ASSESSING BASEFLOW AUGMENTATION OPTIONS FOR HIGH-RISK CREEKS AND STREAMS

City of Coquitlam

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Disclaimer

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This project was conducted under the mentorship of City of Coquitlam staff. The opinions and recommendations in this report and any errors are those of the author and do not necessarily reflect the views of the City of Coquitlam or the University of British Columbia.

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We acknowledge with gratitude and respect that the name Coquitlam was derived from the hən̓q̓əmin̓əm̓ word kʷikʷəƛ̓əm (kwee-kwuh-tlum) meaning “Red Fish Up the River.” The City is honoured to be located on the kʷikʷəƛ̓əm (Kwikwetlem) traditional and ancestral lands, including those parts that were historically shared with the sq̓əc̓iy̓aʔɬ təməxʷ (Katzie), and other Coast Salish Peoples.

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Executive Summary

Urbanization and climate change are significantly impacting hydrologic regimes, resulting in reduced baseflows in many streams across the Lower Mainland. In response, this report explores practical, site-specific baseflow augmentation strategies for five high-priority streams in Coquitlam: Hyde Creek, Hoy Creek, Maple Creek, Partington Creek, and Star Creek.

The project began with a review of best practices and emerging trends in baseflow augmentation. Current industry directions emphasize integrated, flexible, and nature-based solutions supported by advances in monitoring technology and growing recognition of ecological flow needs. These include Low Impact Development (LID) and distributed stormwater controls, flow-regime management, watershed restoration, active-release systems with real-time control (RTC), and water reuse for environmental flows.

Following this review, a SWOT analysis was conducted for five augmentation options relevant to the Coquitlam context: groundwater well and pump systems, gravity diversion, underground baseflow facilities, LID/distributed source controls, and spray park runoff. Each option was evaluated in terms of regulatory feasibility, technical constraints, cost, and opportunities for integration with existing infrastructure. Creek-specific considerations were identified based on flow monitoring data, existing IWMPs, land use plans, and upcoming park developments.

To support strategy selection, a multi-criteria decision matrix was developed, comparing the reliability, baseflow volume supported, cost-effectiveness, implementation timeline, and co-benefits of each option. Results indicate that LID and gravity diversion rank highest overall, offering long-term benefits when implemented as part of a decentralized, adaptive system.

Key recommendations include:

1. Identifying and defining target baseflows for the creeks identified.
2. Prioritizing the implementation of the gravity diversion from the Coquitlam River to Maple Creek.
3. Exploring opportunities to use spray park runoff to support baseflows during summer low-flow periods.

A flow monitoring program is urgently recommended to establish seasonal targets, assess project outcomes, and inform adaptive watershed management.

This report supports a shift toward systems that prioritize natural hydrologic function, using engineered approaches to supplement baseflow and stabilize streamflow regimes. By grounding

local actions in evidence-based best practices and cross-jurisdictional knowledge sharing, Coquitlam can build resilience across its urban stream networks and improve long-term ecological and hydrological outcomes.

Introduction

Urban streams and creeks in the City of Coquitlam face increasing pressures from climate change, urbanization, and evolving land use. These pressures threaten watershed health, particularly the sustained streamflows—known as baseflows—that are vital for aquatic ecosystems, water quality, and long-term ecological resilience. As these pressures intensify, maintaining reliable baseflows is becoming more challenging.

Baseflow augmentation offers a proactive way to stabilize stream conditions by supplementing natural flows through engineered and nature-based interventions. These strategies are increasingly recognized as critical components of climate adaptation and integrated watershed planning. In Coquitlam, where urban growth continues to intersect with sensitive stream corridors, there is a growing need to identify practical, locally relevant approaches to baseflow support.

This report explores potential baseflow augmentation options for five of Coquitlam's high-risk and high-value creeks:

1. Maple Creek
2. Hyde Creek
3. Partington Creek
4. Star Creek
5. Hoy Creek

Drawing on lessons from other jurisdictions, best practices, and a review of Coquitlam's existing watershed management frameworks, this report identifies opportunities to improve ecological outcomes and build climate resilience. The findings are intended to inform future planning, investment, and policy decisions aligned with City's Environmental Sustainability Plan and Climate Adaptation Strategic Plan.

Project Purpose and Scope

The project aims to evaluate and recommend baseflow augmentation strategies that can enhance the ecological and hydrological resilience of Coquitlam's most vulnerable and high-value creeks. Aligned with the City's Environmental Sustainability Plan, the project prioritizes improving ecological conditions for both people and wildlife by supporting consistent streamflows that sustain aquatic ecosystems, water quality, and climate resilience—particularly in urbanizing areas where stream health is most at risk—while promoting an integrated approach to stormwater management.

The research will inform future decision-making for both Engineering & Public Works and Parks Planning and Design. For Engineering, the focus is on reviewing and ranking augmentation options to guide investment in current and emerging practices, such as groundwater wells, infiltration ponds, detention systems, and detention ponds. For Parks Planning, the project explores opportunities to integrate baseflow facilities into recreational spaces, helping maximize ecological and community value within park designs.

The scope of the project included the following:

- Conducting a review of relevant municipal policies, Integrated Watershed Management Plans (IWMPs), and baseflow-related initiatives in Coquitlam.
- Completing a literature review of academic and gray sources to identify best practices, trends, and innovations in baseflow augmentation.
- Selecting and analyzing five high-risk and high-value creeks for targeted assessment.
- Researching and summarizing cross-jurisdictional case studies where baseflow augmentation strategies have been implemented.
- Developing and applying a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis for different baseflow augmentation facility types, with creek-specific considerations.
- Holding informational meetings with City staff across departments (e.g., Engineering & Public Works and Parks Planning and Design) to identify internal needs and opportunities for integration.
- Exploring co-location opportunities for baseflow augmentation facilities within park spaces to enhance both ecological function and recreational value.

- Producing a decision-support matrix and final recommendations to guide future planning, investment, and implementation of baseflow augmentation strategies in alignment with the City's Environmental Sustainability Plan.

Background

Urbanization has significantly altered watershed dynamics in Coquitlam. Increased impervious surfaces such as roads, roofs, and driveways reduce infiltration and groundwater recharge, leading to prolonged reductions in baseflow. These hydrologic changes degrade water quality, disrupt aquatic ecosystems, and compromise overall stream health.[1] Healthy stream corridors also enhance human thermal comfort by cooling the surrounding air temperature, which is critical for mitigating the urban heat island effect.[2]

Defining baseflow augmentation in context

While baseflow is traditionally defined as the portion of streamflow sustained by groundwater or delayed subsurface contributions,[3] this project adopts a broader, functional definition. Here, baseflow augmentation refers to any strategy that supports sustained streamflow during dry periods, regardless of the water's origin. This includes both groundwater-fed mechanisms and engineered or nature-based interventions that simulate delayed flow contributions (e.g., infiltration systems, controlled release tanks, stormwater reuse, or groundwater wells and pumps).

The emphasis is on maintaining consistent ecological and hydrological conditions in high-risk urban creeks, especially as climate change and land development alter the timing and availability of natural flows.

[1] Hamel, P., Daly, E., & Fletcher, T. D. (2013). Source-control stormwater management for mitigating the impacts of urbanisation on baseflow: A review. *Journal of Hydrology (Amsterdam), 485*, 201-211. https://doi.org/10.1016/j.jhydrol.2013.01.001

[2] Coutts, A. M., Tapper, N. J., Beringer, J., Loughnan, M., & Demuzere, M. (2013). Watering our cities: The capacity for water sensitive urban design to support urban cooling and improve human thermal comfort in the Australian context. *Progress in Physical Geography, 37*(1), 2-28. https://doi.org/10.1177/0309133312461032

[3] Hall, F. R. (1968). Base-flow recessions-A review. *Water Resources Research, 4*(5), 973-983. https://doi.org/10.1029/WR004i005p00973

Effects of increased imperviousness

According to the US Environmental Protection Agency, impervious surfaces may reduce baseflow for days, weeks, or sometimes months after a storm event.[4] Coquitlam has experienced a significant increase in impervious cover over time. Historically, impervious surfaces accounted for 50% or less of the total lot area in many residential zones. However, recent development patterns have increased this figure to as much as 90%, significantly reducing infiltration and the potential for natural groundwater recharge.[5] This shift has direct implications for baseflow reduction and watershed health.

Figure 1. Change in impervious cover in single-family areas

[4] From EPA-USGS Technical Report: Protecting Aquatic Life from Effects of Hydrologic alteration

[5] City of Coquitlam. *On-Site Stormwater Management for Small Scale Residential Developments*. File #: 11-5225-01/000/2024-1 Doc #: 5280753. V11. 2024. https://coquitlam.ca.granicus.com/MetaViewer.php?view_id=2&clip_id=2747&meta_id=77690

Current watershed management states & practices

The City of Coquitlam has established a robust foundation for urban watershed stewardship, combining monitoring, policy, and planning tools to respond to the complex challenges of urban hydrology. Central to this work is the City's Monitoring and Adaptive Management Framework (AMF), which supports continuous learning and improvement in its watershed health management.[6]

Each year, streamflow, water quality, and benthic invertebrate monitoring is conducted on a rotational basis across three creeks, with full evaluations completed every five years. The City operates live water quality monitoring stations in four creeks and maintains 19 sanitary flow monitors. Trail cameras provide additional surveillance, helping City staff detect and respond to incidents such as erosion or illegal discharge events in real time. These monitoring efforts are complemented by proactive enforcement tools, including development site patrols,[7] stop-work orders, and spill response guidelines,[8] which aim to safeguard water quality during and after construction activity.

Coquitlam is also developing IWMPs for all urban watersheds. These plans are guided by a Net Environmental Benefit approach, balancing ecological protection with community needs. The Hyde Creek IWMP is currently underway and is expected to be completed mid-2026 and the updated Stoney Creek IWMP is scheduled for completion in early 2027. While the intention is to update these plans regularly, progress is often limited by funding constraints and the complexities of coordinating with multiple partners and jurisdictions. Collaboration with groups like the Coquitlam River Watershed Roundtable and planning initiatives like the Partington Creek Neighbourhood Plan continue to support advancement where possible.

The City of Coquitlam's efforts in watershed planning have been commended by Fisheries and Oceans Canada (DFO) for their collaborative and proactive nature, with the following letter of endorsement for the Partington Creek IWMP:

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[6] Metro Vancouver. *Monitoring and Adaptive Management Framework for Stormwater*. 2014. https://metrovancouver.org/services/liquid-waste/Documents/stormwater-monitoring-adaptive-management-framework-2014-09.pdf

[7] City of Coquitlam. *Management and Maintenance of Construction Sites* ; *Good Neighbour Development Policy* ; *Stream and Drainage System Protection Bylaws*

[8] Spill reporting information: Watercourse Protection | Coquitlam, BC

> "The IWMP is a significant achievement and is expected to be instrumental in ensuring that future development activity in the watershed is congruent with the fish habitat values that currently exist in the Partington Creek watershed.
>
> DFO would like to commend City of Coquitlam staff and their consultants for their dedication to the project and for the efforts that were taken to ensure that the comments and recommendations of the advisory committee were addressed to the fullest extent possible."
>
> - Ms Diane Trager, Area Director, Fisheries and Oceans Canada[9]

The same project received the 2012 Award of Excellence from the Association of Consulting Engineering Companies-BC (ACEC-BC),[10] further emphasizing Coquitlam's leadership in integrating environmental values into long-term land use and infrastructure planning.

Many of these initiatives incorporate low-impact development (LID) principles—also referred to as Water Sensitive Urban Design (WSUD)[11] or Sustainable Urban Drainage Systems (SUDS)[12]—to manage stormwater sustainably. Through campaigns such as "Building Better",[13] the City is working to embed LID into urban planning, improving infiltration, reducing runoff, and supporting more resilient hydrological systems.

Methods

The first phase of this project involved a review of Coquitlam's current watershed management practices, including IWMPs, AMF data, and infrastructure related to stormwater management and baseflow augmentation. This was followed by a comparative review of strategies implemented across other municipalities within and outside the Lower Mainland. Sources included municipal reports, technical documents, internal communication, and policy guidance.

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[9] Canadian Consulting Engineering Awards 2012. *Partington Creek: A New Watershed Development Planning Process.* https://www.canadianconsultingengineer.com/awards/pdfs/2012/C8_PartingtonCreekWatershedPlan.pdf

[10] Kerr Wood Leidal Associated Ltd. *Partington Creek IWMP.* https://www.kwl.ca/project/partington-creek-iwmp/

[11] Wong, T. H. F. (2006). Water sensitive urban design: The journey thus far. *Australasian Journal of Water Resources*, *10*(3), 213–222. https://doi.org/10.1080/13241583.2006.11465296

[12] CIRIA (Construction Industry Research and Information Association). *Sustainable Urban Drainage Systems: Design Manual for England and Wales*. CIRIA, 2000. https://books.google.ca/books?id=jDa6PQAACAAJ

[13] City of Coquitlam. *Building Better*. https://www.coquitlam.ca/377/Building-Better

The second phase of the project involved analyzing this information through a SWOT (Strengths, Weaknesses, Opportunities, Threats) framework, focusing on the applicability of various strategies to Coquitlam's context. Consideration was also given to future climate risks, local land use pressures, operational challenges, and the feasibility of integrated stormwater solutions.

Together, these steps informed the development of a decision-making matrix and a set of tailored recommendations aimed at enhancing the resilience and ecological health of Coquitlam's urban waterways.

Findings: Context Summary, Existing Baseflow Augmentation Strategies, and Current Industry Trends

Identified creeks of concern

Using baseflow trend data from AMF reports, fish presence data from Coquitlam's AcrGIS *QTheMap*, IWMPs, communication with internal staff and consultants, and technical documents, the following five creeks of concern were identified: Maple Creek, Hyde Creek, Partington Creek, Star Creek, and Hoy Creek. Supporting data can be found in Appendix A.

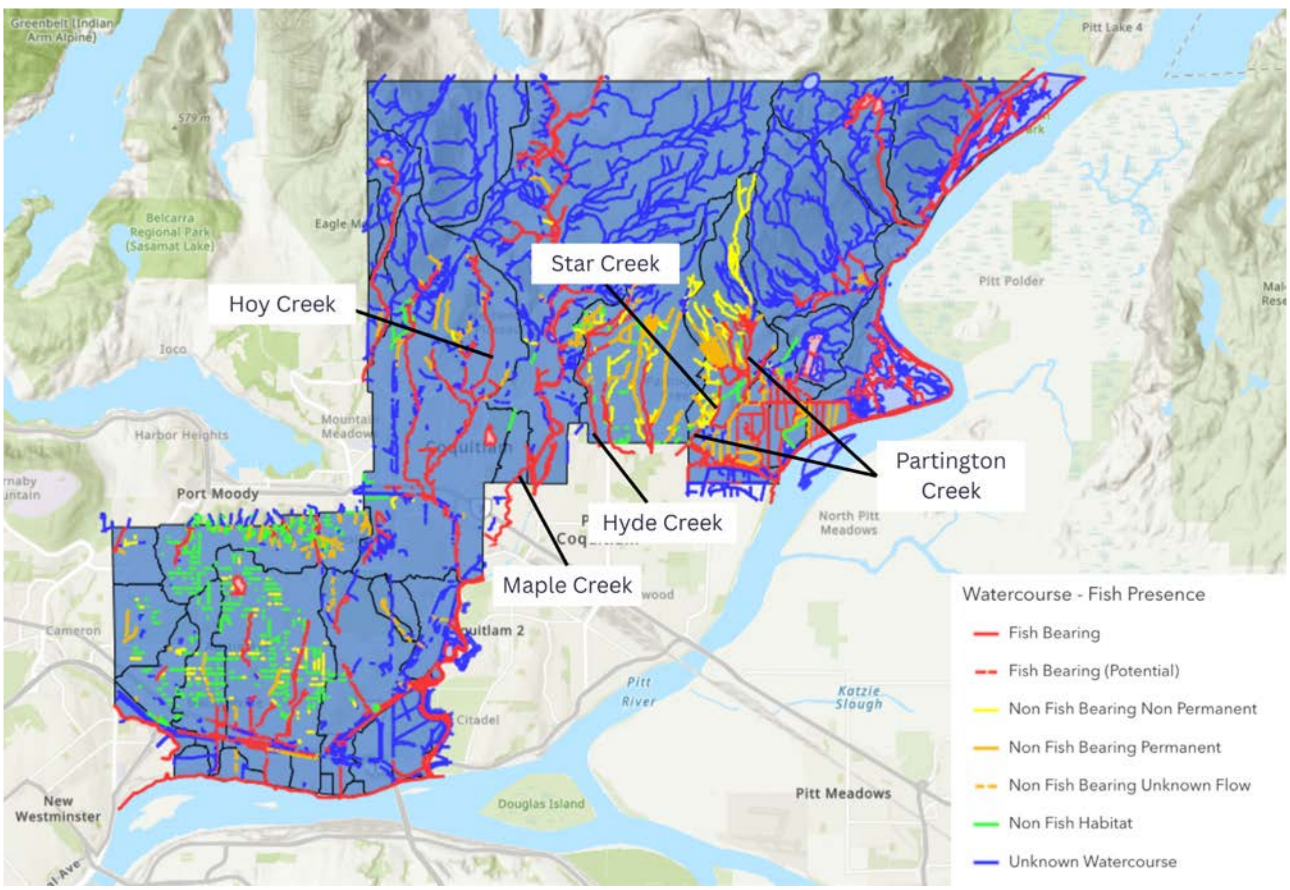
Table 1: Identified high-value and high-risk creeks in Coquitlam

Creek	Ecological Value	Risk Factors
Maple Creek	Inhabited by Salmonids and/or rare or endangered species year-round (coho salmon, cutthroat trout, chum salmon, rainbow trout, threespine stickleback).	Reliant on groundwater pump system; declining pump yields over time & multiple pump failures since installment; potential for current 300 mm orifice opening on Ozada high-flow diversion pipe to be blocked.
Hyde Creek	Inhabited by Salmonids and/or rare or endangered species year-round (coho salmon, cutthroat trout, threespine stickleback); supports Hyde Creek hatchery in Port Coquitlam.	Decreasing baseflows year-round; groundwater loss to gravel substrate.
Partington Creek	Inhabited by Salmonids and/or rare or endangered species year-round (coho salmon, cutthroat trout, chum salmon, rainbow trout, threespine stickleback); important black bear habitat.	Decreasing winter baseflows; under increasing development pressure.

Star Creek	Potential for habitation by salmonids and/or rare or endangered species through access/habitat enhancement or headwater stocking.	Decreasing winter baseflows; summer baseflows at critical levels (<1 L/s); storage facility may not always provide guaranteed flow; under increasing development pressure.
Hoy Creek	Inhabited by Salmonids and/or rare or endangered species year-round (coho salmon, cutthroat trout, chum salmon, rainbow trout, Chinook salmon); supports Hoy Creek Hatchery (an important educational site).	Decreasing winter baseflows; at risk of seasonal ecological distress

Note: Additional flow monitoring is recommended for Stoney Creek and Harmony Creek to evaluate existing baseflows.

Figure 2. Map of identified high-risk creeks in Coquitlam, including fish presence



Note: Map created using Coquitlam's Internal QtheMap (ArcGIS)

Existing baseflow augmentation strategies in Coquitlam

Coquitlam currently uses various strategies to sustain baseflows in its creeks and streams, particularly during dry summer months. These strategies include both distributed stormwater source controls and engineered flow supplementation systems, which together help moderate runoff, enhance infiltration, and maintain hydrologic stability.

Existing engineered sourcewater controls include stormwater detention tanks, infiltration galleries, rain gardens, permeable pavement, green lanes, water quality ponds, and roadside swales. Guided by Metro Vancouver's *Stormwater Source Control Design Guidelines*,[14] these features slow runoff, increase ground infiltration, and reduce peak flow events. These controls play a valuable role in sustaining baseflows by reducing flow variability in receiving streams.

In areas where natural recharge and infiltration are insufficient to maintain streamflow, Coquitlam uses engineered augmentation systems. Notably, diversion pipes are used to redistribute water between stream systems, supplementing low-flow creeks with water from nearby sources. Additionally, a groundwater pump system has been installed in Maple Creek to replenish streamflow, which is highly reliant on this support during the summer. While effective, this system also illustrates a vulnerability: Maple Creek has experienced multiple flow interruptions due to pump failures, causing it to run dry for several days at a time until repairs were completed. This underscores both the potential and risk of mechanical baseflow augmentation, particularly when redundancy is limited.

To address the hydrologic impacts of infill and densification, Coquitlam launched a new residential stormwater policy in June 2025. Under this policy, small-scale or low-density residential developments will be required to incorporate on-site stormwater detention and infiltration structures.[15] This initiative is designed to mitigate the impacts of increasing impervious area, including reduced groundwater recharge, higher peak runoff volumes, elevated stream temperatures, and degraded water quality and aquatic habitat. It also responds to British Columbia's new small-scale multi-unit housing legislation,[16] which is expected to drive significant development across urban neighbourhoods. Given that small-scale residential lots account for

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[14] Metro Vancouver. *Stormwater Source Control Design Guidelines.* 2012. https://www.coquitlam.ca/DocumentCenter/View/237/Metro-Vancouver-Stormwater-Source-Control-Design-Guidelines-Report-PDF

[15] City of Coquitlam. *Council Report: On-Site Stormwater Management for Small Scale Residential Developments*. 2025.

[16] Government of British Columbia. https://www2.gov.bc.ca/assets/gov/housing-and-tenancy/tools-for-government/local-governments-and-housing/ssmuh_provincial_policy_manual.pdf

over 30% of Coquitlam's land use,[17] this policy represents a timely and impactful step toward managing stormwater and preserving the long-term integrity of local streams.

Existing baseflow augmentation strategies in the Lower Mainland

Across the Lower Mainland, municipalities are employing a variety of strategies to manage and augment baseflows in response to growing urbanization, climate change, and seasonal drought. While methods vary, common challenges include system maintenance, monitoring accuracy, cost, and integration with broader water and land use planning.

Table 2 highlights key initiatives underway in Surrey, Abbotsford, the Township of Langley, and the District of North Vancouver.

Table 2: Baseflow augmentation strategies within the Lower Mainland

Municipality	Baseflow Augmentation Strategies Used
Surrey	Surrey has implemented seasonal and opportunistic methods to enhance streamflows, particularly using runoff water from splash parks. Water from these recreational facilities is captured, filtered through bioswales, and released into nearby watercourses. While not part of a formalized baseflow program, this approach aligns with summer baseflow timing and provides co-benefits by maximizing the use of municipal water already being used by public recreation.
Abbotsford	Abbotsford is currently in its 15th year of operating the Bevan Well Mitigation program to offset the impacts of groundwater extraction on local creeks.[18] This program monitors stream flows, water levels, and quality, and uses pre-established triggers to activate mitigation wells that augment surface flows between May 1 and September 30.[19] However, practical issues with flow measurements have led to prolonged pumping even when conditions may not have warranted it, raising concerns about efficiency and environmental impact. Abbotsford also maintains universal water metering across residential and commercial users, helping to manage overall water demand and indirectly reduce pressure on water sources that feed local baseflows.
Township of Langley	The Township of Langley has experienced significant baseflow declines due to historical over-extraction from unconfined aquifers. Groundwater modeling conducted in 2005 predicted that under increased extraction, Bertrand Creek could

[17] City of Coquitlam. *Council Report: On-Site Stormwater Management for Small Scale Residential Developments*.

[18] Enkon Environmental Limited. 2023. *Bevan Avenue Groundwater Supply Development Project: Year 12 Environmental Monitoring Report.* https://www.ourwatermatters.ca/sites/1/files/2024-03/FINAL%20Bevan%20Year%2012%20Report_Part%201.pdf

[19] Ibid.

	begin to lose its baseflow to the nearby aquifer by 2018—effectively reducing baseflow to below zero—while the Salmon and Nicomekl Rivers could see a 36% reduction in annual baseflow due to estimated population growth.[20] In response, the Township developed a Water Management Plan in 2009 which aimed to reduce groundwater extraction by 30% by 2020.[21] In November 2022, the Township of Langley Council directed their staff to formulate a plan to terminate all groundwater extraction and transition to Greater Vancouver Water District (GVWD) water in the upcoming years[22] — a significant policy move aimed at ensuring groundwater and baseflow are replenished. Like Surrey, the Township of Langley has a spray park that might direct 50% of its flow to a nearby creek, but this is opportunistic rather than intentional.
District of North Vancouver	The District of North Vancouver has not yet implemented formal or widespread baseflow augmentation strategies, as its District-wide Integrated Stormwater Management Plan (ISMP) is still in development.[23] However, field observations suggest there have been some opportunistic efforts to direct low flows from infrastructure such as pipes, culverts, and manholes into nearby creeks and wetlands to support baseflows—though these rely on rainfall and are not sustained in dry conditions. A more distinctive feature of the District's approach is its focus on preserving shallow groundwater contributions. In watersheds like Hastings Creek, baseflow is strongly influenced by interflow between surface soils and underlying till. To protect this groundwater-driven flow, the District has introduced relatively strict bylaws aimed at preventing development sites from intercepting and redirecting groundwater into the stormwater system. Under Section 7 of the sewer bylaw,[24] groundwater may not be discharged to the storm sewer system unless it can be demonstrated that the discharge is unavoidable, will not harm baseflows or aquatic habitat, and will not increase loading on the storm system. While similar requirements exist in other municipalities for larger developments, the District of North Vancouver extends these controls to single-family properties, with the Director retaining discretion over approvals. Temporary discharges during construction may be permitted with conditions, but small-scale multi-family redevelopments are prohibited from

[20] Golder Associates. 2005. *Final Report: Comprehensive Groundwater Modelling Assignment*. https://a100.gov.bc.ca/pub/acat/documents/r57709/2_1573686248966_3685907331.pdf

[21] Township of Langley. 2009. *Water Management Plan*. https://www.tol.ca/en/the-township/resources/plans-reports-strategies/Action-Plans/Township-of-Langley-Water-Management-Plan.pdf

[22] Metro Vancouver. 2024, May 8. Greater Vancouver Water District Board May Committee Information Items and Delegation Summaries. https://metrovancouver.org/boards/GVWD/WD-2024-05-31-ADD-I1.pdf

[23] District of North Vancouver. 2025. *Integrated Stormwater Management Plan*. https://www.dnv.org/community-environment/integrated-stormwater-management-plan

[24] The District of North Vancouver. 2024. *Sewer Bylaw 6656, 1994, Amendment Bylaw 8721, 2024 (Amendment 37).* https://docs.dnv.org/documents/Bylaw%206656.pdf

	discharging groundwater entirely.[25] This strong regulatory stance aims to protect stream health and baseflows but has reportedly faced pushback. The District is currently working to reinforce these protections through its ongoing Official Community Plan.

While baseflow declines are increasingly common in British Columbia,[26] dedicated flow monitoring across the Lower Mainland remains limited. In many municipalities, baseflow volumes are either unmeasured or inferred from sporadic observations, with existing watercourse monitoring programs focused primarily on water quality rather than hydrometric data. This absence of reliable baseline flow records makes it difficult to quantify long-term trends, assess the effectiveness of augmentation strategies, or anticipate the compounded effects of urban growth and climate change. As a result, baseflow management is often reactive and opportunistic rather than strategic. Closing this monitoring gap by establishing continuous flow measurement stations, identifying target baseflows, and integrating this data into water management plans should be a regional priority before a comprehensive baseflow augmentation framework can be meaningfully implemented.

Outside the Lower Mainland

Looking beyond the Lower Mainland provides a broader view of how municipalities in varying climate zones, land use contexts, topographies, and soil infiltration conditions manage baseflows. For example, hillslope infiltration trenches have been implemented successfully in the Peruvian Andes—a high-gradient, low infiltration environment—to improve dry-season baseflows.[27] While not directly transferable to the Lower Mainland's context, this example reinforces the potential of distributed, passive recharge infrastructure to enhance groundwater contributions to streamflow.

In more urbanized and space-constrained contexts, active systems are emerging as viable alternatives to infiltration-based solutions. Real-Time Control (RTC) technology has been integrated into rainwater harvesting systems to actively manage storage and release based on

[25] Ibid. (section 7.5)

[26] Murray, J., Ayers, J., & Brookfield, A. (2023). The impact of climate change on monthly baseflow trends across Canada. *Journal of Hydrology (Amsterdam), 618,* 129254. https://doi.org/10.1016/j.jhydrol.2023.129254

[27] Somers, L. D., McKenzie, J. M., Zipper, S. C., Mark, B. G., Lagos, P., & Baraer, M. (2018). Does hillslope trenching enhance groundwater recharge and baseflow in the Peruvian Andes? *Hydrological Processes, 32*(3), 318-331. https://doi.org/10.1002/hyp.11423

forecasted conditions and system performance metrics. This dynamic functionality allows stormwater systems to adapt to limited infiltration opportunities and shifting climate patterns.

A Melbourne study modelled a RTC system in comparison to conventional and passive release systems.[28] The study aimed to determine whether RTC could replicate baseflows while simultaneously meeting demand requirements. The annual rainfall in the study catchment was 1090 mm, and the baseflow target varied from 36 to 92 L/day, with supply and demand ranging from 51 to 401 L/day. The study found that a large real-time rainwater harvest storage system could effectively satisfy these requirements, with a storage volume of 15 kL.

However, Coquitlam faces challenges in implementing this solution. Without the implementation of large storage tanks across the city, it becomes impractical. For instance, sustaining a dry creek with 1 L/s flows for a single day would require 86,400 L of water. In the dry summer months when rainfall is scarce, this level of supply is not feasible.

Industry Trends and Best Practices in Baseflow Augmentation

Current industry trends in baseflow augmentation emphasize integrated, flexible, and nature-based solutions, supported by advances in technology and a growing recognition of ecological flow requirements. Prominent trends include: Low Impact Development (LID) and distributed stormwater management approaches; flow-regime management; watershed restoration; active-release systems and RTC technology; and water reuse for environmental flows. Note that these strategies are not meant to function independently. Rather, they build on one another, with the goal of designing systems where natural processes are prioritized, and technology serves to enhance—not replace—those functions. A layered, integrated approach reflects current best practices in resilient watershed management.

1. Low Impact Development (LID) and Distributed Approaches

Low Impact Development (LID) techniques, also known as Water-Sensitive Urban Design (WSUD) or Sustainable Urban Drainage Systems (SUDS), are increasingly common. These strategies often encourage natural infiltration and recharge groundwater to sustain baseflows, such as bioswales, rain gardens, permeable pavements, and infiltration galleries. Spatially distributed LID facilities

[28] Xu, W., Fletcher, T., Duncan, H., Bergmann, D., Breman, J., & Burns, M. (2018). Improving the multi-objective performance of rainwater harvesting systems using real-time control technology. *Water (Basel), 10*(2), 147. https://doi.org/10.3390/w10020147

are shown to be more effective than centralized solutions, as they better mimic natural hydrologic processes, increase baseflows, and reduce the negative effects of smaller rainfall events on streamflow response.[29]Additionally, LID facilities improve water quality by filtering contaminants through soil and vegetation before they reach watercourses, reducing pollutant loads and enhancing ecosystem health.

2. Flow-Regime Management

Emerging best practices have shifted focus from isolated stormwater and baseflow management towards broader *flow-regime management*.[30] This holistic approach aims to restore elements of natural hydrology by preventing a substantial proportion of stormwater runoff from reaching waterways directly, thus supporting consistent baseflows and enhancing in-stream ecological health.

3. Watershed Restoration and Natural Groundwater Recharge

Restoring natural hydrological functions within watersheds has become increasingly prioritized as a sustainable long-term strategy. Practices such as reforestation, riparian habitat restoration, and soil rehabilitation can significantly enhance natural groundwater recharge, indirectly supporting baseflow augmentation.[31] When groundwater recharge is supported, groundwater-surface connectivity is strengthened, which protects against low-flow periods. However, caution is warranted with constructed end-of-catchment wetlands, as they may reduce rather than enhance baseflows unless outlet modifications are made to simulate natural flows.[32]

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[29] Loperfido, J. V., Noe, G. B., Jarnagin, S. T., & Hogan, D. M. (2014). Effects of distributed and centralized stormwater best management practices and land cover on urban stream hydrology at the catchment scale. *Journal of Hydrology (Amsterdam), 519*, 2584-2595. https://doi.org/10.1016/j.jhydrol.2014.07.007

[30] Burns, M. J., Fletcher, T. D., Walsh, C. J., Ladson, A. R., & Hatt, B. E. (2012). Hydrologic shortcomings of conventional urban stormwater management and opportunities for reform. *Landscape and Urban Planning, 105*(3), 230-240. https://doi.org/10.1016/j.landurbplan.2011.12.012

[31] Jigour, V. M. (2011). Watershed restoration for baseflow augmentation. *UMI*. https://www.proquest.com/dissertations-theses/watershed-restoration-baseflow-augmentation/docview/926427433/se-2

[32] Burns, M. J., Fletcher, T. D., Walsh, C. J., Ladson, A. R., & Hatt, B. E. (2012). Hydrologic shortcomings of conventional urban stormwater management and opportunities for reform. *Landscape and Urban Planning, 105*(3), 230-240. https://doi.org/10.1016/j.landurbplan.2011.12.012

4. Active Release Systems and Real-Time Control (RTC) Technology

Recent technological advancements have enabled dynamic and adaptive stormwater management. Among these, Real-Time Control (RTC) systems—previously discussed through international case studies—are gaining traction as part of broader stormwater management strategies. Often referred to as continuous monitoring and adaptive control (CMAC) systems, RTC technology integrates sensors, predictive models, and automated controls to optimize water retention and release across multiple infrastructure types. When embedded within detention ponds, infiltration galleries, or baseflow tanks, RTC systems help stabilize flows, extend system functionality, and reduce the need for oversized facilities.[33]

While RTC offers promising benefits when used alongside existing stormwater strategies, its application in Coquitlam faces limitations. Specifically, supplementing baseflows during extended droughts would require impractically large storage volumes, making it an infeasible solution for long dry periods. Instead, RTC is better suited for managing frequent, low-intensity winter storms typical of the region's wet season, where its adaptive capabilities can be fully leveraged to improve system responsiveness and efficiency.

5. Water Reuse and Recycled Water for Environmental Flows

Another emerging trend is using reclaimed or recycled water treated specifically for environmental uses—a practice known as *fit-for-purpose* reuse. Environmental reuse involves treating wastewater or stormwater to standards suitable for streamflow augmentation, which supports aquatic ecosystems without demanding high-quality potable standards.[34] This approach has demonstrated significant ecological and hydrological benefits in several jurisdictions.[35]

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[33] Xu, W., Fletcher, T., Duncan, H., Bergmann, D., Breman, J., & Burns, M. (2018). Improving the multi-objective performance of rainwater harvesting systems using real-time control technology. *Water (Basel), 10*(2), 147. https://doi.org/10.3390/w10020147

[34] Eppehimer, D. E., Hamdhani, H., Hollien, K. D., & Bogan, M. T. (2020). Evaluating the potential of treated effluent as novel habitats for aquatic invertebrates in arid regions. *Hydrobiologia, 847*(16), 3381-3396. https://doi.org/10.1007/s10750-020-04343-6

[35] Plumlee, M. H., Gurr, C. J., & Reinhard, M. (2012). Recycled water for stream flow augmentation: Benefits, challenges, and the presence of wastewater-derived organic compounds. *The Science of the Total Environment, 438*, 541-548. https://doi.org/10.1016/j.scitotenv.2012.08.062

Baseflow augmentation options for identified high-risk creeks in Coquitlam

Five baseflow augmentation strategies, shown in Table 3, were identified and assessed for their applicability to the selected high-risk creeks.

Table 3: Baseflow augmentation options assessed

Strategy	Rationale & Alignment With City Documentation	Implementation Status
Groundwater Wells and Pump Systems	Drilling a new production well or rehabilitating the current well were identified as options in the 2021 Maple Creek IWMP.	Existing system at Maple Creek; Hyde Creek is partially supplemented using groundwater pumping in Port Coquitlam but flows remain insufficient.
Gravity Diversion (from Coquitlam River)	Explicitly recommended as preferred baseflow strategy for Maple Creek in the 2021 IWMP. Provides passive, low-maintenance supply.	Identified as preferred option; under review.
Large-Scale Underground Detention and Baseflow Release Facilities	Supported by existing David Avenue facility (Partington Creek), with clear operational guidance and performance metrics and planned for 2027 (southern expansion). A large-scale infiltration/detention facility is also being considered for Blue Mountain Park.	Implemented (David Ave 2017); planned expansion (2027); potential Blue Mountain Park incorporation.
Low Impact Development (LID) & Distributed Source Control Measures	Strong alignment with Hyde Creek watershed plans as development increases in the northwest area of Burke Mountain. LID is encouraged city-wide to maximize infiltration, reduce impervious surfaces, and support/preserve baseflows.	Recommended as standard practice; currently implemented through pervious paving, roadside swales, rain gardens, boulevard infiltration galleries, and water quality ponds; new 2025 residential stormwater policy requires on-site detention and infiltration systems for Small-Scale Multi-Unit (SSMU) developments.
Spray Parks with Integrated Baseflow Support	Combines public amenities with stormwater management through bioswales, ponds, or detention tanks. Supports infiltration, dechlorination, and baseflow via treated splash pad discharge. Aligns with LID principles and multi-functional urban design.	Planned: Burke Village Park (2029) will include a splash pad with treated discharge directed to support Star and Partington Creeks via a swale or pond.

SWOT analysis

Key factors considered in the SWOT analysis include:

- Technical feasibility
- Reliability (system redundancy and consistent performance)
- Volume of water/flows supported
- Implementation time
- Physical area requirements
- Water quality changes
- Maintenance and operation requirements
- Capital and operational cost-effectiveness
- Regulatory and stakeholder acceptance
- Environmental benefits (e.g., reduced flood risk, ecological improvement)
- Public appeal and recreational value
- Adaptability to climate uncertainty

Option 1: Groundwater Well & Pump Systems

These systems draw groundwater and convey it to local streams to supplement baseflow during dry periods. While conceptually straightforward, they have proven unreliable as a standalone solution due to fluctuating groundwater levels, aging infrastructure, and intensive maintenance demands. Reliability can be improved by combining this system with other infrastructure, such as storage tanks or RTC technology.

Groundwater Well & Pump Systems

STRENGTHS

- **Reliable Baseflow Source**: Can provide steady and controlled flow to creeks even during dry conditions.
- **Relatively Simple Installation:** Drilling and piping infrastructure is straightforward compared to diversion systems.
- **Immediate Response Tool:** Suitable for rapid deployment in creeks with urgent low-flow issues (once approvals are in place).

WEAKNESSES

- **Mechanical Vulnerabilities**: Reliance on pumps makes the system prone to failure (as seen in Maple Creek).
- **Limited Sustainability**: Long-term extraction risks aquifer depletion or negative interactions with surrounding hydrology.
- **Monitoring and Maintenance Costs**: Requires ongoing energy input, flow monitoring, and mechanical upkeep.

OPPORTUNITIES

- **Short-Term Solution While Awaiting Larger Projects:** Can be used as a bridge until other options are built.
- **Emergency Option:** Provides backup during low-flow emergencies or infrastructure failures.
- **Redundancy Potential**: Can be combined with other infrastructure (e.g., storage tanks, RTC) to improve reliability.

THREATS

- **Lengthy Regulatory Approval Process**: Groundwater licensing and environmental impact assessments may delay implementation.
- **Public Perception of Overuse**: Risk of community resistance if viewed as unsustainable or wasteful of water resources.
- **Energy Cost Volatility**: Long-term costs may rise due to electricity needs and utility pricing shifts.

Creek-Specific Considerations:

The feasibility of groundwater wells depends on existing hydrogeological conditions. A hydrogeological survey completed in 2022 found less favourable groundwater conditions in the upland areas of northeast Coquitlam.[36]

[36] WSP Golder. (2022, November 30). *Hydrogeological Screening for Potential Groundwater Supply – City of Coquitlam* [Technical Memorandum]. CEDMS #: 4675022.

- **Maple Creek**: Currently uses a groundwater well and pump. Rehabilitation of the existing well and pump is under consideration, and installation of a new production well is listed as a preferred option in the Maple Creek IWMP.
- **Hyde Creek**: Potential site for groundwater augmentation based on IWMP discussions. Site-specific implementation/feasibility has not been confirmed.
- **Hoy Creek:** The unconfined Coquitlam River Aquifer near Town Centre Park (North) has been ranked favourable for groundwater extraction, both in terms of quantity and quality. Groundwater conditions at Panorama Park are uncertain.[37]
- **Star & Partington**: No confirmed plans or recommendations for groundwater well systems based on available documentation.

Option 2: Gravity Diversion (Coquitlam River → Maple Creek)

This option involves diverting flow from the Coquitlam River into Maple Creek using gravity-fed infrastructure. This system was previously identified as a preferred and sustainable solution (IWMP, 2021).

[37] Ibid.

Gravity Diversion from Coquitlam River

STRENGTHS

- **High Volume Potential:** Coquitlam River has sufficient year-round flow to support baseflow needs.
- **Passive System Design**: Gravity-fed, no pumping required - minimizes operational costs and complexity.
- **Proven Long-Term Solution**: Endorsed in previous IWMPs as a sustainable option for Maple Creek.

WEAKNESSES

- **Limited Suitability:** Reliant on Coquitlam River access.
- **High Upfront Cost**: Estimated $1.9M (2021) is significantly more than other interventions.
- **Engineering Complexity**: Requires careful design of diversion structures, intake points, and connection to receiving streams.
- **Maintenance Needs**: Intake screens and structures may require frequent clearing and seasonal upkeep.

OPPORTUNITIES

- **Infrastructure Co-Benefits**: May leverage existing or future stormwater infrastructure corridors.
- **Strong Alignment with Regulatory and Planning Objectives**: Supports climate adaptation, fish habitat protection, and long-term watershed health.
- **Potential Flagship Project**: Demonstrates leadership and innovation in integrated watershed planning.

THREATS

- **Jurisdictional Coordination:** May require alignment with other departments and external agencies.
- **Public and First Nations Concerns**: There may be concern regarding the impact of diverting water from the Coquitlam River.
- **Climate Uncertainty**: Long-term changes to Coquitlam River flow (e.g., snowpack shifts) may affect reliability.

Creek-Specific Considerations:

- Maple Creek: Identified in the 2021 IWMP as the preferred long-term strategy. Would divert water via existing infrastructure to augment baseflows.

Option 3: Large-Scale Underground Baseflow Release Facilities

These engineered storage tanks capture stormwater and gradually release it to mimic natural baseflow conditions. Installed underground, they are well-suited to urban settings with limited surface space. However, they may struggle to sustain flow during extended summer droughts without consistent inflows. When water is stored for prolonged periods, there is the potential for water quality issues to arise, such as low dissolved oxygen or bacterial overgrowth. Mitigation measures are necessary to ensure water quality is suitable for release into adjacent watercourses (e.g., bubblers, water treatment).

Large-Scale Underground Detention & Baseflow Release Facilities

STRENGTHS

- **Engineered Flow Control:** Offers precise regulation of discharge for consistent baseflows.
- **Space Efficient**: Installed underground, ideal for high-density urban areas with limited surface space.
- **Maintains Cool Water Temperatures**: Underground storage releases cool water, supporting temperature-sensitive species like salmon.

WEAKNESSES

- **High Capital and Maintenance Costs:** Installation and upkeep is expensive.
- **Limited Co-Benefits**
- **Water Treatment Required:** Potential for water quality issues with prolonged storage unless treatment/filtration is incorporated into the design.
- **Storage Constraints**: To sustain baseflows between precipitation events, these systems must be exceptionally large and may still fail to provide continuous flow.

OPPORTUNITIES

- **Integration with Existing Infrastructure:** Can be added to existing storm sewer networks or new developments.
- **Mitigation of Flash Flooding and Erosion**: Helps stabilize downstream flows by reducing high discharge events.
- **Customizable for Site-Specific Needs:** Designs can be tailored to fit unique topography, flow requirements, and infrastructure constraints.

THREATS

- **May Not Align with Watershed-Based Design Principles**: Centralized infrastructure can be less effective than distributed approaches in replicating natural hydrologic processes.
- **Failure Risks Without Redundancy:** Malfunctions (e.g., stuck valves, leaks) can lead to flooding or dry creeks.
- **Difficult to Retrofit in Built-Out Areas:** Existing development and underground utilities can limit installation options.

Creek-Specific Considerations:

- Partington Creek: Will be supported by the David Avenue Baseflow Facility (built 2017) and a second facility scheduled for construction in 2027.
- Star Creek: Receives indirect support from the David Avenue Baseflow Facility due to shared catchment area.
- Hyde Creek: Pond 14 is proposed to be replaced with underground infrastructure under a shared works agreement, tentatively scheduled for 2025.
- Hoy, Maple: No confirmed underground facilities planned at this time.

Option 4: LID & Distributed Source Control Measures

LID strategies (e.g., rain gardens, bioswales, and permeable pavement) promote infiltration, groundwater recharge, and delayed runoff release. These decentralized systems support natural hydrologic function and offer additional co-benefits. Performance depends on site conditions and regular maintenance.

LID & Distributed Source Control Measures

STRENGTHS

- **Multi-Benefit Solutions**: Improve infiltration, water quality, habitat, and urban greening.
- **Mimics Natural Hydrology**: Promotes infiltration and slow runoff, helping restore pre-development flow patterns.
- **Public Engagement Potential:** Visible and tangible, encouraging stewardship and education.

WEAKNESSES

- **Low Volume Contributions:** Widespread implementation is necessary for sufficient baseflow improvements.
- **Performance Variability**: Effectiveness depends on site context (e.g., slope, soil infiltration capacity)
- **Space Requirements**: Needs surface area that may compete with other land uses in dense areas.
- **Maintenance Burden**: Requires consistent sediment removal, weeding, and replanting.

OPPORTUNITIES

- **Community Integration:** Can be incorporated into parks, boulevards, and civic spaces.
- **Contributes to Urban Heat Reduction:** Vegetated LID elements can mitigate the urban heat island effect through evapotranspiration and shading.
- **Flexible Implementation Over Time**: Can be phased in as budgets allow, with cumulative benefits across neighborhoods or developments.

THREATS

- **Design Misapplication:** Poorly suited LID designs (e.g., in compacted soils or steep slopes) may fail or cause drainage issues.
- **Fragmented Ownership & Responsibility:** LID features on private property may suffer from unclear maintenance roles or inconsistent upkeep.
- **Downstream Development**: Groundwater flow paths could be disrupted by downstream development.
- **Climate Extremes:** Prolonged drought or severe storms may reduce effectiveness without adaptive designs.

Creek-Specific Considerations:

The suitability of LID and distributed source control measures varies by watershed. See Table 4 for site-specific details.

- **Maple Creek**: The 2021 IWMP suggests using retention source controls where infiltration is limited.

Table 4: LID Suitability by Watershed

Watershed	Infiltration Capacity	Urbanization & Imperviousness	LID Capture Target	LID Suitability For Baseflow Support
Maple Creek	Limited infiltration; underlying glacial till	Highly urbanized; ~50% impervious	55 mm / 24 hrs	**Low** – urban density and soils limit infiltration, but distributed storage and release can modestly support baseflows.
Hyde Creek	Shallow organic layer over till; lateral subsurface flow dominates	~20% avg (6% Coquitlam, 37–39% Port Coquitlam)	*45 mm / 24 hrs	**Low** – groundwater interflow is close to the surface, meaning storage is limited. Infiltration only recommended when it can be dispersed over large areas. Flows may be easily intercepted.
Partington Creek (includes Star)	Glaciofluvial gravels and compact till	Projected TIA up to 22% with development; EIA reduced to 12% with source controls	*63 mm / 24 hrs	**Moderate** – mixed soils and slopes; distributed LID may contribute to baseflow with engineered storage.
Hoy / Scott Creek	Elevation-linked infiltration zones	~40% impervious; Suburban mixed-use	*37–42 mm / 24 hrs (elevation dependent)	**Moderate** – LID with delayed release can supplement baseflow; effectiveness depends on location and connection to stream system.

*The LID capture target reflects the subdivision design requirement, which serves as a proxy infiltration goal in the absence of refined groundwater recharge estimates.

Option 5: Spray Parks

Spray parks represent a seasonal and opportunistic strategy where runoff from recreational water features is captured, treated (via bioswales or ponds), and released gradually into nearby watercourses.

Spray Parks

STRENGTHS

- **Seasonal Alignment with Low Flows**: Provides supplementary baseflow during the summer months when stream flows are lowest and ecosystems are most vulnerable.
- **High-Quality Water Input:** Runoff is sourced from potable water systems and can be easily treated (e.g., via bioswales), making it suitable for release into fish-bearing streams.
- **Multi-Benefit Infrastructure:** Combines recreation, education, and stormwater benefits; aligns well with public engagement and park improvement goals.

WEAKNESSES

- **Seasonal Operation Only:** Spray parks operate seasonally and provide no baseflow support during fall, winter, or spring, limiting year-round effectiveness.
- **Infrastructure Dependence:** Requires retrofits such as storage tanks, controlled release valves, and bioswales, which may be infeasible at certain parks.
- **Flow Variability & Control**: Without dedicated storage and metering, flow contributions can be inconsistent, especially outside of peak park usage hours.

OPPORTUNITIES

- **Retrofit Integration with Park Upgrades:** Upcoming revitalization projects offer an opportunity to incorporate bioswale and flow control systems during design.
- **Public Education and Outreach:** Spray parks provide a platform to engage residents around water conservation, green infrastructure, and urban stream protection.
- **Alignment with Low-Impact Development Goals**: Fits within Coquitlam's broader strategy to embed LID/WSUD into park and stormwater planning.

THREATS

- **Regulatory Approval Requirements:** Discharge into fish-bearing streams may require approvals from DFO and/or other provincial regulators, which could delay or constrain implementation.
- **Budget and Departmental Coordination:** Implementation depends on joint efforts between Parks, Engineering, and Utilities, which may face misaligned timelines or funding cycles.
- **Climate Variability and Water Restrictions:** Drought years may bring water use restrictions that limit spray park operation, reducing the reliability of this augmentation source when it's most needed.

Creek-Specific Considerations:

- Star & Partington Creeks: Burke Village Park (opening 2029) will include a spray deck feature where runoff is dechlorinated and discharged to a nearby tributary, benefiting both creeks.
- Maple & Hoy Creeks: Town Centre Park's spray deck could potentially be retrofitted to support baseflow, but would require major modifications from its current recirculating system.
- Hyde Creek: Norm Staff Park or Marguerite Park may offer future opportunities if spray facilities are added or upgraded to include bioswales or storage mechanisms.

Financial Considerations

Table 5: Financial evaluation for identified baseflow augmentation strategies

Strategy	Capital Cost Estimate	Annual O&M Cost Estimate	20-Year NPV	Estimated BF Volume Supported	Cost per m³ of Water	Cost-Effectiveness
Groundwater Wells & Pump Systems	$115,000–$600,000[1]	$10,000–$85,000[2]	$255,850–$1,797,200	20 L/s	$0.14	Capable of supporting baseflows; costs vary widely by whether a well is rehabilitated or drilled new; high O&M costs due to mechanical systems.
Gravity Diversion (Coquitlam River → Maple Creek)	$2.19M[3]	$0–$5,000	$2,190,000–$2,260,420	20 L/s	$0.18	High upfront cost but very low long-term maintenance; preferred option in 2021 Maple Creek IWMP due to reliability/sustainability.
Large-Scale Underground BF Release Facilities	$1.65M–$1.70M[4]	~$42,000[5]	$2,241,560–$2,291,560	0.75 L/s	$4.84	Proven effectiveness for controlled baseflow release; suitable for urban areas with limited infiltration; moderate ongoing maintenance.
LID & Distributed Source Control Measures [6]	$23.40–$85.20/m²	$0.65–$1.60/m²	-	-	-	Scalable; costs vary widely by method used. Future studies recommended to determine baseflow volume potential and context-specific feasibility.
Spray Parks with Integrated BF Support [7]	$250,000–$1.70M	Variable	-	-	-	Multi-benefit investment; costs vary widely depending on system size and complexity. Future studies recommended to determine baseflow volume potential.

Note: Cost estimates adjusted to 2025 CAD using 3.6% annual inflation (rounded to nearest $5k). Cost per volume of water ($/m³) calculations assume consistent baseflow volumes over 20 years.

1. Based on $100k–$150k (2021) for well rehabilitation and ~$500k for new construction.

2. Lower bound reflects estimated O&M costs for a rehabilitated well using existing infrastructure. Upper bound is based on recent expenditures for the Maple Creek system in 2023–2024, which included major pump replacement and contracted services.
3. Gravity diversion cost (est. $1.9M in 2021) inflated to 2025 = ~$2.19M.
4. David Avenue (2017) and Harper Rd (2020) facilities inflated to 2025 using NPV formula; original costs were $1.26M and $1.4M respectively.
5. Assumes 2.5–3% of capital cost annually for maintenance and monitoring.
6. Capital and O&M costs vary depending on LID strategy used, site conditions, design complexity, and treatment goals, but are typically lower than centralized infrastructure. E.g., TRCA (2016) estimates the cost of constructing bioswales and dry swales at $17.02-$22.17/m², with at $20.53-$29.16/m² in maintenance and rehabilitation costs over a 25-year period, and $53.60-$61.95/m² to install permeable interlocking concrete pavers with $11.95-$21.35/m² in maintenance and rehabilitation over 25 years. Further analysis is recommended to evaluate the potential flow contributions of LID and distributed source controls.
7. Lower bound reflects a spray park with bioswale or pond treatment; upper bound assumes inclusion of underground storage and flow-control infrastructure (similar to David Avenue baseflow facility). Annual O&M costs vary by treatment and storage design. Further analysis is recommended to evaluate the potential flow contributions of spray parks with integrated baseflow support.

Decision Matrix

To support transparent and structured evaluation of baseflow augmentation strategies, a weighted decision matrix was developed (Figure 3). Five options—Groundwater Wells & Pumps, Gravity Diversion, Underground Baseflow Facilities, Low Impact Development (LID) & Source Control Measures, and Spray Parks—were assessed against five criteria:

1. **Reliability**: How consistently the strategy delivers baseflow, particularly during critical low-flow periods.
2. **Volume of Water/Baseflows Supported***: The potential capacity to meaningfully augment streamflow.
3. **Cost**: Based on both capital and operating costs, including considerations of longevity and maintenance needs.
4. **Time to Implement**: Relative speed with which the option could be designed, approved, and constructed.
5. **Co-Benefits**: Supplementary advantages such as ecosystem restoration, public education, recreational value, and alignment with climate resilience goals.

Each criterion was assigned a weighting based on its relative importance to Coquitlam's streamflow augmentation goals: reliability (25%), volume supported (25%), cost effectiveness (25%), time to implement (10%), and co-benefits (15%).

**Specific numerical baseflow targets have not been established. Baseflow targets for each creek require detailed analysis and monitoring, as well as clearly defined objectives. Such analysis is beyond the scope of this project. Instead, the best available information from Integrated Watershed Management Plans (IWMPs) and Adaptive Management Framework (AMF) reports has been utilized to inform strategy selection. Refer to Appendix A for detailed creek-specific data.*

Figure 3. Decision matrix

	Reliability	Volume of Water/BF Supported	Cost	Time to Implement	Co-Benefits	Total
weight	*0.25*	*0.25*	*0.25*	*0.1*	*0.15*	*1*
Groundwater Well & Pump	1*	2	3	2	1	1.85
Gravity Diversion	3	3	2	1	1	2.25
Large-Scale Underground BF Facility	1	2	2	1	1	1.5
LID & Distributed Source Controls	2	2**	3	3	3	2.5
Spray Parks	1	1	2	2	3	1.65

** Groundwater well and pump system reliability could be enhanced with incorporated redundancy (e.g., backup power, storage tank, and/or RTC technology).*

*** Volume of water/baseflow supported using LID & distributed source controls depends on site characteristics. For the purpose of this decision matrix, it is reasonable to assume that LID and distributed source controls support moderate flows, balancing reduced surface discharge with enhanced subsurface contributions.*

With widespread implementation (~5% total watershed area),[38] these strategies have been estimated to increase dry-season baseflows by 43% indicating a significant enhancement in groundwater recharge and sustained streamflow. Similarly, the City of Vancouver found that bioswales reduced underdrain outlet flows by 76-77%,[39] suggesting high soil absorption and retention capacity. However, the effectiveness of these systems is highly context-dependent, influenced by factors such as soil permeability, antecedent moisture conditions, and slope. Site-specific LID analysis is recommended to quantify the proportion of infiltrated water that might augment baseflows in Coquitlam.

Recommendations

Based on the comparative analysis of baseflow augmentation strategies, including the decision matrix, financial assessment, and creek-specific considerations, the following recommendations are proposed.

Initial priority:

- Identify and define target baseflows for the creeks identified, considering input from local stewardship groups. This baseline is critical for evaluating augmentation needs and ensuring ecological flow requirements are met.
- Prioritize implementation of the gravity diversion from the Coquitlam River to Maple Creek, as this has been identified as the most sustainable and reliable long-term solution. Begin detailed planning and design work to move the project forward.
- Explore opportunities to use spray park runoff to support baseflows during summer low-flow periods. Consider incorporating bioswales and temporary storage systems during new park developments or major upgrades (e.g., Burke Village Park, Town Centre Park).

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[38] Han, J., & Lee, S. (2024). Analysis of the effects of securing baseflow and improving water quality through the introduction of LID techniques. *Sustainability, 16*(20), 8932. https://doi.org/10.3390/su16208932

[39] City of Vancouver. 2024. *Vancouver Green Infrastructure Performance Monitoring Report: 2021-2023*. Green Infrastructure Performance Monitoring- 2024

Future/ongoing:

- Establish a comprehensive flow monitoring program across Hyde, Hoy, Maple, Star, and Partington Creeks. Additional monitoring is suggested every 2 years for watersheds under rapid development (e.g., Star, Partington, Hyde).

- Continue to implement Low Impact Development (LID) and distributed source control strategies, particularly in developing areas such as Burke Mountain. These approaches offer co-benefits and can contribute to long-term baseflow stability.

    - To lower the maintenance burden associated with green rainwater infrastructure/LID, Coquitlam could implement a volunteer-based program similar to the City of Vancouver's *Seeding Stewardship Program.*[40]

- Deploy groundwater wells for short-term augmentation where immediate flow support is needed. This could provide interim relief while longer-term solutions are developed.
- Consider pilot project monitoring the effectiveness of LID/source controls over time.
- Conduct a city-wide feasibility study on RTC technology, including cost-benefit analysis and compatibility with Coquitlam's stormwater infrastructure. While not a standalone solution, RTC systems could enhance the effectiveness of existing strategies.

Limitations

Several limitations affected the analysis and warrant attention in future planning.

- AMF data is only collected every five years, with gaps in temporal and spatial coverage. This hinders the ability to assess trends and seasonal flow variability.

- IWMPs often lack detailed climate data, which limits contextual understanding of seasonal and long-term hydrological trends.

- The impacts of climate change—including longer droughts and more variable precipitation—create added uncertainty.

[40] The City of Vancouver. *Seeding Stewardship Program*. Seeding Stewardship Program | City of Vancouver

- Dam release schedules from Coquitlam Reservoir were not explicitly referenced in AMF data or IWMPs. These flows may influence creek hydrology and should be reviewed for potential impacts on baseflow dynamics.
- Most creeks lack defined pre-development or ecologically functional baseflow targets, which limits the ability to measure success or inform adaptive management. Developing these targets is a priority step for long-term strategy implementation.

Appendix A

Supporting data for the selection of high-risk Coquitlam creeks (Maple Creek, Hyde Creek, Partington Creek, Star Creek, and Hoy Creek).

As defined by the Metro Vancouver *Monitoring and Adaptive Management Framework for Stormwater:*[41]

- **Summer Baseflow**- "the average of all daily discharges during July through September with seven-day antecedent rainfall less than 1 mm."
- **Winter Baseflow**- "the average of all daily discharges during November through March with seven-day antecedent rainfall less than 1 mm."

<u>Table Legend</u>

Green	Stable or Increasing trend (does not reflect optimal baseflow conditions)
Red	Decreasing trend

Table A1: Baseflow trends for Partington and Star Creek

	Summer Baseflow (L/s)		Winter Baseflow (L/s)	
	2016/17	**2023**	**2016/17**	**2023**
Partington Creek	0.8	5.1	125	50
Star Creek	0	<1	13.6	2.2

Source: AMF report 2022/23 (CEDMS #5416287)

- **Partington Creek** has no identified baseflow target.

[41] Metro Vancouver. 2014. *Monitoring and Adaptive Management Framework for Stormwater.* Integrated Liquid Waste and Resource Management. https://metrovancouver.org/services/liquid-waste/Documents/stormwater-monitoring-adaptive-management-framework-2014-09.pdf

From the 2011 IWMP:[42]

> *A monitoring station should be established closer to the mouth of Partington Creek to properly quantify low flows and baseflows. Monitoring prior to development will establish baseflow targets to be met once development commences.*

While the City of Coquitlam has a Flowlink® monitoring station at 4189 Cedar Dr, continuous discharge/streamflow is not measured.

- **Star Creek** has no identified baseflow target but has an estimated average summer baseflow rate of 0.069 L/s/ha. According to flow monitoring, Star Creek ran dry for approximately 14.2 days in August 2016.[43]

Table A2: Baseflow trends for Hoy and Maple Creek

	Summer Baseflow (L/s)		**Winter Baseflow (L/s)**	
	2017/18	**2023/24**	**2017/18**	**2023/24**
Hoy Creek	38.9	69.3	161.0	131.6
Maple Creek	3.7	8.7	18.0	50.1

Source: AMF report 2023/24 (CEDMS #5590881)

- Scott Creek Watershed IWMP (2012) identified that lowering of the groundwater table and associated decreases of stream baseflows are an issue for this watershed.
- Diversion structures divert low-flow runoff away from watercourses, diverting first-flush events away from creeks (benefitting water quality but not quantity).
- **Hoy Creek** has no identified baseflow target. Goal from 2012 IWMP:[44]

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[42] KWL. (2011). *Partington Creek Integrated Watershed Management Plan*. Prepared for the City of Coquitlam. https://www.coquitlam.ca/DocumentCenter/View/3359/Partington-Creek-Integrated-Watershed-Management-Plan-PDF

[43] McElhanney Consulting Services Ltd. (2019, March 29). *NE Partington Creek Baseflow Augmentation Final Report.* File 2111-05144-02. CEDMS #: 3336011.

[44] CH2M Hill. (2012). *Scott Creek Integrated Watershed Management Plan*. Prepared for the City of Coquitlam. https://www.coquitlam.ca/DocumentCenter/View/3360/Scott_Creek-Integrated-Watershed-Management-Plan-PDF

> *Re-establish clean baseflows to the creeks along the Panorama, Johnson, and Robson diversion alignments.*

A Flowlink® monitoring station is currently established at Hoy Creek Hatchery but continuous discharge/streamflow is not measured.

- Maple Creek is reliant on a groundwater well and pump system to sustain baseflows. From the 2021 IWMP, the identified goal is to provide 20 L/s baseflow:[45]

> *Baseflow in Maple Creek is currently augmented by a production well located in Coquitlam at Salt Spring Avenue and Gabriola Drive. The current production well has experienced a 75% loss in well efficiency since it was first commissioned in 1996. Its current sustainable yield is approximately 16.4 L/s (260 gal/min). The well was originally rated to produce 44.2 L/s (700 gal/min). The likely cause of loss of performance is accumulation of biomass and packing of fine sediment in and around the well screen.*
>
> *Because of the declining trend of the existing well, baseflow augmentation alternatives were investigated with the goal of providing at least 20 L/s (317 gal/min) to match the current augmentation.*

Table A3: Baseflow trends for Hyde Creek

	Summer Baseflow (L/s)		**Winter Baseflow (L/s)**	
	2010 – 2012	**2021/22**	**2010 – 2012**	**2021/22**
Hyde Creek	150.0 – 200.0	2.0	310.0 – 360.0	57.0

Source: AMF report 2014 (CEDMS #1823907); AMF report 2021/22 (CEDMS #4987213)

- Hyde Creek has experienced a drastic decline in baseflow, yet has no identified baseflow target.

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45 KWL. (2021). *Maple Creek Integrated Watershed Management Plan.* Prepared for the City of Port Coquitlam and the City of Coquitlam. https://www.coquitlam.ca/DocumentCenter/View/7271/Maple-Creek-Integrated-Watershed-Management-Plan-PDF

- Mean annual discharge has also declined from 310–360 L/s (2010–2012) to 205 L/s (2021–2022), reflecting a substantial drop in overall hydrologic input to the system.[46]
- Despite new infrastructure upgrades and enhancements (e.g., water quality ponds, stream diversions), baseflows remain limited. This is likely influenced by interception of groundwater and hillslope runoff by historic logging roads and ditch networks in the upper watershed. These features, particularly within Burke Pinecone Provincial Park, have altered natural flow patterns, contributing to erosion, flooding, and diminished summer baseflow contributions to Hyde Creek and its tributaries.[47]
- Suggestions from the updated 2024 IWMP include increasing AMF monitoring frequency to every 2 years to establish a more robust baseline of seasonal and annual variability, and incorporating a monitoring site in the Hyde Creek Nature Reserve, where baseflow contributions are more consistent.

Additional Option for Future Consideration: Real-Time Control (RTC) Technology

RTC systems use advanced controls for dynamic storage and release of stormwater, optimizing water availability and baseflow augmentation. While currently not identified within city documentation, RTC technology presents a promising future strategy for cost-effective, reliable baseflow management and flood mitigation. Further studies or pilot projects are recommended to assess its viability for integration within Coquitlam's stormwater infrastructure.

[46] KWL. (2023, August 16). *2021-2022 Wet and Dry Season AMF Monitoring Program* [Hyde, Smiling, and Watkins Creek]. CEDMS #: 4987213.

[47] BlueLines Environmental Ltd. (2024, August 22*). Hyde Creek IWMP Update: 2024 Environmental Assessment*. Prepared for Urban Systems Ltd. CEDMS #: 5401655.

Real-Time Control (RTC) Technology

STRENGTHS

- **Adaptive Performance:** Adjusts flow release dynamically based on rainfall and stream conditions.
- **Retrofit-Friendly:** Can enhance existing green and grey infrastructure with minimal excavation.
- **Improved Water Quality Outcomes:** Actively managed systems have demonstrated superior contaminant removal.

WEAKNESSES

- **Dependence on Technology:** Requires functional sensors, power sources, and backup systems to ensure operation.
- **Limited Storage Volume:** Cannot provide long-term augmentation unless paired with large detention capacity.
- **Specialized Expertise Required:** Design, installation, and troubleshooting require technical support and staff training.

OPPORTUNITIES

- **Scalable and Modular**: Can be implemented incrementally across sub-catchments or high-priority sites.
- **Eligible for Smart Infrastructure Grants:** Fits well within innovation, resilience, or digital stormwater management programs.
- **High Compatibility with Urbanizing Watersheds:** Especially valuable in areas like Partington and Hoy Creek with rapid development.

THREATS

- **Sensor or Power Failure Risks:** Hardware malfunction could compromise system function or create unintended discharges.
- **Data Management and Cybersecurity:** Increased reliance on cloud or networked systems may introduce risks.
- **Public Unfamiliarity**: Low visibility and high tech-nature may make it harder to gain community support without outreach.