to validate the plan structure, clarify roles and responsibilities, and coordinate expectations for full plan development. 6. Develop a detailed workplan that outlines the tasks, sequencing, and estimated timelines required to complete the full GEMP.				
Deliverables	Groundwater Emergency Management Plan (GEMP) outline and workplan for completion List of partners and key stakeholders Detailed workplan and resource estimate				
Draft KPIs	Number of partners identified and engaged Percent of key partners who reviewed or provided feedback on the outline Number of successful mock exercises or tests.				
Assumptions	Only include scope of what would be in a GEMP, don't create one Assume 488 hours.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$5M–\$15M	Estimated benefits of avoided costs from mismanaged groundwater emergencies. In the 2015 Beechwood incident, delayed coordination contributed to ~\$12M in emergency response costs. A clearly defined governance structure would enable faster, coordinated mitigation and reduce the scale and cost of future groundwater emergencies.	3	
Economic (Community)	Medium	\$500K–\$2M	Avoided property damage though improved emergency response minimizes flooding, damage, and disruption to homes and businesses, particularly in areas overlying pressurized aquifers.	2	
Social	Medium		Builds public trust in the City's ability to handle high-risk groundwater events. Ensures that residents and businesses feel confident in the City's coordination and response mechanisms.	2	
Environmental	Medium		Prevents uncontrolled groundwater discharge that could degrade surface water, contribute to CSOs, erode banks, or harm nearby GDEs. Supports coordinated response to water quality emergencies.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	37.5K	Staff time (487.5 hours). Future plan development may require additional resources that are not included here.	3	
Economic (Community)	No cost		No direct cost to the public.	3	
Social	No cost		No adverse social impacts.	3	
Environmental	No cost		No disturbance.	3	
Additional Details					
Alignment with other City Strategies	City's Emergency Plans, Emergency Support Services, Emergency Operations Centre, Vancouver Emergency Management Agency, Unified Command (e.g., oil spills)				
Funding Recommendations	Infrastructure Canada – Disaster Mitigation and Adaptation Fund UBCM – Community Emergency Preparedness Fund				
Other considerations	External entities to consult with may include Ministry of Water, Land and Resource Stewardship, Indigenous governments, water users, environmental NGOs				

Action					
Number	43				
Name	Use of Permit Application Data				
Description	Explore options for the City to gain permission to use environmental, geotechnical, and hydrogeological data received as part of permit applications, to support City initiatives.				
Rationale	When developers conduct a hydrogeological study, they often install monitoring wells and submit the data to the City. This action would give the City permission to use this data to protect and manage local groundwater resources. Options could include working with the City's Legal Services to identify a solution or lobbying the Province to amend the Groundwater Protection Regulation to require the submission of borehole data and monitoring wells and add them to its GWELLS database.				
Strategy Objectives	3. Safeguard quality 4. Preserve resources 5. Use sustainably 6. Support ecosystems 7. Reduce risks				
Action Type	Foundational				
Score					
Implementation					
Timeline	6 months				
Methodology	1. Identify existing legal or procedural limitations on how third-party data submitted through permits may be accessed, stored, or used by City staff. 2. Inventory current data submission practices to determine when and how groundwater data is currently received by the City and can be automatically integrated into a data management framework (Action7). 3. Consult with Legal Services and Permitting staff to assess options for enabling or clarifying the City's right to use submitted data for non-regulatory purposes. 4. Review other jurisdictions to understand how municipal governments secure rights to use third-party environmental data, and identify any tested policy or legal templates. 5. Explore adding new language to permit application forms or development agreements that grants the City permission to use submitted environmental and subsurface data for internal and public benefit. 6. Prepare a recommendation memo summarizing legal options, preferred approaches, implementation steps, and the anticipated benefits for groundwater data management.				
Deliverables	The legal means for city staff to freely use 3rd party data.				
Draft KPIs	Draft permit condition or agreement clause prepared (Yes/No)				
Assumptions	One time: Completed by city staff: 1,950 hours				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)		\$150K	Staff time (1,950 hours)		
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Internal departmental budget (legal review and permitting updates could fall under operating budgets for Legal, Development Services, or Planning) FCM – Municipal Asset Management Program BC Local Government Development Approvals Program – administered by UBCM				
Other considerations	Consider piloting new language on high-impact projects (e.g. large redevelopments) before integrating city-wide.				

Action					
Number	46				
Name	Collaborative Forum				
Description	Establish a forum for the Province, Metro Vancouver, and neighbouring governments including local Nations to coordinate and collaborate to assess and mitigate groundwater-related risks (e.g. saltwater intrusion).				
Rationale	The Province of BC has identified two aquifers beneath Vancouver, both of which extend across multiple other municipalities. As the management of these aquifers are shared by many levels of government (including local Nations and the Province of BC), it makes sense to have a coordinated approach. Key groundwater issues could include drought resilience, land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets and establishing a notification or monitoring system for large (e.g. commercial or industrial) water users. Related to #74 (Water Reservation Application). Desired Future State: This is about bringing stakeholders together to share knowledge and expertise and work together on shared issues.				
Strategy Objectives	2. Collaborate 3. Safeguard quality 4. Preserve resources 5. Use sustainably 6. Support ecosystems 7. Reduce risks				
Action Type	Actionable				
Score	15				
Implementation					
Timeline	1 year				
Methodology	1. Identify relevant stakeholders. Develop a stakeholder map showing relationships, overlapping jurisdictions, and aquifer boundaries. 2. Define and prioritize groundwater-related risks. 3. Identify who will lead the initiative (e.g. invitations, agenda setting etc.). 4. Determine the format and frequency of the collaboration. 5. Prepare terms of reference including forum membership and structure, meeting frequency and logistics, roles and responsibilities, data sharing protocols, and conflict resolution. 6. Develop a knowledge sharing platform and terms of reference for decision-making. Specific tasks for the forum related to Action 76 (Water Reservation Application) 1. Encourage regional discussion regarding groundwater allocation, coordination of long term planning. 2. Prepare internal city policies or zoning overlays to limit new groundwater-intensive land uses within reservation zones. Establish a process for future conversation of reserved volumes to active licenses. 3. Prepare public communication materials on topics such as long-term water security under FITFIR, the difference between water licensing and reservation, and ensuring sustainable and Equitable groundwater use. 4. Engage with potentially affected stakeholders. Document support and concerns to help refine the reservations strategy.				
Deliverables	Stakeholder map Shared data platform Reoccurring regional forum				
Draft KPIs	Number of meetings multiplied with the number of partner organizations attended Monetary savings from shared information Number of other action items that benefited from information provided through the forum				
Assumptions	Onetime: Completed by city staff (488 hours) Ongoing: Completed by city staff (195 hours/year)				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Low	<\$500K	Sharing information/data may reduce the City's need to collect data and/or result in improved groundwater management. Communication of issues may preserve the value of groundwater and reduce future risks to aquifers.	1	
Economic (Community)	None		None	0	
Social	Low		May lead to improved protection of shared assets (e.g. groundwater, surface water, parks, infrastructure, etc.), improved drought resilience and land use designations	1	
Environmental	Low		May help better manage land use and groundwater use to preserve this natural asset	1	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$75K	Staff time (975 hours) to coordinate and attend the forum.	3	
Economic (Community)	No cost		None	3	
Social	No cost		None	3	
Environmental	No cost		None	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Government grants that focus on water sustainability and climate change resiliency (e.g., Intact Climate Resiliency Grants, FCM, etc.). Metro Vancouver's Sustainability Innovation Fund (if Metrobank is involved)				
Other considerations					

Action					
Number	52				
Name	Groundwater Rise				
Description	Reduce risks related to groundwater rise, including surface or subsurface flooding: A. Complete an assessment of potential extent and magnitude of groundwater rise. B. Complete an inventory of areas in the City that may be vulnerable to groundwater rise and develop mitigation strategies.				
Rationale	Future State: "Groundwater rise" resulting from increasing sea levels (i.e. due to climate change) can lead to flooding of below ground structures, geotechnical impacts, increased capture of groundwater via drainage systems, surface flooding, and other impacts. There are a number of City-owned facilities (e.g. Kits pool) and other assets (e.g. roads, sewer pipes, etc.) that may be vulnerable to groundwater rise. Desired Future State: Develop mitigation plans for areas vulnerable to 0.5 m and 1.0m sea level rise by the Year 2050 and 2100 (based on Provincial Guidelines) and resulting groundwater rise to provide input into the Fraser River Flood Management Plan by 2030.				
Strategy Objectives	7. Reduce risks				
Action Type	A. Actionable B. Deferred - Scope will be dependent on the area of land at risk to saltwater intrusion				
Score	18				
Implementation					
Timeline	1 year				
Methodology	A1. Define sea-level rise scenarios (e.g. +0.5 m by 2050 and +1.0 m by 2100) using Provincial sea-level rise guidelines. A2. If not already completed in preceding Actions, use the numerical groundwater model to simulate groundwater rise under each sea-level rise scenario; this may involve transitioning the existing groundwater model to a density dependant flow model. A3. Compare current groundwater elevations to groundwater elevation under future climate scenarios. A4. Identify areas where rising groundwater levels intersect or approach the ground surface, and flag locations with shallow infrastructure, basements, or known drainage issues. A5. Produce a citywide map of surface and subsurface flooding risk, classifying areas by risk level (e.g. low, moderate, high) for each time horizon (2050 and 2100). B1. Develop an inventory of City-owned facilities and infrastructure located in areas identified as moderate or high risk from groundwater rise. B2. Conduct a vulnerability screening for inventoried assets, considering depth of flooding, water sensitivity of the asset (e.g. corrosion, flooding, buoyancy), and criticality to City services. B3. Identify and evaluate mitigation strategies for each asset. Prioritize areas and assets for mitigation planning based on risk, asset criticality, and co-benefits. B4. Prepare an inventory and mitigation strategies for areas vulnerable to flooding.				
Deliverables	A. Model of groundwater elevations under 2050 and 2100 sea level rise scenarios. A. Map of areas with subsurface and surface flooding risk. B. Inventory and mitigation strategies for areas vulnerable to flooding				
Draft KPIs	Percent of City by land area prone to negative groundwater impacts due to sea level rise Percent of assets that would be negatively impacted by sea level rise with a funded and/or implemented mitigation strategy				
Assumptions	A. Assume completed by external consultant. B. Assume city staff will complete the inventory of city-owned assets (assume 5850 hours for one year), with guidance from external consultant as to what kinds of assets would be vulnerable. The external consultant would then develop mitigation strategies for those assets. This action item, particularly the extent and magnitude of groundwater rise, and saltwater intrusion induced by sea-level rise, will likely be completed by a consultant with experience in groundwater flow modelling (density-dependent) including sensitivity analysis. City staff will likely be more involved in the identification of City-owned assets that may be vulnerable to the recently determined groundwater rise and/or saltwater intrusion. The City will likely request that a consultant, who has experience in hydrogeology and structural engineering identify mitigation strategies for those assets that will be affected.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Highest	>\$10M	Could provide a framework to ensure city infrastructure and lands are designed and managed in a manner that is resilient to future damage from groundwater level rise, hence avoid rehabilitation costs for City assets	4	
Economic (Community)	Highest	>\$10M	Although this project will focus on City owned assets, it will likely provide valuable information that private asset owners could use to protect their own assets (e.g. low lying land along Jericho Beach, Spanish Banks, Fraser River, poorly drained areas, etc.)	4	
Social	Medium		Could protect assets that provide community services (e.g. seawall, Kitsilano Pool, city beaches, buildings, etc.)	2	
Environmental	Medium		Protection of natural assets	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	High	\$500K	Consulting costs and some staff time to develop request for proposals, collate supporting data and collaborate with other parties (e.g. Parks Board, Metro Vancouver, MOTI, etc.).	0	
Economic (Community)	High	\$500K - \$1M per property	May impact property value and access to insurance for properties mapped within the floodplain and risk area.	0	
Social	No cost		None	3	
Environmental	No cost		None	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Government grants that focus on water sustainability and climate change resiliency (e.g., Intact Climate Resiliency Grants, FCM etc.). Potential funding partners include UBC, UEL and other landowners who have assets within assessment area.				
Other considerations	Consider alignment of climate projections with Fraser River Coastal Adaptation Plan				

Action					
Number	54				
Name	Partnerships to Protect Groundwater Ecosystems				
Description	Explore partnership opportunities with local Nations and stewardship groups to protect groundwater-dependent ecosystems, share data and lessons learned, and collaborate on regional biodiversity goals.				
Rationale	Several ecosystems in the city are believed to be groundwater dependent (GDEs). Many stakeholders and other governments have considerable knowledge and expertise related to the historic and present-day health and well-being of these ecosystems. To better understand and preserve these assets, the City needs to work with these partners towards a shared goal. Regional biodiversity goals could include exploring land use designation under the zoning by-law for Environmental Sensitive Areas (ESAs) for natural assets. Current State: Several ecosystems in the city are believed to be groundwater dependent (GDEs). Many stakeholders and other governments have considerable knowledge and expertise related to the historic and present-day health and well-being of these ecosystems. Desired Future State: To support the UNDRIP Action Plan and better understand and preserve natural assets, the City needs to work with these partners towards a shared goal. This might include providing support to local Nations to facilitate participation in partnerships and to develop stewardship monitoring capacity; additionally, indigenous vendors/consultants should be prioritized for related work. To enhance equity, this work should consider the needs of multiple species and be rooted in moving away from City-control of processes.				
Strategy Objectives	1. Build support 2. Collaborate 6. Support ecosystems				
Action Type	Actionable				
Score	22				
Implementation					
Timeline	1 year				
Methodology	1. Using the results of Action 17 to develop a list of key GDE where collaborative protection efforts would be impactful. 2. Identify potential partners that are already active in monitoring each GDE. Identify potential partners that are not already active but aligned with ecosystem and/or groundwater protection. Understand their mandates, geographic focus, and capacity for collaboration. 3. Initiate dialogue with partners through meetings, workshops, or roundtables. Identify shared goals, roles, and opportunities for Indigenous leadership or co-management stewardship. 4. Explore and document collaborative mechanisms. Formalize agreements where appropriate. 5. Establish formal and regular feedback system (e.g. workshop, communication letter, etc.) to maintain focus, identify issues and celebrate achievements.				
Deliverables	Active working relationships with First Nations and other stewardship groups Identified shared goals and collaborative mechanisms. Continued collaboration on various projects.				
Draft KPIs	Number of organizations contacted and engaged Percent of GDEs with at least one engaged partner Number of active joint initiatives Number of regularly scheduled check ins and communication directed at each organization, such as a First Nations Engagement Forum				
Assumptions	Onetime: Assume completed by city staff - 975 hours for one year Ongoing: Assumed completed by city staff - assume 390 hours/year				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Medium	\$500K–\$1M	Cost avoidance via co-stewardship, reduced restoration costs. Shared monitoring, stewardship, and protection strategies with local Nations and NGOs can lower future restoration costs, support grant eligibility, and prevent degradation of ecosystem services	2	
Economic (Community)	Medium	\$500K–\$1M	Benefit is avoided costs of flood control/erosion mitigation. GDEs provide critical services like flood regulation, water purification, and temperature regulation. Collaborative protection helps sustain these services for residents in Vancouver and adjacent communities.	2	
Social	High		Builds relationships with Indigenous communities and local stewards. Recognizes traditional knowledge, fosters reconciliation, and supports community-based governance.	3	
Environmental	High		Supports the long-term health of GDEs through more localized, responsive, and knowledge-informed management.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$75K	Staff time (975 hours).	3	
Economic (Community)	No cost		No direct financial burden. Community benefits from improved ecosystem protection and collaborative governance.	3	
Social	No cost		No negative social costs.	3	
Environmental	No cost		No adverse environmental impact.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Environment and Climate Change Canada – Habitat Stewardship EcoAction Community Funding Program Private Foundations & NGOs				
Other considerations	Directly supports and builds on Action 17 (GDE water budgets), and complements Actions 16, 26, and 55				

Action					
Number	56				
Name	Managed Aquifer Recharge				
Description	Complete an assessment of the potential for Managed Aquifer Recharge, including the potential for aquifer storage and recovery to be used in the city as a means of storing excess rainwater for use during times of water scarcity.				
Rationale	Currently, the city receives too much rainfall in the winter, and not enough in the summer. This situation is likely to worsen as climate change progresses. This action will assess the potential of using local aquifers to store excess rainwater in winter months for use during times of scarcity, much like reservoirs in the North Shore do.				
Strategy Objectives	4. Preserve resources 5. Use sustainably 7. Reduce risks				
Action Type	Deferred - Scope and applicability of this action is dependent on the groundwater modeling and identified recharge/discharge zones				
Score					
Implementation					
Timeline					
Methodology					
Deliverables	MAR plan that includes city-wide assessment of aquifer storage and recovery system opportunities				
Draft KPIs					
Assumptions					
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Costs				Unweighted Score	Weighted Score
Economic (City)					
Economic (Community)					
Social					
Environmental					
Additional Details					
Alignment with other City Strategies	Climate Emergency Action Plan				
Funding Recommendations					
Other considerations					

Action					
Number	58				
Name	Reduce Impacts of Parkades				
Description	Explore ways to discourage below-grade parking and/or reduce overall impacts of parkades by reducing parkade depths or tanking foundations where groundwater may be encountered.				
Rationale	Current State: Parking and storage is often located in below-grade areas of the development, and depths can be significant. The deeper a development goes below ground, the greater the chances that it will impact groundwater. Groundwater is typically collected in a perimeter drainage system and discharged as waste. Above-grade parking levels may 'count against' the overall FSR (floor space ratio) of a project, resulting in a reduced allowable area for residential or commercial space. Desired Future State: Limit adverse impacts from below-grade development on groundwater. This could be achieved through allowing/encouraging above-grade parking, providing height/density bonuses to developments to make up the loss of below-grade space, and/or setting maximum allowable parkades depths.				
Strategy Objectives	1. Build support 4. Preserve resources 6. Support ecosystems 7. Reduce risks				
Action Type	Actionable				
Score	17				
Implementation					
Timeline	1 year				
Methodology	1. Review existing zoning regulations, design guidelines, height, max/min parking space requirements and Floor Space Ratio (FSR) policies to where restrictions or disincentives exist. 2. Analyze the relation between parkade depth and groundwater impacts using available monitoring, modelling, or permit data to identify typical excavation depths that intersect the water table. 3. Consult with Planning, Urban Design, and Engineering staff to identify strategies to discourage below-grade parking or mitigate impacts of deep parkade foundations (i.e. by using tanked foundations). 4. Review precedents from other jurisdictions. 5. Evaluate technical, financial, and regulatory feasibility of potential policy tools/incentives. 6. Assess development industry impacts and feasibility through consultation with the development community or case study testing of hypothetical bonus/trade-off scenarios. 7. Work with Legal and Planning staff to draft policy or bylaw language that reflects the preferred approach with supporting rationale linked to groundwater protection objectives.				
Deliverables	Policy/bylaw regulating below-grade parkades				
Draft KPIs	Number or % of properties to be impacted by proposed policy/bylaw changes Estimated financial impact of proposed policy/bylaw changes (total or per parcel)				
Assumptions					
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$3M-\$8M	Deferral or reduction of sewer capacity upgrades (\$2M-\$5M), and reduced flooding, treatment and CSO's in combined sewer areas (\$1M-\$3M)	3	
Economic (Community)	High	\$1M-\$3M	Reduced excavation and foundation costs for developers; lower long-term pumping, tanking, and waterproofing investments. Reduction in responsibility for operation and maintenance of mechanical pumping systems for building owners and strata's.	3	
Social	Low		Reduced CSO's may reduce beach closures and water quality issues in recreational areas.	1	
Environmental	Medium		Avoids drawdown from permanent foundation drainage. Preserves or enhances discharge to groundwater-dependent ecosystems. Reduces drainage and settlement of sensitive soils, wetlands, and regional groundwater table. Preserves terrestrial ecosystems and supports community greenspace amenities including trees.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$450K	Staff time (5850 hours).	2	
Economic (Community)	Medium	\$500k-1M	Potential opportunity cost for developers where below-grade parking is preferred for marketability or design. Foundation design and construction may increase to address tanking and/or buoyancy. Assume cost of \$500k for each impacted property.	1	
Social	Low		Minor public resistance to taller buildings depending on location/context	2	
Environmental	No cost		No direct environmental costs	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	FCM – Green Municipal Fund Planning Stream UBCM – Local Government Development Approvals Program				
Other considerations	Parkades depth limits or bonuses tied to groundwater protection must be well-justified in technical terms, may require additional modeling in specific areas of the city for GDE (similar to the Still Creek assessment for traditional vs tanked foundation drains).				

Action					
Number	60				
Name	Requirements for Injection Systems				
Description	Develop requirements, including water quality objectives and maintenance requirements, for stormwater infiltration or injection systems to ensure that groundwater quality is protected.				
Rationale	Although relatively rare in Vancouver presently, injections wells may be used to re-inject water (or other fluid) below ground into a porous geologic formation (e.g., groundwater collected via foundation drainage, or as part of an open-loop geothermal system). It may also be used in the future to manage stormwater, in areas with limited sewer capacity. Although the Province has developed BMPs related to water quality, and the Environmental Management Act (EMA) prohibits "pollution," limited guidance exists to ensure groundwater quality is protected. To protect groundwater quality, this action will set water quality guidelines and other requirements for any injection systems implemented in Vancouver.				
Strategy Objectives	3. Safeguard quality				
Action Type	Actionable				
Score	20				
Implementation					
Timeline	2 years				
Methodology	1. Review applicable regulations and guidance. Identify regulatory gaps or ambiguities in the current frameworks regarding injection/infiltration systems. 2. Identify and classify potential injection scenarios (e.g. stormwater, foundation drainage water, groundwater return from geothermal systems) and potential water quality risks associated with each scenario. 3. Review best practices from other jurisdictions for each injection scenario. 4. Develop water quality objectives for injection, monitoring requirements, and maintenance and operational protocols. 5. Draft municipal requirements, guidance documents, and a compliance and enforcement strategy by engaging with stakeholders, including the Province. 9. Communicate results to development community and City engineering staff.				
Deliverables	Water quality objectives and guidelines for injection systems Design, maintenance and reporting guidelines/requirements				
Draft KPIs	Number and percent of injection/infiltration systems installed under the new requirements. Number and percent of injection/infiltration systems installed after the new requirements that continue to meet the new requirements. Number of water quality incidences from injection/infiltration systems pre and post new requirements per year. Cost of remediating water quality issues from injection/infiltration systems per year.				
Assumptions	Mostly completed by external consultant. Assume 250 hours of City staff time to manage the consultant, support the drafting of municipal requirements and liaising with the Province.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Medium	\$500K–1M	Prevents costly groundwater contamination. Avoids environmental remediation and regulatory penalties. Supports compliance with EMA and other provincial/federal regulations. Preserves resource for other uses.	2	
Economic (Community)	Medium	\$500K–1M	Protection of water quality for use by private wells and reduced liability. Helps prevent the need for treatment on private water sources.	2	
Social	Medium		Increases public trust in City's ability to manage groundwater quality. Reduces concerns from local residents near injection sites.	2	
Environmental	High		Maintains and protects groundwater quality from non-point and point sources of pollution. Anticipates future injection growth and ensures aquifer sustainability.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$95K	\$75K for external consultant work. Staff time (260 hours).	2	
Economic (Community)	No cost		No direct financial burden for residents.	3	
Social	No cost		Policy development may face some resistance from private developers or infrastructure operators if perceived as overly restrictive.	3	
Environmental	No cost		No negative physical environmental impact from development of policies and guidelines. Field testing, if any, would occur under future implementation phases.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Environment and Climate Change Canada – Low Carbon Economy Fund Provincial funding through CleanBC programs				
Other considerations					

Action					
Number	63				
Name	Reduce Contaminants from City Operations				
Description	Reduce the risks of groundwater contamination from City operations: A. Develop an inventory of contaminants of concern that are either stored at city facilities or released to the environment by City operations, and that could contaminate aquifers. B. Following the development of an inventory of contaminants used by City operations, research and acquire less toxic but equally effective alternatives wherever available.				
Rationale	The City uses several chemicals (e.g. pesticides) and other contaminants (e.g. road salt) in its daily operations, some of which may eventually make their way into local aquifers. This action will identify all contaminants of concern used by the City and Park Board and consider opportunities for less toxic but equally effective alternatives to minimize groundwater pollution. It may also identify additional measures that may be taken to reduce risks (e.g. secondary containment, education regarding proper use).				
Strategy Objectives	1. Build support 3. Safeguard quality				
Action Type	A. Actionable B. Deferred - Costing will be dependent on the number of identified contaminants of concern				
Score	21				
Implementation					
Timeline	1 year				
Methodology	A1. Identify City-owned or operated facilities, infrastructure, and operations that involve the storage, handling, or release of substances with potential to contaminate groundwater. This may require discussions with other stakeholders (e.g. Metro Vancouver and Ministry of Transportation and Transit). A2. Compile a list of chemical and physical substances currently used or stored at each facility through review of existing material safety data sheets (MSDS), spill response plans, and operational permits. A3. Categorize contaminants of concern into risk categorizes based on mobility in the subsurface, persistence, toxicity to humans and ecosystems, and likelihood of release under normal or failure conditions. A4. Cross-reference identified contaminants with provincial or federal groundwater quality guidelines and aquifer protection regulations to refine contaminant inventory. A5. Map proximity of contaminant sources to sensitive hydrogeologic features using the groundwater model and monitoring well data, including aquifer recharge areas, high water table zones, and known groundwater-dependent ecosystems. A6. Prepare an inventory report summarizing the locations, types, and quantities of contaminants of concern. This may be presented as a GIS layer.				
Deliverables	A. Contaminant inventory, risk classification map and summary report B. City operation risk mitigation plan				
Draft KPIs	Number of contaminants of concern identified and assessed Number of products replaced with less harmful alternatives				
Assumptions	A. Assume completed by city staff (5,850 hours for one year). B. Assume 1,950 hours of city staff as a support role to external consultant. City staff would liaise internally with the various groups that use these contaminants to understand their needs and eventually help acquire alternatives. External consultant would assist with the identification and selection of alternatives.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$2M–\$10M	Avoided future remediation costs (e.g. excavation, pump-and-treat systems, regulatory fines), which can range from \$1M–\$10M per site depending on severity and aquifer sensitivity.	3	
Economic (Community)	Medium	\$500K–\$2M	Reduces threats to drinking water sources and ecosystems. Prevents spill-related disruptions to services, recreation, or land use.	2	
Social	Medium		Improves public confidence in the City's stewardship of groundwater and transparency in environmental risk management. May support better staff practices and interdepartmental coordination.	2	
Environmental	High		Prevents aquifer degradation from common urban sources like road salt, fuels, de-icing chemicals, and pesticides. Supports proactive containment and source control strategies.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$450K	Staff time (5,850 hours).	2	
Economic (Community)	No cost		No direct cost to the public.	3	
Social	No cost		No social disruption.	3	
Environmental	No cost		Action is protective and non-invasive; no environmental footprint beyond potential follow-up mitigations.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Environment and Climate Change Canada – EcoAction or Environmental Damages Fund UBCM – Asset Management Planning Program Provincial Ministry of Environment & Climate Change Strategy – BC Groundwater Protection Programs				
Other considerations	Inventory results may identify untracked or non-compliant contaminant storage practices, potentially triggering internal audits or regulatory follow-up.				

Action					
Number	65				
Name	Request Provincial Enforcement				
Description	Request that the Provincial government increase their enforcement efforts with regards to laws related to well decommissioning and temporary construction dewatering authorizations.				
Rationale	Despite Provincial legislation, some unused wells are not decommissioned, leading to safety concerns and the potential for contaminants to enter local aquifers via these wells. In addition, the Water Sustainability Act requires that Provincial approval be granted for construction dewatering. The intention of this requirement is to ensure the impacts of these activities on the environment and other water rights holders are assessed. Neither the well closure requirements, nor the requirements for approval to dewater (referred to as Use Approvals), are actively enforced by the Province. As both impact City resources, the intention is to engage with the Province to convey our concerns and seek a commitment for additional efforts to ensure compliance with these requirements.				
Strategy Objectives	2. Collaborate 3. Safeguard quality				
Action Type	Actionable				
Score	21				
Implementation					
Timeline	1 year				
Methodology	1. Review relevant provincial legislation and regulations related to well decommissioning and temporary construction dewatering (e.g., Water Sustainability Act, Ground Water Protection Regulation) and enforcement responsibilities. 2. Summarize current challenges or gaps in enforcement observed at the municipal level, including known instances of non-compliance or risks to groundwater from improperly decommissioned wells or unregulated dewatering. This includes engaging with internal City staff to compile & document technical and operational evidence supporting the need for increased provincial oversight. Construction dewatering associated with the City of Vancouver's self-performed work should also be considered even though there is an exemption from STUA requirements for municipal and regional governments. 3. Consider consulting with neighbouring municipalities to determine if similar concerns exist and whether a joint request or coordinated approach is appropriate. 4. Draft a formal letter to the provincial authority outlining the City's concerns, examples of risk or non-compliance, and a request for specific enforcement actions or program enhancements. 5. Submit the request to the Province. Track the Province's response and, if needed, follow up with additional documentation, coordination offers, or participation in regional groundwater governance discussions. 6. Document the process and outcomes internally.				
Deliverables	Summary of challenges, examples of non-compliance and need for increased enforcement. Formal letter to the Province. Increased enforcement of the GWPR well closure and STUA requirements.				
Draft KPIs	Number of case examples or documented instances of non-compliance included in the request - total and per year. Number of instances of non-compliance per year, after the request is made. Number of enforcement actions by Province for not following requirements of WSA and GWPR.				
Assumptions	Completed by city staff (488 hours for one year)				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1M–\$5M	Reduces risks of safety, groundwater contamination, settlement, and aquifer depletion from abandoned wells and/or overzealous construction dewatering.	3	
Economic (Community)	Medium	\$500K–\$1M	Reduces risks from excessive dewatering and settlement (e.g. impact on nearby building and landscape infrastructure).	2	
Social	Medium		Reduces safety risk from abandoned wells. Increases public and professional confidence in groundwater governance. Supports fairness in permitting and construction practices. Reduces conflict and complaints.	2	
Environmental	Medium		Protects aquifers from direct vertical contaminant pathways (e.g., open wells), prevents baseflow loss, and supports integrity of shallow groundwater regimes during temporary dewatering.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$37.5K	Staff time (487.5 hours) for legal/policy review, internal coordination, letter drafting, and engagement follow-up.	3	
Economic (Community)	No cost		No direct cost to residents or businesses.	3	
Social	No cost		No disruption.	3	
Environmental	No cost		No environmental footprint.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations					
Other considerations					

Action					
Number	67				
Name	Internal Education				
Description	Conduct regular learning sessions with key City departments about the importance of groundwater and how staff can help protect it (e.g. through process changes).				
Rationale	While the profile of groundwater is gradually increasing within various City departments, there is still a long way to go in terms of raising internal groundwater literacy. This action will involve hosting regular learning sessions with different City business units, particularly those whose work touches on groundwater. The goal will be to foster greater awareness and interest in protecting groundwater (and minimizing groundwater-related risks) through their work. Education should also include awareness of the liability the city carries due to wastewater and groundwater in our sewer system.				
Strategy Objectives	1. Build support 7. Reduce risks				
Action Type	Actionable				
Score	18				
Implementation					
Timeline	6 months to initiate, then ongoing				
Methodology	1. Identify the internal City departments whose operations, planning decisions, or policies influence groundwater quality or quantity. 2. Identify existing knowledge gaps, operational practices, and opportunities where education could influence groundwater-positive process changes. 3. Develop a groundwater learning framework that outlines key themes for training (e.g., introduction to aquifers, importance of groundwater, water balance, interactions with infrastructure construction and operations, aquifer vulnerability, contaminant pathways, recharge protection, foundation drainage impacts, land use links to drawdown). 4. Prepare adaptable training materials suited to different audiences, including presentations, visual aids (e.g., 3D geological model, maps of water levels, etc.), case studies, and department-specific examples. Incorporate interactive elements such as discussion prompts, scenario walk-throughs, or process mapping to connect groundwater impacts with staff roles and decisions. 5. Schedule recurring learning sessions (e.g., biannual) and tailor content to align with relevant projects, seasonal issues (e.g., de-icing chemicals), or planning cycles. 6. Deliver sessions through a mix of formats such as in-person workshops, recorded videos, or virtual 'live' sessions to ensure accessibility and broad participation. 7. Collect feedback from participants after each session to evaluate relevance, identify remaining knowledge gaps, and improve future content. 8. Track attendance and department coverage to ensure ongoing participation and to monitor progress in cross-departmental awareness.				
Deliverables	Training materials for each department. Development and delivery of regular training sessions to relevant City staff. Feedback and evaluation summaries				
Draft KPIs	Percent of targeted departments with at least one session completed Number of staff attending sessions Percent of participants rating content as useful or very useful in feedback survey Number of sessions delivered per year Number of positive actions resulting from increased staff awareness (e.g., positive groundwater impact flagged during a DP review, construction project or policy change)				
Assumptions	One time: Completed by city staff (1,950 hours for one year) to develop and deliver initial sessions. Ongoing: Completed by city staff (195 hours/year)				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Medium	\$500K–\$2M	Reduced unintentional groundwater impacts through improved internal decision making (e.g., design reviews, road salt use, dewatering practices). Reduces unplanned O&M or mitigation costs due to poor coordination or lack of awareness.	2	
Economic (Community)	None	\$100K	No substantial benefit to third parties.	0	
Social	Medium		Fosters a culture of environmental stewardship within the City. Enhances transparency, consistency, and internal collaboration on groundwater issues.	2	
Environmental	High		Supports informed operational and planning decisions that reduce long-term risks to aquifers and GDEs, especially in areas vulnerable to contamination, settlement or overuse. Can prevent small but cumulative impacts across departments.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$150K	Staff time (1,950 hours + 195 hours annually for ongoing administration) for Initial development and delivery of learning sessions across departments (curriculum, materials, engagement), with modest ongoing staff effort for program continuity and tracking.	2	
Economic (Community)	No cost		No direct cost to the public.	3	
Social	No cost		No disruption.	3	
Environmental	No cost		No environmental disturbance.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	WorkSafeBC – Education and Training Funding where groundwater risks intersect with worker safety (e.g., exposure to contaminated sites or infrastructure vulnerability) Internal Departmental Training Budgets				
Other considerations	Consider co-delivery and development of content with local groundwater experts, provincial agencies, NGOs, or First Nations partners.				

Action					
Number	68				
Name	GRI at City-owned Buildings				
Description	To enhance aquifer recharge, explore ways to support Rain City Strategy actions related to implementing innovative Green Rainwater Infrastructure practices at City-owned buildings.				
Rationale	As part of the City's efforts to show leadership on water management, this action entails developing internal policy to build and/or renovate future city buildings to manage a certain amount (e.g. 90%) of stormwater through infiltration / Green Rainwater Infrastructure (GRI). This may also include building at least one civic facility to manage all (i.e. 100%) collected stormwater through infiltration. This would demonstrate to others that infiltration is a feasible and affordable means of managing stormwater, with additional co-benefits (e.g. supporting aquifer recharge, supporting ecosystems, etc.), and help generate support for these types of actions by the public who visits the facility.				
Strategy Objectives	1. Build support 4. Preserve resources				
Action Type	Actionable				
Score	22				
Implementation					
Timeline	2 years				
Methodology	1. Use the results of Action 16 to screen and prioritize City-owned buildings and future capital projects where infiltration-based GRI is feasible. 2. Confirm internal goals for GRI retrofits and new builds, including targets for managing stormwater through infiltration to support aquifer recharge based on infiltration potential. Consider the performance criteria developed in Action 15 (Stormwater Infiltration Incentives) to identify GRI typology and operational targets for new builds or retrofits. 3. Engage City departments involved in facilities management and capital planning to align GRI objectives with internal processes and funding streams. 4. Identify a high-profile civic facility suitable for 100% infiltration-based stormwater management and design a pilot program for the site. 5. Implement the pilot program for the selected high-profile facility and monitor infiltration performance. 6. Prepare a summary report or internal briefing that includes lessons learned and recommended processes/tools for future implementations. 7. Work with communications staff to develop educational materials, signage, and public engagement tools that highlight the role of GRI and aquifer recharge at City buildings.				
Deliverables	List of City-owned facilities overlapping with high infiltration potential areas, recommended GRI, and infiltration targets. Pilot program plan including communication strategy. Internal briefing document. Pilot installation.				
Draft KPIs	Percent of candidate City-owned buildings evaluated for GRI feasibility Percent of City-owned sites suitable for GRI Infiltration percent measured during pilot project Cost per unit stormwater infiltration (i.e., \$/m3)				
Assumptions	Provide GRI tools for range of civic facilities in City (i.e. 700 sites).				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Highest	\$1M–\$4M	Immediate and sustained reduction in sewer system load (\$500k-\$2M), deferral or downsizing of capital infrastructure (\$500k-\$2M), lifecycle cost savings from reduced runoff management and potential co-benefits with energy or landscaping systems (\$5k-\$10k)	4	
Economic (Community)	High	\$1M–\$3M	Reduced local flooding and water-related wear/maintenance on existing infrastructure and public space (\$0.5M–\$1.5M), improved aquifer recharge to support vegetation, trees, and localized cooling (\$0.5M–\$1.5M).	3	
Social	Medium		Demonstrates City leadership in climate adaptation and sustainability. Enhances public engagement and literacy through high-profile GRI installations with visible aquifer recharge benefits. Increased vegetation can reduce the heat island effect, improve aesthetics and reduce stress.	2	
Environmental	High		Improves aquifer recharge, reduces risk of CSO's in combined sewer areas, supports stream baseflow, and protects downstream groundwater-dependent ecosystems (GDEs). Increased vegetation can increase carbon sequestration and biodiversity.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Medium	\$500K–\$800K	Staff time (2,925 hours), plus external consultant and monitoring costs (\$50K–\$350K) for feasibility screening, pilot project implementation, infiltration tracking, and communications.	1	
Economic (Community)	No cost		No cost.	3	
Social	No cost		No cost to residents.	3	
Environmental	No cost		Action is protective and supports long-term aquifer and watershed resilience.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Natural Infrastructure Fund (Infrastructure Canada) Partnership with academia to study the impact and success of the pilot project (potentially an MSc project), supports Action 173 BC Infrastructure Planning Grant				
Other considerations	Consider deep infiltration wells into the upper Quandra Sands aquifer. Incorporate infiltration design within broader flood and drought adaptation planning. The pilot should be designed with replication in mind—lessons learned can inform future GRI policy and standards for civic buildings. GRI assets installed as part of the pilot should be tracked in the City's asset inventory.				

Action					
Number	71				
Name	Groundwater Use Potential				
Description	Explore the potential for the City to use groundwater: A. Complete an assessment of sustainable extraction potential across the City. B. Evaluate the feasibility of using groundwater in the future for non-potable, emergency, and/or potable use (i.e. determine demand and infrastructure requirements).				
Rationale	Jurisdictions with multiple water sources that includes groundwater (e.g. San Francisco) have redundancies in terms of their water supply in the event of emergencies (e.g. after earthquakes). Other jurisdictions, including some located with Metro Vancouver, have either considered or installed wells solely for emergency purposes, and there is growing interest in the City to use groundwater for non-potable and even potable purposes. This action would determine the sustainable yield (i.e. how much groundwater can be used without depleting the aquifers or causing other adverse impacts) to determine where, how much, and for what purposes groundwater can be used. This would be followed by a demand assessment and subsequently by evaluating the feasibility of adding emergency groundwater supply to Vancouver. This could include such options as installing wells at key facilities (e.g. hospitals), adding wells to our existing water supply system as a redundancy, or installing wells in specific areas for specific purposes (e.g. for firefighting). Several scenarios should be considered, such as major disasters (e.g. earthquakes) or more frequent emergencies (e.g. drought or extreme heat). Considerations should include prioritizing new water sources in under-served or otherwise vulnerable areas. The action would also include recommendations related to effective operation and maintenance of these wells when not in use (if used solely for emergencies).				
Strategy Objectives	5. Use sustainably 7. Reduce risks				
Action Type	A. Actionable B. Deferred - Scope and applicability dependent on results from part A.				
Score	23				
Implementation					
Timeline	A. 1 year				
Methodology	A1. Establish quantitative and qualitative definitions of sustainable extraction (e.g., no long-term drawdown, no harm to GDEs or baseflow) and establish evaluation criteria (e.g. short term vs. long term sustainable yield; impacts on GDE's, etc.) A2. Delineate assessment zones based on identified aquifer extents, boundaries, sub-catchments, recharge areas, neighbourhood plans, etc. which may extend beyond City of Vancouver limits to natural boundaries. A3. Determine water balance for each aquifer and estimate well yield based on saturated thickness, hydraulic conductivity of aquifer materials and groundwater quality. Assessment should consider climate change and future development potential without any active extraction from water supply wells by the City. A4. Document and visualize results by defining aquifer and regions where there is low, medium, and high potential yield. Summarize groundwater quality for a variety of end uses. Summarize assumptions, constraints, and additional characterization needs to verify results. A5. Develop characterization program to confirm findings.				
Deliverables	Sustainability Criteria and Assumptions Document Summary of estimated well yield for each aquifer and region presented in tables and maps Feasibility assessment of groundwater use, that considers the extraction potential assessment, but also city demand for the various types of water use.				
Draft KPIs	Percent of assessment zones evaluated against ecological and hydrological thresholds Number of test wells installed in each identified aquifer				
Assumptions	A. Completed by external consultant B. Completed by external consultant, with city staff support to liaise with internal groups (assume 1,950 hours of city staff for one year)				
Dependencies					
Required Predecessors					
Successor(s)	16, 74, 174				
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$5M–\$15M	Benefit is identification of alternative water source that could be developed to establish a new water supply for use during emergencies. Also may avoid the cost of mislocated or ineffective infrastructure and enabling system resilience planning. Potentially reduces cost of potable water used for non-potable uses.	3	
Economic (Community)	High	\$1M–\$5M	Benefit is the avoided cost of water access during disaster scenarios. Enables planning for decentralized and redundant emergency groundwater supply (e.g. hospitals, firefighting, underserved areas). Supports equitable access to non-potable and potable alternatives during heat or drought.	3	
Social	High		Strengthens disaster preparedness and public confidence in City readiness. Supports vulnerable populations with improved water security in crisis.	3	
Environmental	High		Protects aquifers by ensuring any proposed extraction is within sustainable limits. Helps preserve baseflow and ecosystem function by evaluating long-term impacts under various stress conditions.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$300K	Cost of consultant-led evaluation leveraging largely existing tools and may involve groundwater modeling, scenario testing, and mapping. Includes water balance development, sensitivity analysis, water quality evaluation and reporting.	2	
Economic (Community)	No cost		No direct cost; communities benefit from future infrastructure based on the findings.	3	
Social	No cost		No direct disruption since this is a technical planning and analysis exercise.	3	
Environmental	No cost		Action prevents over-extraction and degradation through proactive planning. No ecological disturbance occurs during modeling.	3	
Additional Details					
Alignment with other City Strategies	Drinking Water Demand Management Strategy				
Funding Recommendations	Federation of Canadian Municipalities – Green Municipal Fund Infrastructure Canada – Green Infrastructure Stream UBCM – Asset Management Planning Program Natural Resources Canada – Climate Change Adaptation Program				
Other considerations	The resolution of spatial data should be carefully considered. Spatial resolution should be fine enough for planning of future extraction wells. However, data interpolation and model discretization may limit resolution in some areas of the city. Results from actions aimed at increasing infiltration may be integrated into the model in the future to reassess sustainable yield. Would support Action 74.				

Action					
Number	73				
Name	Request Province Consider Subsidence Risks				
Description	Request that the Province consider the potential for offsite subsidence in geotechnically problematic areas when adjudicating water licenses and use approvals for groundwater extraction.				
Rationale	Currently, the Province does not consider offsite subsidence when adjudicating water licenses and use approvals, yet groundwater extraction (including for perimeter drainage) can cause subsidence at neighbouring properties as well as City roads and underground utilities. This action will involve lobbying the Province so that they consider these potential offsite impacts.				
Strategy Objectives	2. Collaborate 7. Reduce risks				
Action Type	Actionable				
Score	20				
Implementation					
Timeline	2 years				
Methodology	1. Compile examples of measured ground settlement or damage to adjacent properties attributed to groundwater extraction 3. Use geotechnical datasets, City of Vancouver mapping, and the hydrogeologic conceptual model to delineate compressible soils, historical areas of measured or observed subsidence, locations with shallow groundwater, and high extraction activity. 4. Draft a policy brief for provincial consideration using risk mapping to recommend policy revisions and to require site-specific subsidence risk screening in areas of elevated risk. 5. Meet with the Province to present a summary of the policy brief.				
Deliverables	Outreach efforts with the Province to better explain the issues at hand. Ideally resulting in change in their adjudication process that considers subsidence, or at the least results in a condition on the approval that the licensee must consider and mitigate the potential impacts of subsidence.				
Draft KPIs	Incorporation of recommendations into provincial policies and review processes. Lack of reported subsidence issues related to licensed groundwater abstraction.				
Assumptions	Assume 300 hours of City staff to collaborate with the Province.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1M–5M	Helps reduce damage to roads, pipes, utilities, buildings and other infrastructure resulting in costly infrastructure repairs due to settlement or structural failures induced by adjacent groundwater extraction. Reduces need for emergency interventions. May also prevent lawsuits against the City.	3	
Economic (Community)	Medium	\$500K–1M	Reduces subsidence-related risks to neighbouring homes, foundations, and small scale infrastructure. Helps avoid disputes and insurance claims.	2	
Social	Medium		Builds public trust in both City and Provincial oversight. Reduces inter-property conflict related to settlement induced by groundwater pumping.	2	
Environmental	Low		Indirectly preserves shallow aquifers and terrestrials and aquatic ecosystems from over-extraction. Helps sustain urban water balance.	1	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$23K	Staff time (300 hours)	3	
Economic (Community)	No cost		No direct cost to the community.	3	
Social	No cost		Some stakeholders (e.g. developers) may resist added scrutiny, but the action is advisory and policy-oriented, not regulatory.	3	
Environmental	No cost		No environmental cost.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	NRCan's Climate Adaptation Fund (for infrastructure resilience) Infrastructure Canada – Disaster Mitigation and Adaptation Fund Partnerships with academic institutions for applied research grants (e.g., NSERC Alliance)				
Other considerations	Coordinate with Engineers and Geoscientists BC (EGBC) on risk-based groundwater withdrawal thresholds Integrate satellite InSAR or GPS baseline data for long-term observation				

Action					
Number	74				
Name	Water Reservation Application				
Description	Following an assessment of extraction potential, apply for a "water reservation" under the Province's Water Sustainability Act to set aside water rights for future City use.				
Rationale	Because the Province's approach to groundwater use is “first in time, first in right” – meaning that during times of water scarcity, licensees with earlier authorization dates are prioritized and entitled to take their full allocation of water before more recent licensees – it is important for the City to engage with the Province to determine how best to secure future water rights. This may be in the form of a water license or a water reservation. This action may also include discussions around prohibiting commercial activities that are reliant on large quantities of groundwater, or that extract and sell groundwater (e.g. water or other beverage bottlers). Related to #46 (Collaborative Forum).				
Strategy Objectives	5. Use sustainably 7. Reduce risks				
Action Type	Actionable				
Score	22				
Implementation					
Timeline	2 years				
Methodology	1. Engage with the Province to discuss the need for reservation based on long-term planning, conditions under which the reservation would be maintained or converted to a license, reservation term, renewal requirements, and information. 2. Review the potential municipal uses and projected groundwater demands that were assessed as part of Action 71. 3. Evaluate potential for interference with current and anticipated water license holders, environmental flows within streams, City interests, or areas where groundwater extraction could induce settlement of soils. 4. Prepare a water reservation for Quadra Sands Aquifer within City limits. 5. Submit water reservation application.				
Deliverables	Submitted water reservation application				
Draft KPIs	Approval of water reservation(s) Completion of license holder review				
Assumptions	Completed by city staff - assume 975 hours. Assume action 71, and other related actions, provide the necessary technical work that will be required by the Province (i.e. no further technical assessment required).				
Dependencies					
Required Predecessors	71				
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Highest	>\$10M	Securing future groundwater rights avoids the potential cost of developing costly new supply sources (e.g. new surface water infrastructure, desalination) or purchasing rights from other licensees. Also offers opportunity to develop and utilize resource to offset potable water use and establish emergency supply.	4	
Economic (Community)	High	\$1M–5M	Helps build a reliable water supply in the long term by minimizing the need for emergency water sourcing, especially in drought scenarios. May reduce risk of over-abstraction and prevent saltwater intrusion that would limit future use of the aquifer.	3	
Social	Medium		Improves community confidence in the City's long-term water security planning. Prevents water conflicts and inequities in future allocation. May lead to improving post-disaster water supplies.	2	
Environmental	Medium		Enables sustainable groundwater use planning by incorporating environmental flow needs and groundwater-dependent ecosystems into reservation design.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$75K	Staff time (975 hours)	3	
Economic (Community)	No cost		No direct community financial cost.	3	
Social	Low		Minimal to no social resistance anticipated. Process is administrative and does not affect current users or rights.	2	
Environmental	No cost		No environmental disturbance.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	BC Ministry of Municipal Affairs – Infrastructure Planning Grant Program UBCM – Community Emergency Preparedness Fund (for water security) Federation of Canadian Municipalities – Municipal Asset Management Program Natural Resources Canada – Climate Change Adaptation Program				
Other considerations	Engage First Nations for input on groundwater allocation and planning Ensure reservation won't negatively affect groundwater-dependent ecosystems				

Action					
Number	75				
Name	Groundwater Partnerships Plan				
Description	Create outreach programs for the development community and industry/businesses on groundwater-related risks (e.g. uncertain water levels, dependent ecosystems, flowing artesian conditions, etc.) as well as best management practices.				
Rationale	Desired Future State: Developers navigate managing groundwater during and post construction with clarity. Background Current State: Vancouver has very unique geotechnical conditions that vary between sites that can impact developments, and that developments can impact as well. However, developers and industry members do not always know or understand what best practices exist to manage groundwater to minimize risks, impacts and costs to the environment and their developments. Gap Addressed by Action: By developing digital and development-focused engagement materials, the City can equip developers and industry with the tools they need to manage groundwater effectively so as to minimize impacts, risks and costs. Potential topics include groundwater-related risks (e.g. artificially lowered water levels, drainage-induced subsidence, flowing artesian conditions, etc.), environmental impacts (e.g. to groundwater-dependent ecosystems), as well as best management practices (e.g. site and foundation drainage). Desired Outcome: Developers understand the risks, costs and impacts that come with managing groundwater during and post construction and achieve compliance with clarity.				
Strategy Objectives					
Action Type	Actionable				
Score	17				
Implementation					
Timeline	1 year				
Methodology	1. Determine target audiences for outreach programming 2. Identify effective ways to communicate groundwater risks, issues, and best management practices with each target audience 3. Develop an implementation plan and timeline for each outreach program 4. Execute implementation plans which may include the development and delivery of communicate materials annually. 5. Gather feedback for improvement of programs in future iterations				
Deliverables					
Draft KPIs	1. Number of people reached per year 2. Number of development applications per year that did not initially meet City groundwater requirements 3. Number of 311 calls 4. Page views to a website set up for this imitative 5. Inquires received through a dedicated project inbox				
Assumptions	Would likely to completed by a few staff (DWRM with support from Communications staff). Assume 1,950 hours of staff time.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Medium		May reduce risks to existing infrastructure (settlement, capacity limitations, etc.) associated with dewatering and discharge to combined sewer network.	2	
Economic (Community)	Low		May prevent private developers from having to do significant rework to meet groundwater requirements and avoid significant & costly groundwater risks. Provides greater certainty to development community to inform investment decisions.	1	
Social	Medium		Could lead to reduced risk to property owners, existing infrastructure, and improve the City's reputation.	2	
Environmental	Low		May help preserve groundwater levels which serves groundwater dependent ecosystems.	1	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$150K	Staff time (1,950 hours) to develop communication materials. Annual cost of printing communication materials and delivery of communication materials (195 hours).	2	
Economic (Community)	No cost		None	3	
Social	No cost		None	3	
Environmental	No cost		None	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Funded through development application fees				
Other considerations					

Action					
Number	78				
Name	Groundwater Public Outreach Plan				
Description	Engage with residents and businesses to reduce the impact of groundwater-related risks to the public.				
Rationale	One of the most cost-effective means of protecting groundwater is to educate the public. Currently there is almost no information on the City's website about groundwater, and none that is of much interest to the general public. Additionally, there are a number of ecosystems throughout the city that are either known, or suspected, to be significantly supported by groundwater. The City may also develop educational materials with particular venues or target audiences in mind (e.g. schools, public events), and educate businesses and residents about actions they can take to reduce the contamination of groundwater with commonly used chemicals. Some sites in the city (e.g. civic golf courses, Hillcrest community center) already use some groundwater (e.g. for watering lawns, flushing toilets, etc.), but the public is largely unaware of these initiatives. Public installations including signs and artwork would raise awareness of the city's groundwater resources and create interest in what the City is doing to protect it. A water well would demonstrate the feasibility of using groundwater in emergencies such as earthquakes, and at all other times it would be used for non-potable purposes such as watering parks. Examples may include: A. Explore targeted outreach opportunities (e.g. in schools or at public events) including by partnering with NGOs, local Nations, and/or academic institutions on the importance of groundwater and how to protect it. B. Educate residents and businesses about the safe handling, storage, use of common chemicals, and less toxic alternatives to mitigate potential impacts on groundwater (e.g. lawn chemicals, de-icing agents, oil, paint, etc.). C. Install signage in high-traffic areas to inform the public on the importance of groundwater, what the City is doing to protect it, and how everyone can play a part. D. Engage local artists to create groundwater-themed art for public spaces to educate and inspire residents to protect local aquifers. E. Install at least one pumping well in a high profile location to showcase opportunities related to groundwater use.				
Strategy Objectives	1. Build support 3. Safeguard quality				
Action Type	Actionable				
Score	20				
Implementation					
Timeline	1 year				
Methodology	1. Define the goals and desired outcomes of the outreach plan. 2. Identify target audience groups and describe how outreach could inform, influence, or benefit each group. 3. Review existing City communication channels and physical asset locations and assess their potential for groundwater messaging. 4. Consult with internal departments and external partners (e.g. TransLink, Metro Vancouver, Science World, QE Park, etc.) to align outreach priorities and identify collaboration opportunities. 5. Develop key themes and messages that reflect local risks, uses, and values. 6. Explore a range of outreach formats and venues, leaving flexibility to choose appropriate methods. This may include demonstrative exhibits. 7. Identify ways to highlight the City's current and planned groundwater initiatives to build public interest and trust. 8. Consider how external collaborators (e.g. NGOs, artists, schools, government agencies, local First Nations) could support outreach efforts. 9. Create an implementation framework outlining strategies, audiences, roles, timing, funding procurement, and resource needs. 10. Propose an approach for tracking outreach effectiveness and updating the plan over time.				
Deliverables	Outreach plan document Evaluation strategy				
Draft KPIs	Percent of target audience groups represented in plan strategy Number of external partners engaged Development of a tracking system or feedback mechanism				
Assumptions					
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Medium	\$500K–\$2M	Public awareness can reduce illicit discharges, chemical overuse, and damage to infrastructure and promote water conservation. Benefit is the avoid cost of remediation and infrastructure damage.	2	
Economic (Community)	Low	\$200K–\$750K	Avoided costs of foundation-related issues (\$100K–\$500K), and testing/treatment due to groundwater contamination (\$100K–\$250K).	1	
Social	High		Increases public understanding and valuation of groundwater. Helps preserve alternative water supply for non-potable or emergency use. Builds community trust and engagement in municipal sustainability initiatives. Strengthens environmental literacy.	3	
Environmental	High		Promotes changes in public and business behavior (e.g., chemical handling, landscaping practices) that protect groundwater quality, recharge areas, and groundwater-dependent ecosystems.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$150K	Staff time (1,950 hours).	2	
Economic (Community)	No cost		No financial burden on businesses or community.	3	
Social	No cost		No disruption	3	
Environmental	No cost		None	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Environment and Climate Change Canada – EcoAction Community Funding Program Partnerships with NGOs, academic institutions, and community organizations UBCM – Community Resiliency Investment or CEPF (Risk Mapping & Education Stream)				
Other considerations	Entities to consult with include local Nations, community groups, school districts, arts organizations, academic researchers.				

Action					
Number	100				
Name	Terrestrial Groundwater Thresholds				
Description	Define minimum groundwater elevations for the protection of terrestrial groundwater-dependent ecosystems.				
Rationale	Several terrestrial ecosystems in Vancouver (including parks, street trees, and vegetation on private property) are believed to be dependent on shallow groundwater to survive. This action will help determine the minimum local groundwater elevation that is needed to support these ecosystems, thereby helping to protect them. This action will also support the Urban Forest Strategy. Desired Future State: Provide guidance to developers or staff on groundwater elevations to minimize risk to environment and financial				
Strategy Objectives	6. Support ecosystems				
Action Type	Actionable				
Score	21				
Implementation					
Timeline	1 year				
Methodology	1. For each terrestrial GDE identified in Action 17, classify the ecosystem type (e.g., parks, street trees, and vegetation on private property). 2. Conduct a literature review and develop a tailored local approach for determining minimum groundwater level thresholds required to sustain ecosystem under current and future climate conditions in consideration of current and future target ecosystems. 3. Quantify and define thresholds for each GDE considering interannual variability, frequency, and duration of minimum groundwater elevations. 4. Consider future shifts in groundwater levels due to development, and climate stressors. 5. Identify GDEs where groundwater elevations are not meeting or are projected to not meet minimum thresholds or focused guidance to developers.				
Deliverables	Map of relevant terrestrial GDEs Defined terrestrial thresholds report Table of groundwater elevation thresholds				
Draft KPIs	Number of GDEs with defined EFNs Percent of GDEs with defined EFNs Number of GDEs that meet EFNs				
Assumptions	AECOM to use their budget from similar past projects they've conducted				
Dependencies					
Required Predecessors					
Successor(s)	21, 71				
Benefits				Unweighted Score	Weighted Score
Economic (City)	Medium	\$500K–\$1M	Avoided replacement / restoration of parks and urban vegetation associated with vegetation die-off, tree mortality, or habitat degradation requiring expensive interventions (e.g., replanting or irrigation infrastructure).	2	
Economic (Community)	Medium	\$500K–\$1M	Avoided cost of urban cooling, erosion control and revegetation. Terrestrial ecosystems are also shown to increase property values. Reduction in health care costs associated with extreme heat and poor air quality.	2	
Social	Medium		Enhances livability, biodiversity, and environmental justice in urban areas. Supports Vancouver’s Urban Forest Strategy and public health co-benefits via green space preservation (including air quality, reduced heat island effect and improved mental health).	2	
Environmental	High		Directly protects ecosystems reliant on shallow groundwater. Prevents ecosystem degradation from drawdown and supports habitat resilience under climate and urban stressors.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$75K	Assumes external consultant and ecological support.	3	
Economic (Community)	No cost		No cost to community.	3	
Social	No cost		No cost or social disruption.	3	
Environmental	No cost		Action is non-invasive and does not have associated costs.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Environment and Climate Change Canada – Habitat Stewardship Program Natural Resources Canada – Climate Change Adaptation Program Real Estate Foundation of BC (potential funder for research and planning that supports sustainable land use and groundwater–ecosystem linkages)				
Other considerations	Consider integration of natural asset management frameworks. Critical zone research should be considered in determining minimum groundwater elevations				

Action					
Number	101				
Name	Aquatic Groundwater Thresholds				
Description	Define thresholds for aquatic groundwater-dependent ecosystems that define the minimum acceptable water level (e.g. for wetlands and bogs) and/or flow volumes (e.g. for streams) for the protection of ecosystem health.				
Rationale	Several aquatic ecosystems in Vancouver (including wetlands, bogs, and streams) depend on groundwater. This action will help determine the minimum local groundwater elevation that is needed to support these ecosystems, thereby helping to protect them.				
	Desired Future State: Provide guidance to developers or staff on groundwater elevations to minimize risk to environment and financial				
Strategy Objectives	6. Support ecosystems				
Action Type	Actionable				
Score	21				
Implementation					
Timeline	1 year				
Methodology	1. For each aquatic GDE identified in Action 17, classify the ecosystem type (e.g., swamp, bog, fen, marsh, stream, etc.). 2. Conduct a literature review and develop a tailored local approach for determining environmental flow needs (EFNs) in line with available guidance documents in British Columbia. 3. Quantify EFNs for each GDE in terms of minimum groundwater and surface water elevations, groundwater temperatures, and flows considering interannual variability and life cycles of biota using the GDE. The city wide groundwater model and sewer flow monitoring data could be used to estimate baseflow for each of the existing and historical streams. 4. Consider future shifts in environment due to timing, development, and climate stressors that may impact EFNs. 5. Identify GDEs that are not meeting or are projected to not meet EFNs for focused guidance to developers.				
Deliverables	Map of relevant aquatic GDEs Defined EFNs and threshold report Table of groundwater elevation and flow thresholds				
Draft KPIs	Number of GDEs with defined EFNs Percent of GDEs with defined EFNs Number of GDEs that meet EFNs				
Assumptions	AECOM to use their budget from similar past projects they've conducted				
Dependencies					
Required Predecessors					
Successor(s)	21, 71				
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1M–\$3M	Avoided stream restoration, regulatory penalties for habitat degradation, or flood control retrofits that would require costly interventions (e.g. channel restoration, fish habitat offsetting).	3	
Economic (Community)	Medium	\$500K–\$1M	Increases in property value due to local flood mitigation, water filtration, and aesthetic/recreational value.	2	
Social	Medium		Publicly visible aquatic features offer social, cultural, and health-related value. Supports stewardship and biodiversity engagement initiatives.	2	
Environmental	High		Directly protects critical aquatic habitats from groundwater drawdown. Enhances resilience of fish-bearing streams and groundwater-dependent wetlands under climate stress and urban growth.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$200K	Assumes external consultant or internal modeling and ecological support. Assumes 8 weeks of effort for field data collection (survey, flow monitoring, habitat assessment, etc.). Costs will vary depending on number of GDEs identified.	2	
Economic (Community)	No cost		No direct cost to residents.	3	
Social	No cost		No disruption.	3	
Environmental	No cost		No cost, action is environmentally protective.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Environment and Climate Change Canada – Habitat Stewardship Program Natural Resources Canada – Climate Change Adaptation Program Real Estate Foundation of BC (potential funder for research and planning that supports sustainable land use and groundwater–ecosystem linkages)				
Other considerations	Align with BC’s Environmental Flow Needs Policy and federal EFN guidelines				

Action					
Number	113				
Name	Geoexchange Impacts				
Description	Develop requirements for geoexchange systems to limit the impact on groundwater resources and groundwater-dependent ecosystems. A. Research and assess known impacts of geoexchange systems and provide recommendations for potential mitigation tools (e.g. by-law requirements). B. As needed, develop and implement tools (e.g. by-laws) to mitigate impacts. May also include cross-governmental collaboration to further mitigate impacts.				
Rationale	Desired Future State: Determine magnitude of risk for thermal pollution and develop plans to mitigate impacts (to aquifers and groundwater dependent ecosystems). While geoexchange systems are currently not very common in the city, their use could expand as developers and homeowners seek opportunities to reduce energy use and greenhouse gas emissions. However, as these systems become more common, there is a risk of thermal pollution of the aquifers, which could have some negative effects (e.g. on groundwater-dependent ecosystems). There is also some concern that geothermal systems can potentially degrade groundwater quality as a result of coolant fluid leaking underground from a closed-loop system, or as a result of the water injected back into the geological formations from an open-loop system. This action will research those potential impacts, and ways to possibly mitigate them.				
Strategy Objectives	3. Safeguard quality				
Action Type	A. Actionable B. Deferred				
Score	20				
Implementation					
Timeline	1 year				
Methodology	1. Review existing literature, best practices and case studies on the impacts of geoexchange systems. 2. Compile known or suspected risks associated with open-loop, closed-loop, and standing column geoexchange systems (e.g. groundwater quantity, thermal impacts, geochemistry/water quality impacts, etc.). 3. Identify mitigation tools and regulatory strategies used in other jurisdictions. 4. Identify current geoexchange system permitting and oversight mechanisms at the provincial level (e.g. under the Water Sustainability Act) and any relevant City or regional regulations or gaps. 5. Cross-reference results of other actions to identify areas of shallow groundwater elevations, recharge zones, and contributing groundwater catchments to GDEs to identify locations where geoexchange system impacts may pose greater risk. 6. Prepare a summary report or internal guidance document with recommendations for new tools and approaches to mitigate impacts.				
Deliverables	A. Summary report from literature review. Map of potential areas of increased risk. Recommendations for new tools. B. By-law requirements (or other tools) for geoexchange systems				
Draft KPIs	Number of jurisdictions or strategies reviewed Number of system types and risks documented				
Assumptions	A. Completed by an external consultant B. City staff - assume onetime 1,950 staff hours and ongoing 195 staff hours / year.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1M–\$5M	Avoided emergency or remediation costs from aquifer degradation or thermal pollution (\$500K–\$2M), reduced legal liability and regulatory risk (\$250K–\$1.5M), improved permitting efficiency and consistent compliance oversight (\$250K–\$1.5M)	3	
Economic (Community)	Low	\$250K–\$1M	Increased market clarity and innovation incentives for geoexchange professionals	1	
Social	Medium		Improves public confidence in renewable energy deployment and its alignment with environmental protection. Supports informed permitting and equitable standards.	2	
Environmental	High		Prevents aquifer thermal and/or geochemical degradation, protects habitat in GDEs, and informs placement of systems in areas with minimal sensitivity.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$150K–\$250K	Staff time (1,950 hours) one time Annual staff cost (195 hours) External consultant costs. Varies based on level of GIS integration and depth of regulatory analysis	2	
Economic (Community)	No cost		No direct cost.	3	
Social	No cost		No disruption.	3	
Environmental	No cost		Action is research-based; no adverse environmental impacts.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Cost-sharing with Planning or Sustainability departments if aligned with low-carbon buildings, VBBL updates, or climate action planning.				
Other considerations	Geoexchange system risks are not yet widely regulated in BC, so this work could be precedent-setting or inform provincial conversations. Framing is important—emphasize enabling low-carbon technology while protecting aquifers, not restricting innovation.				

Action					
Number	130				
Name	Vancouver Landfill Considerations				
Description	Working with Vancouver Landfill operations staff, and their groundwater consultants, explore additional measures for the protection of the underlying aquifer and nearby ecosystems.				
Rationale	Current State: The City's landfill in Delta currently discharges approximately 2,000 m3 of contaminated groundwater to Annacis Island per day, resulting in significant water treatment costs. Current practical measures to prevent further contamination include a two-ditch system that separates contaminated runoff, as well as a demolition debris land clearing process to prevent contaminated water from infiltrating into the peat area. Desired Future State: While the City's landfill in Delta is run exceptionally well, there may be opportunities to strengthen groundwater protection measures. These measures could exceed Provincial requirements but are important for the City to show leadership with all of its operations, regardless of their location. In addition, these measures can result in minimizing the cost of contaminated groundwater (also known as 'leachate') being sent to Annacis Island for treatment (e.g. options to manage groundwater on-site).				
Strategy Objectives	3. Safeguard quality 6. Support ecosystems				
Action Type	Actionable				
Score	21				
Implementation					
Timeline	2 year				
Methodology	1. Review findings from the most recent Hydrogeology Review, Stormwater Management Plan (SWMP), Annual Monitoring Reports and other recent projects. 2. Coordinate with landfill operations staff and groundwater consultants to understand ongoing projects, and potential areas of collaboration and support. 3. Identify opportunities for further analysis or risk refinement in areas where low-level leachate flux may eventually reach deeper aquifers, focusing on contaminant attenuation, dilution, and regional groundwater flow conditions. 4. Collaborate on the SWMP update process to determine which additional groundwater-relevant measures or refinements (e.g. I&I reduction or groundwater-surface water separation) should be incorporated into the next iteration of the plan. 5. Explore the feasibility of further reducing inflow of clean water (e.g. precipitation on closed and open landfill areas, groundwater inflow from Burns Bog and Dredge Pond) into the leachate collection system, using a combination of infrastructure improvements, progressive closure, diversion strategies, and operational controls. 6. Investigate the potential for on-site water recycling during both landfill operations and closure phases, including expanded use of stored runoff (e.g. from Pond 3) for dust suppression, irrigation of revegetated areas until they are established, or other non-potable uses. 7. Evaluate technical and financial feasibility of proposed additional measures, considering geotechnical constraints (e.g. soft soils), cost-benefit trade-offs, regulatory requirements, and operational complexity.				
Deliverables	Collaboration and support with Vancouver Landfill to deliver initiatives.				
Draft KPIs	Reduction in flow discharged from the landfill's leachate system to Delta/Metro's sanitary system. Number of groundwater exceedances of BC CSR standards at property boundary for leachate indicator parameters. Number of resultant action items implemented.				
Assumptions	975 hours for ongoing staff time				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$2M–\$10M	Avoided groundwater remediation and leachate containment upgrades (\$1M–\$5M), reduced leachate generation and treatment costs via clean water diversion (\$500K–\$3M), operational cost savings from on-site reuse of stormwater runoff (\$500K–\$2M)	3	
Economic (Community)	Low	\$250K–\$500K	Reduced health, land use, and recreational risks to nearby third-party users (\$250K–\$500K)	1	
Social	Medium		Demonstrates commitment to environmental responsibility in a high-profile facility. Enhances community trust in landfill management and the City's environmental safeguards.	2	
Environmental	High		Strengthens aquifer protection, reduces nutrient and contaminant flux to surface water bodies, maintains quality of irrigation water for crops, and safeguards downgradient GDEs.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$75K	Staff time for coordination, technical (975 hours) review, integration with landfill operations and planning processes. Consultant costs for groundwater modeling or engineering design are assumed to be covered under existing landfill programs.	3	
Economic (Community)	No cost		No cost to community.	3	
Social	No cost		No disruption.	3	
Environmental	No cost		No adverse impacts.	3	
Additional Details					
Alignment with other City Strategies	Vancouver Landfill's Stormwater Management Plan				
Funding Recommendations	Internal landfill capital and operations budgets Federation of Canadian Municipalities – Green Municipal Fund				
Other considerations	Effective communication and collaboration with Landfill staff are critical to ensure duplication of effort is avoided.				

Action					
Number	135				
Name	Conservation Measures				
Description	Explore opportunities to apply conservation measures to groundwater use				
Rationale	The City has several strong conservation programs to reduce water use in City and Park Board operations; however, given that groundwater use is regulated by the Province, City/Metro Vancouver conservation measures are not applicable to it. To protect the potential for groundwater to provide emergency water supply and/or offset potable water demand, per the City's Drinking Water Demand Strategy, this action will seek a range of tools (e.g. requirements to adhere to summertime watering restriction) to ensure groundwater is available for both human needs and ecological health. These measures would also ensure that groundwater-dependent ecosystems are not impacted by unsustainable groundwater extraction. These measures may first be applied to high volume users or high priority areas.				
Strategy Objectives	4. Preserve resources 5. Use sustainably				
Action Type	Actionable				
Score	17				
Implementation					
Timeline	3 years				
Methodology	1. Inventory all groundwater uses within the City, including both civic and private withdrawals. 2. Review existing conservation policies, measures and targets. Highlight areas where groundwater use may undermine conservation goals. 3. Complete a jurisdictional scan to review groundwater conservation approaches. 4. Approach the Province to provide an overview of the City's groundwater conservation goals and concerns. Discuss the potential to include conservation targets as conditions on future water licenses within the City of Vancouver. 5. Develop a groundwater conservation framework that is complementary to other initiatives and recognizes value of offsetting potable water use. 6. Implement framework and monitor compliance. 7. Assess conservation effectiveness. Adapt and improve measures based on performance.				
Deliverables	Inventory report of civic and private groundwater uses. Groundwater conservation gap analysis and compilation of best practices documented in literature. Groundwater conservation framework.				
Draft KPIs	Percent of civic groundwater users subject to conservation measures. Compliance rate with conservation measures. Peak daily, monthly and annual volume of ground water used per well. Annual cost of groundwater extraction per well. Monthly sustainable aquifer extraction rates (based on aquifer levels and the need to protect aquifer dependent ecosystems) per well.				
Assumptions	Completed by city staff.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1M–2M	Conservation of groundwater can reduce potable water consumption, reducing operational water costs, avoiding overuse, and avoiding future water sourcing or infrastructure expansion.	3	
Economic (Community)	None		None	0	
Social	Medium		Promotes equity and consistency in water use expectations across City operations. Enhances transparency and public trust in City sustainability practices.	2	
Environmental	Medium		Reduces pressure on aquifers and groundwater-dependent ecosystems, particularly during summer when aquifer recharge is limited and demand peaks. Consistent with water sensitive planning and design approaches.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$90K	Staff time (1,170 hours). May require minor investments in metering or monitoring of a relatively small number of water supply wells and systems.	2	
Economic (Community)	No cost		No direct impact on private users or external organizations.	3	
Social	Low		Internal application of policies avoids negative social perception. May face minor internal resistance due to procedural changes.	2	
Environmental	No cost		No adverse environmental impacts.	3	
Additional Details					
Alignment with other City Strategies	Water Demand Management Strategy				
Funding Recommendations	Federation of Canadian Municipalities – Green Municipal Fund CleanBC – Community Efficiency Funding Streams Natural Resources Canada – Energy and Water Efficiency Programs BC Ministry of Municipal Affairs – Infrastructure Planning Grants Metro Vancouver's Sustainability Innovation Fund (if MetroVan is involved)				
Other considerations	Monitor risk of over-reliance on groundwater post-conservation shift. Benchmark against municipal leaders in groundwater conservation (e.g., Guelph, ON)				

Action					
Number	139				
Name	Impacts of Utility Trenches				
Description	Develop a BMP to reduce the potential for utility trenches to act as preferential pathways that drain groundwater (e.g. seepage collars on utility trenches).				
Rationale	Excavation backfill in utility trenches can become a preferential pathway for groundwater. In certain situations, these trenches may become unintended drainage systems that stretch over large distances. Where these trenches intercept aquifers, significant loss of groundwater may result. They could also lead to, or exacerbate, the diversion of groundwater to the sewer. This action would identify situations where additional measures may be necessary and propose solutions (e.g. require the installation of seepage collars).				
Strategy Objectives	4. Preserve Resources				
Action Type	Actionable				
Score	19				
Implementation					
Timeline	1 year				
Methodology	1. Review relevant case studies and literature. 2. Use resulting groundwater elevation map from numerical groundwater modelling (Action 4) to identify locations and conditions where utility trenches are most likely to intercept groundwater or infiltration. 3. Consult with other internal staff/departments (e.g., water and sewer operations) to gather field insights on trench-related groundwater issues, whether groundwater interception has been observed, and options for mitigation. 4. Develop a screening framework or decision criteria to determine when and where additional mitigation measures may be warranted based on depth, utility trench design, soil type, permeability contrast between soils and backfill materials, aquifer proximity, topographic slope and groundwater flow conditions. 5. Assess potential mitigation solutions (technical feasibility, constructability, cost, lifecycle maintenance). Consider long-term measures that can be embedded in trench design standards. 6. Consult with the utilities group to determine whether this should be applied to third party utilities (e.g., BC Hydro, Fortis, Telus, etc.) and mechanisms for doing so. 7. Draft design guidance or technical notes on how and when mitigation features should be incorporated. 8. Prepare an internal summary report or guidance document.				
Deliverables	Internal summary report or guidance document including design guidance				
Draft KPIs	Percent of the City where utility trenches should be mitigated Estimated cost (total or % increase) of recommended mitigation measures Estimated impact of recommended mitigation measures (e.g., aquifer preservation, I&I reduction, etc.)				
Assumptions					
Dependencies					
Required Predecessors	22				
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1.5M–\$5M	Avoided inflow and infiltration to storm/sanitary infrastructure due to trench drainage (\$1M–\$3M), deferral or downsizing of system retrofits or dewatering measures (\$500K–\$2M)	3	
Economic (Community)	Medium	\$500K–\$1M	Where utility trenches intersect areas of contamination (e.g., adjacent to contaminated sites), utility trench BMPs can avoid the further spread of contamination and associated remediation costs (\$500K–\$1M). The current estimate assumes 5-10 impacted sites but the potential City-wide economic benefits will depend on the number of contaminated sites that could be impacted, which has not yet been determined.	2	
Social	Low		Reduced groundwater drainage and prevention of contaminant spreading will help maintain natural function of the aquifer and support local vegetation.	1	
Environmental	Medium		Protects shallow aquifer storage and hydrologic connection to groundwater-dependent ecosystems (GDEs), especially in areas where utility corridors cross recharge zones or drain sensitive subsoils. Reduces cumulative groundwater depletion from widespread linear infrastructure.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$75K–\$150K	Staff time (975-1,950 hours)	2	
Economic (Community)	No cost	<\$10K per site (private development only, as needed)	For developers where trench damming or seepage collars may be required near high water table areas, costs are modest and scale with trench length and groundwater depth. May be offset by avoided future liability or restoration needs.	3	
Social	No cost		Minimal to no disruption to residents.	3	
Environmental	No cost		No direct environmental disturbance	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	UBCM – Asset Management Planning Program CleanBC – Climate Preparedness and Adaptation Strategy BC Infrastructure Planning Grant Internal capital project budgets (trench design improvements could be integrated into large utility replacement or road reconstruction projects)				
Other considerations	Where infiltration is being promoted (e.g. parks, GRI retrofits), care should be taken that trench designs do not unintentionally drain GRI stored/infiltrated water.				

Action					
Number	146				
Name	VBBL Regulations for Non-Potable Use				
Description	Develop regulations in the Vancouver Building By-law to facilitate the sustainable use of groundwater for non-potable applications.				
Rationale	Groundwater in Vancouver could be used for non-potable purposes such as watering green spaces or even flushing toilets, assuming that it is used sustainably and does not deplete the aquifers. Currently, the Vancouver Building By-law (VBBL) does not include groundwater as an approved source of water, requiring that an exemption process (called an "Alternative Solution") be followed if someone wishes to use groundwater for non-potable purposes. If the VBBL could be amended to accommodate groundwater use, it may become more common. Currently, Vancouver Coastal Health and Development, Buildings & Licensing are exploring ways to do this, and the Groundwater Team could assist with this work.				
Strategy Objectives	1. Build support 3. Safeguard quality 7. Reduce risks				
Action Type	Actionable				
Score	17				
Implementation					
Timeline	3 years				
Methodology	1. Identify people from VCH and VBBL who should be on a working committee 2. Form the working committee and set specific goals related to non-potable application of groundwater 3. Develop requirements and use-cases for non-potable groundwater uses 4. Revise development approval processes/forms 5. Develop communication materials for developers				
Deliverables					
Draft KPIs	1. Number of applications for non-potable use of groundwater (exemption process vs new process) 2. Reduction in per-capita volume and cost of potable water used in buildings with exemptions The development/modification of VFRS policy and/or procedure that includes the acquisition of fire-fighting foams that do not contain PFAS.				
Assumptions	City staff will need to work with VCH and DBL. Assume one-time costs to amend the VBBL such that an alternate water source system may be sourced from groundwater or perimeter drainage water. Completed by City staff. Estimated a total of 3,900 hours (which could be spread out over multiple years).				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1M-\$10M	May reduce costs in reviewing groundwater use 'exemptions' and may reduce the load on the City's drinking water system. Could defer multi-billion dollar projects by Metro Vancouver to find alternative water sources. Reduce demand on chlorinated water system.	3	
Economic (Community)	Low	<\$500k	Can reduce the cost to developers for receiving approval for groundwater uses and may reduce water fees through reduced City water consumption	1	
Social	Low		Facilitate development through a streamlined approval process and can improve a property's water resilience (e.g., if something happens to the City's water system)	1	
Environmental	Low			1	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$300K	Staff time (3,900 hours).	2	
Economic (Community)	No cost		None	3	
Social	No cost		None	3	
Environmental	No cost		May slightly lower water table and increase vegetation stress in unconfined aquifers.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Some funding through development application fees				
Other considerations					

Action					
Number	148				
Name	Replace PFAS in Firefighting Foams				
Description	Support the Vancouver Fire Rescue Services (VFRS) in transitioning to firefighting foams that are equally effective, but do not contain toxic per- and polyfluoroalkyl substances (PFAS) or other harmful chemicals which can accumulate in local aquifers and compromise the health of firefighters.				
Rationale	Many firefighting foams in use today contain toxic per- and polyfluoroalkyl substances (PFAS). PFAS are known as "forever chemicals" and are becoming an urgent global public health issue because they do not degrade and may accumulate in groundwater. The cost of cleanup for known PFAS-contaminated sites is significant (e.g. CFB Comox) and can range to billions of dollars t. PFAS are carcinogenic and have many risks to human health. In 2024, the Vancouver Fire Rescue Services (VFRS) spent \$2.8 million to purchase PFAS-free gear [See: https://vancouver.ca/news-calendar/vancouver-protecting-firefighters-with-new-pfas-free-gear-april-2024.aspx]. The next logical step is to replace PFAS-containing firefighting foams. This action would reduce PFAS contamination of local aquifers, protect firefighter health, and show City leadership on this important issue.				
Strategy Objectives	1. Build support 3. Safeguard quality 7. Reduce risks				
Action Type	Actionable				
Score	23				
Implementation					
Timeline	2 years				
Methodology	1. Meet with VFRS to discuss their efforts to transition towards PFAS-free foams and how the groundwater group can help. Determine where PFAS foams have been used, are and where their use continues. 2. Use vulnerability assessment to prioritize foam transition. If available, apply the groundwater vulnerability assessment to identify areas where PFAS-free foam use should be prioritized (e.g., high vulnerability zones) and where existing foam stocks may pose lower risk (e.g., low vulnerability zones). 3. Identify areas where the use of PFAS-free foam should be prioritized. 4. Support VFRS policy development and vendor outreach. Research PFAS-free foam alternatives and engage with vendors to understand availability and performance. Support the development or modification of VFRS internal policy to prioritize future acquisition of PFAS-free fire-fighting foams. 5. Explore provincial/federal grant programs or green innovation funding sources to offset transition costs. 6. Identify areas where they could be used with lower risk to groundwater quality if alternatives cannot be identified and implemented in a timely manner.				
Deliverables	Business case support: Information that helps VFRS to build the business case to continue to move away from foams with PFAS. Groundwater risk mapping: Maps illustrating areas where PFAS free foam should be avoided or would pose a lower risk to groundwater quality until alternatives can be implemented. Draft policy and procedure framework: A proposed framework to support the development or modification of VFRS internal policy and procedures, including guidance for the future acquisition and use of PFAS-free fire-fighting foams.				
Draft KPIs	Percent of foam replaced with PFAS-free alternatives Grant dollars obtained for foam transition Improvement in groundwater quality (lower PFAS concentrations) in areas where there are documented impacts.				
Assumptions	Completed by city staff - assume 300 hours.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$5M–10M	Avoids environmental remediation and legal liabilities associated with PFAS contamination. Preserves resource for alternative potable and non-potable uses.	3	
Economic (Community)	High	\$1M–5M	Avoids increased community healthcare costs and prevent declines in property values due to contamination concerns.	3	
Social	High		Enhances firefighter health and safety by eliminating exposure to toxic PFAS chemicals.	3	
Environmental	High		Prevents long-term groundwater contamination from PFAS, protecting local groundwater-dependent ecosystems and water quality.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$46K	Staff time (600 hours). Does not include cost to purchase non-PFAS foams	3	
Economic (Community)	No cost		No direct financial impact on the community.	3	
Social	Low		Minimal social resistance anticipated.	2	
Environmental	No cost		No adverse environmental impacts assuming replacement is inert.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Green Municipal Fund – supports sustainable municipal initiatives UBCM Community Emergency Preparedness Fund – fire/resilience upgrades Infrastructure Canada ECCC EcoAction or Pollution Prevention Programs BC Ministry of Environment				
Other considerations	Ensure PFAS-free foams do not introduce other harmful compounds (e.g., fluorine-free alternatives with unknown toxicology). Align with international transition protocols (e.g., ITRC PFAS Best Management Practices).				

Action					
Number	162				
Name	Engagement with Local Nations				
Description	Continue to engage with xʷməθkʷəy̓əm (Musqueam), Skwxwú7mesh (Squamish) and səliwətaʔ (Tsleil-Waututh) to support local Nations' priorities throughout the implementation of the strategy's actions.				
Rationale	Reconciliation is one of the Guiding Principles of the Groundwater Strategy. While the City has made regular efforts to meet with and engage with local Nations on groundwater issues during the consultation phase of the Groundwater Strategy, this action will ensure that engagement continues during the implementation phase of the strategy.				
Strategy Objectives	2. Collaborate				
Action Type	Actionable				
Score	22				
Implementation					
Timeline	1 year to initiate, then ongoing				
Methodology	1. Identify opportunities for meaningful engagement in the groundwater strategy and associated action items for in the spirit of reconciliation. 2. Co-develop a framework or protocol with local Nations that respects their governance systems, timelines, and knowledge-sharing expectations that integrates Traditional Knowledge and Western Science. Include guidance for consistent and respectful engagement across departments building on existing frameworks. 3. Host initial meetings or workshops to identify shared concerns, opportunities, and goals (e.g., aquifer protection, cultural water uses, groundwater-dependent ecosystems, habitat enhancement, etc.) that leverage time on the land with multiple age groups. 4. Collaborate on project scoping, timelines, collaboration and funding opportunities. 5. Create reporting structures that allow both the City and First Nations to track progress on commitments. Conduct regular check-ins to adjust plans accordingly.				
Deliverables	Engagement Framework or Protocol Summary of Shared Priorities Knowledge Sharing Mechanisms Identified Collaboration Opportunities				
Draft KPIs	Number of engagement meetings held Participant satisfaction/feedback Number of priorities/goals accomplished				
Assumptions	Completed by city staff - assume 195 hours/year				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Medium	\$500K	Early and ongoing engagement avoids project delays or rework due to misalignment with Indigenous rights, land use, or cultural priorities. Supports funding eligibility for co-governance projects.	2	
Economic (Community)	Medium	\$500K	Collaboration improves environmental and cultural outcomes, which enhance ecosystem services and community resilience.	2	
Social	High		Advances reconciliation through action, builds trust, and supports Indigenous governance, rights, and cultural values in water and land management. Enhances intergovernmental relationships.	3	
Environmental	High		Indigenous-led water stewardship emphasizes ecosystem-based management, long-term aquifer health, and cultural water uses aligned with sustainability. May lead to strengthened protection of groundwater-dependent systems.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$15K	Staff time (195 hours) to support ongoing dialogue, meeting coordination, and co-development of engagement frameworks.	3	
Economic (Community)	No cost		No direct financial cost.	3	
Social	No cost		No social cost.	3	
Environmental	No cost		Engagement-centered action with no physical disturbance.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	UBCM – Strengthening Local Government–Indigenous Relations Grant Federation of Canadian Municipalities – Green Municipal Fund (if tied to shared environmental outcomes) Indigenous Services Canada – First Nation–Municipal Community Infrastructure Partnership Program				
Other considerations					

Action					
Number	167				
Name	Mitigate Artificial Turf				
Description	Work with the Vancouver Park Board to explore opportunities for using alternatives to, or developing mitigation strategies for, artificial turf in City-owned facilities, parks, and sports fields where microplastics and 6PPD from the turf can be released to groundwater and surface water.				
Rationale	While the use of artificial turf has expanded across the city, there are some concerns over its use. For example, runoff from artificial turf may contain harmful substances such as microplastics, 6PPD, and heavy metals that can migrate into surface waters or groundwater. Moreover, with a short lifespan of 10-20 years, the turf typically ends up in landfills where it can further break down and can lead to more serious groundwater contamination. This action will explore possibilities for reducing the use of artificial turf in city-owned facilities, parks, and sports fields, or otherwise developing mitigation strategies for managing potential contamination.				
Strategy Objectives					
Action Type	Actionable				
Score	15				
Implementation					
Timeline	5 years				
Methodology	1. Complete a literature review of alternative materials and a jurisdictional scan 2. Consult with the Park Board on alternatives and identification of possible projects/applications 3. Consider any additional source protection strategies 4. Development and implementation of mitigation strategy				
Deliverables					
Draft KPIs	Number of locations where an alternative to artificial turf is installed Number of locations where an alternative contamination protection measure is implemented				
Assumptions	One-time costs: - Synturf Infiltration Program - Completed by city staff. City staff originally estimated 1,950 hours/year but revised to 975 hours for 1 year.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Low	<\$500k	May reduce requirement for water treatment for future groundwater uses if replacements do not have same issues. Also may reduce the need for surrounding soil to be rehabilitated and/or specially treated for disposal.	1	
Economic (Community)	None		None	0	
Social	Low		Will help protect groundwater resources that protect and/or provide public amenities (e.g., emergency water source or water features).	1	
Environmental	Medium		Will help protect the quality of groundwater and groundwater dependent ecosystems.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	<\$100k	Staff time (975 hours). Does not consider additional costs of alternate materials, if applicable.	2	
Economic (Community)	No cost		None. Cost of replacement not accounted for.	3	
Social	No cost		May be some minor disruption of access to public amenities if on-site testing/monitoring required.	3	
Environmental	No cost		None	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations					
Other considerations					

Action					
Number	170				
Name	Well Acquisition				
Description	Explore options for the City to acquire a well on City property once it is no longer needed by the well owner.				
Rationale	The City issues permits to private entities, for the use of our road right of ways, for the purpose of installing monitoring wells. These wells are often only needed temporarily and are decommissioned (ideally) when no longer needed. This action will allow the City to acquire a well when it is no longer needed by the well owner, and potentially initiate groundwater monitoring at the well.				
Strategy Objectives	1. Build support				
Action Type	Actionable				
Score	18				
Implementation					
Timeline	1 year				
Methodology	1. Establish database and mapping tools that illustrate existing and desired monitoring well network across City. Track additional wells through existing permitting processes and identify targeted areas for increased monitoring well coverage. 2. Scan GWELLS to identify old wells that could be re-purposed as monitoring wells. 3. Review existing permit agreement language and identify provisions regarding ownership, decommissioning, and transfer of wells. 4. Assess legal implications of well ownership transfer including liability, access, rights for future monitoring, and responsibilities under GWPR and WSA. 5. Consult with City's legal team to understand necessary changes to permitting and procedure. 6. Develop a well evaluation process. This may include developing a standardized checklist for well integrity, historical data, future monitoring needs, and costs. 7. Develop a well acquisition policy and handover procedures (transfer agreements, inspections reports). 8. Draft communications template to notify owners of potential interest in acquiring wells, outline and transfer process, clarify owner responsibilities. 9. Complete a pilot program and evaluate effectiveness of procedures. Address any gaps or challenges. Develop asset management plan.				
Deliverables	Database and maps illustrating existing city-owned monitoring wells, those owned by others, and areas where additional wells are desired. Well Acquisition Program Policy document to guide well acquisition and asset management				
Draft KPIs	Number of wells acquired Number of well owners contacted Spatial density of monitoring well network				
Assumptions	Completed by city staff - assume 500 hours. Assume action 71, and other related actions, provide the necessary technical work that will be required by the Province (i.e. no further technical assessment required).				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Medium	\$500K–\$1M	Acquiring existing wells avoids cost of monitoring well installation and new data acquisition. Provides valuable data that improves the foundation for future decision making.	2	
Economic (Community)	Low	\$50K	May reduce the costs by avoiding the need to decommission water wells that the City acquires.	1	
Social	Medium		Promotes transparency in groundwater data and planning. Enhances public trust in municipal groundwater management and stewardship.	2	
Environmental	Medium		Increases the density of groundwater monitoring points, supporting more accurate aquifer assessments and early detection of contamination or water level trends that could impact aquifer water quality or groundwater-dependent ecosystems.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	No cost	\$40K	Internal staffing and potential legal consultation to develop policy and transfer mechanisms.	3	
Economic (Community)	No cost		No direct financial impact.	3	
Social	Low		Minimal public engagement required. Could raise minor concerns around property rights, but those are mitigated through transparent permitting processes.	2	
Environmental	No cost		None	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	UBCM Asset Management Planning Program				
Other considerations	Ensure acquired wells are integrated into the City's groundwater monitoring network				

Action					
Number	173				
Name	Academic Partnerships				
Description	Explore partnerships with academic institutions to advance the City's understanding of local aquifers and groundwater resources.				
Rationale	Build collaborative relationships with academic institutions to develop our understanding of groundwater resources. This may include research or studies as part of students' Capstone projects.				
Strategy Objectives	1. Build support				
Action Type	Actionable				
Score	18				
Implementation					
Timeline	1 year				
Methodology	1. Identify research needs and priorities. Create a list of pre-approved project ideas, themes, and topics that offer benefits to the City and academic partners. 2. Develop a research collaboration framework that outlines types of partnerships (funded research projects, capstone projects, graduate theses), intellectual property considerations, data sharing, expectations and deliverables. Determine if formalized engagement is needed through MOUs or LOIs. 3. Identify potential academic partners and City liaisons for each partnership. 4. Arrange meetings with potential partners and present the City's strategic objectives and groundwater initiatives. 5. Develop funding support opportunities.				
Deliverables	Continued support and guidance for grad students (scholarships, etc.) who will be completing Vancouver-focused research, including the development of research objectives. List of partnered institutions. Research collaboration framework document. Capstone/Graduate thesis project library. Legal agreement governing intellectual property, data sharing, publication, etc. Procedures for data integration, maintenance and knowledge dissemination.				
Draft KPIs	Number of identified potential partnerships Number of pre-approved project ideas or research focus areas Annual funding available Number of finished research projects				
Assumptions	Onetime: Completed by city staff - assume 975 staff hours for one year. Ongoing: Assume \$50K of CoV funding per year, plus 390 hours of city staff time per year to support the research.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Low	<\$500K	Leverages low-cost or no-cost research capacity via capstone and thesis projects results in cost-avoidance on research/studies that would otherwise require consulting contracts. Scope of projects will need to be limited to meet academic requirements and schedule. UBC capstone projects valued at \$25K–\$50K	1	
Economic (Community)	Low		Indirect benefit through better groundwater planning and risk mitigation.	1	
Social	High		Enhances collaboration between academia and local government. Builds public trust and inspires future professionals in water management.	3	
Environmental	Medium		Facilitates scientific studies of limited scope and complexity (e.g. tracer studies, aquifer recharge modeling, development of GIS layers, contamination risk assessments, etc.) that directly inform sustainable aquifer management.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$155K	Staff resources (975 hours, onetime) and (390 hours ongoing for research support) Project funding (50K) covers software, data licensing, materials, or student stipends	2	
Economic (Community)	No cost		No direct financial cost.	3	
Social	No cost		No adverse social impacts; only positive community–university synergy.	3	
Environmental	No cost		None	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	NSERC Alliance Grants, MITACS Accelerate or Elevate				
Other considerations	Consider the long-term collaboration potential by prioritizing institutions with capacity for multi-year partnerships and ongoing engagement				

Action					
Number	174				
Name	Coordinate City Groundwater Use				
Description	Develop a coordinated approach and decision-making forum between the City and Park Board to manage groundwater extraction activities, ensuring critical uses are prioritized and over-extraction is avoided. Develop decision-making forum to coordinate groundwater use to ensure critical uses are prioritized and over-extraction is avoided.				
Rationale	This action would help facilitate discussions to reach a consensus and have a joint understanding of what activities may use groundwater in the future and establish a coordinated approach to prioritize use and avoid over-extraction. Current consideration for uses include irrigation of park grounds, irrigation of green infrastructure assets, non-potable uses to offset drinking water uses, etc. An example approach would be a decision-making body similar to PIAC (Policy Implementation Advisory Committee). Desired Future State: Using a water budget balance, groundwater use is managed sustainably to ensure availability of groundwater in emergency use cases. An example approach would be a decision-making body similar to PIAC (Policy Implementation Advisory Committee).				
Strategy Objectives	1. Build support 5. Use sustainably				
Action Type	Actionable				
Score	19				
Implementation					
Timeline	1 year to initiate, then ongoing				
Methodology	1. Identify participants and convene a working group. 2. Develop a shared inventory of current and planned groundwater uses, including existing extraction locations, permitted volumes, intended uses (e.g. irrigation, non-potable water), and associated departments or projects. 3. Review the citywide water balance and sustainable yield estimates (completed in previous actions) to determine available groundwater volumes. Projected future demands should be considered. 4. Establish criteria for groundwater use prioritization. 5. Develop a decision-making framework for evaluating new groundwater use proposals. 6. Document and formalize the governance structure including the decision-making body, membership, roles, escalation paths, and workflows. 7. Draft a Groundwater Use Plan.				
Deliverables	Groundwater Use Plan, developed to identify priorities for use, and a procedure for determining if a project should move forward (internal decision making process).				
Draft KPIs	Working group formed (Yes/No) Number of known and planned uses identified and categorized Prioritization criteria defined (Yes/No)				
Assumptions	Onetime: Completed by city staff - assume 2,925 staff hours for one year. Ongoing: Completed by city staff - assume 195 staff hours / year.				
Dependencies					
Required Predecessors	71				
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1M–\$1.5M	Improved groundwater use efficiency, offsetting of potable water use (\$500K–\$1M) and preservation of groundwater for highest value uses (\$500K)	3	
Economic (Community)	None		None	0	
Social	Medium		Better prioritization of essential water uses, especially in drought or emergency conditions	2	
Environmental	High		Reduces aquifer drawdown risk and associated consequences, supports GDEs, and increases resilience to climate stress	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$225K–\$275K	Staff time (2,925 hours). Additional 195 hours annually for ongoing coordination.	2	
Economic (Community)	No cost		No direct cost to third parties. May impact access to groundwater if water reserve established across the City of Vancouver.	3	
Social	No cost		No disruption to public services	3	
Environmental	No cost		No physical or ecological impact	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	FCM – Green Municipal Fund Planning Stream CleanBC – Climate Preparedness and Adaptation Strategy BC Infrastructure Planning Grant				
Other considerations	Clearly defining shared institutional authority and roles will help reduce ambiguity in future groundwater-related decisions.				

Action					
Number	175				
Name	Guidelines for Permanent Groundwater Management Structures				
Description	Support development of design guidelines for permanent groundwater management structures with the Province.				
Rationale	The City currently does not have guidelines or set minimum design requirements for permanent groundwater management structures (which include tanked foundations and groundwater cut-off walls). These types of structures are becoming increasingly common in new developments, and there is a level of inconsistency in the designs submitted with development applications and the performance of these features after construction. There is also relatively little guidance available through regulatory authorities (i.e., EGBC) that outlines typical professional responsibilities and sign-off requirements for these types of structures. This action would aim to clarify submission requirements, simplify development review process and improve overall performance of these structures to protect the City from future risks, protect future owners from building enclosure failures, and protect groundwater resources from depletion. This action may include working with EGBC to develop a Professional Practice Advisory related to permanent groundwater management structures, developing minimum submission requirements for development applications proposing these features, and/or developing requirements to be included in the Vancouver Building Bylaw (VBBL).				
Strategy Objectives	1. Build support 4. Preserve resources 7. Reduce risks				
Action Type	Actionable				
Score	19				
Implementation					
Timeline	3 years				
Methodology	1. Review current regulatory and guidance documents. 2. Conduct comparative jurisdictional scan. Summarize best practices and lessons learned 3. Consult with the City's Building Department, EGBC and the general development community (Assume EGBC will lead the development of a Practice Advisory, with the City contributing heavily through expert input and CoV case studies). 4. Establish performance-based criteria. Draft technical standards and guidelines. 5. Finalize guidance/regulation.				
Deliverables	Design guidelines for tanked foundations and groundwater cutoff walls, in either the VBBL or as an EGBC practice advisory in consultation with other jurisdictions.				
Draft KPIs	Implementation of City's new design requirements for tanked foundations, groundwater cut off walls and baseflow preservation in streams. Number of projects constructed according to the guidelines. Volume of groundwater being diverted to sewers				
Assumptions	Completed by city staff - assume 1950 staff hours.				
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$1M–\$5M	Avoided sewer and water treatment costs for systems that discharge to combined sewer. Reduced groundwater treatment/disposal.	3	
Economic (Community)	Medium		Reduced development uncertainty and long-term costs for property owners using effective drainage solutions. Potential for reduced sanitary utility rates due to decreased collection/treatment costs.	2	
Social	High		Improves public confidence in the City's sustainable water infrastructure planning. Could reduce future conflicts over water-related construction delays or retrofits. Potential avoidance of costs and damages for future strata and tenants. Reduced dewatering-related settlement issues, reduced risk of building performance issues for future owners.	3	
Environmental	Medium		Limits anthropogenic alteration of the groundwater regime. Prevents excessive dewatering, supports aquifer sustainability, and reduces inadvertent discharge of pollutants to sewer or surface waters. Follows water sensitive design approach and preserves baseflow reporting to aquatic ecosystems. Tanked foundations and cutoff walls will be still effective in many instances without this additional work.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$150K	Staff time (1950 hours).	2	
Economic (Community)	Medium		Developers may experience costs if new requirements demand more expensive designs, particularly for cutoff walls or waterproofing tanked designs.	1	
Social	No cost		No direct social cost. Possible higher capital costs for reinforcement of subsurface structures but reduced operational costs for drainage and pumping systems in long term.	3	
Environmental	No cost		No environmental cost.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	BC Housing Research Centre or BC Energy Step Code Support Programs if aligned with resilient or efficient building practices Cost-sharing with developers or industry groups for pilot installations or technical validation				
Other considerations					

Action					
Number	176				
Name	Saltwater Intrusion				
Description	Reduce risks related to saltwater intrusion: A. Complete an assessment of the potential extent and magnitude of saltwater intrusion, induced by sea-level rise and other factors. B. Complete an inventory of City-owned assets that may be vulnerable to saltwater intrusion and develop mitigation strategies for those assets.				
Rationale	Groundwater near the coast is naturally saline and the inland extent of saltwater can change over time. This process, known as saltwater intrusion, will occur in Vancouver due to a rising sea level, but the geographical extent and magnitude of intrusion is unknown. Saltwater Intrusion degrades potential groundwater resources and other receptors such as groundwater dependent ecosystems. It can also impact infrastructure, through the process of corrosion. There are several City-owned facilities (e.g. Kits pool) and other assets (e.g. water & sewer pipes, etc.) that may be vulnerable to this increased corrosion. This action will further the City's understanding of where these types of impacts are most likely and will be subsequently used to inventory susceptible infrastructure and other receptors, and to develop a mitigation strategy related to these impacts. To maximize cost-effectiveness, this assessment may also include an assessment of saltwater intrusion induced by reduced aquifer recharge and increased groundwater extraction.				
Strategy Objectives	7. Reduce risks				
Action Type	A. Actionable B. Deferred - scope dependent on size of vulnerability area and number of overlapping City assets.				
Score	20				
Implementation					
Timeline	A. 1 year				
Methodology	A1. Review provincial guidance and scientific literature on saltwater intrusion mapping methods, with a focus on BC-specific resources (e.g. Ministry of Environment reports, regional studies in coastal BC). A2. Using results of the numerical groundwater model (Action 4), compile baseline data including digital ground surface elevation data, groundwater levels, aquifer geometry, recharge estimates, and hydraulic conductivity. Collect groundwater salinity data from monitoring wells where available. A3. Use established mapping methodology for BC to identify coastal zones most vulnerable to saltwater intrusion. A4. Compare vulnerability mapping to groundwater chemistry data to identify locations with known salinity issues. A5. Use the existing 3D numerical groundwater model or alternatively 2D density-dependent cross sectional models to simulate saltwater intrusion under multiple stressors, including projected sea-level rise, changing Fraser River hydrology, reduced recharge, and increased groundwater extraction for high risk areas. These results may already be available from Action 52 or build upon those previously developed. A6. Prepare a summary report and GIS deliverables. B1. Overlay mapped results with infrastructure and environmental receptor layers, including known well locations, Parks/Engineering assets, groundwater-dependent ecosystems, and corrosive risk to underground utilities. B2. Validate model outputs and refine understanding of actual saltwater impacts by conducting site-specific assessments for high-risk zones that overlap valuable assets. B3. Develop an asset vulnerability inventory by identifying specific infrastructure components that intersect the saltwater intrusion zone. B4. Identify and evaluate mitigation options. B5. Develop a saltwater intrusion asset mitigation strategy to guide internal departments on how to respond to vulnerability findings. B6. Establish a monitoring program for high vulnerability areas to track changes in groundwater salinity near critical infrastructure over time. B7. Consider updating design guidelines and construction standards to prevent future exposure for new infrastructure. This may include corrosion-resistant materials, trenching/backfill specifications, and saltwater risk screening in project planning.				
Deliverables	A. Vulnerability map for current and future conditions with associated GIS layers. B. Asset vulnerability inventory. Mitigation options matrix. Asset management strategy. Updated guidelines and construction standards (if applicable).				
Draft KPIs	Percent of city by area, impacted by salt-water intrusion. Number of impacted assets identified. % of impacted assets with mitigation strategies. Number of monitoring locations already showing saltwater intrusion. Number of groundwater monitoring locations added or upgraded.				
Assumptions					
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	Highest	>\$10M	Will provide a framework to ensure city infrastructure and lands are designed and managed in a manner that is resilient to future damage from saltwater intrusion, hence avoid rehabilitation costs for City assets	4	
Economic (Community)	Highest	>\$10M	Although this project will focus on City owned assets, it will likely provide valuable information (e.g. saltwater intrusion risk map) that private asset owners could use to inform design of their own assets to ensure they are protected from saltwater intrusion now and in the future in anticipated high risk areas (e.g. low lying land along Jericho Beach, Spanish Banks, Fraser River, etc.).	4	
Social	Low		Could protect assets that provide community services (e.g. seawall, Kitsilano Pool, pump stations, city beaches, parks, etc.)	1	
Environmental	Medium		Inform future design and landscaping of natural assets (e.g. parks, streams, etc.) to include salt resistant terrestrial and aquatic ecosystems.	2	
Costs				Unweighted Score	Weighted Score
Economic (City)	High	\$150K	Consulting costs and some staff time to develop request for proposals, collate supporting data and collaborate with other parties (e.g. Parks Board, Metro Vancouver, Vancouver Port Authority, MOTI, etc.).	0	
Economic (Community)	No cost		None	3	
Social	No cost		None	3	
Environmental	No cost		None	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Infrastructure Canada – Disaster Mitigation and Adaptation Fund CleanBC – Climate Preparedness and Adaptation Strategy UBCM – Asset Management Planning Program Federation of Canadian Municipalities – Green Municipal Fund (Adaptation, Resilience, and Disaster Mitigation stream)				
Other considerations	Corrosive water risks should be flagged early for asset classes like sewer pipes, pump stations, and pools. Mitigation options should be material-sensitive considering PVC, iron, concrete, and steel respond differently to saline conditions. Align mitigation efforts with scheduled replacements or upgrades to optimize cost-efficiency.				

Action					
Number	177				
Name	Increase infiltration through parks				
Description	Infiltrate stormwater into shallow aquifers through available large permeable spaces such as parks.				
Rationale	Current State: Parks currently drain stormwater into the sewer and drainage system. Gap: Draining stormwater from parks into the sewer and drainage systems adds burden to the sewer system capacity, and also misses an opportunity for some of the City's largest permeable spaces to recharge groundwater. Desired Future State: Large permeable spaces such as turf and natural parks are infiltrating into the underlying aquifers.				
Strategy Objectives	4. Preserve resources 6. Support ecosystems				
Action Type	Actionable				
Score	22				
Implementation					
Timeline	2 years				
Methodology	1. Review existing drainage network using GIS data to identify park spaces that currently drain to storm or combined sewers. Overlay enhanced recharge mapping results (Action 16) to identify parks where increased recharge is both feasible and beneficial. Consider deep infiltration opportunities at same time. 2.Consult internal stormwater and drainage staff to prioritize park spaces identified in Step 1 based on areas where the sewer capacity is most needed for flood mitigation and to reduce CSO's. 3. Screen candidate parks based on site constraints, such as land use intensity, winter conditions, soil type, groundwater conditions, vegetation sensitivity, and proximity to existing subsurface utilities. 4. Quantify current stormwater volumes from parks entering the sewer system and estimate the potential reduction in sewer load through implementation of enhanced infiltration measures. 5. Coordinate with Park Board and Engineering staff to align infiltration opportunities with park design standards, turf and irrigation management, and upcoming capital projects. 6. Select one or more parks for pilot implementation and scope early design concepts and monitoring components. Monitoring components may include the quality, volume and rate of stormwater being infiltrated. 7. Prepare a project plan and budget in collaboration with the Park Board. 8. Implement the pilot project in collaboration with the Park Board. 9. Provide a summary report with recommendations for similar projects in the future.				
Deliverables	Map of candidate park sites prioritized based on estimated value and costs. Summary report with findings, costs, co-benefits (recharge, sewer relief, resilience), and pilot project recommendations.				
Draft KPIs	Number or percent of parks reviewed citywide Number of candidate parks identified as draining to storm or combined sewers Number of candidate parks where implementation is anticipated to be viable. Percent of viable parks with enhanced infiltration systems implemented.				
Assumptions					
Dependencies					
Required Predecessors					
Successor(s)					
Benefits				Unweighted Score	Weighted Score
Economic (City)	High	\$5M–\$15M	Immediate and sustained reduction in sewer system load (\$2M–\$6M), deferral or downsizing of capital infrastructure (\$2M–\$6M), lifecycle cost savings from stormwater management and dual-use park infrastructure (\$1M–\$3M)	3	
Economic (Community)	Medium	\$500K-\$1.5M	Improved stormwater resilience. Reducing localized runoff and improving groundwater recharge helps lower flood risk and water damage to neighbouring homes, commercial lots, and infrastructure because of overland flow in areas where water table is deep and there is room for subsurface water table rise without basement flooding.	2	
Social	High		Demonstrates climate adaptation and water sustainability leadership. Enhances the function and reputation of City while fostering public engagement.	3	
Environmental	High		Improves shallow aquifer recharge, supports baseflow in urban streams, supports GDEs, reduces pollutant loads to receiving waters, and helps regulate soil moisture and vegetation health.	3	
Costs				Unweighted Score	Weighted Score
Economic (City)	Low	\$250K–\$400K	Cost covers technical assessment, interdepartmental coordination, scoping level design of a pilot implementation project, infiltration modeling, and load reduction quantification. Pilot construction is scoped but not included in costing.	2	
Economic (Community)	No cost		No cost.	3	
Social	No cost		No disruption.	3	
Environmental	No cost		No adverse impacts expected.	3	
Additional Details					
Alignment with other City Strategies					
Funding Recommendations	Infrastructure Canada – Natural Infrastructure Fund FCM – Green Municipal Fund BC Infrastructure Planning Grant				
Other considerations	Overflow routes and backup capacity may need to be incorporated in design. Pilot designs should include signage or educational elements to support broader Rain City Strategy engagement goals.				

