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Watershed Performance Targets for Rainwater Management – French Creek Water Region

Phase 2 – Implementation, Monitoring and Adaptive Management

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EXECUTIVE SUMMARY

The Regional District of Nanaimo (RDN) has selected the French Creek Water Region to serve as the location for a pilot study to determine performance targets for rainwater. The purpose of the study is to test the concept and approach for setting similar targets elsewhere in the RDN. Phase 1 of the study was completed in 2021, and focused on hydrologic model development and establishing performance targets for various future land use and climate scenarios. This study is Phase 2 of the pilot program, which provides recommendations on implementation, monitoring and adaptive management.

This study focuses on the technical aspects of performance targets as applied to the French Creek Water Region, and has a different scope from the RDN's Regional Strategy for Rainwater Management (EOR, 2022), which focuses on collaborative rainwater management, coordinated actions between jurisdictions, and regulatory and educational tools for rainwater management across the RDN.

Performance targets for the water region are based on the water balance methodology, and aim to mitigate adverse impacts from development by mimicking the natural water balance of a watershed (Partnership for Water Sustainability, 2014). With this approach, four targets are specified: 1) baseflow release rate, 2) retention volume, 3) infiltration system area, and 4) flood detention volume.

Recommended performance targets to be applied in the upper, mid and lower regions of the French Creek Water Region are given in Appendix A. These targets would be applied to all new or retrofit developments. The targets represent mitigation of future land use back to a pre-development (i.e. natural forested) state, while providing some mitigation of the effects of climate change.

Development applications and standards within the French Creek Water Region come from the City of Parksville, Town of Qualicum Beach, and Ministry of Transportation and Infrastructure, and the RDN Area G and Area F). Successful implementation of the performance targets will require close cooperation, communication, and collaboration between the RDN, Parksville, Qualicum Beach, and MOTI. The use of these targets as a pilot study in the French Creek Water Region is expected to help identify gaps and issues that need to be addressed prior to applying the approach elsewhere.

Very little reliable observed hydrometric data is available within the French Creek Water Region. For the pilot study to be effective, continuous flow and water level data should be collected at several locations within the water region. This will help to establish baseline conditions in the watersheds, and can also be used for calibration of the hydrologic model to improve the performance targets. Future data can then be compared to the baseline data to identify trends. Collection and trend analysis of water quality and benthic invertebrate data can further evaluate whether watershed health is improving or degrading.

Trends identified in the analysis of hydrometric, water quality, and B-IBI data, along with feedback received about the practical implementation of performance targets will be the two aspects that inform whether a change to the rainwater management approach is needed. The types of adaptive management needed will be dependent on what type of trends are observed and feedback is received. Collection and organization of information will be critical to support adaptive management.

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1 INTRODUCTION

1.1 Project Overview and Objectives

The Regional District of Nanaimo (RDN) retained Northwest Hydraulic Consultants Ltd. (NHC) to conduct a pilot study to determine performance targets for rainwater management in the French Creek Water Region. The purpose of the study is to test the concept and approach for setting similar targets on a regional scale.

Phase 1 of the study was completed in October 2021 (NHC, 2021), and consisted of developing and running long-term hydrologic simulations to determine target base flow release rates, retention volume, infiltration area, and flood detention volume that would be required to mitigate the effects of future development or future development and climate change to either pre-development or current development conditions. Phase 1 was a technical analysis and considered several options for potential targets in the upper, mid, and lower region of the French Creek water region.

Phase 2 builds on the work done in Phase 1, focusing on the implementation, monitoring, and adaptive management of the performance targets. Through discussions with the RDN, the study focuses on the French Creek Water Region, rather than how performance targets could be extended to other areas of the RDN.

1.2 Summary of Phase 1 Work

Phase 1 of the study focused on developing performance targets for rainwater management in the French Creek Water Region based on the water balance methodology (Partnership for Water Sustainability, 2014). The water balance methodology aims to mitigate adverse impacts from development by mimicking the natural water balance of a watershed. Four targets which help replicate natural processes were specified: 1) baseflow release rate, 2) retention volume, 3) infiltration system area, and 4) flood detention volume.

The three overall objectives of the targets were 1) to achieve no increase in the magnitude of flood events, 2) provide similar performance below the 2-year duration on a flow duration curve, and 3) maintain the groundwater component of the water balance.

To establish the performance targets, an HSPF[1] model of the French Creek Water Region was developed, and simulations were run using long-term precipitation data as inputs. Refer to the Phase 1 report for detail on development of the precipitation data series. The model was run using current, pre-development, and future land use conditions as well as a climate change scenario. The Water Region was split into three regions (upper, middle, and lower as shown in Appendix A) based on dominant land use and physiographic character which govern the hydrologic response. Performance targets were

[1] HSPF stands for Hydrologic Simulation Program Fortran; Version 12.5 of the U.S. EPA modelling framework was used for the study.

established for the middle and lower regions where development pressure is the greatest. In the upper region, which is primarily steep forested land, with minimal development pressure, performance targets were not established.

Four potential scenarios of performance target values were established for each region that consider mitigating the hydrologic changes resulting from future development and climate change, back to both pre-development and current conditions (the four scenarios are listed in Section 2.1.1). Overall, widespread application of the performance targets was able to mitigate adverse changes in flows resulting from the future development condition back to both pre-development and current conditions. However, the performance targets were unable to completely negate the impacts of climate change back to current and pre-development levels. Mitigation in all scenarios was only applied to impervious areas and could not compensate for the increase in peak flows and flow durations which will also occur in the pervious regions of the watershed, particularly when changes to precipitation due to climate change were considered. NHC recommended that other adaptation and mitigation measures should be explored in conjunction with the rainfall management targets to address climate change on a watershed scale. For further detail, refer to the Phase 1 report (NHC, 2021).

1.3 Regional Strategy for Rainwater Management

Concurrent to Phase 1 of the study, a regional strategy for rainwater management (RSRM) was developed and adopted by the RDN (EOR, 2022). The stated objectives of the RSRM are:

1. To outline a strategy for collaborative rainwater management in the region, at the watershed scale, for the protection of private property and the environment.
2. To coordinate actions across jurisdictions to maintain healthy watersheds in the context of climate change, land use pressures, and evolving best practices for rainwater management.
3. To provide a basis to update policies, standards, and bylaws, inform education and outreach, and support grant funding applications for infrastructure upgrades.

The recommendations in the RSRM apply to the entire RDN and are not confined to a single water region.

The RSRM identifies the setting and use of rainwater management performance targets as a method of improving watershed health across the RDN and recommends these be set based on the water balance methodology and include release rate targets, retention volume targets, recharge volume targets, and water quality targets.

The implementation, monitoring and adaptive management outlined in this Phase 2 report focuses on the technical aspects of the performance targets as applied to the French Creek Water Region. For regulatory, policy, and strategic planning implementation tools, refer to the RSRM.

2 IMPLEMENTATION

2.1 Performance Targets

2.1.1 Performance Target Options

In Phase 1 of the study, a series of rainwater management targets for different scenarios were developed for the French Creek region based on the water balance methodology, summarized in Table 2.1. Four different sets of performance targets were developed:

1. Mitigating future land use to pre-development (i.e. natural forested) conditions.
2. Mitigating future land use and climate change effects to pre-development conditions.
3. Mitigating future land use to current development conditions.
4. Mitigating future land use and climate change effects to current development conditions.

Options 3 and 4 use the present-day watershed condition as the baseline condition to maintain. Options 1 and 2 aim to improve watershed health further by restoring the approximate natural water balance in the watersheds, prior to the existence of any land development. As noted in the Phase 1 report, climate change is an important consideration; however, fully mitigating the effects of both development and climate change (Option 2 and 4) is difficult. Even with no future land use change, the water balance, peak flows, and flow durations would change within the water region due to expected changes in rainfall. Furthermore, in setting the targets, mitigation is only applied to impervious areas, and so cannot compensate for changes in runoff from the pervious areas associated with climate change. Performance targets were established based on an hourly timestep using unit flow rates from the three regions. The baseflow release rate is representative of the mean annual discharge from the natural conditions.

Table 2.1 Performance target options developed in the Phase 1 study.

	Option 1	Option 2	Option 3	Option 4
	Future land use to pre-development	Future land use and climate change to pre-development	Future land use to current development	Future land use and climate to current development
Mid Region and Upper Region				
Baseflow Release Rate (L/s/ha)	0.2	0.2	0.2	0.2
Retention Volume (m^3/ha)	450	900	150	850
Infiltration System Area (m^2/ha)	120	60	75	30
Flood Detention Volume (m^3/ha)	750	3000	450	1750
Lower Region				
Baseflow Release Rate (L/s/ha)	0.12	0.12	0.12	0.12

	Option 1	Option 2	Option 3	Option 4
	Future land use to pre-development	Future land use and climate change to pre-development	Future land use to current development	Future land use and climate to current development
Retention Volume (m^3/ha)	350	550	75	200
Infiltration System Area (m^2/ha)	100	60	30	10
Flood Detention Volume (m^3/ha)	650	1800	250	470

2.1.2 Performance Target Selection Criteria

To select a single set of performance targets for the French Creek region, several factors were considered, with the first being the RDN's overall rainwater management objectives. Key concepts from the RSRM that support the selection of targets are summarized below:

- The RSRM notes that the goal of resilient rainwater management is to mimic the natural hydrologic condition (i.e. the pre-development condition).
- The RSRM promotes mimicking the natural functional hydrology of watersheds, and methodologies that preserve natural hydrologic features.
- In the RSRM, recharge and retention volume targets are defined as the volumes required to mimic the natural watershed condition.
- The RSRM emphasizes practicality. If the targets selected are overly ambitious, they may result in too many applications for exemptions from the target, which greatly reduces their effectiveness at a watershed scale.

2.1.3 Recommended Performance Targets for the French Creek Water Region

Based on our review of the potential sets of targets, and supported by the language in the RSRM, NHC recommends that the RDN adopts the 'Option 1' targets. These targets represent mitigation of future land use back to the pre-development (i.e. natural forested) state, and are reproduced in Table 2.2. A map showing the extent of upper, mid and lower regions along with the performance targets is included in Appendix A.

Table 2.2 Recommended performance targets for the French Creek Water Region.

Category	Recommended Performance Targets	
	Upper and Mid Region	Lower Region
Baseflow Release Rate (L/s/ha of impervious area)	0.2	0.12
Retention Volume (m^3/ha of impervious area)	450	350
Infiltration System Area (m^2/ha of impervious area)	120	100
Flood Detention Volume (m^3/ha of total development area)	750	650

Ideally, the set of performance targets could mitigate both future land use and climate change back to the pre-development watershed conditions (Option 2); however, these targets would be very difficult to achieve. Under a changing climate, a watershed in its natural, forested state without land development would experience a change in water balance. This cannot be fully mitigated through simple application of performance targets, and instead we suggest that the targets focus on mitigating effects of land use change.

Note that explicit water quality targets are beyond the scope of this study. Water quality is included in the monitoring recommendations (Section 3) – if persistent water quality concerns are identified, further steps should be taken to address them.

2.1.4 Anticipated Effects of the Selected Targets on Climate Change Mitigation

Although the recommended performance targets do not replicate the pre-development condition of the watersheds when climate change effects are added, they will provide some mitigation.

To assess the level of mitigation, we ran an additional hydrologic model scenario using the HSPF model developed in Phase 1 of the study. The run used the performance targets from Option 1, but with the climate-adjusted precipitation data as the model input. We evaluated the effectiveness of the targets in climate change mitigation by comparing the results for peak flows, the flow duration curve, high pulse count, and 7-day winter low flows.

Table 2.3 shows how climate change would affect peak flows if the recommended performance targets (Option 1) were applied throughout the water region. Figure 2.1 shows the same for the flow duration exceedance curves and Table 2.4 for the high pulse count and 7-day winter low flows.

Table 2.3 Effect of climate change on peak flows under the application of the recommended performance targets.

Region	Return Period	Target Flows (L/s/ha)		Peak Flows with Performance Targets Applied (L/s/ha)	
		Pre-development	Current Condition	Option 1	Option 1 under climate change
Mid	2-year	1.9	2.2	1.9	2.3
	5-year	2.9	3.3	2.9	3.6
	50-year	3.5	3.9	3.6	4.5
Lower	2-year	0.9	1.5	0.9	1.2
	5-year	1.5	2.3	1.6	2.3
	50-year	1.9	2.9	2.0	3.6

Notes:

1. Option 1 refers to the performance targets that mitigate future land use to pre-development (i.e. natural forested conditions).

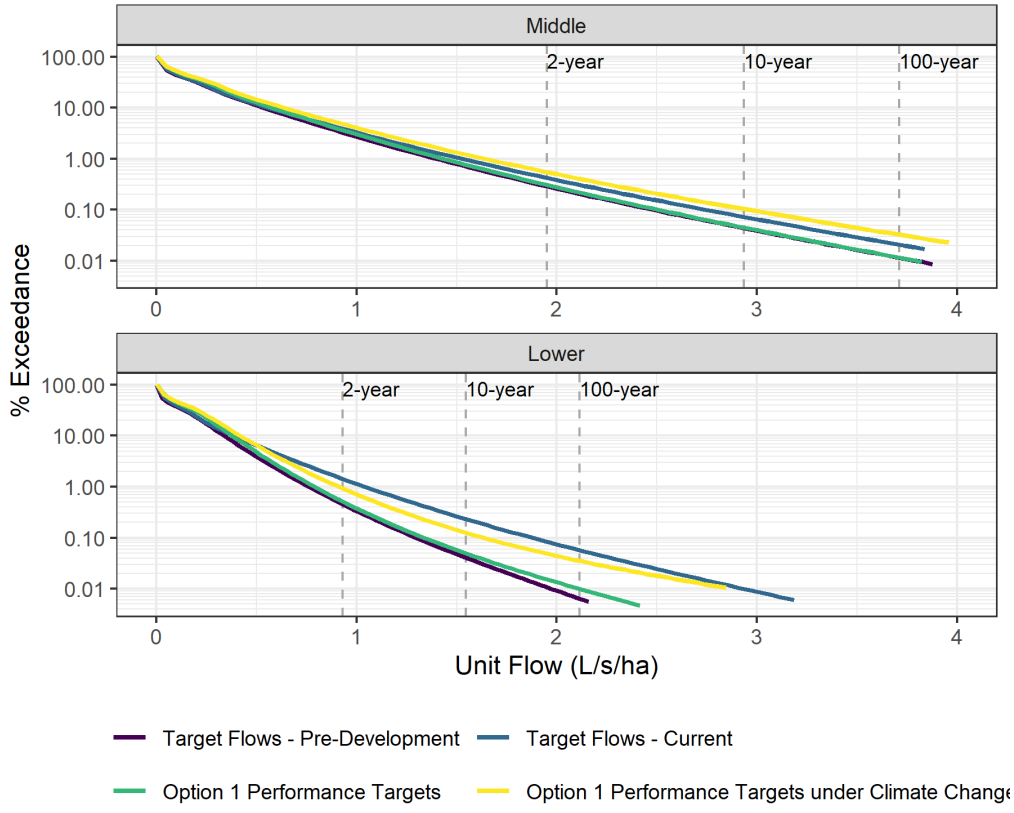


Figure 2.1 Effect of climate change on the flow duration curves under the application of the recommend performance targets. Scenario in yellow represents Option 1 targets under the climate change rainfall.

Table 2.4 Effect of climate change on high pulse count and 7-day low flow.

Region	Scenario	High Pulse Counts (No. of Events)	Winter 7-Day Low Flow (L/s/ha)	Summer 7-Day Low Flow (L/s/ha)
Mid	**Pre-Development**	**9**	**0.15**	**0.004**
	Current Condition	**12**	**0.15**	**0.006**
	Option 1	11	0.18	0.013
	Option 1 under climate change	11	0.19	0.010
	Option 2	11	0.19	0.016
Lower	**Pre-Development**	**6**	**0.10**	**0.001**
	Current Condition	**16**	**0.10**	**0.002**
	Option 1	8	0.15	0.010
	Option 1 under climate change	9	0.16	0.008
	Option 2	9	0.16	0.021

Notes:

1. High pulse count is the number of times that daily flow increases to above twice the mean annual discharge. It is correlated with measures of the effect of development in a watershed and the degradation of biological health (DeGasperi, C.L. et al., 2009)

This analysis suggests that if the recommended performance targets are applied across the region, they will provide some mitigation of the effects of climate change. In particular:

1. **Peak flows.** In the lower region, lower return period peak flows (2-year and 10-year) are mitigated below the current condition but do not reach the pre-development condition, and higher return period peak flows (50-year) show a slight increase over current conditions. In the mid-region, all peak flows increase to slightly higher than the current conditions. Notably, even the Option 2 of the performance targets were not able to fully mitigate peak flows as a result of climate change (NHC, 2021).
2. **Flow duration curves.** In the lower region, flows are mitigated to below the current condition but do not reach the pre-development condition. In the mid-region, flows increase to higher than current conditions.
3. **High pulse count and winter low flows.** In the mid and lower regions, high pulse counts are mitigated below the current conditions but do not reach the pre-development condition. 7-day low flows increase, but these increases also could not be mitigated using the more stringent performance targets from Option 2.

The Option 1 targets do mitigate some of the effects of climate change. The level of mitigation they provide is least for peak flows (as opposed to low and moderate flows), and is less effective in the mid region than the lower region. This is likely because the mid region is more rural and so has less impervious area coverage planned with future development and consequently less opportunity for the

performance targets to be applied than the lower region with the City of Parksville and Town of Qualicum Beach.

In essence, areas with less development planned have fewer opportunities to construct rainwater management features that can help to mitigate the effects of climate change, and so a change in the water balance is to be expected because of the change in the precipitation inputs.

This highlights the importance of other measures to maintain and improve watershed health, and that performance targets alone should not be relied upon. Construction of regional detention basins strategically located throughout the water region could be used to help attenuate peak flows under climate change. Other potential initiatives are discussed in Section 2.3.

2.2 Application of Performance Targets within French Creek Water Region

These sections provide guidance to the RDN on how to apply the performance targets within the French Creek Water Region, and what RDN staff should look for when reviewing development applications.

The broader policy and regulatory framework needed to successfully apply the performance targets within the French Creek Water Region should ultimately follow the guidance in the RSRM, so that a unified approach is created across the RDN. It is assumed that the pilot application of performance targets within the French Creek Water Region to help identify gaps and issues before formalizing the requirements into policy, but this requires commitment from and collaboration with RDN, MOTI, Parksville, and Qualicum Beach staff.

2.2.1 Roles and Responsibilities

In the French Creek Water Region, municipalities (City of Parksville and the Town of Qualicum Beach) are responsible for reviewing development applications within their boundaries. Elsewhere, the Ministry of Transportation and Infrastructure's (MOTI) design standards for land development are applied (BC MoTI, 2021). The recommended performance targets will need to override local rainwater management targets from MOTI, Parksville and Qualicum Beach. Buy-in in these jurisdictions is critical to the success of the performance targets.

The RDN will need to work closely with staff from each jurisdiction to ensure the performance target requirements are clearly documented and understood. The RDN may need to provide technical guidance to help understand the rationale, importance, and potential application of the targets.

MOTI, Parksville, Qualicum Beach, and the RDN will need to ensure the pilot application of the targets is communicated to developers and encouraged. An important distinction is that the performance targets represent criteria that should be achieved on development sites, but that there are many ways to achieve them. The RDN should seek opportunities to educate land owners, planners, and developers about some of the tools that are already available to help achieve the targets.

Collaboration will be required to collect and document feedback on the performance targets and any challenges faced by each jurisdiction in applying the targets.

Site developers and planners will need to ensure rainwater management needs are accounted for early in the site planning process, so that sufficient space for rainwater management features can be allocated. Drainage design engineers will need to ensure that rainwater management features are designed to achieve the performance targets.

2.2.2 Guidance for the Review of Development Applications

As part of this study, NHC completed a high-level review of several development applications that have been received by the RDN in the past. This was to assess the level of detail on rainwater management provided in a typical application. There was a wide variation in the level of detail provided in the reviewed applications, confirming challenges of consistency, as noted in the RSRM. Most of the applications focused only on traditional stormwater engineering: sizing of ditches, culverts, and detention storage to limit increases in peak flows due to developments. Some applications provided clearly defined rainwater management goals, and outlined the process that was used for sizing detention basins, infiltration, and achieving water quality targets.

The lack of consistent application content can make it difficult for the RDN to review, and ultimately, RDN staff needs to rely on the seal of the engineer on the development application. Below is a list of content that the RDN and jurisdictions could check for to improve confidence that the performance targets are being met. Note that this is for general adherence to the performance target application, and does not guide the review of specific elements of rainwater management feature design.

- Summary of the assumed pre-development (i.e. natural), existing site conditions, and post-development site conditions, including the area of different land covers, the total impervious area, and the impervious area coverage as a percentage of the developed area.
- Explicit acknowledgement of the performance target values recommended in this study.
- An overview of the rainwater management features being proposed on site and how they address each category of the performance targets / water balance approach. A summary should be provided that states the actual baseflow release rate, retention volume, infiltration area, and flood detention volume achieved on site, and a comparison to the performance target values.
- Presence of retention and detention storage facilities meeting the volume requirements outlined in the performance targets, relative to the total development area. These features could be ponds, below-ground infrastructure, bioswales, rain gardens, etc. but their purpose should be clearly identified in the development applications.
- Presence of an outlet structure from the retention storage to meet the baseflow release rates described in the performance targets (e.g. a pipe with an orifice or other means of restricting outflow). The assumed outflow rate should be documented within the development application.
- Inclusion of features that encourage infiltration. If the recommended performance targets are met, at least 100 m^2 of infiltration area should be provided for every ha of impervious area (1.0% of the impervious area on the development site) in the upper and mid regions, and 120 m^2 in the lower region (1.2%).

- If the recommended performance targets cannot be met, clear justification of why, and what values of baseflow release rate, retention volume, infiltration area, and flood detention volume are achieved in the design. Typically, inability to achieve the recommended targets should not be an excuse to ignore them. Alternative targets should be proposed by the designers that meet the intent of the overall rainwater management objectives. The RDN may want to introduce a form of in-lieu payment where performance targets are not met, to encourage implementation. Funds could be applied to subwatershed / community level initiatives to enhance watershed health. Further discussion is provided in Section 2.2.4.

The above information should be tracked by the RDN to support monitoring and adaptive management of the performance target implementation.

2.2.3 Scale of Development

As per the RSRM, performance targets for rainwater management should be applied consistently and equitably across development within the RDN. However, how the performance targets are achieved will vary depending on the scale of development, and so the content of development applications that the RDN receives will likely vary.

- **Site level.** At the site level, performance targets will be achieved through the application of source controls. That is, rainwater management features that capture and retain water where it falls. For smaller residential and rural lots, predominant features would likely be the retention of pervious and vegetated areas, minimal traditional stormwater infrastructure (e.g. catch basins and pipes), and possibly constructed features such as rain gardens. Smaller lots will likely have the greatest challenge meeting the flood detention performance target. In larger multi-family residential, commercial, and industrial lots, rainwater management features should be more obvious and might include combinations of dedicated greenways, bioswales, rain gardens, infiltration trenches, permeable pavers, ponds or wetlands, or below-ground infrastructure with flow attenuation.
- **Neighbourhood level.** At the neighbourhood level (e.g. subdivisions), performance targets will be achieved by the aggregate of source controls applied at the site level, but will also provide additional opportunities for features that receive runoff from multiple lots. These centralized features can be beneficial additions since they can be designed and maintained more reliably but should be used in addition to source controls at the site level, and not substitutions for them. At the neighbourhood level, rainwater management features for road runoff will also apply. At this development scale, developers and planners need to work with the engineers early in the planning stages of the project to ensure adequate space for rainwater management is preserved.
- **Subwatershed or community level.** At the subwatershed or community level, further opportunities for regional, dispersed flood detention should be explored. This responsibility applies more to the RDN, Parksville, and Qualicum Beach than individual developers. It can provide the opportunity for strategic placement of facilities that can attenuate flood flows, and further mitigate effects of climate change on peak flows. Also, at the subwatershed level, other initiatives can be applied beyond the performance targets to improve watershed health (see

Section 2.3). At this scale, the RDN will be relying on private forestry to ensure their operations are working towards improving the water balance and improving watershed, and on MOTI for ensuring their road networks are incorporating rainwater management features.

2.2.4 Deviation from Targets

Deviation from the recommended performance targets may be required in certain situations, and should be reviewed on a case-by-case basis. In most situations, difficulty in achieving the target should not be sufficient rationale for doing nothing. Instead, the challenges or concerns should be submitted to the RDN for review along with a description of what measures are proposed, and what level of performance (baseflow release rate, retention volume, infiltration area, and flood detention volume) is being achieved. Scenarios that may require a variation in the target include:

- Targets are considered unnecessary due to discharge to marine waters.
    - The focus of the performance targets is ensuring watershed and stream health by targeting changes in runoff which ultimately discharge to streams. For developments that directly discharge to marine waters, the water quantity (peak flow and volume) targets are less critical. However, in this instance, consideration of erosion and of the water quality of the runoff remains important, and so some form of source controls are likely still needed.
- Infiltration target is deemed impractical due to site conditions.
    - Requests to deviate from the infiltration area performance targets might be received for lots where there is shallow bedrock present, a seasonally high groundwater table, or low infiltration rates. In these instances, supporting information should be provided to the RDN, including (as applicable): maps of the bedrock coverage, groundwater measurements, boreholes, soil type maps, infiltration tests, and geotechnical reports. In most cases, some infiltration should still be achievable, for example:
        - For lots with shallow bedrock, there may exist parts of the lot where some infiltration is achievable.
        - With seasonally high groundwater tables, infiltration would still occur when groundwater levels are low. Additional measures may be needed where groundwater quality is of concern, such as pre-treatment.
        - For low-permeability soils, features can be added to promote infiltration without surface ponding, such as reservoirs, subdrains or flow restrictors, or soil amendments (Metro Vancouver, 2012).
- Targets are considered risky due to water quality concerns.
    - Where the development is located in close proximity to wetlands, lakes, or other sensitive receiving watercourses and the land use of the proposed development could negatively impact water quality, additional retention or restrictions on infiltration and baseflow may be needed.

- While source control practices are important for groundwater recharge, care should also be taken to ensure that pollutants of concern are not entering groundwater, especially near drinking water wells. The use of source controls near wells and septic fields should be carefully considered by the designer. In most cases, performance targets should still be achievable, but may need to be located strategically, or have pre-treatment applied before infiltrated in areas with high-risk land uses.
- The nature of development should also be considered. Some commercial, industrial, or transportation land uses will generate more pollutants of concern.
- These concerns may not be apparent during the review of development applications, but may be identified through the monitoring and specific guidance added as part of future studies.

- Infiltration target is considered risky due to presence of steep slopes.
  - Where the development is located near the top of steep slopes, potential hazards should be identified and mitigated. In a natural watershed, infiltration is dispersed over an area, but on developed lots, that same amount of total infiltration is targeted in smaller, concentrated areas. When infiltration facilities are applied near steep slopes, the concentrated infiltration can pose a risk of slope failure. For these areas, geotechnical engineering advice should be retained. Potential solutions include applying setbacks, dispersing the infiltration, or modifying the design of the rainwater management features or the slopes to mitigate the risks.
- Infiltration target may cause nuisance flooding of utilities or underground parking.
  - Where the development is located in close proximity to utility trenches, underground parking, or other underground structures, high infiltration rates can increase risk of below-ground nuisance flooding. Infiltrated rainwater will preferentially follow the paths of least resistance and will often flow through the granular material used to surround underground utilities, or flood parkades or utility boxes. This is a bigger concern in denser urban centres. In these areas, potential paths of infiltrated water should be understood, and the infiltration targets may need to be adjusted.
- Performance targets are considered not applicable to the type of development.
  - The performance targets set out in this pilot study are focused on mitigating impacts due to an increase in residential, commercial and industrial development. The performance targets are not suited for other alterations to the landscape, such as forestry practices. In these cases, industry best management practices should be applied to avoid disturbance to the hydrologic response, to the degree possible.

2.2.5 Implementation Tools

The performance targets set out in this study are part of a pilot project to be applied in the French Creek Water Region. The pilot implementation of the targets will require close oversight from staff at the RDN, Parksville, and Qualicum Beach. To promote engagement, the RDN should consider public outreach and awareness campaigns about the pilot program, and consider offering incentives for participation.

For the application of performance targets to be successful in the long-term and in other areas of the RDN, a self-sustaining framework for implementation will be needed. This framework should be established following recommendations within the RSRM. The implementation of the performance targets in the French Creek Water Region should be used as a pilot for the RSRM's recommendations. Key recommendations from the RSRM that should be considered in the French Creek Water Region are summarized in Table 2.5.

Table 2.5 Recommendations from the RSRM to support implementation of the pilot performance targets in the French Creek Water Region.

Category	RSRM Implementation Recommendation (EOR, 2022)
Policies	• T.14 Clarify roles and responsibility with MOTI regarding enforcement of new performance targets. • T.15 Create a memorandum of understanding with neighbouring municipalities (Qualicum Beach and Parksville) for applying rainwater management within the French Creek watershed. • T.16 Create an information sharing agreement with the province and Mosaic Forest Management to facilitate sharing of data for adaptive management.
Bylaws	• T.18 and T.19 – Amend the zoning bylaws to incorporate elements of better site design and more rainwater management friendly landscaping requirements. Bylaw 1285 is specific to Zone F within the French Creek Water Region and could be used as a pilot prior to amending Bylaw 500 which spans multiple regions.
Development Permit Applications	• T.21 – Amend the freshwater and fish habitat DPA to specify adherence to performance targets or amend the aquifer DPA for zone G, which is contained primarily within the French Creek Water Region.
Official Community Plans	• T.24 - Create draft wording around meeting updated rainwater management requirements for inclusion into OCPs when they are updated.
Strategic Planning	• T.28 – Create a rainwater strategy implementation group to oversee implementation of strategy across the region. This could be a scope of the current RDN rainwater working group. • T.29 – Regional Rainwater facility. Research feasibility of creating a regional facilities program to align with performance targets. • T.30 and T.31 – Continue to foster community partnership to help achieve watershed monitoring and continue to leverage community partnerships around education.
Development Approvals	• T.34 Conduct a review of development approvals process that require rainwater management within the RDN to clarify current procedures and identify and clarify all roles and responsibilities with respect to rainwater management and potential gaps in rainwater management requirements.

Category	RSRM Implementation Recommendation (EOR, 2022)
Asset Management Planning	• T.37 Identify co-benefits of parkland assets for rainwater management. To help to adapt to climate change, parkland assets could be considered as part of the rainwater management strategy.
Education and Outreach	• T.40 Host a workshop with the development community when new performance targets are implemented to provide clarity and justification.

2.3 Other Watershed Health Initiatives

Application and enforcement of the performance targets is important to restore and maintain the watershed's natural water balance, but performance targets are tied to assumed development within the water region. Other initiatives should be pursued in the water region to improve overall watershed health and adapt to and mitigate climate change effects at a watershed scale. Initiatives could include:

- Vegetation retention and planting programs.
- Inclusion of rainwater management features into infrastructure programs, including road construction and rehabilitation.
- Protection of riparian corridors and enforcement of setbacks.
- Identifying and addressing areas of bank erosion, water quality issues and degraded instream habitat.
- Maintaining natural assets (forests, and wetlands).
- Integrating flood management into land use planning.
- Modelling and reducing agricultural and irrigation water demand.

Initiatives could be undertaken in partnership with local landowners, business, organizations, and First Nations. The cumulative effectiveness of the projects can be tracked against the metrics described in the monitoring section. Several initiatives are already underway and should be documented.

2.4 Potential Application to Other Water Regions

The purpose of the current project is to act as a pilot program. The performance targets that have been developed here are specific to the watersheds in the French Creek Water Region. Other water regions will have different performance targets that reflect the variability in land use and hydrologic parameters.

As noted in the RSRM, each water region should set performance targets developed through individual watershed studies. A similar modelling approach as used in Phase 1 of this pilot study can be applied to other watersheds. Based on the findings in this pilot study, the number of hydrologic model scenarios needed to determine the performance targets can be reduced to include those listed in Table 2.6. The

hydrologic modelling software used does not matter, as long as it can capture the essential components of the water balance needed to set the targets (i.e. groundwater, interflow, and surface runoff).

Table 2.6 Suggested hydrologic model scenarios to set performance targets elsewhere in the RDN.

Scenario	Development Condition	Climate Condition	Purpose
1	Pre-development (i.e. natural forested)	Current climate	To estimate the natural water balance prior to any development. The water balance defined in this scenario will be what the mitigation from Scenario 4 aims to achieve.
2	Current development	Current climate	To establish the baseline water balance under existing land development. Where sufficient data is available, this scenario will support calibration and validation of the hydrologic model.
3	Future development, no mitigation	Current climate	To assess the change in water balance due to land use change if no performance targets are applied.
4	Future development, with mitigation	Current climate	To determine the performance targets (baseflow release rate, retention volume, infiltration area, and flood detention volume) required to replicate the pre-development water balance from Scenario 1. This scenario will require several iterations to determine the performance target values.
5	Future development, with mitigation	Future climate	To see how well the performance targets can mitigate the effects of climate change on the water balance.

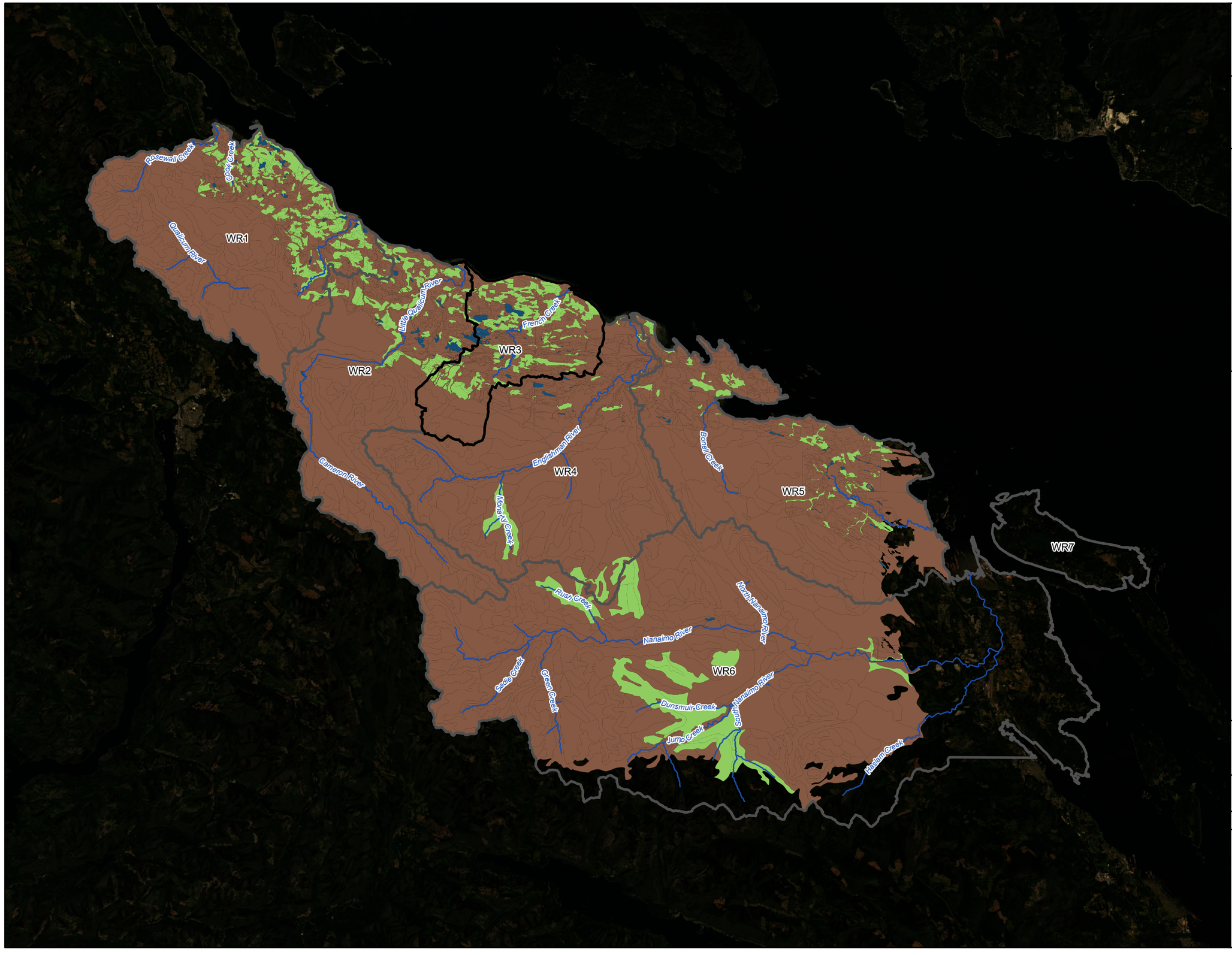
Developing performance targets for the other water regions will take time. The RDN may wish to apply performance targets in the interim to begin to improve watershed health until region-specific targets can be developed.

NHC reviewed the variability of soil type, topography, elevation, and land use across the RDN (Figure 2.2 to Figure 2.5). These are considered the most influential characteristics on the hydrology and setting of performance targets. The characteristics of the other water regions match most closely with the mid and upper regions of the French Creek Water Region, in particular:

- The steep, high-elevation areas in each water region are primarily zoned as conservation areas, forestry and resource areas, and parks and open space.
- The remainder of most of the water regions seem most similar to the mid region of the French Creek Water Region, consisting of smaller, dispersed development communities, and lacking the urban centres seen in the lower region of the French Creek Water Region.

We recommend that until site-specific hydrologic modelling can be conducted in other water regions, the mid-region targets from French Creek can be applied. These are slightly more conservative than the lower region targets, so may also apply to areas with denser development until further studies are done.

Note that the land use and soil maps have some gaps in the data outside of the French Creek Water Region. These areas are outside of the project extent and have not been processed. Inclusion of these areas is not expected to change the recommendation.



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French Creek Water Region
RDN Water Region

Soil Type
- Outwash
- Saturated
- Till

BACKGROUND – ESRI WORLD IMAGERY, INSET – WORLS TOPOGRAPHIC, ELEVATION DATA - CDEM, LAND USE - GOVERNMENT OF CANADA, SOIL POLYGONS - GEO BC

SCALE - 1:300,000
0 1 2 3 4 5 6 7 8 9 10 11 12 km
N

Coordinate System: NAD 1983 CSRS UTM ZONE 10N
Units: METRES; Vertical Datum: CGVD28

Job: 3006259 | *Date: 04-NOV-2022*

FRENCH CREEK RAINFALL MANAGEMENT

SOIL TYPE

FIGURE 2.2

JXD: \\mainfile-nan\Projects\Active\3006259 French Creek Rainfall Management\95 GIS\3006259_JXD_Fig_RND_WaterRegions1.aprx

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French Creek Water Region
RDN Water Region
Layer
Slope Raster
0 - 6
6 - 15
>15 %

BACKGROUND – ESRI WORLD IMAGERY, INSET – WORLS TOPOGRAPHIC, ELEVATION DATA - CDEM, LAND USE - GOVERNMENT OF CANADA, SOIL POLYGONS - GEO BC

SCALE - 1:300,000
0 1 2 3 4 5 6 7 8 9 10 11 12 km
N

Coordinate System: NAD 1983 CSRS UTM ZONE 10N
Units: METRES; Vertical Datum: CGVD28

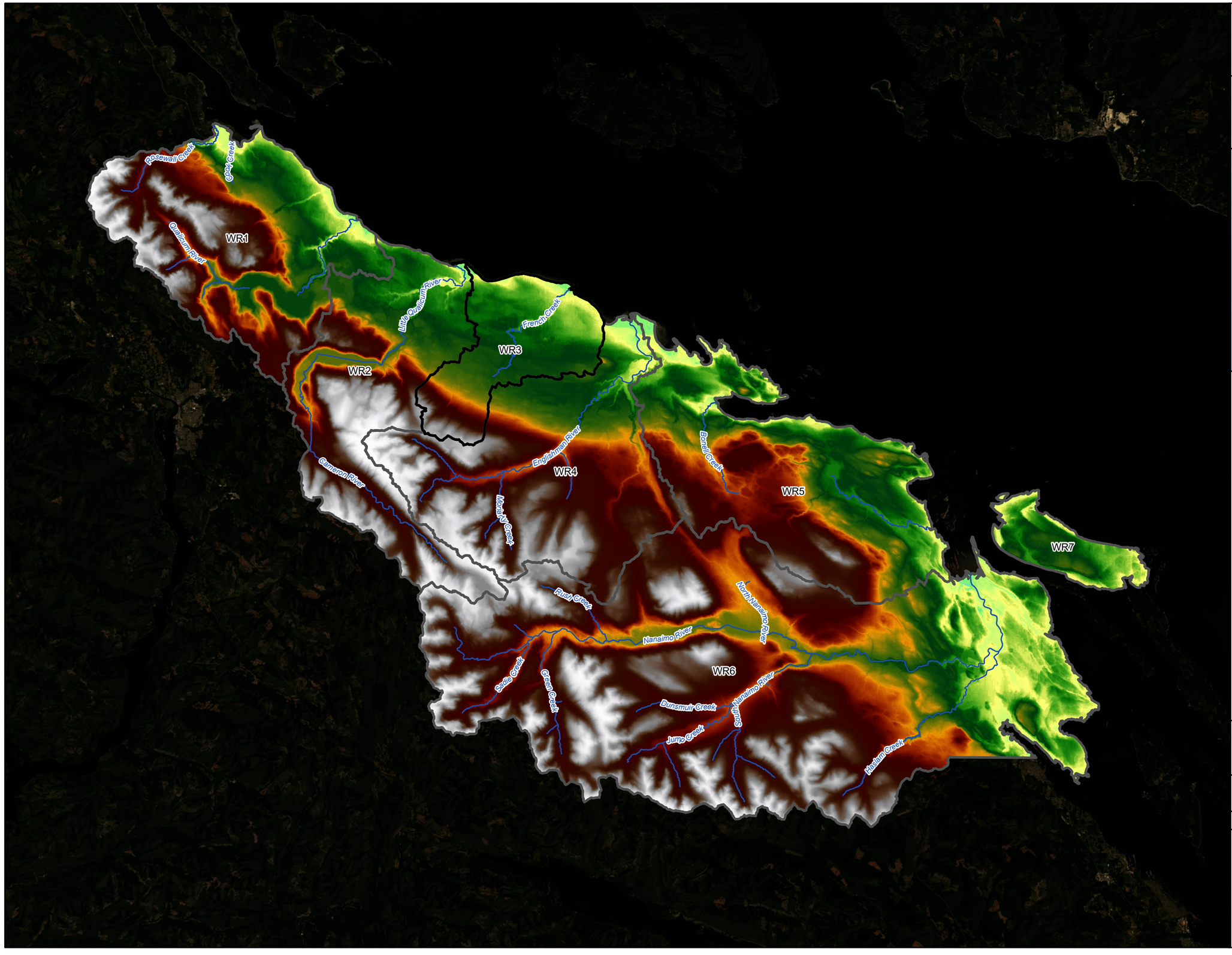
Job: 3006259	*Date: 04-NOV-2022*

FRENCH CREEK RAINFALL MANAGEMENT

SLOPE RASTER

FIGURE 2.3

JXD_\\mainfile-nan\Projects\Active\3006259 French Creek Rainfall Management\05 GIS\3006259_JXD_Fig_RND_WaterRegions1.aprx



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French Creek Water Region
RDN Water Region
Digital Elevation Model
Units (m)
1815
0

BACKGROUND – ESRI WORLD IMAGERY, INSET – WORLS TOPOGRAPHIC, ELEVATION DATA - CDEM, LAND USE - GOVERNMENT OF CANADA, SOIL POLYGONS - GEO BC

SCALE - 1:300,000
0 1 2 3 4 5 6 7 8 9 10 11 12 km
N

Coordinate System: NAD 1983 CSRS UTM ZONE 10N
Units: METRES; Vertical Datum: CGVD28

Job: 3006259	*Date: 04-NOV-2022*

FRENCH CREEK RAINFALL MANAGEMENT DIGITAL ELEVATION MODEL

FIGURE 2.4

JXD: \\mainfile-nan\Projects\Active\3006259 French Creek Rainfall Management\95 GIS\3006259_JXD_Fig_RND_WaterRegions1.aprx

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French Creek Water Region
RDN Water Region

Land Use

- Agriculture, Rural, Rural Residential
- Commercial, CD-18 Alberni Highway Mini Storage
- Comprehensive Developments
- Conservation Zones, Forestry/ Resource, Parks and Open Space, Resource Management
- Industrial, Salvage and Wrecking
- Institutional/Community Facility
- Village Residential, Residential, Manufacture Home Park
- Water

BACKGROUND – ESRI WORLD IMAGERY, INSET – WORLD TOPOGRAPHIC, ELEVATION DATA - CDEM, LAND USE - GOVERNMENT OF CANADA, SOIL POLYGONS - GEO BC

SCALE - 1:300,000
0 1 2 3 4 5 6 7 8 9 10 11 12 km
N

Coordinate System: NAD 1983 CSRS UTM ZONE 10N
Units: METRES; Vertical Datum: CGVD28

Job: 3006259	*Date: 20-DEC-2022*

FRENCH CREEK RAINFALL MANAGEMENT

LAND USE

FIGURE 2.5

JXD: \\mainfile-nan\Projects\Active\3006259 GIS\3006259_JXD_Fig_RND_WaterRegions1.aprx

3 MONITORING

3.1 Recommended Approach

To evaluate the effectiveness of the performance targets on improving watershed health over time, a monitoring network is needed to periodically compare conditions in the future with baseline (current) conditions. Monitoring specific to achieving a natural water balance through rainwater management is difficult to perform due to multiple compounding factors (i.e. groundwater extraction, multi-decadal time-scale for meaningful change, the effects of climate change, etc.). The monitoring therefore focuses on metrics which help to understand overall watershed health and the influence of rainwater management.

Metro Vancouver has completed work to support effectiveness monitoring of Integrated Stormwater Management Planning within a Monitoring and Adaptive Management Framework (MAMF), and it has been applied to a wide range of watersheds in coastal BC. We recommend that similar approaches be adopted within the RDN. This will also encourage knowledge-sharing between jurisdictions so that monitoring and adaptive management can incorporate lessons learned.

Within the French Creek Water Region, we recommend that a strategic hydrometric and water quality monitoring network be set up to track the effectiveness of the performance targets on improving watershed health. Monitoring would typically be applied on natural watercourses, as opposed to piped systems.

The monitoring should follow the approaches outlined within the MAMF. Under this approach, continuous hydrometric data would be collected and analyzed at key locations within the French Creek Water Region, and key metrics be compared to baseline (current) conditions. The hydrologic metrics would include (Metro Vancouver, 2014):

1. **T_{Qmean}.** Proportion of the year that daily discharge exceeds annual average discharge.
2. **Low pulse count and low pulse duration.** Number of times daily discharge is less than half the mean annual discharge, and average duration of these events.
3. **7-day summer low flow.** Average of daily discharge between July and September where rainfall in the prior 7 days is not more than 1 mm.
4. **High pulse count and high pulse duration.** Number of times daily discharge exceeds twice the mean annual discharge, and the annual duration of these events.

Water quality and benthic invertebrate monitoring should also be conducted in accordance with the methodology in the MAMF. Under this approach, water quality sampling is conducted weekly over a 5-week period in both the wet and dry seasons. Benthic invertebrate sampling is also conducted to determine the benthic index for biotic integrity (B-IBI) score. The water quality parameters and metrics can be adjusted to suit the RDN's needs, but the MAMF provides well defined categories for assessing whether results are either good, satisfactory, or needing attention, developed with watershed health specifically in mind.

Trends in the hydrologic metrics, water quality parameters, and B-IBI scores support adaptive management by indicating whether the performance targets are effective at improving watershed health, or whether they need to be revisited.

The sections below describe the availability of historical monitoring data, and describe a recommended monitoring network to provide the data needed to evaluate the performance targets.

3.2 Monitoring Network

Interpreting whether the implementation of the proposed performance targets is effective can only be made where there is sufficient data available. Therefore, an extensive network of hydrometric, water quality, and B-IBI monitoring is recommended for this pilot study. Data collection should begin immediately to establish an understanding of the current (baseline) conditions within the water region.

3.2.1 Existing and Past Monitoring Locations

Where feasible, monitoring should be done in locations where information has been collected in the past to maximize the data record length. We reviewed locations where hydrometric, water quality, and B-IBI data is being collected or has been collected in the past. Unfortunately, the French Creek Water Region does not have any high quality, long-term hydrometric data records. Existing and past monitoring locations are summarized in Table 3.1 and shown in Figure 3.1.

Table 3.1 Existing Hydrometric Monitoring Network

Station Name	Station ID	Parameters	Data Frequency	Station Record	Owner	Status
French Creek DS of Barclay Cres	08HB0021	Stage, Flow	Hourly	August 2018 – Present	BC ENV	Active
Morningstar Creek at Lee Rd	08HB0026	Stage, Flow	Field Measurements	July 2019	BC ENV	Unknown
French Creek near Miller Rd	08HB0014	Stage	Hourly Data	August 2012 to October 2017	BC ENV	Unknown
Beach Creek at Hemsworth Road	08HB0031	Flow, Stage	Field Measurements	June 2021 – February 2022	BC ENV	Unknown
French Creek above Pumphouse	08HB087	Flow	Daily Data	1989 - 1996, Seasonal (Jan-Mar)	WSC	Discontinued
French Creek at Coombs	08HB038	Flow	Daily Data	1969 - 1971, 1983 - 1989, Seasonal (Apr-Sept)	WSC	Discontinued

Table 3.2 Existing Water Quality Monitoring Network

Station Name	Station ID	Parameters	Data Frequency	Station Record	Owner	Status
French Creek at New Highway	E243021	Water Temperature, Dissolved Oxygen, Specific Conductivity, Turbidity, Nutrients, Metals, Biological Indicators	Weekly during seasonal flows (fall high flows and summer low flows) Monthly otherwise	2000-2002[1], 2011-2022	BC EMS (2000-2002), RDN/FFCCS (2011-2022)	Program currently active under RDN/FFCCS.
French Creek at Barclay Bridge	E243022	Water Temperature, Dissolved Oxygen, Specific Conductivity, Turbidity, Nutrients, Metals, Biological Indicators	Weekly during seasonal flows (fall high flows and summer low flows) Monthly otherwise	2000-2002[1], 2011-2022	BC EMS (2000-2002), RDN/FFCCS (2011-2022)	Program currently active under RDN/FFCCS.
French Creek at Coombs	E243025	Physical, carbon, nutrients, metals, biological indicators	Weekly during seasonal flows (fall high flows and summer low flows) Monthly otherwise	2000-2002	BC EMS	Discontinued
French Creek at Grafton Road	E243024	Water Temperature, Dissolved Oxygen, Specific Conductivity, Turbidity, Nutrients, Metals, Biological Indicators	Weekly during seasonal flows (fall high flows and summer low flows) Monthly otherwise	2000-2002[1], 2011-2022	BC EMS (2000-2002), RDN/FFCCS (2011-2022)	Program currently active under RDN/FFCCS
French Creek at Winchester Road	E243023	Physical, carbon, nutrients, metals, biological indicators	Weekly during seasonal flows (fall high flows and summer low flows) Monthly otherwise	2000-2002	BC EMS	Discontinued
Grandon Creek at West Crescent	E288090	Water Temperature, Dissolved Oxygen, Specific Conductivity, Turbidity	Seasonal grab samples	2011-2022	QBS	Program currently active with FFCCS
Grandon Creek at Laburnum Road	E288091	Water Temperature, Dissolved Oxygen, Specific Conductivity, Turbidity	Seasonal grab samples	2011-2022	QBS	Program currently active with FFCCS

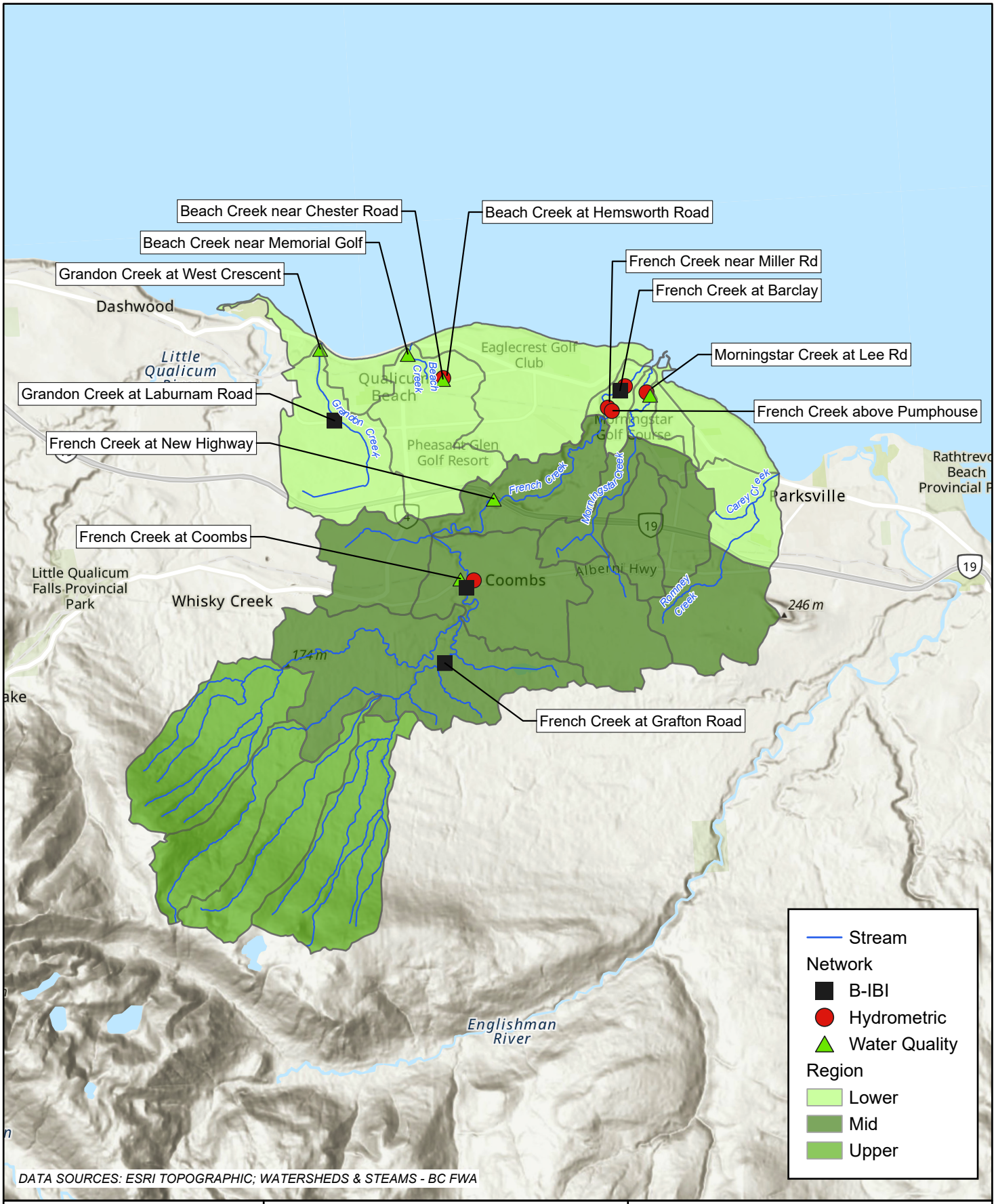
Station Name	Station ID	Parameters	Data Frequency	Station Record	Owner	Status
Beach Creek near Chester Road	E288092	Water Temperature, Dissolved Oxygen, Specific Conductivity, Turbidity	Seasonal grab samples	2011-2022	QBS	Program currently active with FFCCS
Beach Creek near Memorial Golf	E299093	Water Temperature, Dissolved Oxygen, Specific Conductivity, Turbidity	Seasonal grab samples	2011-2022	QBS	Program currently active with FFCCS
Morningstar Creek u/s Lee Rd W	E318151	Water Temperature, Dissolved Oxygen, Specific Conductivity, Turbidity	Seasonal grab samples	2018-2020	FFCCS	Program currently active with FFCCS

Notes:
1. Turbidity, nutrients, metals and biological indicators limited to 2000-20002 monitoring program
2. FFCCS = Friends of French Creek Conservation Society; QBS = Qualicum Beach Streamkeepers

Table 3.3 Benthic Invertebrate Monitoring Network

Station Name	ID	Station Record	Owner
French Creek at Barclay	CABIN NAL-FREN-01	2010	ECCC
French Creek at Highway	CABIN NAL-FREN-02	2010, 2019 (RDN-ENV)	ECCC
French Creek at Coombs	CABIN NAL-FREN-03	2010	ECCC
Grandon Creek at Laburnum Road	E288091	2019	RDN
Grandon Creek at West Crescents	n/a	2019	RDN
French Creek at Grafton Road	E243024	2019	RDN
Beach Creek at Hemsworth	n/a	2022	RDN

Notes:
1. The list above was provided by the RDN and may not be exhaustive of all sites sampled.



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SCALE - 1:120,000

0 1 2 3 4 km

N

Coordinate System: NAD 1983 CSRS UTM ZONE 9N
Units: METRES

Job: 3006259

Date: 04-NOV-2022

FRENCH CREEK RAINFALL MANAGEMENT

EXISTING AND HISTORIC MONITORING LOCATIONS IN FRENCH CREEK WATER REGION

FIGURE 3.1

3.2.2 Recommended Monitoring Network

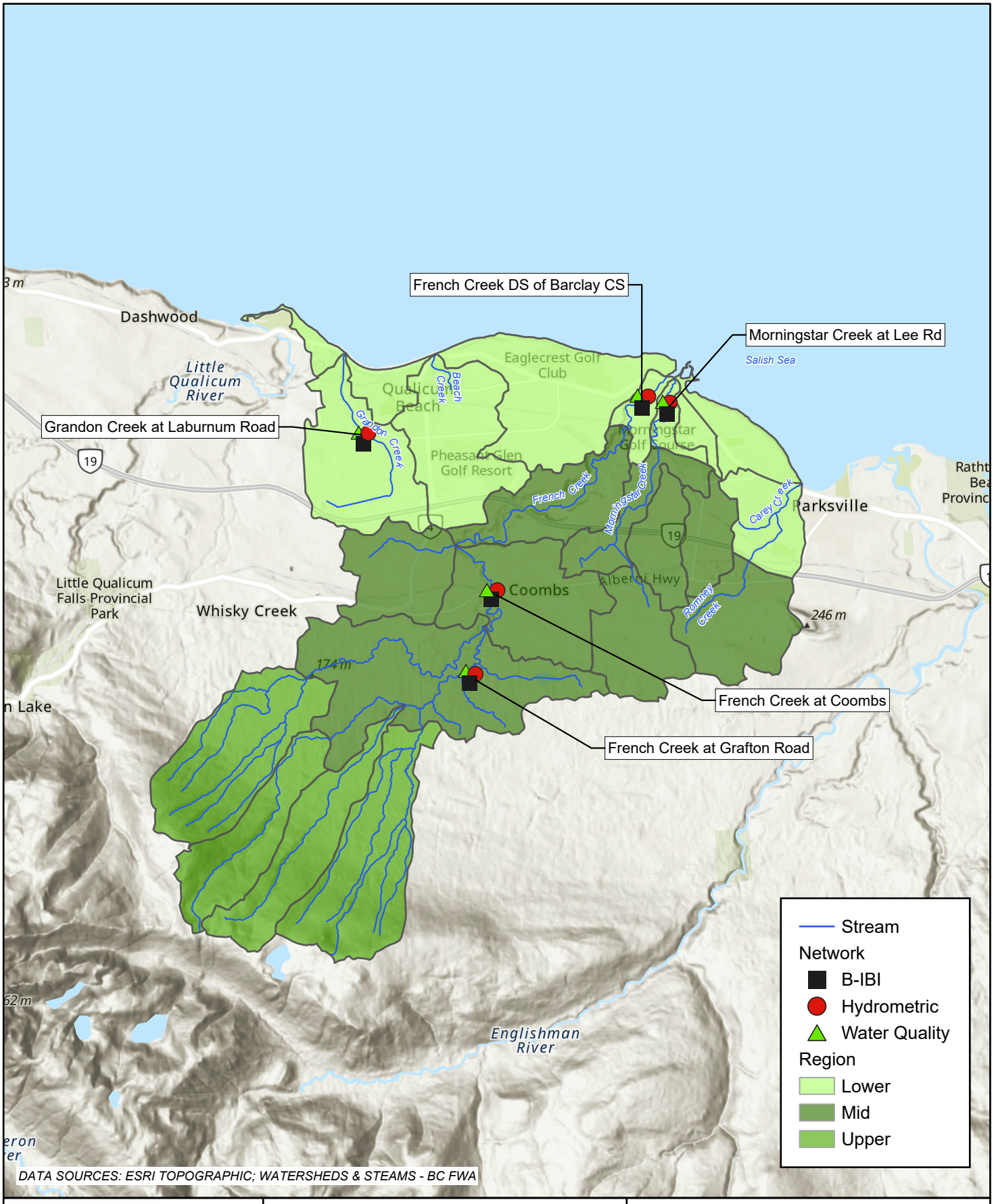
The recommended monitoring network is shown described in Table 3.4 and shown in Figure 3.2. To achieve the objectives of the pilot program, we recommend hydrometric, water quality, and B-IBI data be collected at all locations. This will assist in the interpretation of observed trends. The network utilizes locations where hydrometric, water quality, and B-IBI data has been collected in the past, where applicable. Data that has been collected previously should undergo quality assurance reviews prior to its use along with new data. The recommended network supports the objectives of the performance targets. Existing water quality programs elsewhere in the water region should be continued, but are not listed here.

Table 3.4 Recommended monitoring network.

Type	Location	New/Existing	Comments
Hydrometric Water quality B-IBI	French Creek Downstream of Barclay Cres (08HB0021)	Existing hydrometric and water quality; new B-IBI	• Partnership with BC ENV should be maintained such that hydrometric data continues to be collected. Gauge provides an indication of baseline and changes downstream of mid-region, but use of data collected to date requires QA/QC. • Continue water quality monitoring • Reinstate B-IBI sampling
Hydrometric Water quality B-IBI	French Creek at Coombs	New	• Reinstate a gauge at French Creek at Coombs (previously WSC 08HB038). Historical data can be compared to new gauge. Provides indication of potential development within Coombs. • Reinstate water quality monitoring • Reinstate B-IBI sampling – last sample was Fall 2010
Hydrometric Water quality B-IBI	French Creek at Grafton Road	New	• Install a gauge which corresponds to the location with active water quality and B-IBI monitoring. Will provide an indication of the baseline of the upper water region. • Continue water quality monitoring • Continue B-IBI sampling
Hydrometric Water quality B-IBI	Grandon Creek at Laburnum Road	New	• Install a gauge which corresponds to the location with active water quality and B-IBI monitoring. Will provide an indication of the lower water region. • Continue water quality monitoring • Continue B-IBI sampling
Hydrometric Water quality B-IBI	Morningstar Creek at Lee Road	New	• Install a gauge which corresponds to the location with active water quality monitoring • Continue water quality monitoring • Implement B-IBI sampling

Notes:

1. Water quality parameters to be analyzed should include dissolved oxygen, pH, water temperature, conductivity, turbidity, nitrate as nitrogen, e. coli, fecal coliforms, total iron, total copper, lead, zinc and cadmium.



REGIONAL DISTRICT OF NANAIMO

SCALE - 1:120,000

0 1 2 3 4 km

N

FRENCH CREEK RAINFALL MANAGEMENT

RECOMMENDED MONITORING NETWORK FOR FRENCH CREEK WATER REGION

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Coordinate System: NAD 1983 CSRS UTM ZONE 9N
Units: METRES

Job: 3006259

Date: 04-NOV-2022

FIGURE 3.2

SWM, \\mainfile-nan\Projects\Active\3006259 French Creek Rainfall Management\95 GIS\3006259_SWM_Figures1to6.aprx

3.2.3 Timing and Quality of Data Collection

For the collection and review of data to be effective, it needs to be of sufficient length and quality to identify trends. Notes on the timing and quality of the recommended monitoring program is summarized below, following the guidelines from Metro Vancouver's Monitoring and Adaptive Management Framework (Metro Vancouver, 2014). The RDN should engage with Metro Vancouver to discuss successes and challenges associated with the monitoring programs outlined in that document. Community and streamkeeper groups within the RDN should be utilized for data collection when possible; however, they should be trained by qualified professionals to ensure reliability of the data. This is particularly important for hydrometric data, which is subject to rating curve shifts and other changes that must be accounted for.

- **Hydrometric data**
    - Stations should be built and maintained in accordance with guidance in the Manual of British Columbia Hydrometric Standards (MOECCS, 2018). Sufficient budget should be allocated so that rating curves (relationship of water level and discharge) can be created and maintained at each site, and that proper quality assurance and control checks can be done.
    - For the purposes of the pilot program, data should be collected continuously for a minimum period of 5 years. To adequately monitor changes to the watershed, we strongly recommend data is collected indefinitely.
- **Water quality monitoring**
    - Water quality sampling should be done twice a year: once in the wet season (November to February) and once in the dry season (July to August). In each season, samples should be collected once a week for 5 weeks, consisting of both in situ and laboratory tests.
    - Sampling budgets should account for blank and replicate samples, needed for quality assurance and quality control.
    - Water quality sampling should be completed by a qualified environmental professional.
    - Assessment of water quality results can be compared with Table 4 in the Metro Vancouver framework (Metro Vancouver, 2014), which classifies the results as either good, satisfactory, or needs attention. These ranges were developed specifically for evaluating watershed health.
- **B-IBI monitoring**
    - At locations where B-IBI sampling has been done before, the location and timing of those previous samples should be maintained in the future. For proposed monitoring locations, sampling should be done in the late summer to early fall. This can likely coincide with the end of the water quality sampling program in the dry period.
    - Sampling should be completed by a qualified environmental professional, and analyzed by a qualified taxonomist.
    - Trends in species composition and diversity should be reviewed to identify trends.

3.3 Additional Effectiveness Tracking

Collecting and comparing hydrometric and water quality data to a baseline condition provides a quantitative indication of changes to the watershed, and to identify when adaptive management is needed. However, the organized tracking of other items can help more quickly identify and catalogue the benefits and challenges of the implementation of performance targets. Other items that the RDN should track include the following.

1. The number of development applications received that are or are not implementing rainwater management.
2. Feedback received from land owners, developers, and private industry on understanding and incorporating features to meet the performance targets.
3. Using select sites implementing rainwater management features to meet the performance targets for site-scale effectiveness monitoring. Incentives could be provided to developers opting in to this type of program.
4. Periodic collection of high-resolution aerial imagery. Land use and riparian changes can be reviewed along with hydrometric and water quality data to better interpret trends in the results.
5. GIS analysis of total vegetative cover in the water region.
6. GIS analysis of intact riparian areas in the water region.
7. Internal tracking of watershed restoration initiatives that are planned, started, completed, or stalled, along with detail on what worked and did not.

4 ADAPTIVE MANAGEMENT

Results from the monitoring and additional effectiveness tracking described in Section 3 should be periodically reviewed to determine whether changes to the rainwater management approach are necessary. Given the timeline over which development occurs, it will likely take several years for trends to be detectable in the hydrometric, water quality and B-IBI data. Over this period, it will be important to limit deviations from the recommended performance targets. Aspects of the monitoring program that should be reviewed periodically to assess whether changes to the approach are needed are summarized below.

- **Persistent trends in hydrometric, water quality and B-IBI data**. If trends towards improvement are seen, performance target implementation is likely on track and effective. If adverse trends are seen, such as increase in stream flashiness, reductions in baseflow, and increases in high and low pulse counts, it may indicate that the performance targets are not being implemented, or that they are not aggressive enough to counter the effects of development. Relating the trends to observations from aerial imagery and GIS analysis of vegetative cover and intact riparian areas can inform the type of adjustments to the target that may be needed. Given the timeline over which development occurs and translates to changes in watershed response, these effects are likely to appear over a 3 to 5 year time horizon. If pilot programs are initiated to monitor

effectiveness at the site level (see Section 3.3), the results of those programs can be used to further interpret the trends.

- **Number of development applications requesting variances from the performance targets.** Tracking and cataloguing the number of development applications that request variances can be an indicator of whether there are practical challenges experienced by developers. The type of challenges noted by developers can indicate whether the performance targets need to be adjusted, or whether additional performance targets are needed to address common site-related challenges, such as shallow bedrock or high groundwater tables. At the start of implementation, there are likely to be more variance requests as developers, planners, and engineers become familiar with the performance targets and what rainwater management techniques are applicable to achieve them. Over this period, the RDN may need to provide additional support and education about the program's intent.

The type of response needed for observations from the above categories will depend on the trends that are observed. For example,

- Adverse trends in the hydrologic metrics: revision of performance targets or supplemental watershed restoration initiatives.
- Adverse trends in water quality / B-IBI: further study to assess water quality parameters of most concern, identification of the sources, and potential addition of formal rainwater treatment targets.
- Loss of vegetative coverage: implementation of requirements for vegetation retention in developments.
- Loss of intact riparian areas: creation and enforcement of riparian setbacks.
- Challenges in meeting performance targets in certain types of development: further detail provided to developers and designers on source control design and best management practices for rainwater management.

Over the course of the pilot program, collection and organization of information will be critical to support adaptive management. We recommend the RDN designates internal staff resources towards the tracking of this information.

5 RECOMMENDATIONS AND CONCLUSIONS

The key findings and recommendations of the Phase 2 study are summarized below.

1. The recommended performance targets to be applied to the French Creek Water Region are based on mitigating the effects of future development to pre-development (i.e. natural) conditions.
2. The recommended performance targets will provide some mitigation of the effects of climate change, resulting in an improvement of the water balance over current conditions, but cannot replicate the water balance associated with pre-development conditions. Further mitigation of

climate change effects may be achieved through targeted watershed restoration initiatives, and regional flood detention systems.

3. Until watershed-specific hydrologic modelling of other water regions can be done, the performance targets for the mid region of the French Creek Water Region may be adopted elsewhere in the RDN.
4. The RDN will need to work closely with MOTI, Parksville, and Qualicum Beach to ensure the performance targets are communicated to developers, and made a requirement of all development within the French Creek Water Region. The RDN should be kept informed of all development applications received, and review using the guidelines listed in Section 2.2.2.
5. Requests for variation of the targets may be received, especially early on in the pilot program when stakeholders will be less familiar with methods of how to achieve the targets. The RDN and other jurisdictions may need to initiate engagement and outreach programs to educate stakeholders on the pilot program and the intent of the performance targets. In most cases, deviations from the performance targets should not be necessary. In rare cases where the targets cannot be met, substitutions may be considered, but exemptions should not be permitted.
6. A network of hydrometric, water quality, and B-IBI monitoring should be established as soon as possible to develop the baseline conditions within the watershed. The recommended network builds on existing monitoring locations. For the pilot program to be effective, collection of continuous, high quality data should be collected for a minimum of 5 years, and preferably continued beyond that point.
7. Trends in hydrologic metrics, water quality, and B-IBI scores should be reviewed against criteria from Metro Vancouver's monitoring framework (Metro Vancouver, 2014). We recommend that the RDN consults with Metro Vancouver on successes and challenges they have seen in areas similar to the French Creek Water Region in order to support knowledge-sharing.
8. In addition to quantitative data, the RDN should track and catalogue all feedback from stakeholders about successes and challenges implementing the recommended performance targets, conduct GIS analyses of changes in the watershed, and catalogue all additional watershed restoration initiatives occurring in the French Creek Water Region.
9. Adaptive management will depend on the review and understanding of changes being observed in the watershed. Many trends will not be immediately apparent, as changes will rely on changes due to development being translated into watershed response. We recommend the RDN designates dedicated staff to the pilot program to maximize its effectiveness.

6 REFERENCES

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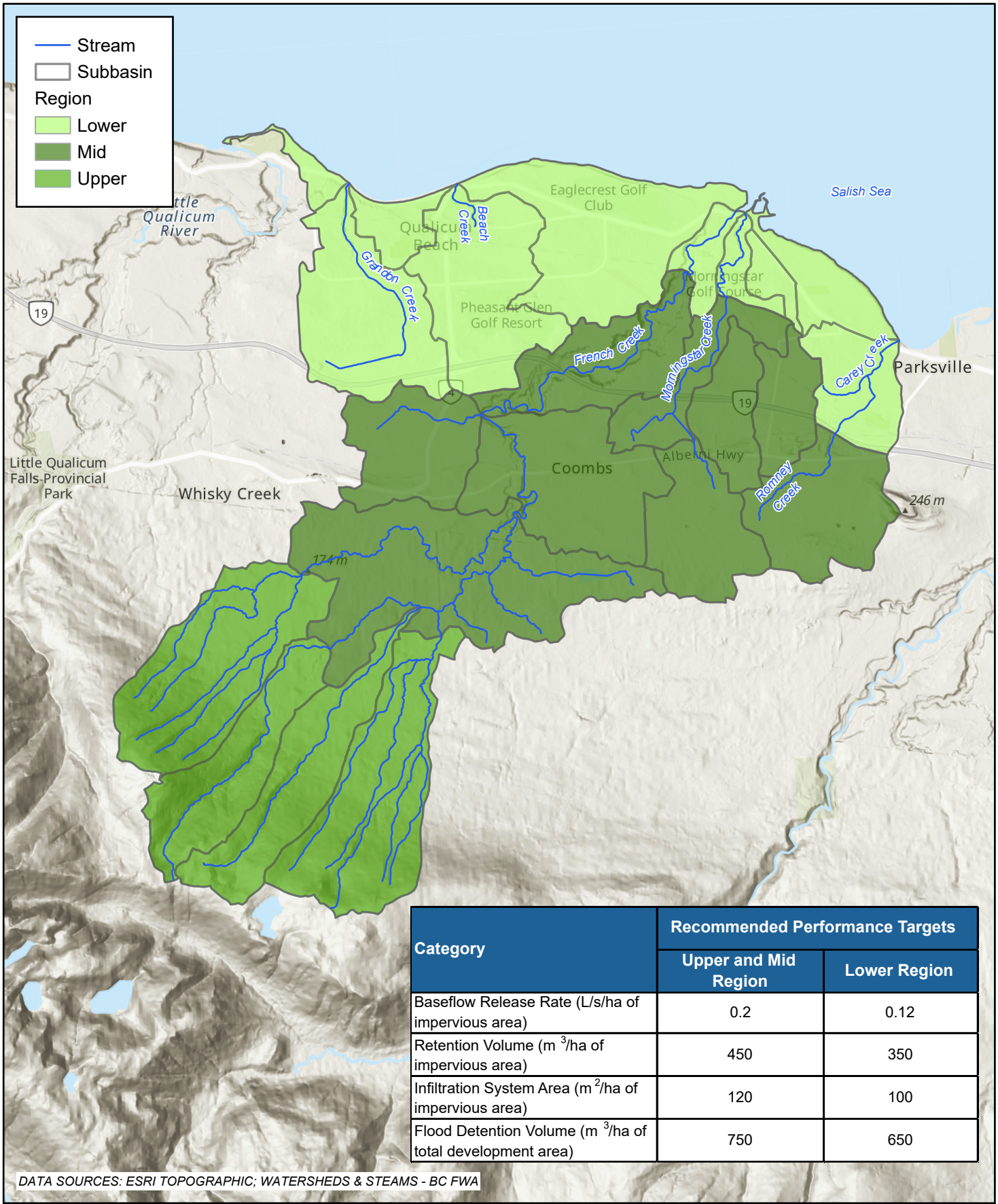
APPENDIX A

RECOMMENDED PERFORMANCE TARGETS – FRENCH CREEK WATER REGION



Category	Recommended Performance Targets	
	Upper and Mid Region	Lower Region
Baseflow Release Rate (L/s/ha of impervious area)	0.2	0.12
Retention Volume (m^3/ha of impervious area)	450	350
Infiltration System Area (m^2/ha of impervious area)	120	100
Flood Detention Volume (m^3/ha of total development area)	750	650

DATA SOURCES: ESRI TOPOGRAPHIC; WATERSHEDS & STEAMS - BC FWA

Regional District of Nanaimo

SCALE - 1:100,000

0 1 2 3 4 km

N

nhc northwest hydraulic consultants

Coordinate System: NAD 1983 CSRS UTM ZONE 9N
Units: METRES

Job: 3006259 | Date: 04-NOV-2022

FRENCH CREEK RAINFALL MANAGEMENT

RECOMMENDED PERFORMANCE TARGETS

FIGURE A1