MEMORANDUM

DATE:	September 8, 2026
TO:	Joel Clary, P.Eng.
CC:	Adrien d'Andrade, P.Eng.
FROM:	Alex Kempa, P.Eng., Ehren Lee, P.Eng.
FILE:	1688.0013.01
SUBJECT:	Storm Sewer Asset Management Plan: Infrastructure Prioritization & Capital Planning

1.0 INTRODUCTION

The Storm Sewer Asset Management Plan (SSAMP) is a comprehensive, 20-year guide for managing both stormwater infrastructure and stormwater quality. This memo summarizes the results of a risk-based infrastructure assessment guided by the methodology outlined in the *Esquimalt Storm Sewer Asset Management Plan: Risk Prioritization* (February 6, 2026), attached in Appendix A to create a list of priority renewal projects for linear infrastructure. The outcomes of the risk assessment are considered among other stormwater-related priorities such as improving stormwater quality and operations and maintenance practices. As recommended herein, these discussions will focus on raising infrastructure funding needs, managing risk levels, and efficiently delivering projects to support the long-term service delivery of the storm sewer system. In addition to capital prioritization, the Township's operation and maintenance practices for the storm system were reviewed, with recommendations to maintain and/or enhance service delivery based on best practices, and insights from Township staff. Findings from this review are detailed in Appendix B, which includes high level cost estimates to give an order of magnitude understanding of the funding required to align storm sewer operations and maintenance with industry standards. The recommended operational improvements also support stormwater quality objectives discussed in Section 2.0, while the resulting stormwater quality priorities help inform the capital investments identified throughout the SSAMP, creating an integrated approach to stormwater management.

2.0 STORMWATER QUALITY REVIEW

Rainfall washes fine sediments and pollutants from hard surfaces into piped systems that discharge into receiving waters, such as the Pacific Ocean and Gorge Waterway, as is the case in Esquimalt. Esquimalt's commitment to the Capital Regional District's (CRD's) Core Area Liquid Waste Management Plan (CALWMP) includes working in partnership on the ongoing Stormwater Quality Program (the Program) managed by the CRD. This Program works to identify and reduce contamination in stormwater, waterways and the ocean through monitoring, assessment, collaboration and education, with the goal of protecting human health and the environment. More specifically, the CRD collects and analyzes stormwater quality samples throughout the Core Area, including approximately 17 locations in Esquimalt (based on 2024 data), for a range of physical, chemical and bacterial parameters. Key parameters assessed through the Program are summarized in Table 1.

Table 1: Stormwater Quality Monitoring - Key Parameters

Parameter Name	Description
Bacteriological Indicators (e.g., *E. coli* and total coliforms)	Elevated concentrations may indicate sanitary cross-connections, inflow and infiltration (I&I), or other conditions that pose potential public health risks.
Total Metals	Analysis of total metals supports the identification of contaminants commonly associated with urban runoff, including roadway-related inputs, sediment transport, industrial and commercial activities, and the influence of aging infrastructure.
Polycyclic Aromatic Hydrocarbons (PAHs)	PAHs are monitored to assess the presence of hydrocarbon-related compounds typically linked to petroleum products, vehicle emissions, industrial sources, and the accumulation of contaminants in urban environments.
Water Data	Used to evaluate immediate risks to aquatic life, public health, and downstream receiving environments.
Sediment Samples	Provide insight into historical and chronic contamination conditions and are collected specifically at sites identified as having environmental concerns.

Together, these monitoring components provide a robust framework for understanding both short-term variability and long-term trends in stormwater quality within Esquimalt. To identify recurring and chronic areas of concern within the Township, Urban Systems reviewed and analyzed raw CRD stormwater quality data and reports from 2011 – 2024, which reflected the most current information at the time of reporting. This review and assessment are reported in Appendix C: *Storm Sewer Asset Management Plan – CRD Water Quality Review* (CRD Water Quality Review) and summarized below.

Based on CRD reports and data, sites exhibiting persistent water or sediment quality issues were designated as 'Priority Sites' for further evaluation. This designation was informed by both environmental and public health concerns identified by the CRD, whereby:

- **Environmental concern ratings** are based on measured concentrations of metals and PAHs relative to established sediment quality guidelines; and
- **Public health concern ratings** are based on Escherichia coli (E. coli) concentrations and the associated potential for human exposure.

These Priority sites, along with the CRD's raw datasets were used to develop a stormwater quality risk matrix that was also applied to all monitoring locations with documented historical exceedances of applicable guidelines. This risk matrix considered:

- Exceedance frequency
- Exceedance magnitude
- Exceedance severity

More information on the stormwater quality risk matrix is provided in Appendix C. Overall, this broader application of the risk matrix enabled the evaluation of temporal trends, recurring exceedances, and persistent water quality concerns, and provided an opportunity to identify any additional sites of concern that may not have been captured within the CRD's original prioritization framework.

Recommendations and actions to improve stormwater quality priorities in the Township are summarized in Table 2 and taken directly from the CRD Water Quality Review in Appendix C. Figure 1 shows the associated outfall locations referenced in Table 2.

The most significant overall risk identified through the assessment relates to elevated E. coli concentrations and associated public health concerns. Several outfalls demonstrated persistent and elevated bacteriological exceedances that are commonly associated with human-related contamination sources, such as sanitary cross-connections and combined sewer infrastructure. As a result, investigation and rehabilitation of aging sewer and storm infrastructure should remain the highest priority action item moving forward.

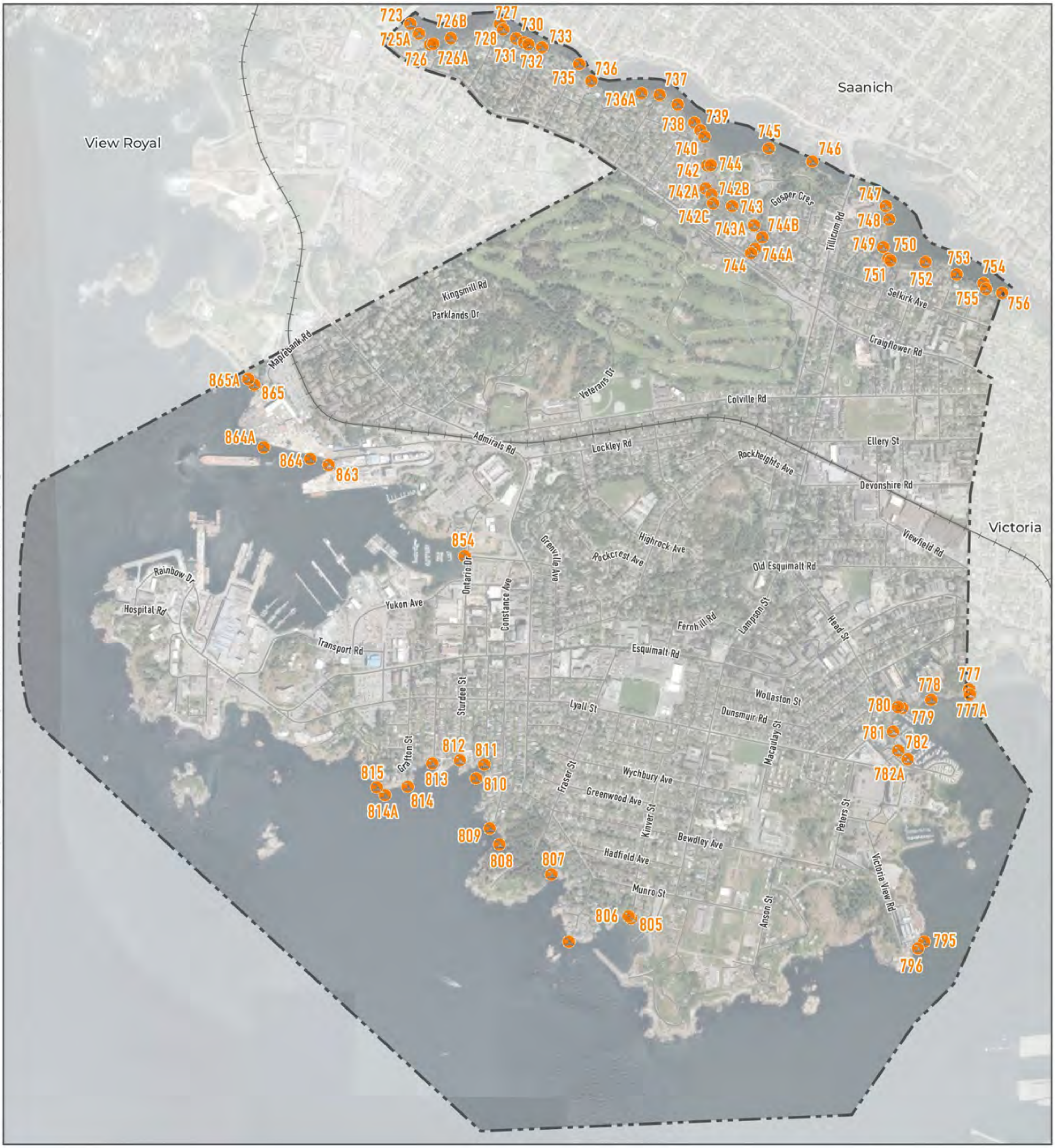
Recurring exceedances of metals and PAHs were also identified within both stormwater and sediment samples, particularly at sites influenced by roadway runoff, urban sediment accumulation and deteriorating infrastructure conditions. While some sediment exceedances may reflect naturally elevated regional background concentrations, the recurrence and spatial distribution of exceedances indicates that urban runoff and infrastructure-related contaminant loading continue to influence stormwater quality throughout the Township.

The outcomes of this review help inform capital prioritization implementation, as discussed in Section 5.0 and 6.0, and also informs improvements to operations and maintenance practices, as discussed in the *Operations and Maintenance Practices Review,* Appendix B.

Table 2: Recommendations Based on Priority and Actions to Improve Stormwater Quality Within the Township

Proposed Stormwater Quality Improvement Strategy	Priority	Primary Risk Type	Target Outfalls / Areas	Primary Target Contaminants	Key Findings / Identified Infrastructure Issues	Recommended Actions / BMPs	Expected Water Quality Benefit
Investigate and Eliminate Sewage Cross-Connections and I&I at High-Risk Outfalls	**Immediate**	Public Health	**744B, 780, 806/805, 749, 737**	E.coli, Enterococci	• Combined sanitary infrastructure structural pipe defects • Potential sanitary cross-connections • Elevated wet weather bacteriological loading. Prioritize and follow recommendations for: • **744B** - Upgrade gravity mains on Gosper Cres. – SGM0790 and SGM0561 (KWL, USL) • **780** - Upgrade combined manhole SMH0163 (KWL) • **737** – Upgrade level 2 and 3 structural defects and forcemain upgrades identified along Rhoda Lane (USL) • **749** – Upgrade pipe SGM0862 (USL, KWL)	• CCTV inspection of priority sewer mains • Dye and smoke testing • Manhole rehabilitation • Pipe relining or replacement • Disconnect and abandon inactive services • Wet-weather source tracing • Private lateral investigations • Separation of combined infrastructure where feasible	• Significant reduction in bacteriological contamination • Improved marine recreational water quality • Improved long-term infrastructure performance
Enhanced Catch Basin Cleaning, Sediment Removal and Street Sweeping Program	**Immediate**	Environmental	**742, 749, 737, 806/805, 744B** commercial and high traffic corridors	Metals, PAHs and sediment	• Elevated sediment-bound metals • Recurring PAHs and hydrocarbons • Sediment accumulation within the storm system • Results suggest roadway runoff influences Prioritize streets within **Kinver, Uganda, Forshaw and Garthland areas.**	• Increase catch basin cleaning frequency to 2–4 times annually • Vacuum sediment removal • Bi-weekly street sweeping in commercial/high traffic areas • Storm sewer flushing program • Develop sediment disposal protocols	• Reduction in sediment-bound metals and PAHs entering marine receiving environments. • Reduced long-term sediment accumulation
Prioritize Structural Rehabilitation of Aging Storm and Sewer Infrastructure	**Immediate**	Public Health / Environmental	**737, 744B, 749, 780**	Metals and E.coli	Multiple outfalls identified aging gravity mains, force mains, combined infrastructure, and structural defects contributing to infiltration/inflow and sediment accumulation. Prioritize and follow recommendations for: • **812/814** – Grafton pumpstation upgrades (USL) • **744B, 744A & 742, 749 and 737 –** Prioritize pipe upgrades with structural defects. Extreme exceedances of iron, aluminum and copper suggest failing infrastructure. • **Garthland and Forshaw Area.** • **Kinver and Uganda** areas - Prioritize pipes highlighted as flood risk (GeoAdvice)	• Pipe relining/replacement • Manhole rehabilitation • Repair priority structural defects • Abandon inactive sewer connections	• Reduced infrastructure-derived metals and lower contamination risk.
Install Water Quality Structures (Oil-Grit Separators and Hydrodynamic Separators)	Immediate / Short Term	Environmental	**742, 749, 806/805, 780**	Copper, Zinc, Nickel, Benzo(a)pyrene, Pyrene	• High imperviousness and roadway runoff likely contribute significant metals and PAHs. • Recurring metals, hydrocarbon and sediment-related exceedances • Evidence of roadway and commercial runoff influences • Limited stormwater treatment within existing infrastructure	• Install OGS units at high-risk areas. • Retrofit deep sump catch basins • Install hydrodynamic separators and filter cartridges • Prioritize commercial, industrial and arterial drainage systems • Implement bylaw requirements for redevelopment and new developments	• Improved capture of sediment, grit, oils, grease, and hydrocarbon-associated contaminants. • Most effective for hydrocarbons.

Proposed Stormwater Quality Improvement Strategy	Priority	Primary Risk Type	Target Outfalls / Areas	Primary Target Contaminants	Key Findings / Identified Infrastructure Issues	Recommended Actions / BMPs	Expected Water Quality Benefit
					Prioritize areas with reoccurring PAH: • **749, 780, 781 and 737 (Garthland and Uganda)**		
Implement Best Management Practices (BMPs), Low Impact Development (LID), and Green Infrastructure	Short Term	Environmental	Township-wide priority catchments	Metals and PAHs	• Urban runoff, high imperviousness, and limited infiltration opportunities contribute to elevated contaminant loading Prioritize the following: • **780** – Grafton area surrounding outfall has an impervious rating of 60-100% (GeoAdvice) • **747** – outfall has an impervious rating of 60-70% (GeoAdvice). • **Kinver and Uganda** existing storm pipes were highlighted to have potential flood risk due to pipe capacity constraints (GeoAdvice).	• Prioritize LID and BMPs in redevelopment projects as outlined in **Section 7.1 and 7.4.** • Retrofit stormwater outfalls and treatment systems • Implement source control measures • Protect and restore natural drainage features	• Reduced runoff volume • Improved infiltration and filtration • Improved watershed resilience.
Undertake Detailed Industrial / Commercial Source Control Program	Medium Term	Environmental	**742, 749, 806/805**	Copper, Zinc, Nickel, Mercury, PAHs	• Broad suite of metals and hydrocarbon exceedances suggest potential industrial/commercial runoff and spill-related sources. • Prioritize sites which show no improvement after infrastructure upgrades.	• Upstream manhole sediment sampling • Business inspections • Spill prevention and response requirements • Covered storage requirements • Illicit discharge enforcement	• Reduced contaminant loading from high-risk land uses. • Improved source identification and spill prevention
Implement Stormwater Management Bylaws and Rainwater Management Policies	Long Term	Environmental / Public Health	Township-wide priority catchments	All contaminants	• Redevelopment and infrastructure renewal provide opportunities to improve long-term stormwater quality.	• Require Rainwater Management Plans prepared by Qualified Professionals • Require OGS for commercial, industrial, CD, institutional, and multi-family developments • Require treatment of first flush runoff • Establish runoff reduction and infiltration targets • Require LID integration into redevelopment • Require ESC plans and enhanced sediment controls during construction • Implement illicit discharge and spill prevention bylaws	• Long-term reduction in stormwater contaminant loading and improved runoff quality. • Improved runoff quality • Improved watershed protection and stormwater management outcomes
Implement Wet Weather Outfall Monitoring and Source Tracking Program	Medium Term	Public Health / Environmental	**737, 744B, 749, 780, 806/805** and other historically elevated outfalls	All contaminants	• Multiple outfalls demonstrated elevated wet weather bacteriological contamination, recurring metals exceedances, and indications of storm-driven contaminant loading • Prioritize sites which show no improvement after infrastructure upgrades.	• Complete minimum five wet-weather sampling events annually at priority outfalls (include five dry weather samples where possible). • Monitor for E. coli, Enterococci, metals, PAHs, TSS, and field parameters • Undertake source tracing investigations where recurring exceedances occur • Correlate results with rainfall intensity and infrastructure condition data • Prioritize recreational marine receiving environments and historically elevated discharge locations	• Improved identification of contaminant sources and loading patterns • Earlier identification of sanitary cross-connections and infrastructure failures • Improved prioritization of infrastructure rehabilitation projects • Long-term reduction in bacteriological and contaminant loading to receiving environments



Township of ESQUIMALT

Storm Sewer Asset Management Plan

Stormwater Quality Sampling Locations

Figure 1

Outfalls

Roads

Railway Track

Township Boundary

0 100 200 300 400

Meters

N

Coordinate System:
NAD 1983 UTM Zone 10N

Scale:
1:20,000
(When plotted at 8.5"x11")

Data Sources:
- Data provided by Township of Esquimalt, DataBC, ESRI

Project #: 1688.0013.01
Author: RS
Checked: AK
Status:
Revision: A
Date: 2026 / 6 / 16

URBAN SYSTEMS

The accuracy & completeness of information shown on this drawing is not guaranteed. It will be the responsibility of the user of the information shown on this drawing to locate & establish the precise location of all existing information whether shown or not.

3.0 ASSET MANAGEMENT

The Township owns, operates, and maintains approximately 67.2 km of storm sewer mains. Each year, Engineering and Public Works replaces or refurbishes portions of this infrastructure to maintain system performance.

The total value of the Township's linear assets, based on the unit rates reported in the *Storm Sewer Asset Management Plan Unit Cost Estimating,* technical memo appended to this report, are approximately $263.3 M. Many municipalities use a life-cycle planning approach to support capital planning and ensure adequate funding is invested and evenly distributed, year over year. For instance, the estimated service life of stormwater mains ranges from 60 – 90 years depending on the material type. The life-cycle planning approach evenly distributes capital investments over this 60-to-90-year period which translates to an annual investment of roughly 1-2% of the total value of linear sewer infrastructure. Applying this approach to Esquimalt's storm sewer mains would require a minimum annual investment of approximately $3.57M. The AALCI becomes a key metric for comparison in Section 5.0 which explores the gap between existing spending levels, the cost of capital needs determined through the risk assessment, and sustainable funding levels based on the AALCI. Closing the gap between existing spending and funding targets is largely influenced by the existing cost recovery mechanisms funding service delivery. Therefore, the following section provides an overview of the Township's current storm sewer funding sources.

3.1 STORM SEWER FUNDING MECHANISMS

The Township currently funds storm sewer replacement through property taxes. A portion of the Township's annual property tax revenue is allocated to the maintenance and improvement of public infrastructure, including the storm sewer system. These funds support capital projects like the construction of new storm sewers, or upgrades to existing infrastructure. Based on the Township's *Budget Overview 2026*, $250,000 is budgeted for storm sewer replacement in 2027, which is expected to increase annually by $250,000.

Understanding the funding sources and fee structure of Esquimalt's storm sewer system is essential for identifying factors that can be adjusted to meet risk-based capital requirements and achieve sustainable funding goals. Related recommendations are outlined in Section 6.0.

4.0 RISK ASSESSMENT

Risk rankings consider and weigh an asset's likelihood to fail, which is determined by condition, capacity results from hydraulic modelling, and the associated consequence should it fail, informed by a triple bottom line evaluation of financial, social and environmental risks. These rankings are assigned on a scale from priority 1 through priority 3 for storm sewers, defined as follows.

- **Priority 1 (P1):** Projects that exhibit the highest level of risk, associated with an elevated likelihood of failure triggered by both condition <u>and</u> capacity concerns, and an elevated consequence of failure.
- **Priority 2 (P2)** Projects not already captured by P1 that have a moderately high level of risk driven by either:
    - A high likelihood of failure (triggered by condition <u>and</u> capacity) but less severe consequence, relative to P1 assets.

 - A moderate likelihood of failure (triggered by condition or capacity, but not both) and a high consequence of failure.

- **Priority 3 (P3):** Projects that exhibit modest risk, driven by a moderately high likelihood of failure (triggered by condition or capacity, but not both) but with less severe consequences of failure.
- **Non-Ranked:** all other projects in the storm sewer network.

These priority rankings are first assigned to assets based on existing conditions (e.g., existing flows and climate), referred to as the existing scenario. Assets prioritized under the existing scenario are required to address deficiencies, driven by condition and/or capacity concerns that exist today. Typically, assets identified as priorities under the existing scenario are recommended for renewal in the next 10 years. This process is repeated for the future scenario which identifies renewal needs to accommodate increases to stormwater flows from land use and climate changes, and deteriorating asset condition. More information on the incorporation of future land use and climate change is discussed in Section 4.1, below.

4.1 HYDRAULIC MODELLING

Identifying system deficiencies through hydraulic modelling is one of the first steps to gathering the information necessary to perform a risk assessment. The performance of the Township's storm sewer system was assessed under existing and future conditions using an updated and calibrated hydraulic model (March 2026). This model considers the best available information at the time of development and reflects the Township's 2025 GIS network data and calibrated to 2025 – 2026 flow monitoring data. Details on the model update and calibration process are outlined in Appendix D.

Six scenarios were assessed using the Township's hydraulic model and are summarized in Table 3.

Table 3: Hydraulic Simulation Scenarios

Return Period	Land Use	Climate Change
10-Year	Existing	No
100-Year	Existing	No
10-Year	Future Official Community Plan (OCP) Land Use	No
100-Year	Future OCP Land Use	No
10-Year	Future OCP Land Use	Yes
100-Year	Future OCP Land Use	Yes

These return periods were selected in alignment with typical engineering specifications which require the minor system (i.e., the piped system) to convey flows of a 10-year return frequency, and the major system (i.e., the overland system such as roads) to convey flows of a 100-year return frequency. The model is also evaluated under future land use conditions, with and without climate change to help indicate if capacity deficiencies are driven by land uses changes, versus climate change, or some combination of the two.

For the purposes of this analysis, climate change was accounted for using the Intensity-Duration-Frequency Climate Change (IDF-CC) tool developed by the University of Western Ontario and the Institute for Catastrophic Loss Reduction. The tool combines historical Environment and Climate Change Canada rainfall data with climate model projections to generate climate-adjusted IDF curves for future time horizons. More specifically, in Esquimalt, climate adjusted IDF curves were based on historical data from the *Victoria Gonzales CS* weather station and an ensemble of global, bias corrected, climate change models. Projections were developed for a planning horizon of 50-years, and a climate change scenario corresponding to RCP 4.5 which assumes that global greenhouse gas emissions peak mid-century and then decline due to the implementation of mitigation measures, resulting in stabilization of warming trends, rather than continued acceleration. More information on the incorporation of climate change and future OCP land uses in the Township's hydraulic model is discussed in GeoAdvice Engineering Inc.'s (GeoAdvice's) *Township of Esquimalt Stormwater System Capacity Analysis* (May, 2026), appended.

4.1.1 Capacity Findings

The performance of the Township's minor system was evaluated across all six scenarios presented in Table 3, including both the 10-year and 100-year storm events. However, since storm sewers are typically intended to convey run-off from a 10-year event, results from the 100-year scenarios were provided for information purposes only and are detailed in Appendix E.

The results of the minor system assessment under the 10-year scenarios were used to inform capacity-based likelihood of failure scores for the risk assessment and informed the need for storm sewer improvements in Esquimalt. Overall, the model indicates that the storm sewer system is performing well under existing and future land use conditions and despite the impacts of climate change. Under today's conditions, less than 0.7km of pipe require upgrading. This is less than 1% of the Township's entire storm sewer network. Under future conditions, OCP land use changes do not impact hydraulic system performance, while climate change triggers an additional 0.2km of pipe upgrades.

This assessment provides valuable insights into minor system performance and is a key input for evaluating infrastructure risks but it did not include a detailed assessment of overland flow routes or major system conveyance. This approach is consistent with standard stormwater asset management/master planning practices for communities comparable to Esquimalt, largely due to the additional data requirements, model complexities, computational effort and costs associated with an overland flow model. However, as the Township considers opportunities moving forward to enhance their understanding of system performance, the development of an overland flow model would help provide a more complete picture of stormwater behaviour throughout the Township. This is captured in the list of recommendations in Section 6.0.

4.2 RISK RESULTS

The existing and future prioritization results are discussed in the following subsections. A more comprehensive list of individual asset prioritization ratings are included in the enclosed. This file also specifies other critical and supporting information for each prioritized asset including (but not limited to):

- Likelihood of failure score – including condition and capacity scores
- Consequence of failure scores – including financial, social, and environmental scores
- Priority rating – as described above
- Priority trigger – e.g., condition and/or capacity
- Existing and future replacement cost. Where existing costs reflect like-for-like replacement (i.e., no capacity upgrades) and demonstrate the existing value of the network, and future replacement cost which accounts for pipe upsizing, where deficiencies have been identified.

4.2.1 Existing Scenario Priority Summary

The following section discusses the prioritization results for storm sewer gravity mains under existing conditions.

Table 4 and Figure 2 highlight the gravity mains recommended for renewal to address existing condition and/or capacity deficiencies. In total, approximately 27.1 km of pipe are recommended for improvement, equating to approximately 40% of the Township's total network length. It should be noted that the costs included in Table 4 reflect full asset replacement, and account for pipe upgrades in cases where:

- Capacity deficiencies have been identified. Given the typical lifespan of storm sewer pipes (e.g., 50-90 years), recommended upgrades are sized to accommodate future runoff conditions over the long-term using the Township's storm sewer hydraulic model. In Esquimalt, this has been done by sizing capacity deficient upgrades to convey runoff under the 10-year climate change storm, while also accounting for OCP land use changes; and
- Condition deficient pipes do not meet current engineering standards. More specifically, where replacement is triggered and existing pipe diameters are less than 250mm, these assets are upsized to meet the Master Municipal Construction Document (MMCD) minimum storm sewer diameter of 250 mm (MMCD Design Guidelines, 2022). Where condition deficiencies are identified and engineering standards are achieved (i.e., diameter ≥ 250mm) the cost of replacement is based on like-for-like pipe sizing.

The above parameters also apply to upgrades recommended under the future scenario in Section 4.2.2.

It is important to highlight that using full pipe replacement as the default solution for all condition-related deficiencies, while prudent, is a highly conservative approach that likely overstates long-term capital needs. In some cases, alternative renewal options, such as trenchless relining or targeted point repairs may suffice to restore a condition-deficient pipe so long as there are no related capacity issues. This is especially relevant for Esquimalt where nearly 98% of prioritized mains are triggered solely by condition, with a replacement value over $100M, as shown in Table 4. However, determining whether a pipe can be rehabilitated, rather than fully replaced, depends on asset-specific details. General factors that can influence this decision include:

- Structural condition and defect characteristics. Example: isolated cracks may be patched, versus fully collapsed segments that may demand full replacement;
- The extent and location of damage. Example: a short, isolated defect may be suitable for a point repair while widespread moderate deterioration could be addressed using lining;
- Site and constructability constraints. Example: pipes within close proximity of buildings or other sensitive areas may favour trenchless methods;
- Cost-effectiveness and longevity. This is meant to ensure that the chosen option yields sufficient additional service life and risk reduction relative to its cost.

Without the information above readily available (e.g., recommended renewal action detailed in CCTV records), this SSAMP conservatively carries forward full replacement costs for condition-driven pipes and offers tailored recommendations on how to close this information gap over the short and long-term so that more practical capital cost estimates can be determined over time.

Overall, the existing prioritization results in Table 4 show that the capacity of the existing storm sewer network is performing well, with less than 0.7km of pipe needing replacement. This is less than 1% of the Township's entire storm sewer network. On the other hand, the significant number of condition-based priorities emphasizes the deteriorating nature of the Township's storm sewer network and the current level of asset replacement backlog.

Furthermore, the condition of priorities identified under this scenario are fully informed by CCTV records which offers a more accurate assessment of asset condition compared to remaining life estimates based on age and material. The locations of the prioritized assets are displayed in Figure 2 and later considered alongside stormwater quality results in Section 6.0.

Table 4: Existing Scenario (Years 1-10) Priorities and Triggers

Existing Prioritization	Asset Count	Length (Km)	Replacement Cost (2025 $)
Condition & Capacity Projects*	**6**	**0.4**	**$1.1M**
P2	6	0.4	$1.1M
Capacity Projects	**4**	**0.25**	**$1.1M**
P2	2	0.11	$0.5M
P3	2	0.14	$0.6M
Condition Projects*	**398**	**26.4**	**$101.2M**
P2	184	12.3	$50M
P3	214	14.1	$51.2M
TOTAL	**408**	**27.1**	**$103.4M**

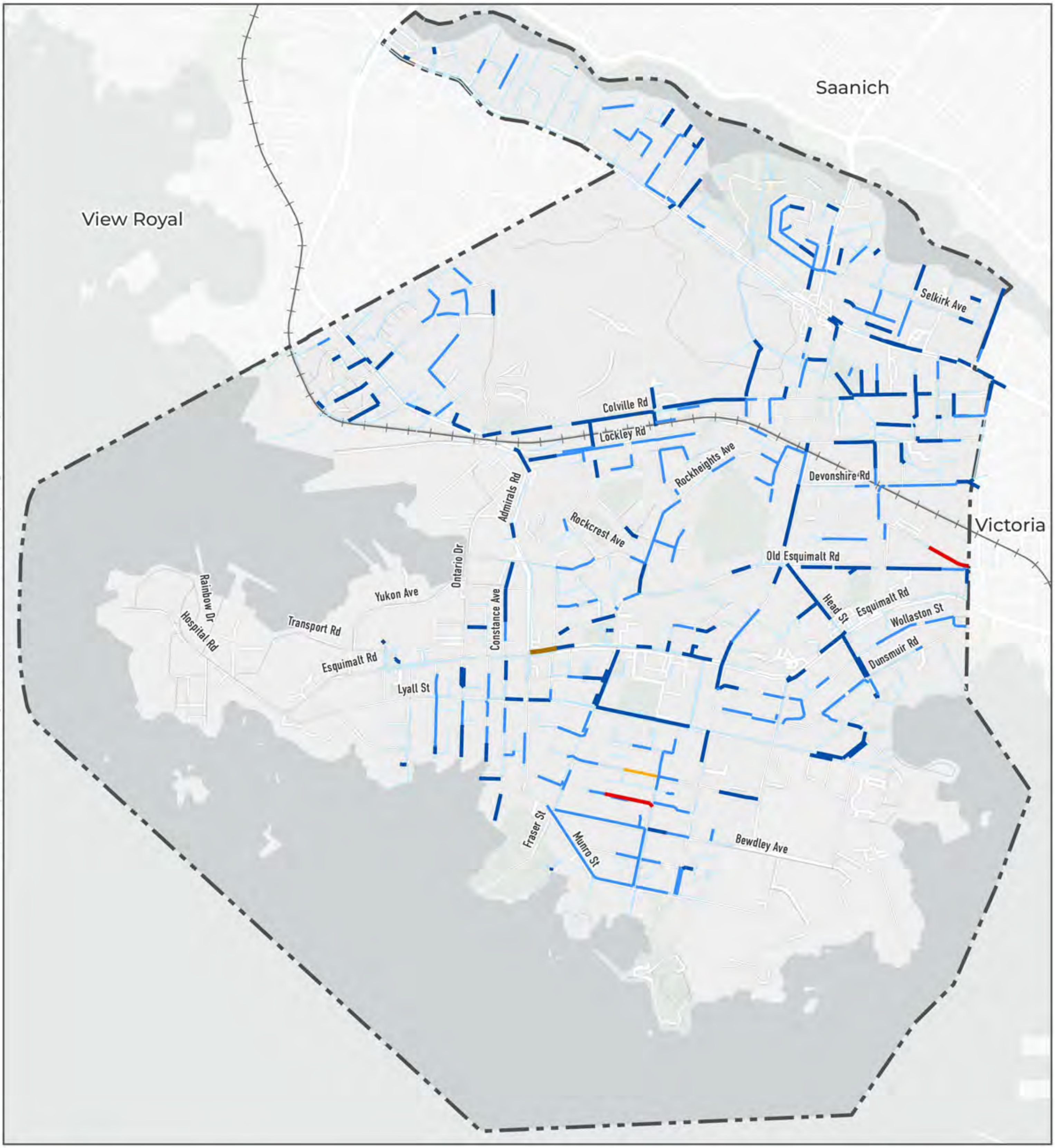
*Condition fully informed by CCTV records, rather than estimated remaining life

The absence of P1 projects in Table 4 indicates that no assets have both condition and capacity deficiencies combined with a high consequence of failure. However, there remain high-priority projects for the Township to complete, such as P2 projects where condition and capacity deficiencies have been identified, but consequence of failure is lower than P1 projects.

Unlike condition-based infrastructure, capacity-driven projects may require multiple pipes to be upgraded simultaneously to resolve a deficiency, or in some cases, a capacity-deficient main can be resolved by an upgrade elsewhere in the system. For this reason, a summary of the capacity-based projects is provided in Table 5.

Table 5: Existing Capacity-Triggered Project Summary

Project Number	Asset IDs	Total Length (m)	Notes	Replacement Cost (2025 $)
Project 1 (P2)	DGM0618, DGM0734, DGM0617	192	Condition & Capacity Project: Pipe upgrades required to address deficiency at DGM0618	$0.6M
Project 2 (P2)	DGM1251, DGM0774	112	Capacity-Only Project: Pipe upgrades required to address deficiency at DGM1251	$0.5M
Project 3 (P2)	DGM0467, DGM0568, DGM0570	170	Condition & Capacity Project: Pipe upgrades required to address deficiency at DGM0568	$0.5M
Project 4 (P3)	DGM0502, DGM1069	138	Capacity Project: Pipe upgrades required to address deficiency at DGM0687. Alongside pipe upgrades, DGM0688 is recommended to be capped, with manhole rebenching, as required. This will eliminate the existing flow split on Wychbury Ave west of Kinver St.	$0.6M



Township of
ESQUIMALT

Storm Sewer Asset Management Plan

Existing Infrastructure Priorities

Figure 2

Replacement Priority (Existing)

- P2 - Capacity
- P3 - Capacity
- P2 - Condition
- P3 - Condition
- P2 - Condition & Capacity
- Existing Storm Mains (No Current Deficiency)

0 100 200 300 400
Meters

N

Coordinate System: NAD 1983 UTM Zone 10N

Scale: 1:20,000 (When plotted at 8.5"x11")

Data Sources:
- Data provided by Township of Esquimalt, GeoAdvice, DataBC, ESRI

Project #: 1688.0013.01
Author: RS
Checked: AK
Status:
Revision: A
Date: 2026 / 6 / 16

URBAN SYSTEMS

4.2.2 Future Scenario Priority Summary

Table 6 outlines the storm sewers recommended for replacement to address future condition and/or capacity deficiencies driven by deteriorating asset condition and increases in flow due to climate and land use changes, as discussed in Section 4.1. In total, approximately 6.9 km of additional pipe is recommended for upgrade in the future scenario, equating to approximately 10% of the Township's total network. The renewal cost of the future priorities is estimated at approximately $27.1M and conservatively reflect full asset replacement, however as stated in Section 4.2.1, alternative renewal options, such as point repairs and relining, may be deemed suitable for condition-triggered assets, on a case-by-case basis.

Similar to risk findings under the existing scenario, capacity results from the storm sewer hydraulic model indicate that the Township's network is performing well under future climate and land use conditions, with only 170m of additional pipe recommended for upgrade. Meanwhile, condition-deficiencies continue to drive the majority of prioritized assets in the future scenario. These condition driven renewals are predominately informed by CCTV, whereby existing CCTV scores are ranked on a scale of 0 – 5 (0 indicating no defects, and 5 indicating defects requiring immediate attention) and increased by a score of 1 to a maximum of 5 to account for pipe deterioration over the next 10 plus years. Of the 6.7km of pipes recommended for upgrade due to condition in the future scenario, 6.6km is flagged based on CCTV information, while the remaining 0.1km is based on estimated remaining life.

The future priorities summarized in Table 6 are also shown in Figure 3.

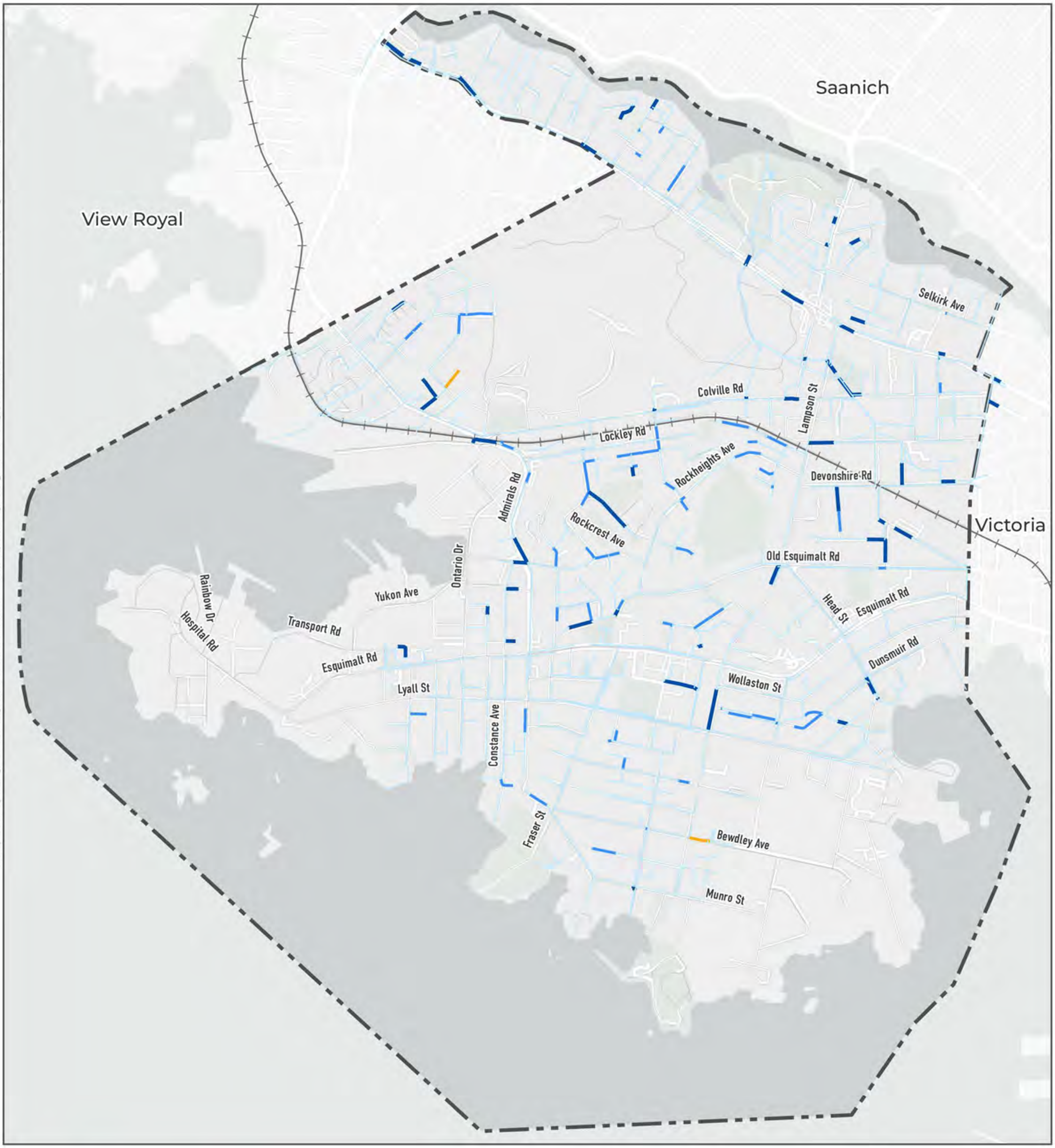
Table 6: Future Scenario (Years 11-20) Priorities and Triggers

Future Prioritization	Asset Count	Length (Km)	Replacement Cost (2025 $)
Capacity Projects	**3**	**0.2**	**$0.7**
P3	3	0.2	$0.7M
Condition Projects	**124**	**6.7**	**$26.4M**
P2	59	3.3	$14.2M
P3	65	3.4	$12.2M
TOTAL	**127**	**6.9**	**$27.1M**

A summary of the future, capacity-triggered projects is provided in Table 7 and highlights storm sewers requiring upgrades simultaneously to resolve the identified capacity deficiency.

Table 7: Future Capacity-Triggered Project Summary

Project Number	Asset IDs	Total Length (m)	Notes	Replacement Cost (2025 $)
Project 5 (P3)	DGM0934	83	Capacity Project: Single pipe upgrade required to address deficiency at DGM0934	$0.3M
Project 6 (P3)	DGM0152, DGM1157	87	Capacity Project: Pipe upgrades required to address capacity issue at DGM0152 which causes flooding one pipe upstream (at the manhole upstream of DGM1157).	$0.3M



Township of ESQUIMALT

Storm Sewer Asset Management Plan

Future Infrastructure Priorities

Figure 3

Replacement Priority (Future)

- P3 - Capacity
- P2 - Condition
- P3 - Condition
- Existing Storm Mains (No Current Deficiency)

0 100 200 300 400

Meters

N

Coordinate System: NAD 1983 UTM Zone 10N

Scale: 1:20,000 (When plotted at 8.5"x11")

Data Sources:
- Data provided by Township of Esquimalt, GeoAdvice, DataBC, ESRI

Project #: 1688.0013.01
Author: RS
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Date: 2026 / 6 / 16

URBAN SYSTEMS

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5.0 CAPITAL PRIORITIZATION

This section combines the findings from the risk assessment results presented in Section 4.2, and asset management principles and funding mechanisms discussed in Section 3.0 to provide an understanding of planned budgets, and how these compare to sustainable funding levels (the AALCI), and prioritized capital needs. These metrics are displayed over a 20-year time frame in Figure 4 and further discussed below.

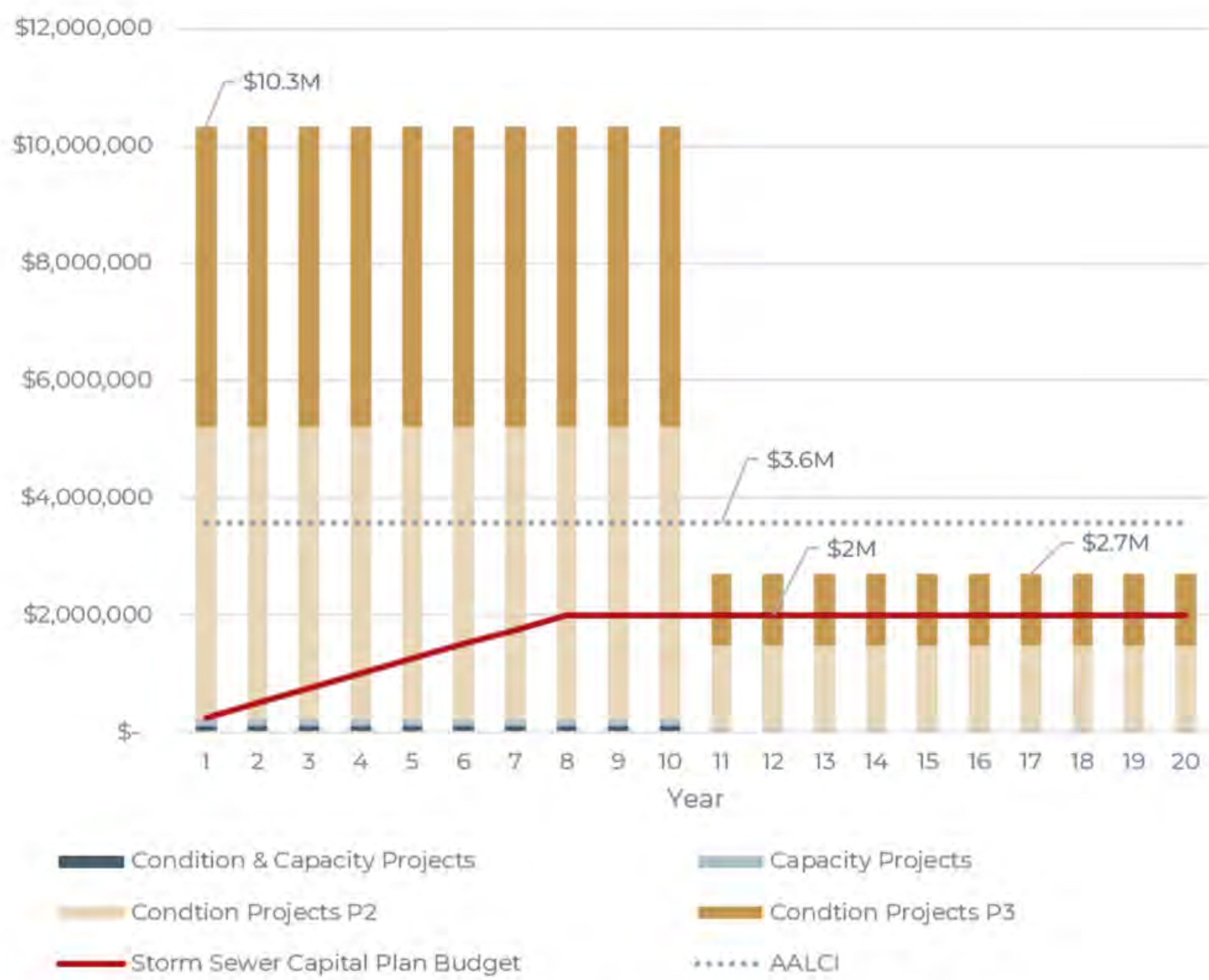


Figure 4: Capital Prioritization Summary, 20-Year Outlook

Figure 4 illustrates the following concepts:

- Existing and future deficiencies signal annual investment needs of approximately $10.3M for years 1-10 and $2.7 M for years 11-20.
- Based on current budgets for 2027 ($250,000) and annual increases estimated at $250,000 until spending reaches $2M in year 8, there exists a gap in annual investment and capital replacement needs. Over the first 10-year horizon, this gap ranges from approximately $10.1M annually over the short-term, and decreases to roughly $8.3M, annually towards year 10. Over the second 10-year horizon, this gap is approximately $0.7M, annually.
- The gap between targeted spending levels ($2M) and the AALCI ($3.6M) is approximately $1.6M annually. The $1.6M gap indicates a funding shortfall of nearly 44% compared to the required investment. This shortfall means that the Township will not be investing enough in the rehabilitation and replacement of its aging infrastructure, causing a growing backlog of deferred rehabilitation. This backlog is exacerbated by current spending levels which are closer to $250,000. As a result, the Township may face increasing risks associated with infrastructure failure, higher emergency repair costs, and potential service disruptions.
- The majority of infrastructure renewal is driven by condition under the existing and future scenarios. The values presented in Figure 4 conservatively reflect full replacement, however, in some cases, alternative renewal options such as trenchless relining, or targeted point repairs may be appropriate. As discussed in Section 6.0, review of CCTV records for select condition-driven priorities are recommended to confirm the appropriate form of renewal.
- Although total project costs significantly exceed existing budgets, planned spending appears sufficient to complete all capacity related projects under the existing and future scenarios. This means that while additional CCTV investigation/review is underway to better understand condition-driven infrastructure needs, Esquimalt can begin addressing priorities driven by capacity, where the scope of work is well understood.
- Funding for dedicated stormwater quality improvements (e.g., oil-grit separators, rain gardens, source control programs, etc.) are not included in Figure 4. While some water quality benefits are expected to result from storm sewer renewal, dedicated investment is also needed. To support this, it is recommended that the Township allocate approximately 15% of prioritized storm sewer renewal costs to stormwater quality initiatives in catchments where improvement strategies have been identified. The resulting allocations by catchment are summarized in Table 8. This funding approach will help the Township advance opportunistic stormwater quality projects and address identified concerns more proactively across the Township.

Table 8: Stormwater Quality Improvement Allocation by Outfall Catchment

Site	Length of Prioritized Storm Mains (Existing & Future Scenarios)	Stormwater Quality Improvement Allocation (15% of Prioritized Storm Sewer Renewal Costs)
742 & 744	0.5km	$0.4M
812	0.7km	$0.3M
749	0.2km	$0.1M
737	0.3km	$0.2M
805/806	3.8km	$2.2M
780	1.5km	$0.8M
Total	**7.0km**	**$4.0M**

Like most local governments across British Columbia and Canada, the level of investment required to address all priorities far exceeds the level of funding available, leading to a growing backlog. Based on the capital needs presented herein and shown in Figure 4, two funding scenarios have been reviewed to help conceptualize this backlog in Esquimalt:

1. Continue with existing funding plans to increase annual spending by $250,000, until annual investment levels reach $2M
2. Continue with existing funding plans to increase annual spending by $250,000, until annual investment levels reach the AALCI, at ~$3.6M

Table 9 compares the two funding scenarios described above and in terms of capital projects funded and deferred. This comparison reflects a purely financial perspective and does not consider other resources necessary to complete capital works (e.g. labourers, equipment, management etc.). Additionally, these scenarios assume full pipe replacement and that no new or unexpected capital priorities arise during the subject time period.

Table 9: Financial Comparison of Funding Scenarios

Scenario	Existing Scenario (Year 1 – 10)	Future Scenario (Year 11 – 20)	Costs of Deferred Projects (Year 1 – 20)
Current Spending Target*	• 13% of all existing projects funded, excluding contributions to stormwater quality improvements • Total funding: $13M	• 74% of all future projects funded, excluding contributions to stormwater quality improvements • Total funding: $20M	$97.4M
Increase Annual Spending by $250K Until AALCI Reached in Year 15	• 13.3% of all existing projects funded, excluding contributions to stormwater quality improvements • Total funding: $13M	• 125% of all future projects funded, excluding contributions to stormwater quality improvements • Total funding: $33.9M	$82.7M

*Starting at $250,000, increasing annually by $250,000 until annual investments reach $2M

As a result of this backlog, local governments are inherently balancing and adopting higher levels of risk as they knowingly defer lower priority projects (i.e., lower risk) into the future. When considering deferral, it is important to acknowledge the role of borrowing as a potential mechanism to address funding shortfalls. While this analysis does not factor in recurring borrowing as a long-term strategy, it recognizes that loans may serve as a bridge for the Township to address emergency failures. This is common practice to address funding shortfalls but is not an optimal strategy to finance long-term funding needs. Moving forward, the Township will need to focus on raising more funds for infrastructure and stormwater quality, accepting some level of risk and ensuring priority projects are delivered efficiently. Until a comprehensive financing discussion takes place with Finance and Council, the Township should be prepared to rely on loans for emergency failures where projects are being deferred. Additionally, enhancing capacity to manage and deliver capital projects will be key as the scale of work expands.

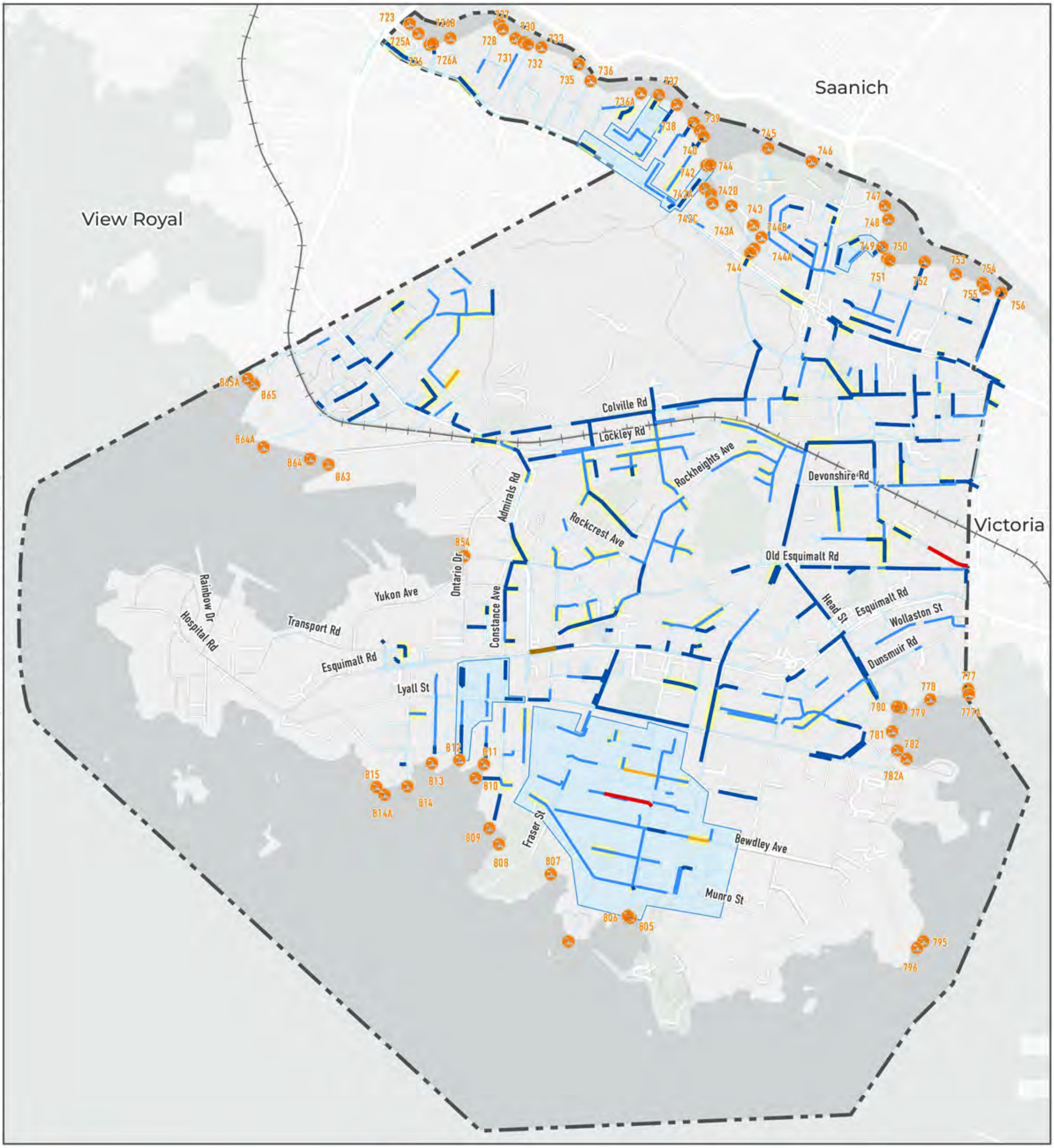
6.0 RECOMMENDATIONS SUMMARY

The following recommendations arise from the findings of this risk assessment and are aimed to support the Township in making confident and consistent capital decisions to ensure investments are strategically dedicated towards areas they are needed most:

- Review CCTV records of condition-driven priorities to inform appropriate renewal approaches. This review is recommended to start in catchments where stormwater quality has been identified as a concern, particularly in areas with metal exceedances and infrastructure upgrades recommended (sites prioritized in order of highest metal occurrences: 742, 744, 812, 749, 737, 805 and 806). These locations are mapped in Figure 5 and form a subset of Table 8. Within the listed catchments, approximately 5.5km of main are prioritized. The enclosed risk assessment also includes a detailed list of the prioritized storm sewers for review, by stormwater quality catchment/site. These reviews should be initiated in year one.
- As part of the CCTV review process ensure recommended renewal actions are tracked to understand trends throughout the Township. Use these trends to estimate updated capital needs for condition-driven storm sewer projects. Bring these updated estimates to the Township's Finance Department to review storm sewer funding options. The Township should be prepared to increase spending levels, balance the trade-offs between capital investment and risk tolerance.
- The Township should use an integrated capital planning approach when developing its 5-year capital plan, so storm sewer projects are considered alongside water, sanitary sewer, and road projects. In some cases, stormwater needs may drive project timing where risk or service concerns are highest; in other cases, storm improvements may be advanced as part of corridor or utility projects led by other services to reduce costs, limit disruption, and improve overall delivery efficiency. Storm sewer projects that may act as project drivers include those that are capacity-deficient, where the required upgrades are already defined through hydraulic modelling. In order of priority, these may include:
    a. **Projects 1 or 3** - Both of these projects are classified as P2 and are driven by both condition and capacity.
        i. Project 1: $0.6M + $0.1M stormwater quality improvement allocation
        ii. Project 3: $0.5M
    b. **Project 2** - P2 driven solely by condition ($0.5M)
    c. **Project 4** – P3 driven solely by condition ($0.6M + $0.1M stormwater quality improvement allocation)

- Complete condition-based improvements based on the outcomes of CCTV record review, and in alignment with other capital works, or as funds become available for high-risk projects the Township is unwilling to defer. When projects are initiated in the following stormwater quality catchments, the Township should also consider opportunities to install oil-grit separators to help address high concentrations of metals and/or PAHs: 742, 737, 749, 780.
- As suggested in the appended, Operations and Maintenance Practices Review, implement a CCTV program so that all storm sewer pipes are inspected every 10-years and include recommended action for renewal. This program should start in order of the oldest CCTV records, and highest prioritization (e.g., inspected 2017, P2). The resulting action from this investigation should be implemented in alignment with other capital projects, or as funds become available, in order of prioritization. When projects share a common prioritization ranking and resources are limited, confirm with Public Works staff where there are routine maintenance issues or challenges. If clusters of assets emerge in a common area, address these together as a single project.
- Similarly, align green infrastructure and/or LID opportunities with other capital/corridor projects, especially in areas where imperviousness is high. Corresponding operations and maintenance needs should be considered alongside investment decisions to ensure these facilities are appropriately maintained and resourced over the long-term.
- Address E.coli concentrations and associated public health concerns by implementing improvements to sanitary infrastructure, as outlined in Table 2 and in the CRD Water Quality Review, appended.
- To support the delivery of higher volumes of capital projects, the Township should develop a targeted list of key stakeholders to facilitate streamlined and high-quality service delivery. This list should include project managers, administrative staff, Public Works and contractors. More specifically the Township should:
    - Define clear roles and responsibilities for staff involved in capital works to ensure accountability and clarity.
    - Assign a dedicated staff member to keep information systems up to date as work progresses, including the integration of real-time field data into project identification and delivery processes (e.g., repair records, CCTV inspections etc.),
    - Hire a dedicated capital project manager to oversee planning, delivery, and coordination of the expanded storm sewer program,
    - Build internal capacity for engaging with external consultants and contractors to improve oversight and decision-making, and
    - Build internal capacity to address stormwater quality concerns proactively and continue to collaborate with the CRD on stormwater quality results and recommended courses of action.
- Prepare for infrastructure deferral by:
    - Adapting current maintenance practices (refer to Appendix B - Operations and Maintenance Practices Review) with the aim of preserving/extending asset life as long as possible, and
    - Being prepared to borrow funds for reactive infrastructure replacement, as needed.

- Adapt current maintenance practices based on those outlined in Appendix B, to enhance stormwater quality. These practices primarily focus on catch basin cleaning, street sweeping and storm sewer flushing.
- Use the outcomes of this assessment to identify a list of eligible development cost charge (DCC) projects, including the appropriate benefit allocation to support fund raising for capacity-triggered capital projects.
- Consider alternative cost-recovery models for the storm sewer service that can contribute to a more sustainable and transparent funding approach that reflects actual service use and aligns with broader financial and environmental goals (e.g., flat fee per parcel or variable rate(s) based on different property characteristics such as property type, size, and/or impervious surface area, among others).
- Complete storm sewer network model updates every 5 years and/or when network conditions change significantly, or if new information arises which is relevant to the model. In preparing for the next model update, the Township should evaluate their stormwater management priorities and consider the need for overland flow modelling.
- Complete the risk-assessment process, at a minimum, every 5 years and incorporate the latest data (e.g., storm main physical inspection data, model results, etc.) to improve near-term decision-making confidence.
- Implement medium-to-long-term recommendations to improve stormwater quality (refer to Table 2 and the CRD Water Quality Review, appended):
    - Stormwater management bylaws and rainwater management policies (e.g., require OGS for commercial, industrial, institutional and multi-family development, require treatment of first flush runoff, and LID integration into redevelopment, among others)
    - Implement wet weather outfall monitoring and source tracking program based on indications of storm-driven contaminant loading



Township of
ESQUIMALT

Storm Sewer Asset Management Plan

Catchments with High Metal Occurrences

Figure 5

Outfalls

Replacement Priority (Existing)

- P2 - Capacity
- P3 - Capacity
- P2 - Condition
- P3 - Condition
- P2 - Condition & Capacity

Replacement Priority (Future)

- P3 - Capacity
- P2 - Condition
- P3 - Condition

High Metal Catchments

0 100 200 300 400
Meters

N

Coordinate System:
NAD 1983 UTM Zone 10N

Scale:
1:20,000
(When plotted at 8.5"x11")

Data Sources:
- Data provided by Township of Esquimalt, GeoAdvice, DataBC, ESRI

Project #:	1688.0013.01
Author:	RS
Checked:	AK
Status:	
Revision:	A
Date:	2026 / 6 / 16

URBAN SYSTEMS

Sincerely,

URBAN SYSTEMS LTD.

PROFESSIONAL
PROVINCE OF
A. M. E. KEMPA
66331
BRITISH COLUMBIA
ENGINEER

PERMIT TO PRACTICE
URBAN SYSTEMS LTD.
Signature
Date 2026-09-08
PERMIT NUMBER: 1000527
Engineers and Geoscientists BC (EGBC)

Alex Kempa, P.Eng.
Project Steward & Engineer

Ehren Lee, P.Eng.
Senior Advisor

/ak
Enclosure

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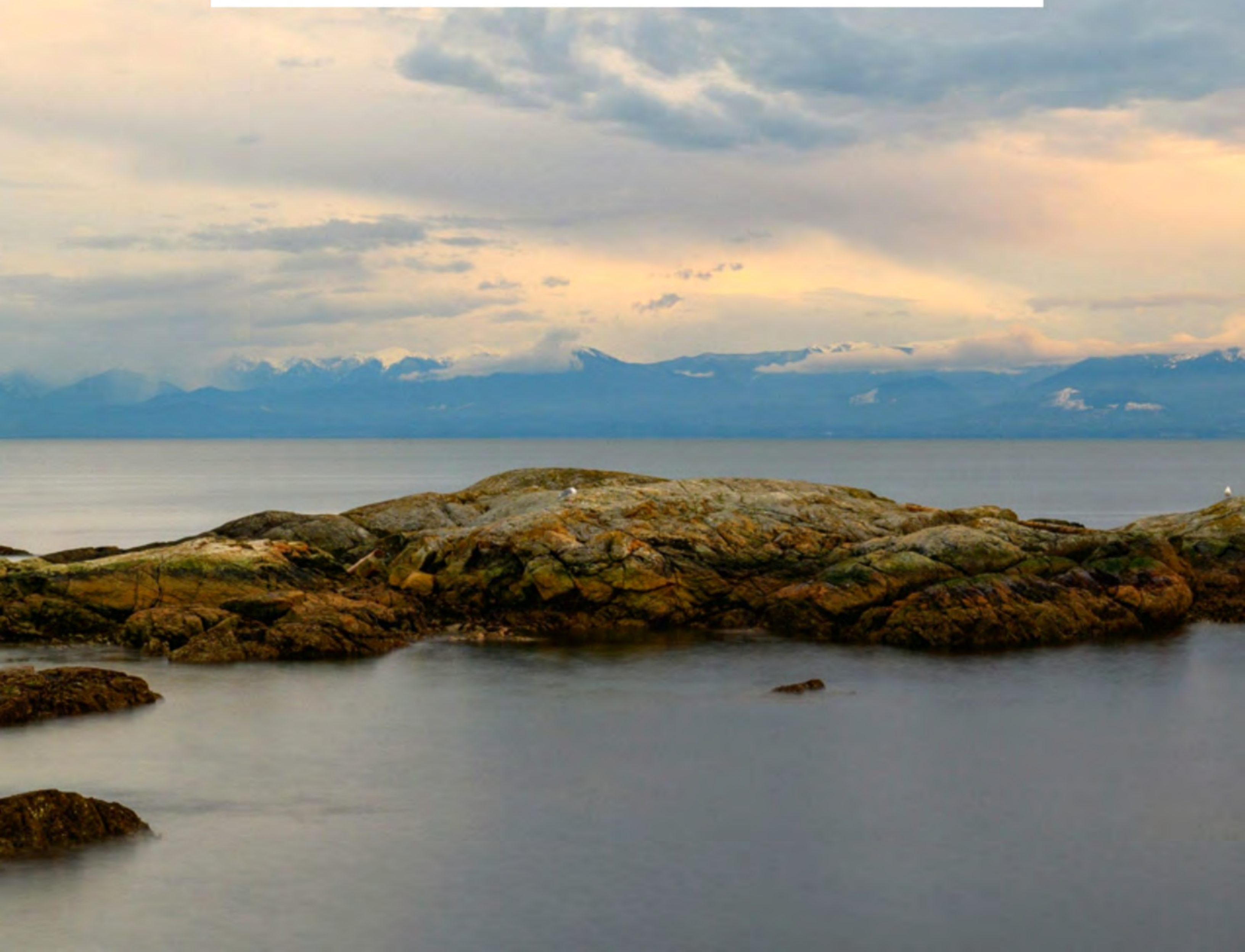
APPENDIX A:

ESQUIMALT STORM SEWER ASSET MANAGEMENT PLAN: RISK PRIORITIZATION



URBAN SYSTEMS MEMORANDUM

DATE: September 8, 2026
TO: Joel Clary, P.Eng., PMP
CC: Adrien d'Andrade, P.Eng.
FROM: Alex Kempa, P.Eng., Mark Stafford, P.Eng.
FILE: 1688.0013.01
SUBJECT: Esquimalt Storm Sewer Asset Management Plan: Risk Prioritization

1.0 INTRODUCTION

The following memo outlines the risk methodology developed for prioritizing the renewal of the Township of Esquimalt's (the Township) linear storm sewer assets, as part of the Storm Sewer Asset Management Plan. This methodology aligns with the risk principles and approaches developed as part of the Township's 2025 Sanitary Sewer Asset Management Plan.

Risk of failure is a primary consideration for determining *when* and *why to r*enew an asset. It is determined by considering two key components:

1. **Likelihood of failure (LoF)**– typically based on an asset's condition and capacity to identify the probability of failure (both structurally and hydraulically), where failure is defined as the inability to meet level of service commitments (e.g. providing adequate capacity, ensuring protection of the environment and property).
2. **Consequence of failure (CoF)** – evaluates the level of impact an asset's failure would have on elements such as economics, the environment, and social considerations.

When a specific asset's likelihood and consequence of failure are both high, the risk associated with failure is high, therefore warranting a high priority ranking on the list of renewals. Alternatively, when an asset's likelihood and consequence are both low, the risks associated with failure are also low, suggesting renewal of that asset is a lower priority. The methodology outlined below specifies how likelihood and consequence of failure are each determined, and how they are combined to determine risk and arrive at a prioritization ranking for each asset. Applying this framework contributes to consistent and confident asset renewal decision-making.

The outcomes of this process are intended to be considered alongside other capital priorities to develop an integrated capital plan. This may include aligning storm asset renewals with adjacent scheduled projects where appropriate.

2.0 GRAVITY MAIN METHODOLOGY

The methodology for assessing the risk of failure for linear storm sewer assets consists of three parts:

- An assessment of the combined likelihood of failure;
- An assessment of the combined consequence of failure; and
- Combining these condition and consequence assessments to produce asset risk and prioritization ratings

2.1 COMBINED LIKELIHOOD OF FAILURE

The combined likelihood of failure is a function of an asset's condition and capacity deficiencies.

2.1.1 Condition

One of the most common technologies used to evaluate the structural integrity of a gravity main includes closed-circuit television (CCTV). In 2024, Urban Systems supported the Township in translating CCTV records from PDF format into a more user-friendly, codable format in Excel. This CCTV data was originally collected in accordance with the Pipeline Assessment Certification Program (PACP) which uses a standard format and methodology for collecting CCTV data, coding, observations, and data storage. The PACP condition grades assess defects related to either pipe structure or operations and maintenance (O&M). Whereas O&M grades typically trigger routine maintenance and operational activities (e.g., pipe cleaning), the structural grades signal more urgency for replacement or rehabilitation needs which directly informs the prioritization of capital replacement projects, and will therefore be used to inform condition-based likelihood of failure scoring for this analysis. More specifically, the first two values of the structural quick rating provided by PACP will be used in this analysis:

- The **first digit** represents the highest structural defect grade of a pipe segment, where a structural defect affects the structural integrity of the pipe, such as breaks, separation, and pipe deformation, among others. These grades are assigned on a scale of 1-5, with a score of 5 indicating failure and 1 indicating minor defects with failure unlikely in the foreseeable future, as outlined by Table 1.

Table 1: PACP Scoring System—Structural Defect Grade Descriptions

Structural Defect Grade	Defect Description	Estimated Time to Failure
1	Minor defects	Unlikely in the foreseeable future
2	Minor defects	≥ 20 years
3	Moderate defects that will continue to deteriorate	10 – 20 years
4	Severe defects that will become Grade 5 in the foreseeable future	5 – 10 years
5	Defects requiring immediate attention	Has failed or will likely fail within the next 5 years

- The **second digit** represents the number of times the highest structural defect grade has occurred for a pipe segment

PACP combines these two digits, and divides by 10 to achieve a PACP-based likelihood of failure score which will be used to inform the condition rating of gravity mains, where available.

For example, a quick score of 4232 means that the highest structural defect grade of a pipe is 4 and is observed twice over the pipe segment. As a result, the PACP-based likelihood of failure score for this pipe is 4.2. Note, the last two digits of the quick score are not used for this analysis: they represent the next highest structural severity grade and occurrence of this grade over the pipe. The PACP LoF scores range from 1 to 6, however, this risk methodology uses a 1 to 5 scoring system, where 1 indicates very good condition, and 5 indicates very poor condition. Table 2 translates PACP LoF scoring into a 1 to 5 condition ranking that will later be combined with capacity considerations to determine an overall likelihood of failure score for each gravity main.

Table 2: Condition Rank Corresponding to Estimated Remaining Life of Asset

Condition Rank	PACP Likelihood of Failure (LoF)	Asset Age Relative to Design Life (DL)	Condition Description
1	1≤ PACP LoF <1.5	Asset Age is <75% of DL	Very good condition
2	1.5 ≤ PACP LoF < 2.5	Asset age is ≥75% of DL, and <100% of DL	Good condition
3	2.5 ≤ PACP LoF < 3.5	Asset age exceed DL by 0-25%	Fair condition
4	3.5 ≤ PACP LoF < 4.5	Asset age exceed DL by >25%	Poor condition
5	4.5 ≤ PACP LoF ≤ 6	Only applicable where actual, field-level condition data is available	Very poor/failed condition

In certain cases, CCTV data is not always available for the Townships' gravity mains. Therefore, an asset's age and standard service life (based on pipe material) will be used to estimate the remaining useful life of a pipe and gauge its condition ranking. This correlation between remaining useful life and condition rating is described in Table 2. While age serves as a supplemental proxy for condition, its accuracy in representing condition is less certain relative to results from physical property technologies (e.g., CCTV), particularly considering the Township's uncertainty in install year records. For this reason, an asset's age is only recommended to gauge condition in the absence of more reliable data (CCTV). Moreover, to reduce the number of capital projects driven by age alone, the maximum possible condition ranking based on asset age is 4, also shown in Table 2.

The following service life estimates will be used for evaluating pipe condition and are based on a combination of service lives from other local municipal asset management plans and Township staff recommendations:

- *Asbestos Concrete (AC) = 85 Years*
- *Concrete = 90 years*
- *Clay Tile (CT) = 60 years*
- *High-Density Polyethylene (HDPE) = 90 years*
- *Non-reinforced Concrete (NRC) / Reinforced Concrete (RC) / RCCP = 75 years*
- *Polyvinyl Chloride (PVC) = 80 years*
- *Vitrified Clay Pipe (VCP) = 70 Years*
- *VC Relined (VC_Relined) = 60 years*
- *Unknown= 60 years*

2.1.2 Capacity

For capacity, the likelihood of asset failure is based on the hydraulic capacity, hydraulic grade line (HGL) and surcharging/flooding. The flooding criteria is considered as part of the likelihood of failure, rather than consequence of failure because it helps inform the need for pipe upsizing. More specifically, the flooding criteria helps distinguish short-duration, high-intensity events from longer duration events, whereby addressing deficiencies identified under short-duration events through pipe capacity upgrades may not always be the most practical or cost-effective solution, especially when the major system would carry the burden of these events.

Together, Tables 4 and 5 define how these attributes correlate to an overall capacity grade from A (no concerns) to F' (significant concerns). These grades will be linked with condition scoring to arrive at a combined likelihood of failure score, as detailed in section 2.1.3. It is recommended that for storm mains showing the HGL above the crown of the storm main, that services in the area be compared to the HGL during pre-design of identified upgrades.

Table 3: Hydraulic Level of Servicing Criteria for Scoring

Criteria	Score
Hydraulic Capacity (q/Q*)	
q/Q < 1.0	1
q/Q ≥ 1.0	2
Hydraulic Grade Line (HGL)	
HGL < Crown	1
Crown ≤ HGL < Rim Elevation	2
HGL ≥ Rim Elevation	3
Surcharge	
Surcharge Time ≤ 5 minutes	1
Surcharge Time > 5 minutes	2
Flood	
Peak Flood Rate < 0.05 m^3/s OR Flood Volume < 15m^3**	1
Peak Flood Rate ≥ 0.05 m^3/s AND Flood Volume ≥ 15m^3**	2

*q/Q = peak flow/full pipe flow
**Flood volume requirement is the equivalent of a 0.05 m3/s flood lasting for 5 minutes

Table 4: Gravity Main Hydraulic Level of Servicing Rating

HLoS Rating	Capacity	HGL	Surcharge	Flood	Description
A	1	1	1	1	Gravity Main performing as designed
B	1	2	1	1	Adequate capacity; Minimal backwater caused by downstream condition
	1	3	1	1	Adequate capacity; Minimal backwater caused by downstream condition (potential for small flood event)
C	1	2	2	1	Adequate capacity; Significant backwater caused by downstream condition
	1	3	2	1	Adequate capacity; Significant backwater caused by downstream condition (potential for small flood event)
	1	3*	2	2	Adequate capacity; Significant backwater caused by downstream condition (potential for large flood event)
D	2	1	1	1	Marginal capacity
	2	2	1	1	Marginal capacity; Surcharge event < 15 minutes
	2	3	1	1	Marginal capacity; Surcharge event < 15 minutes (potential for small flood event)
E	2	2	2	1	Capacity exceeded; Significant surcharge (> 15 minute) event likely
	2	3	2	1	Capacity exceeded; Significant surcharge (> 15 minute) event likely (potential for small flood event)
F	2	3	2	2	Capacity exceeded; Large flood event likely
F**	1	3***	2	1	Discharge restriction; Large flood event likely

*Applies when the downstream node HGL is rated as a '3', with no consideration for upstream conditions.
**Considers the case when a downstream manhole configuration (sharp bends under high velocities, lack of benching, etc.) or outlet creates backwater conditions without an existing downstream backwater condition.
***Applies only when the downstream node HGL is rated '1', while the upstream node HGL is also rated as a '3'.

2.1.3 Likelihood of Failure: Combining Condition and Capacity

A combined likelihood of failure score is derived by linking an asset's individual condition and capacity scores. Table 5 outlines how the condition and capacity of an asset are considered together to arrive at a combined likelihood of failure score whereby 5 indicates that the probability of failure is very high and a score of 1 indicates that the likelihood of failure is very low.

Table 5: Combined Likelihood of Failure (Gravity Mains)

LoF Score	Condition Ranking	Capacity (hydraulic level of service rating)	Overall Combined Score (Start at bottom, assess if the statement is true to determine overall score. If false, continue upwards until true)
1	1—Very good condition	A/B- Okay to adequate capacity	All remaining scores
2	2—Good condition	C/D-Adequate to marginal capacity	Condition ***OR*** capacity scores: ≥2
3	3—Fair condition	E- Capacity exceeded; Significant surcharge (> 15 minute) event likely (potential for small flood event)	Condition ***OR*** capacity scores : ≥3
4	4—Poor condition	F- Capacity exceeded; Large flood event likely	Condition ***OR*** capacity scores: ≥4
5	5—Very Poor/failed condition	F'- Discharge restriction; Large flood event likely	Both condition ***AND*** capacity score: ≥4

2.2 COMBINED CONSEQUENCE OF FAILURE

The combined consequence of failure is typically a function of the social/community service impacts, financial liabilities (incurred directly or indirectly by the Township), and environmental impacts that might occur should the infrastructure fail. The magnitude of these categories are respectively estimated using adjacent up and downstream land uses, road classification, and proximity to downstream watercourses, as further described in the following sections.

Health and safety, and reputation are among other categories sometimes considered in evaluating consequence, however, proxies of the former category are typically unknown, while proxies for the latter are already represented by existing categories. The severity of injury/illness (health and safety consequence) in the case of a storm asset failure is difficult to accurately estimate and without accurate estimation, this category provides minimal value in the consequence assessment.

2.2.1 Social/Community Service Consequences

The scale of population impacted by a service failure is the dominant driver for social/community service consequence. This is estimated based on the upstream and downstream land uses immediately adjacent to the pipe, as the repair of an asset located in a highly populated area (e.g., commercial area) is likely to inflict greater social impacts in comparison to that located within a minimally populated area (e.g. industrial area). These impacts are primarily associated with the asset repair/construction process, rather than service interruptions, which can typically be rapidly mitigated by bypass pumping. Therefore, adjacent land use designations are used to assign a baseline score for social/community service consequences on a scale from 1 to 5, as shown in Table 6, where 1 indicates minimal/ no social impacts and 5 indicates high social impacts.

A main's depth is another factor that can impact social consequence by prolonging the level of service disruption. Therefore, the baseline score for social consequence (described above) increases when a gravity main is at a depth of 3m or greater.

2.2.2 Financial Consequences

The cost to repair a storm main is often closely linked to the type of road affected. For instance, a failure within an arterial corridor or highway presents greater traffic control and road reconstruction requirements compared to a failure within a local residential road. Road classification, therefore, serves as a proxy to establish a baseline score for financial consequence on a scale from 1 to 5, as shown in Table 6. A score of 1 indicates that the financial liabilities incurred by the Township are lower, whereas 5 indicates that financial implications are significant.

A main's proximity to neighbouring structures is another factor that can also impact financial consequence of failure. Therefore, the baseline score for financial consequence increases when a main is within 6 m of a structure.

Finally, the size and depth of a main also impacts the cost of a repair. As such, the consequence increases with mains 375 mm and larger or at depths of 3m or greater.

2.2.3 Environmental Consequences

Prior to entering the piped stormwater system, runoff can collect and transfer pollutants such as metals, hydrocarbons, and sediments, among others. If a stormwater asset fails, this contaminated runoff may be discharged directly to nearby watercourses, potentially introducing pollutants, increasing flow volumes and causing downstream erosion and sedimentation issues. These issues can pose significant risk to sensitive ecosystems. For this reason, the scoring of environmental consequence is based on a pipe's proximity to watercourse as defined in Table 6. The baseline scoring for environmental consequence ranges from 1 to 5, where a 1 indicates that asset failure would have minimal impacts on a watercourse, whereas a 5 indicates that a watercourse is close, and failure would have significant impacts.

A main's proximity to a contaminated site can also lead to environmental impacts in the event of flooding. As such, the environmental consequence increases when a pipe is within 15m of a contaminated site.

2.2.4 Combined Consequence of Failure

Typically, the more significant the combined social, financial and environmental consequences, the greater the reputational impact of an asset's failure. Therefore, the combined consequence of failure scores quantified in Table 6 can also be considered the reputational consequence, whereby the greater the combined consequence, the greater the reputational risk.

Table 6: Combined Consequence of Failure Matrix for Gravity Mains

Score	**Social/Community Services**[1] Indicator: Immediate adjacent upstream land uses	**Financial**[2] Indicator: Road classification	**Environmental** Indicator: Proximity to watercourse[3]	**Combined (Reputational) Consequence** (start at bottom, assess if the statement is true to determine overall score, continue upwards until true)
1	Agricultural land uses (lowest risk, <5 people impacted, if any)	RSV (service road)	No downstream watercourse within 50m	All remaining scores
2	Industrial land uses (low risk, approx. 5-20 people impacted)	RLN (road lane), RRT (restricted road, not publicly accessible)	Asset is 30m to 49m from downstream watercourse	1 category scores: 3 OR ≥ 2 categories score: 2
3	Low-density land uses (moderate risk, approx. 20-50 people impacted)	RLO (local road), RST (strata road)	Asset is 15m to 30m from downstream watercourse	1 category scores: 4 OR ≥ 2 categories score: 3
4	Medium-density land uses (high risk, approx. 50-100 people impacted)	RC1 (major collector), RC2 (minor collector), RRC (recreation road), RYL (yield lane)	Asset is 10m to 15m from downstream watercourse	1 category scores: 5 OR ≥2 categories scores: 4
5	High-density and critical land uses (highest risk, approx. 100-500 people impacted)	RA1 (major arterial)	Asset is within 10m of downstream watercourse	≥ 2 categories score: 5 OR 1 category scores: 5 AND 2 categories score: 4

[1] *Increase score by 1 (to a maximum of 5) if depth of pipe is ≥3m*

[2] *Increase score by 1 (to a maximum of five) if pipe is within 6m of a structure, or size is ≥ 375mm, or depth of pipe is ≥3m*

[3] *Increase score by 1 (to a maximum of five) if pipe is within 15m of a contaminated area*

2.3 RISK FACTORS FOR CAPITAL PLANNING

Integrated capital planning is reliant on the prioritization of asset renewal. This process is driven by the risks associated with individual asset failure and derived from the asset's combined likelihood (probability) and consequence (impact) of failure. Table 7 correlates the combined likelihood and consequence of failure into a risk-based prioritization ranking for capital planning. This table uses input values resulting from the combined likelihood and consequence of failure tables above to determine a risk-based priority ranking from P1 (Priority 1, top priority) to P3 (Priority 3) whereby a P3 asset renewal is important, but less urgent in comparison to the higher risk P1 or P2 assets.

Table 7: Risk Prioritization Matrix for Gravity Mains

Combined Consequence of Failure					
5				P2	P1
4				P2	P1
3		N/A		P3	P2
2				P3	P2
1				P3	P2
	1	2	3	4	5

Combined Likelihood of Failure

The risk-matrix above builds off asset management best practices and is tailored to serve the unique needs and data availability of the Township. We have seen similar prioritization schemes adopted by other municipalities on Vancouver Island, all rooted in the following core principles:

- As a critical community service, the storm sewer system demands proactive attention and investment decisions. The goal is to replace assets before they fail and cause service disruptions and other impacts, as described above. Therefore, all assets with a likelihood of failure (LoF) of 4 or 5 (i.e., failed or failing) are prioritized, regardless of the consequence of failure (CoF) score (as asset failure is not accepted even when the consequence of failure is low).
    - Recall that assets with a LoF score of 5 are characterized by either failing (or nearing failure) in terms of condition AND capacity, while assets with a LoF score of 4 are characterized by failing (or nearing failure) in terms of condition OR capacity.
- Priority ratings are additionally differentiated by CoF scores; mains with a high combined CoF (4 or 5) naturally present higher risks, but such risks may be managed by performing maintenance/upgrades throughout the asset's life. The need for more extensive maintenance associated with these higher risk assets results in their prioritization over storm sewers with lower CoF scores (3 or lower).
- The renewal of lower priority assets may require deferral depending on funding availability. A tool is needed (e.g., the risk-matrix and methodology) to help understand which prioritized assets can be safely differed (if needed) and what this means for risk tolerance levels. Deferring the renewal of prioritized assets will be discussed on an as-needed basis in the Asset Management Plan, pending results of the risk assessment.

It is important to recognize that an asset with a moderate or unclassified prioritization ranking may transition to having a higher risk and prioritization over time, becoming a more urgent priority due to the simple deterioration of the asset. With this in mind, there must be emphasis on keeping the risk and prioritization assessment a dynamic and living process, requiring monitoring and reviews on a regular basis.

Sincerely,

URBAN SYSTEMS LTD.

A. Kempa

Alex Kempa, P.Eng.
Project Steward and Engineer

Mark Stafford, P.Eng
Civil Engineer

/ak

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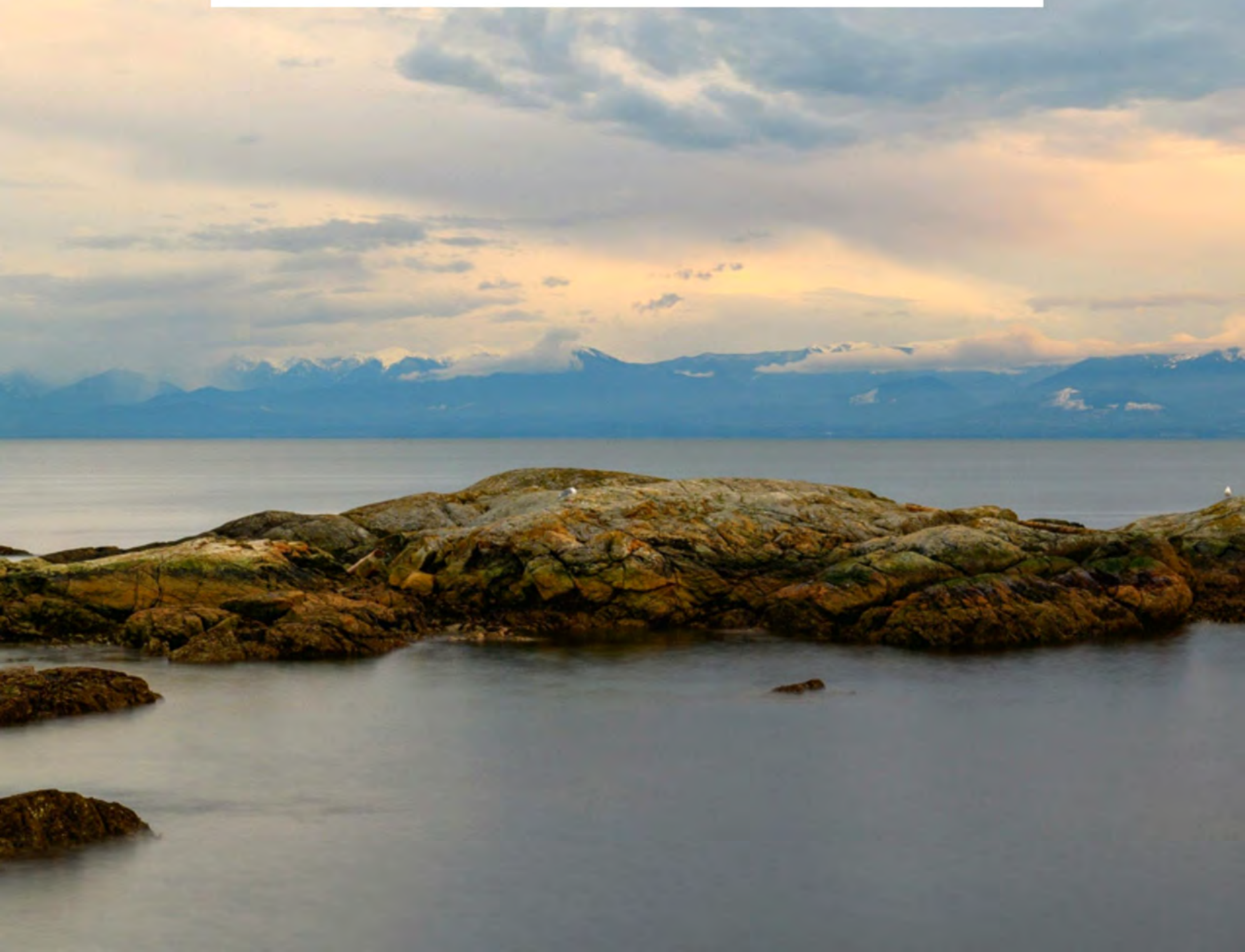
APPENDIX B:

STORM SEWER ASSET MANAGEMENT PLAN: OPERATIONS AND MAINTENANCE PRACTICE REVIEW



DATE: September 8, 2026
TO: Joel Clary, P.Eng.
FROM: Alex Kempa, P.Eng., Mark Stafford, P.Eng.
FILE: 1688.0013.01
SUBJECT: Storm Sewer Asset Management Plan: Operations and Maintenance Practices Review

1.0 BACKGROUND

Urban Systems is working with GeoAdvice and the Township of Esquimalt (the Township) to complete a Storm Sewer Asset Management Plan (SSAMP) which includes the identification of priority upgrade projects required in the sewer system to maintain and improve overall system performance and enhance stormwater quality. Part of this scope includes identifying the Township's current operation and maintenance (O&M) practices for the storm sewer system and comparing them to industry standards / best practices to create a list of recommended improvements. By improving O&M practices, the Township helps optimize system performance, enhance stormwater quality, reduces risks of infrastructure failure, and can extend the lifespan of assets.

Generally, the Township's day-to-day O&M activities are reactive in dealing with breaks, backups, root intrusion and flushing, while other practices such as catch basin vacuuming and street cleaning are more routine. A summary of the Township's existing O&M practices are captured in **Table 1** and based on a meeting with Township staff, including Public Works on April 10, 2026. This table also includes a list of recommended actions to help align current practices with industry standards and provides high-level, order-of-magnitude cost estimates that focus on next-step funding needs.

2.0 O&M BUDGET

In 2026, the Township budgeted approximately $430,000 for storm sewer O&M activities. Township staff indicated that the current state of the storm sewer system is similar to that of the sanitary sewer program. Existing funding is generally sufficient for existing tasks and often goes underspent due to a lack of staffing to manage additional work. Although excess funding is available, the existing budget is not large enough to significantly expand services such as a hiring additional staff members, annual CCTV inspections or flushing programs. Furthermore, due to the absence of integrated digital systems, for tracking O&M costs, activities and infrastructure repair expenses in the Township, there is an opportunity to enhance access to detailed information in a centralized manner that would provide a clearer understanding of the breakdown of existing budgets and a more refined estimate of O&M funding needs. In the meantime, this analysis proposes high level budgetary considerations based on our understanding of existing practices, needs identified by staff and alignment with industry standards.

To meet the increasing demands of capital project delivery, stormwater quality improvements and the ongoing maintenance of the existing storm sewer system, additional resources will likely be required. This is driven by the priorities of replacing deficient infrastructure, actioning stormwater quality improvements, and addressing the O&M needs of the system to optimize service level and life.

If prioritized replacement projects are deferred, the risk of infrastructure failure escalates, leading to a greater reliance on reactive maintenance to sustain service levels and a lessened ability to complete proactive maintenance. This reactive approach is not only more resource-intensive but can also result in increased service disruptions, and higher repair costs. Conversely, timely investment in capital replacement reduces the likelihood of system failures and allows for a more proactive O&M strategy. Balancing these priorities necessitates a robust staffing plan that can effectively support both areas.

Table 1: Township O&M Practices vs. Recommendations Based on Best Practice

Recommended Practice	Current/Previous Practices	Recommended Actions
CCTV Inspection Program	No active program – temporary program (2017 – 2023) completed ~50km (~74% of network) based on CCTV records. Currently, the Township has access to push cameras to do their own inspections, where appropriate, but otherwise rely on contractors to perform inspections. Generally, these inspections are relatively reactive.	Short-Term, Esquimalt-Specific Needs: • Create a formal CCTV Program focused on: o Reviewing existing CCTV records in high priority areas, as determined in the SSAMP. The purpose of this review if to identify appropriate renewal methods for condition-driven priorities (e.g., repair, replace, reline) o Scheduling CCTV inspections so that the complete network is captured every 10 years. Aim to execute the start of this program within the next year and ensure inspection includes recommended actions to assist with future capital planning (e.g., lining, point repair, full replacement, etc.). General Best-Practices: • Identify and re-CCTV any pipes near the end of their lives (e.g., < 20% of design life remaining, or CCTV score greater than 3) every 5 years. • Aim to complete point repairs/rehabilitation of infrastructure based on CCTV outcomes as soon as funding becomes available. Note, best practice is to complete within one year of inspection, however, this will be difficult given the Township's current backlog of capital priorities but should be a target for the future as backlog is addressed. • Regularly update the internal CCTV results database as additional inspections are performed. • Continue to complete flushing prior to CCTV inspections.

Recommended Practice	Current/Previous Practices	Recommended Actions
Flushing Program	Flushing is generally performed reactively and does not follow a formal program. A formalized flushing schedule, and tracking program is desired by Township staff.	• Identify and document hot spots requiring flushing (e.g., areas prone to sediment and debris build up, and/or bellied pipes). Where possible, use existing CCTV data and GIS attributes (e.g., shallow pipe-grade, land uses, service record call outs etc.) to help inform this list of hot-spots. At a minimum, these hotspots should be flushed annually, unless otherwise specified by staff.
Catch Basins/Street Sweeping	Catch basins vacuuming is reactionary and typically completed annually to remove sediment, debris and other materials. A full-time operator is dedicated to street sweeping. Although scheduling is not synced with other stormwater operations (e.g., catch basin vacuuming), operators have a strong understanding of excessive leaf fall areas that need to be cleaned in the fall.	• Increase catch-basin cleaning frequency to 2-4 times annually, especially in areas where metals, polycyclic aromatic hydrocarbons (PAHs) and sediment is high (e.g., streets within the Kinver, Uganda, Forshaw and Garthland areas)[1]. • Review street sweeping program and confirm commercial/high traffic areas are cleaned bi-weekly to help improve stormwater quality. • Coordinate street sweeping and catch basin vacuuming schedules so that catch basin cleaning will follow street sweeping. Document areas that have been cleaned in a database (e.g., GIS). • Develop sediment disposal protocols.

[1] Refer to the *Storm Sewer Asset Management Plan – CRD Water Quality Review* (Urban Systems, 2026) for more information including opportunities for oil and grit separators.

Recommended Practice	Current/Previous Practices	Recommended Actions
Ditches	No specific maintenance practices are in place, however, staff identified an opportunity to improve public awareness regarding the function of roadside ditches, including the importance of preserving their drainage capacity.	• Develop a targeted education program highlighting the role of ditches in conveying stormwater, the risks and consequences of unauthorized infill and maintenance responsibilities overall.
Culverts	No active program in place, although staff have noted several culverts requiring specialized maintenance needs.	• Develop and implement a Culvert Replacement Program, inclusive of condition assessments and associated upgrade costs. Clearly outline what maintenance activities will be the responsibility of staff and the expectations of residents. • Create a targeted education program based on the outcomes above to inform residents of their responsibilities.
Stormwater Quality Monitoring & Maintenance	Practices are primarily reactive, with actions typically initiated in response to public reports of spills or other observed water quality concerns. The Capital Regional District (CRD's) has a Stormwater Quality Program that includes the collection and analysis of stormwater quality samples to identify pollutant levels and understand impacts to receiving waters. Through this program, the CRD identifies priority outfalls, potential contaminant sources, and locations for further investigation.	• Follow recommendations to improve stormwater quality, as outlined in the *Storm Sewer Asset Management Plan – CRD Water Quality Review* (Urban Systems, 2026) and ensure O&M requirements (including responsibilities, access, inspection and maintenance frequency) are defined and documented to support long-term performance. • Continue collaborating with the CRD on stormwater data collection, findings and follow-up actions.
Low Impact Development (LID), and Green Infrastructure (e.g., rain garden, bioswale, permeable pavement etc.)	Staff indicated that there are several green infrastructure locations across the Township, including Yarrow Place and Sioux Place rain gardens, however they are not maintained or operated by the Township.	• As staff consider opportunities to integrate LIDs and other green infrastructure into capital planning, ensure O&M requirements (including responsibilities, access, inspection and maintenance frequency) are defined and documented to support long-term performance.

Recommended Practice	Current/Previous Practices	Recommended Actions
Maintaining Private Facilities (e.g., storage facilities, swales, rock pits etc.)	Staff confirmed that the location of private stormwater facilities (e.g., storage facilities) are not well documented and performance testing and maintenance compliance varies. Any private facility is currently maintained by owners.	• Develop an education and outreach program that clearly identifies an owner's maintenance responsibilities and the importance of properly functioning facility. • Consider requiring proof of maintenance from facility owners to ensure systems are operating as designed. • As part of the next update to the Subdivision and Development Servicing Bylaw, consider design requirements and the application of private stormwater management facilities to ensure they provide effective and sustainable long-term performance.
Flow Monitoring	Currently there is no active flow monitoring program, although temporary monitoring was completed as part of the Storm Sewer Asset Management Plan.	• In major watersheds (e.g., south of Craigflower Rd.) install 2 – 4 flow monitors per catchment, depending on size and land-use variations. Monitor these sites for four months during the winter/spring when rainfall is likely. Aim to monitor all catchments over a 5-year period. These monitors should be accompanied by a rain gauge. • Use flow monitoring data to re-calibrate the hydraulic model as part of the next model update • Complete regular maintenance activities for active flow meters and rain gauges to ensure good working condition (e.g., cleaning accumulated debris and silt from area, checking battery etc.) Maintain records of such activities/inspection.

Recommended Practice	Current/Previous Practices	Recommended Actions
Record Keeping	Field reports do not currently follow a standard structure and are stored on the Township's server using a folder for each pipe segment that includes CCTV records, where available. GIS notes section is also used to record field information. Overall, there is a strong desire for structured tracking and asset management systems to record maintenance activities and transition from reactionary to proactive maintenance.	• Explore available software options for work-order-tracking and evaluate their complexity, integration requirements, costs, and alignment with operational needs and budget. Consider collaborating with other local governments of similar size to gather input on their experiences and challenges with software adoption.
Develop a Maintenance Calendar	Not implemented	• Develop a comprehensive maintenance calendar/guide that documents specific maintenance needs for the various components of the storm sewer system. • Consider dividing the service into maintenance 'zones' such that maintenance practices are completed by zone (e.g. address zones 1 and 2 in Year 1, address zones 3 and 4 in Year 3 etc.). Zones may be based on variety of factors including infrastructure condition, type, or age, critical service areas/infrastructure, and maintenance access. There will likely be efficiencies to developing this calendar alongside the Standard Operating/Safe Work Procedures.
Standard Operating/ Safe Work Procedures	Not implemented	• Create a manual outlining the protocols to perform operations and maintenance practices safely. These procedures are intended to standardize work processes, ensure compliance with regulatory requirements and enhance safety.

Recommended Practice	Current/Previous Practices	Recommended Actions
Emergency Response Plan	Not implemented	• Create an Emergency Response Plan specific to the storm sewer system including the identification of potential emergencies and response plan procedures.

3.0 RECOMMENDATIONS

Proactive investment in both capital replacement and O&M is essential for managing the storm sewer system effectively. While capital projects reduce long-term risks, robust O&M practices are key to maintaining system performance and mitigating immediate challenges.

Overall, the results of the storm sewer risk assessment reveal that the majority of capital priorities are condition deficient, as informed by CCTV inspection. Furthermore, the funding gap between current budgets and capital needs indicates that deferral is expected as part of Esquimalt's capital implementation plan. This emphasizes the importance of operations and maintenance practices, such as continued CCTV inspection, and flushing, among others, to help ensure Esquimalt continues to meet desired service levels.

Acknowledging the need for staffing resources, and additional funding to align with O&M best practices, the list of recommended actions below are categorized based on priority, with consideration of level of effort and staff capacity to adopt and implement.

Due to the limitations of tracking historic O&M costs, activities and infrastructure repair expenses, the budgets proposed below are high-level estimates and based on our understanding of staff O&M practices and our experience working in other communities. As outlined in the list of actions below, there is important foundational work required to finetune future O&M needs and therefore budgets. These items have been prioritized over the short-term to support the Township in advancing their understanding of O&M needs.

3.1 HIGH PRIORITY/SHORT-TERM (1-2 YEARS)

- Develop a formal CCTV program that includes review of high-priority CCTV records (refer to the Storm Sewer Asset Management Plan) to inform appropriate renewal approaches (e.g., point repair vs. lining vs. replacement), and create a schedule for updating CCTV inspections across the Township's storm sewer network.
    - **Budget:** $5,000
- Begin implementing the above CCTV program so that all storm sewer pipes are inspected every 10-years and those nearing end of life (e.g., <20% of design life remaining, or CCTV score greater than 3) every 5 years. This approach avoids repeatedly inspecting newer or good-condition pipes where the likelihood of significant deterioration is low, while ensuring that assets with known deficiencies remain a top priority for inspection. Based on the most recent CCTV inspections completed from 2017 – 2023, the program should be completed by 2033 (i.e., over the next 7-years). This should include a review of CCTV records and documentation or recommended action (e.g., repair, reline, replace, etc.)
    - **Budget:** Minimum of $65,000 annually, for the next 7-years. After year 7, budget approximately $45,000 annually as program completion is spread across 10-years, rather than 7.
- Increase frequency of catch-basin cleaning to 2-4 times annually
    - **Budget:** Moving forward, add an additional $10,000, annually, to existing catch-basin cleaning budgets. This will increase the frequency of catch-basin cleaning in high priority, stormwater quality concern areas to ~2-times per year. This frequency should be reviewed after 2-3 years, alongside updated stormwater quality data and operator comments to determine if frequency needs to be adjusted.

- Engage with street sweeping operators to confirm existing practices around commercial/high-traffic areas and determine potential funding needs to achieve bi-weekly cleanings in these areas.
  - **Budget:** Assuming these areas are already cleaned weekly, the Township should be prepared to add an addition $5,000 annually toward street sweeping efforts to ensure these priority areas are swept bi-weekly.
- Identify and formally document a list of known and potential hot-spots for flushing, including frequency requirements. Implement program within the next 2 to 3-years.
  - **Budget:** Estimated $20,000 investment to set up a database/system (ideally that integrates with the Township's GIS) of hot-spot locations and frequency requirements. The cost of implementation will depend on the results of the initial investigation and should consider flushing that will take place as part of CCTV investigations. Furthermore, the Township will also need to consider if this activity will be completed by Public Works staff or a contractor. To assist with planning, roughly 700m of gravity main can be flushed in a single day. If contracted out, this is equivalent to approximately $1,800 in flushing fees per day.
- Complete additional flow monitoring in advance of the next SSAMP, or sooner as funds become available.
  - **Budget:** $12,000 per catchment for four months of temporary monitoring. We recommend the Township monitor ~2 - 3 catchments per year to capture the majority of the network over a 5-year period.
- Initiate software exploration/options evaluation for work order tracking, including collaboration with other local governments. While the exploration phase is recommended over the short term, software adoption and integration (e.g., training) will be a multi-year process, whose cost will depend on the outcomes of the options analysis. Note, this recommendation is repeated from the Township's Sanitary Sewer Asset Management Plan and is not intended to be completed as part of a separate process. A single process for software exploration can be completed so long as evaluation considers the needs of both services. To this extent, the budget proposed below could be split across sanitary and storm sewer O&M budgets.
  - **Budget:** $50,000.
- Document Standard Operating / Safe Work Procedures and create and maintenance calendar in parallel.
  - **Budget:** $50,000 - $100,000
- Create a Storm Sewer Emergency Response Plan over the next 2 – 3 years.
  - **Budget:** $25,000

3.2 MODERATE PRIORITY/NEAR-TERM (3-5 YEARS)

- Develop a Culvert Replacement Program including a condition assessment of the Township's culverts, and documentation of staff-led maintenance responsibilities. Condition inspections should be completed every 5-years.
  - **Budget:** $15,000. This assumes ~10 culverts, based on GIS data.

- Develop and deliver public education program(s) focused on the maintenance of culverts, private stormwater facilities and ditches. The purpose of these initiatives is to educate the public of the importance of these systems on drainage management and their individual responsibilities for their upkeep. These topics could form part of a broader stormwater education campaign or be delivered individually.
  - **Budget:** $10,000
- Plan for increased O&M needs as LIDs and green infrastructure are implemented to support stormwater quality objectives.
  - **Budget:** $1,000 annually. The cost of maintaining these facilities will depend on the type of LID/green infrastructure installed, along with the quantity. For now, the proposed budget assumes maintenance of additional oil & grit separators, however, will need to be revisited as capital decisions are made.
- Update Township's SSAMP:
  - **Budget:** ~$200,000. Like the Sanitary Sewer Asset Management Plan, this budget is not typically included within the O&M budget profile, however, is listed here to support comprehensive utility planning and to emphasize the importance of future updates to the Master Plans.

3.3 LOWER PRIORITY/LONG-TERM (+6 YEARS)

- Continue implementing CCTV program and inspections, so the entire stormwater network is re-inspected over the next 7-years and re-assessed every 10-years. Include time to review inspection results and record recommended action (e.g., repair, line, replace etc.). Both short and long-term budgets for this task are proposed in Section 3.1.

3.4 BUDGET SUMMARY

Based on the recommendations proposed above, but not including the SSAMP update nor the software exploration budget (as this has already been accounted for in the Sanitary Sewer Asset Management Plan), the average annual, additional budget needs for each of the time horizons is estimated as follows:

- High Priority, Years 1 – 2: Approximately $175,000, annually,
- Moderate Priority, Years 3 -5: Approximately $130,000 annually,
- Low Priority, Years 6 – 10: Approximately $108,000, annually.

The distributions of these costs over a 10-year period are shown in Table 2.

Please note, these estimates are intended to provide an order of magnitude appreciation for budgetary needs and does not include the effort of existing staff to respond to emergency repairs, back-ups, or new connections which are understood to account for the majority of Public Works' existing day-to-day activities. Furthermore, we have not included fees associated with software adoption/integration (e.g., license fees, procurement, training etc.) or annual flushing fees. Budgets for these practices should be determined following additional investigation as proposed above. Similarly, annual budgets should be refined as more information on operator responsibilities is known with respect to culvert maintenance, and LIDs/green infrastructure, in particular.

Table 2: 10-Year O&M Funding Needs

YEAR	1	2	3	4	5	6	7	8	9	10	TOTAL
CCTV Program	$2,500	$2,500									$5,000
CCTV Inspection	$65,000	$65,000	$65,000	$65,000	$65,000	$65,000	$65,000	$45,000	$45,000	$45,000	$590,000
Catch-Basin Cleaning	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$10,000	$100,000
Street Sweeping	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$5,000	$50,000
Flow Monitoring (6 monitors for 4 months each)	$36,000	$36,000	$36,000	$36,000	$36,000	$36,000	$36,000	$36,000	$36,000	$36,000	$360,000
Standard Operating / Safe Work Procedures	$50,000	$50,000									$100,000
Storm Sewer Emergency Response Plan		$12,500	$12,500								$25,000
Culvert Replacement Program					$15,000					$15,000	$30,000
Public Education Programs			$3,333	$3,333	$3,333						$10,000
LID & Green Infrastructure O&M			$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$1,000	$8,000
TOTAL	$168,500	$181,000	$133,000	$120,500	$135,500	$117,000	$117,000	$97,000	$97,000	$112,000	$1,278,000
Average Annual	**$175,000**		**$130,000**			**$108,000**					

Overall, the reactive approach to existing O&M practices is understandable given the poor condition of the storm sewer system. While existing budgets are generally proportional to those in other communities, the difference primarily lies in system condition – better maintained systems allow others to adopt more proactive practices, rather than react to the demands of a more deteriorated system. The practices and preliminary budgets proposed herein help align the Township with best practices; however, are expected to change as the scope of O&M practices are finetuned (e.g., street sweeping practices, installation of LIDs/green infrastructure), and existing reactionary practices are accounted for.

Without additional resources available to the Township, it will be difficult to increase the volume of capital project delivery, continue to react to system challenges through O&M and increase the level of proactive O&M practices. These resources may include the hiring of more staff or external contractors who will likely be needed to support a transition toward more proactive O&M practices while continuing to address the realities of a deteriorated stormwater system. Before determining the level of additional resources needed, the Township should complete the investigations proposed herein to identify specific funding needs related to services such as flushing, and maintenance of LIDS/green infrastructure and culverts.

Sincerely,

URBAN SYSTEMS LTD.

A. Kempa

Alex Kempa, P.Eng.
Project Steward and Engineer

Mark Stafford, P.Eng.
Civil Engineer

/ak

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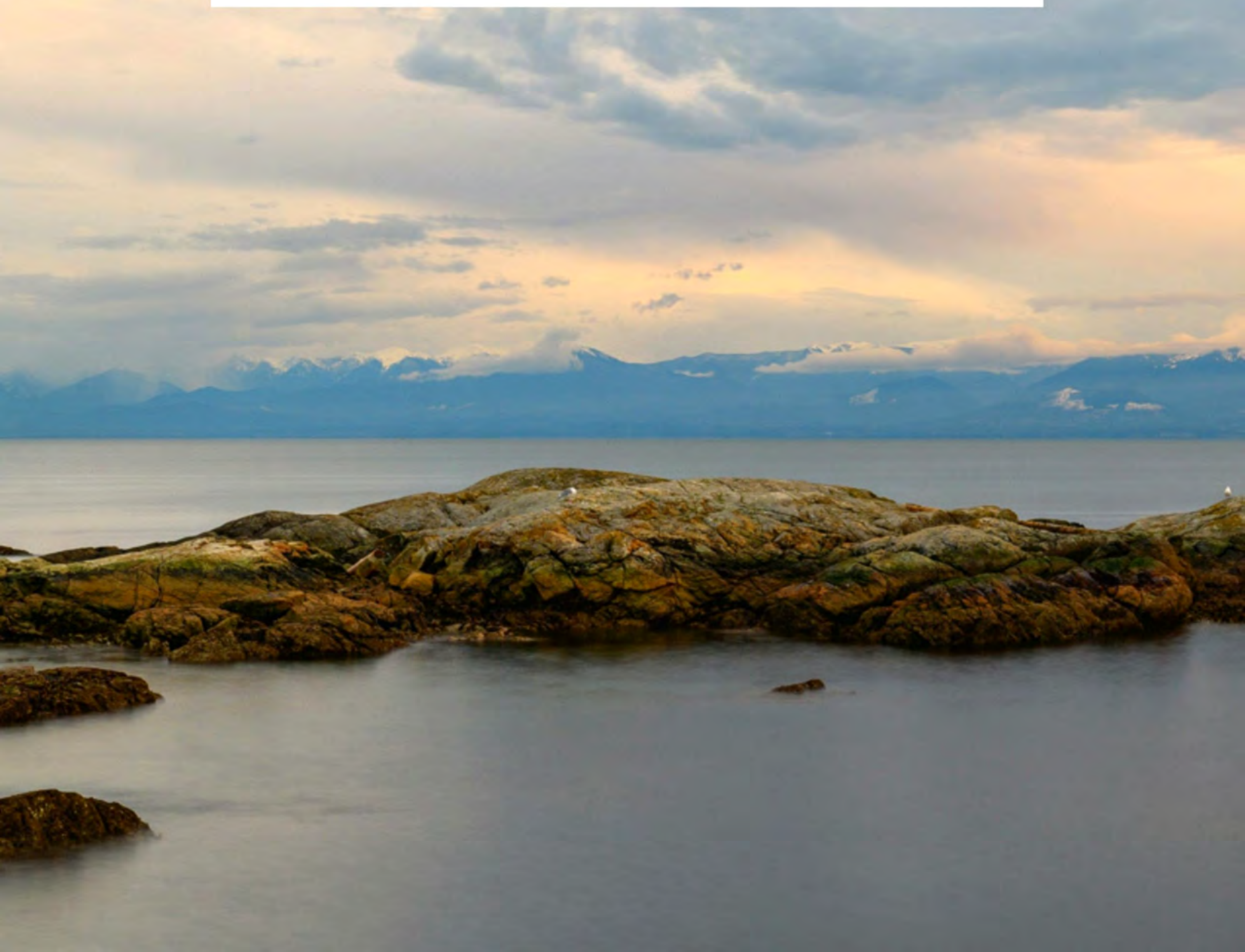
APPENDIX C:

STORM SEWER ASSET MANAGEMENT PLAN - CRD WATER QUALITY REVIEW



URBAN SYSTEMS MEMORANDUM

DATE: May 27, 2026
TO: Joel Clary, P.Eng, PMP
CC: Adrien d'Andrade, P.Eng
FROM: Zoe Tarren, R.P.Bio, Alex Kempa, P.Eng.
FILE: 1688.0013.01
SUBJECT: Storm Sewer Asset Management Plan - CRD Water Quality Review

1.0 INTRODUCTION

The following memo outlines the review methodology of available stormwater discharge and sediment quality data collected throughout the Township of Esquimalt's (the Township's) storm drainage system. The purpose of the review was to identify potential public health concerns, environmental risks, and opportunities to improve stormwater quality management. The review was undertaken to provide targeted recommendations and strategic guidance to support the Township's 2026 Storm Sewer Asset Management Plan.

The review included:

1. **Background Review** – Review of Capital Regional District (CRD) Stormwater Quality Reports and historical monitoring data.
2. **Prioritized Sites** – Detailed analysis of CRD stormwater and sediment quality datasets to identify trends, data gaps, and additional monitoring requirements.
3. **Risk Matrix** – Development of exceedance frequency, exceedance magnitude, and weighted risk analysis.
4. **Cross Reference Infrastructure Issues** – Review of previous infrastructure studies and cross-referencing of identified infrastructure deficiencies with observed water quality trends.
5. **Prioritized Recommendations** – Development of prioritized recommendations to improve stormwater quality and reduce public health and environmental risk.

2.0 CAPITAL REGIONAL DISTRICT (CRD) STORMWATER QUALITY PROGRAM (2011-2025)

The CRD Core Area Stormwater Quality Reports assess the stormwater discharge quality throughout their Core Area municipalities to identify potential public health and environmental concerns associated with stormwater outfalls and drainage systems. The program evaluates indicators including E. coli, metals and polycyclic aromatic hydrocarbons (PAHs) within both stormwater and sediment samples, while also considering factors such as discharge location, receiving environment sensitivity, public interaction, and known infrastructure conditions.

2.1 CRD'S ENVIRONMENTAL & PUBLIC HEALTH FRAMEWORK

The initial review focused on the CRD's existing stormwater public health and environmental concern rating framework to identify known and previously documented priority stormwater discharge locations within the Township. The CRD framework is used to categorize and prioritize stormwater outfalls based on factors such as bacteriological contamination, chemical contaminant concentrations, environmental risk, and potential public health concerns.

The CRD uses the following framework to monitor, categorize, and prioritize stormwater discharges throughout the Township:

1. High or moderate public health concern ratings
2. High or moderate environmental concern ratings
3. Listed for corrective action
4. Recommended for action due to elevated chemical contaminant concentrations

The CRD framework and prioritization process formed the basis of Urban Systems' initial desktop review and helped identify previously documented areas of concern prior to undertaking the more detailed data review, exceedance analysis, and risk assessment completed as part of this study.

The CRD framework categorizes stormwater quality results using the matrix presented in **Figure 1.1.**

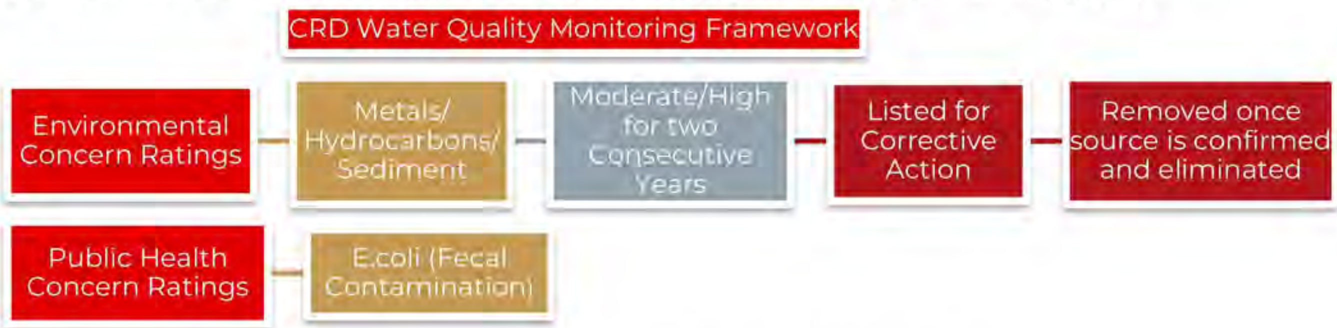


Figure 1.1: CRD Water Quality Monitoring Framework

Once the known priority discharge sites were identified, the assessment evaluated long-term trends, exceedance frequency, exceedance magnitude, recurring contaminant patterns, and sediment accumulation trends to better identify chronic issues, potential contaminant sources, and areas requiring further investigation or corrective action.

2.2 PARAMETERS MEASURED

The CRD stormwater sampling program monitored stormwater discharges across the Township biannually for a range of physical, chemical, and bacteriological parameters to assess stormwater quality, identify potential contaminant sources, and evaluate potential risks to receiving environments.

The key parameters included:

1. **Bacteriological (e.g., E. coli and total coliforms)** – to assess potential human and animal waste inputs and identify possible sanitary cross-connections, inflow and infiltration (I&I), or other public health concerns.
2. **Total metals** – to assess water quality and identify contaminants commonly associated with roadway runoff, sediment transport, industrial/commercial activities, and aging infrastructure.
3. **Polycyclic Aromatic Hydrocarbons (PAH)** - to assess the presence and concentration of hydrocarbon-related compounds typically associated with petroleum products, vehicle-related runoff, industrial activities, and urban sediment accumulation.
4. **Water v Sediment Data** - Water and sediment samples assess different parts of the aquatic environment:
   a. **Water Samples:** provide a snapshot of current conditions and are often influenced by recent rainfall, runoff events, stormwater discharges, tides, seasonal variation, and active contaminant inputs. They are commonly used to assess immediate risks to aquatic life, public health, and downstream receiving environments.
   b. **Sediment samples**: assess contaminants which have settled/accumulated within bottom sediments over time. They provide detailed insight of long-term contamination conditions within the aquatic environment *(**NOTE** – sediment samples were only taken for sites which have been listed as an 'Environmental Concern').*

2.3 WATER QUALITY GUIDELINES

Water quality guidelines (WQGs) are used to support decision-making related to water quality and provide a framework for assessing potential environmental risk. Exceeding a WQG does not necessarily indicate unacceptable environmental effects; however, it may indicate an increased potential for adverse impacts and the need for additional investigation.

Several different WQGs exist, and the applicable guideline depends on the sample type, receiving environment, and assessment objective.

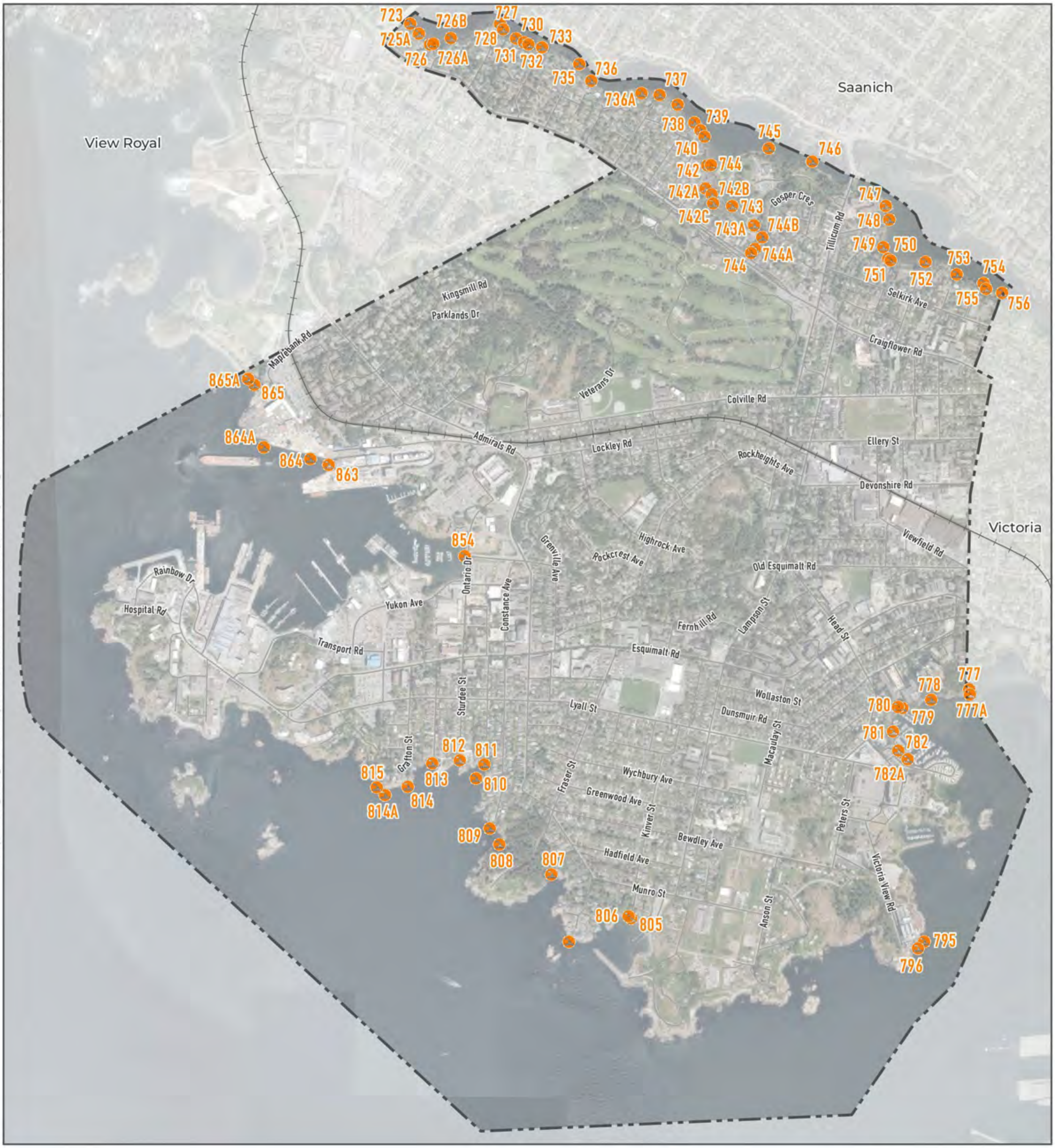
The guidelines used in this assessment were:

- BC Water Quality Guidelines for the Protection of Aquatic Life (BCWQG),
    - Freshwater and Marine
- Canadian Council of the Ministers of the Environment (CCME) Guidelines for the Protection of Aquatic Life.
    - Freshwater and Marine

Although storm drains are not considered viable aquatic habitat, comparison to aquatic life guidelines provides an indication of the potential risk to downstream receiving environments. Marine aquatic life guidelines were considered the most applicable, as the stormwater discharges ultimately drain to the marine foreshore. However, freshwater aquatic life guidelines were also considered, as stormwater runoff may pass through streams, ditches, and other freshwater conveyance systems that may provide fish habitat prior to discharging to the marine environment.

3.0 CRD BACKGROUND REVIEW & KNOWN PRIORITY SITES

The results outlined within the CRDs Stormwater Quality Reports from 2011- 2024 were used to identify recurring or chronic areas of concern. These sites were then flagged as '**Priority Sites**' for further review. **Figure 3.0** shows the CRD sampling locations and their associated site identification numbers, referenced throughout this report.



Township of ESQUIMALT

Storm Sewer Asset Management Plan

Stormwater Quality Sampling Locations

Figure 3.0

Outfalls

Roads

Railway Track

Township Boundary

0 100 200 300 400

Meters

Coordinate System:
NAD 1983 UTM Zone 10N

Scale:
1:20,000
(When plotted at 8.5"x11")

Data Sources:
- Data provided by Township of Esquimalt, DataBC, ESRI

Project #: 1688.0013.01
Author: RS
Checked: AK
Status:
Revision: A
Date: 2026 / 6 / 16

URBAN SYSTEMS

3.1 CRD'S ENVIRONMENTAL CONCERN RATING - HIGH AND MODERATE RATINGS

The heat map shown in **Table 3.1** summarizes stormwater discharge locations which received Moderate or High environmental concern ratings by the CRD between 2011 and 2024. These ratings are based on concentrations of metals and PAH relative to sediment quality guidelines, assessed by the CRD.

Sites 749, 742, and 737 demonstrated the highest recurrence of environmental concern ratings during the review period, while several locations remained identified as Moderate or High concern in recent monitoring years, including 2024.

Table 3.1: Sites which received a moderate or high environmental concern rating by the CRD between 2011 - 2024.

Site ID	Years														Total
	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
737	Moderate		High	High		High					High		Moderate	Moderate	7
742	High		High	High			High			High	High	High			7
744	Moderate	High		Moderate	Moderate					Moderate	Moderate				6
749	Moderate	High	Moderate	High	Moderate		High			Moderate	Moderate				8
780	High	High		Moderate	Moderate									Moderate	5
781					High									Moderate	2
806		High	High	High	High									Moderate	5

Moderate High

3.2 CRD CORRECTIVE ACTION LIST

The following heat map shown in **Table 3.2** summarizes stormwater discharge locations identified by the CRD for corrective action between 2013 and 2024. The sites listed in the table have been classified as either moderate or high environmental risk for two consecutive years, indicating persistent or chronic water quality concerns that warrant further investigation. Sites are only removed from the list once the contaminant source has been identified and appropriate corrective actions have been implemented or the issue has otherwise been resolved.

In 2024, the CRD identified three discharge locations within the Township that remained on the corrective action list (**742, 749 and 806**).

Table 3.2: Sites for corrective action, identified by the CRD between 2013 - 2024.

Site ID	Years											Total
	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	
737	High	High	High	High	High	High	High	High	High	High	High		11
742	High	High										High	3
749	High	High	High	High	High	High	High	High	High	High	High	High	12
780	High	High	High										3
806	High	High	High	High	High	High	High	High	High	High	High	High	12
812	High												1

Table 3.3 below summarizes the corrective action guidance recommended by the CRD within previous stormwater quality reports. As shown, many of the recommended corrective actions have remained consistent since 2021. Based on discussions with the Township, several of these actions have not yet been implemented and should therefore be considered and prioritized within the Storm Sewer Asset Management Plan.

Table 3.3: List of corrective action items as outlined by the CRD within the Stormwater Quality Reports

<table>
<tr><th>Site ID</th><th>Contaminant of Concern</th><th>2024 Action</th><th>2023 Action</th><th>2022 Action</th><th>2021 Action</th></tr>
<tr><td>737</td><td>Elevated PAHs and Zinc</td><td>Take off action list</td><td colspan="3">Source Identified– Catch basin, Garthland Place (737-1)
Esquimalt to clean</td></tr>
<tr><td>742</td><td>Mercury 5x Guideline</td><td colspan="4">Source narrowed
Esquimalt notified</td></tr>
<tr><td>744</td><td>Elevated Zinc</td><td>Resample 2025</td><td colspan="3">Resample 2024</td></tr>
<tr><td>749</td><td>Elevated Zinc and Mercury</td><td>Action Required
Esquimalt Contacted</td><td colspan="3">Source Narrowed
Esquimalt Notified</td></tr>
<tr><td>780</td><td></td><td>No sediment
No sample collected
Resample 2025</td><td>No sediment
No sample collected
Resample 2024</td><td>No sediment in 2020
No sample collected
Resample in 2023</td><td>No sediment in 2020
No sample collected
Resample in 2021</td></tr>
<tr><td>781</td><td>Elevated Lead</td><td>Difficult to find sediment</td><td colspan="3">No sediment</td></tr>
<tr><td>806</td><td>Elevated copper, Zinc and PAH</td><td colspan="4">Narrowed down to two blocks</td></tr>
</table>

3.3 CRD'S PUBLIC HEALTH CONCERN - HIGH AND MODERATE RATINGS

The heat map shown in **Table 3.4** summarizes sampling locations which received a Moderate or High public health concern rating by the CRD between 2012 and 2025. The public health concern rating is based on the level of E.coli contamination and potential for public contact. The heat map was used to identify recurring or chronic areas of concern for further review.

At the time of this assessment, the 2025 CRD public health ratings had not yet been finalized or published. As a result, formal Moderate and High concern ratings were not available for the 2025 monitoring year. The raw CRD water quality and sediment quality datasets were provided to Urban Systems Ltd. by the Township in Microsoft Excel format. Therefore, instead, the red symbols shown for 2025 represent locations where E. coli exceedances were identified based on the CRD 2025 Monitoring Program water quality results.

The analyzed and refined datasets used as part of this review are included in **Appendix A.**

Table 3.4: Sites which received a moderate or high environmental concern rating by the CRD between 2011 - 2024.

DISCHARGE ID	YEAR 2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	YEARS WITH MODERATE OR HIGH RATING (2012–2025)	HIGHEST RATING RECORDED	TREND[1] (2019–2025)
PRIORITY / CHRONIC HOTSPOTS																	
744B	–	🔴	🟠	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	11	High	↗
806	🟠	🟠	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	🔴	11	High	–
780	–	–	🟠	–	🔴	🔴	🟠	🟠	🔴	🟠	🟠	🟠	🟠	🔴	10	High	↗
854	–	🟠	🔴	🟠	🟠	🟠	🟠	🟠	🟠	🟠	🟠	🔴	🟠	🟠	10	High	–
749	–	🟠	🟠	–	–	🟠	🟠	🟠	🟠	🟠	–	🔴	🟠	🔴	9	High	↗
MODERATE / RECURRING																	
737	–	–	🟠	–	–	🔴	🟠	🟠	🟠	🟠	🟠	🟠	🟠	🟠	7	High	–
742	–	–	🟠	🟠	–	🟠	🟠	🟠	–	🟠	🟠	🟠	🟠	🟠	7	Moderate	↘
781	–	–	–	–	–	🟠	🟠	🟠	–	–	🟠	🟠	🟠	🟠	6	Moderate	–
812	–	–	🟠	🟠	–	–	🟠	🟠	–	–	–	🟠	🟠	🟠	5	Moderate	–
OCCASIONAL / ISOLATED EXCEEDENCES																	
722AA	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	Moderate	–
726	–	–	–	–	–	–	–	🟠	–	–	–	–	🟠	🟠	2	Moderate	↗
727	–	–	–	–	–	🔴	–	–	–	–	–	–	🟠	🟠	2	High	↗
0736A	–	–	🟠	–	🔴	–	–	🟠	–	–	–	–	–	🔴	3	High	–
0742B	–	–	–	🟠	–	–	–	–	–	–	–	–	–	–	1	Moderate	–
0743A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1	Moderate	–
744	–	–	–	–	–	–	🟠	🟠	–	–	–	–	–	🟠	2	Moderate	–
0744A	–	–	–	–	🟠	–	–	–	–	–	–	–	–	🟠	2	Moderate	–
748	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1		–
0749A	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1		–
751	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1		–
754	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1		–
779	–	–	–	–	–	–	–	–	–	–	–	–	🟠	–	1		–
810	–	–	–	–	–	–	–	–	–	🟠	–	–	–	–	2	Moderate	–
811	–	–	–	–	–	–	–	–	–	–	–	–	–	–	1		–
813	–	–	–	🟠	–	–	–	–	–	–	–	–	–	–	2	Moderate	–
814	–	–	–	–	–	–	–	–	–	–	–	–	🟠	🟠	2	Moderate	–
0865D	–	–	–	–	–	–	–	–	🟠	–	–	–	–	–	1		–
0865F	–	–	–	–	–	–	–	🟠	–	–	–	–	–	–	1		–

🔴 HIGH – Exceeded public health guideline for *E. coli*
🟠 MODERATE – Elevated *E. coli*, below high threshold
– NOT ANALYSED – No data available

↗ Increasing – More frequent or persistent exceedences in recent years
↘ Decreasing – Fewer exceedences in recent years
– Stable – No clear upward or downward trend

[1] Trend is based on comparison of the most recent 7 years (2019–2025) to the preceding 7 years (2012–2018).

URBAN SYSTEMS

3.3.1 Priority Locations

Based on the CRD heat map and concern rating framework, the following sites were identified as having ongoing E. coli concerns and were therefore identified as key locations for the detailed review and assessment:

744, 744A, 744B, 749, 780, 781, 805, 806, 812, 814 and 854.

4.0 RAW DATA REVIEW FOR PRIORITIZED SITES

The Township provided Urban Systems with the CRD's raw stormwater and sediment quality datasets. These datasets were used to develop a stormwater quality risk matrix for the priority locations identified in **Section 3.0.** The matrix was also applied to all sites with historical guideline exceedances to evaluate potential trends, recurring exceedances, and persistent water quality concerns over time, and to identify whether any additional priority locations or recurring concerns may not have been previously flagged within the CRD prioritization framework.

Priority sites included all locations historically identified by the CRD as high or moderate environmental concern or sites requiring corrective action. For public health concerns associated with E. coli, the review focused on the priority locations identified in **Section 3.3.1.**

4.1 COMPARISON TO WATER QUALITY GUIDELINES

Each analyzed parameter was compared to the applicable water quality guidelines as outlined in **Section 2.3**.

Not all parameters assessed during the review currently have established provincial or federal water or sediment quality guidelines available for comparison. As such, a combination of approved, working, freshwater, and marine BC Water Quality Guidelines (BCWQG) and Canadian Council of Ministers of the Environment (CCME) guidelines were used, where applicable, to support the assessment of both stormwater and sediment quality data.

The resulting datasets were synthesized to identify key areas of concern, recurring exceedances, and spatial trends across the prioritized sites (analysed data sets for water and sediment provided in **Appendix A**). To note, any cells highlighted either exceed the BCWQG or CCME WQG).

5.0 TREND ANALYSIS AND RISK MATRIX

As the number of sampling events varied between sites and parameters, the total number of exceedances (per site) were not considered an effective indicator of ongoing trends or risk levels.

Therefore, a risk matrix was developed to help identify:

- **Key contaminants of concern for each site**
- **Priority sites of concern based on contaminant risk level**

The risk matrix is intended to support future storm sewer asset management planning, targeted capital upgrades, stormwater quality improvement initiatives, and future monitoring programs throughout the Township.

5.1 RISK MATRIX METHODOLOGY

The number, frequency, and severity of guideline exceedances were calculated for each parameter and sampling location. The following metrics outlined in **Table 5.1** and **5.2** were used as the basis of the analysis to better account for both the frequency and severity of exceedances.

Table 5.1: Formulas used to develop risk matrix to assess level of contamination concern.

Metric	Formula	Purpose
Exceedance Frequency (%)	$\frac{\text{Number of Exceedances}}{\text{Total Number of Samples}} \times 100$	Assesses how frequently a parameter exceeded the applicable guideline at each site.
Exceedance Magnitude	$\frac{\text{Result}}{\text{WQG}}$	Assesses the severity of each exceedance relative to the guideline value.
Average Exceedance Magnitude	$\frac{\text{Exceedance Magnitude}}{\text{Number of Exceedances}}$	Represents the average severity of exceedances for each parameter and site.
Weighted Risk Score	Exceedance Frequency × Average Exceedance Magnitude	Combines exceedance frequency and severity to identify higher-risk sites and contaminants.
Risk Category	(see Table 5.1)	Categorizes the level of risk based on the weighted score.

Table 5.2 Stormwater quality risk category thresholds and weighted risk score methodology used to prioritize contaminants and discharge locations

Risk Category	Weighted Risk Score Range	Interpretation
Extreme	**> 1000**	Extremely elevated and/or persistent exceedances indicating severe ongoing contamination concerns and likely infrastructure or contamination source issues requiring immediate action.
Severe	**100 – 1000**	Very high exceedance frequency and/or magnitude indicating significant recurring contamination concerns and high environmental or public health risk.
High	**25 – 100**	Persistent exceedances and elevated contaminant concentrations indicating moderate-high concern and targeted investigation or mitigation required.
Moderate	**5 – 25**	Recurring or moderate exceedances indicating localized or intermittent contamination concerns requiring monitoring and potential mitigation.
Low	**0.1 – 5**	Minor or infrequent exceedances. Limited concern but continued monitoring recommended.
No Exceedance	**0**	No exceedances of applicable guidelines identified.

5.2 RESULTS

5.2.1 Public Health Risk Assessment (2011-2020)

The raw data provided by the CRD included E. coli measurements collected between 2011 and 2025. This dataset was reviewed to assess overall contamination trends and identify sampling locations associated with the highest potential public health concern.

SOURCE INDICATORS (MAGNITUDE)

E. coli contamination can originate from a variety of sources, including wildlife, agricultural runoff, pet waste, and sanitary sewer inputs. However, the magnitude of exceedance can help indicate the potential source of contamination. For example, contamination associated with wildlife or agricultural sources (e.g., geese or livestock) is typically substantially lower than contamination associated with sewage or human waste inputs.

In municipal stormwater investigations, persistently elevated E. coli concentrations in the thousands to tens of thousands CFU/100 mL are commonly considered indicators warranting further investigation for potential sanitary sewer cross-connections, sewage leaks, or other human-related contamination sources.

RESULTS

As shown in **Table 5.3** below, several sampling locations exhibited exceedance rates of 100%, indicating persistent and ongoing water quality concerns. In addition to the frequency of exceedances, several locations also exhibited extremely elevated concentrations. For example, Site **744B** had an average exceedance magnitude of **3,656**, meaning that E. coli concentrations were, on average, **3,656 times greater** than the applicable **200 CFU/100 mL** guideline. Such elevated concentrations are generally more indicative of potential sanitary sewer cross-connections, infiltration and inflow (I&I), or other human-related contamination sources.

Table 5.3 summarizes the E. coli risk matrix and associated exceedance trends across the Township.

Table 5.3: Risk matrix results based on E.coli exceedances between 2011-2025.

Site	Guideline Used (CFU/100 mL)*	Total Data Points	Total Exceedances	Exceedance %	Average Magnitude (x Guideline)	Maximum Result	Date of Maximum Exceedance	Risk Category
SW0744B	200	29	29	100.0%	3190.52	5400000	2019-07-03	Extreme
SW0780	200	15	12	80.0%	1061.71	2200000	2019-03-08	Extreme
SW0805	200	23	23	100.0%	598.70	520000	2022-07-14	Extreme
SW0812	200	7	7	100.0%	143.06	110000	2023-04-26	Extreme
SW0806	200	21	19	90.5%	102.97	120000	2021-08-25	Extreme
SW0749	200	15	6	40.0%	153.10	110000	2017-08-24	Extreme
SW0781	200	15	10	66.7%	79.30	72000	2020-11-20	Extreme
SW0744A	200	10	4	40.0%	90.63	52000	2018-02-15	Extreme
SW0744	200	13	11	84.6%	39.71	64000	2017-09-19	Extreme
SW0814	200	11	9	81.8%	35.11	41000	2024-07-24	Extreme
SW0742	200	12	3	25.0%	53.33	22000	2016-09-29	Severe
SW0742B	200	5	1	20.0%	19.00	3800	2016-09-29	High
SW0737	200	11	1	9.1%	6.00	1200	2017-09-19	Low
SW0742-1	200	5	1	20.0%	2.20	440	2021-08-05	Low

(*) All samples were compared to the BCWQG Freshwater Aquatic Life - Long Term Guideline

SITES OF CONCERN

Based on the risk matrix analysis, the following sites were identified as the primary areas of concern due to recurring and extreme E. Coli exceedances: **744B/744A, 780, 781, 806, 805, 749, 737 and 812.**

5.2.2 Environmental Risk Assessment (2020-2025)

The raw CRD data provided by the Township included metals, hydrocarbons, and PAH measurements collected as part of the Core Area stormwater quality monitoring program.

Sediment quality data generally covered sampling events between 2011 and 2025, while

Stormwater quality data included results from approximately 2020 to 2025.

The datasets were reviewed to assess overall contamination trends, identify recurring exceedances, and determine sampling locations associated with the highest environmental concern and public health risk.

5.2.3 Polycyclic Aromatic Hydrocarbons (PAH's)

Only two PAH parameters were identified by Urban as repeatedly exceeding applicable guidelines throughout the monitoring period. Many sampling locations did not demonstrate recurring PAH exceedances; however, five sites exhibited persistent exceedances over multiple years.

The exceedances and associated environmental concern ratings are summarized in **Table 5.4** below.

Table 5.4: Risk matrix results based on PAH exceedances between 2011-2025.

Site	Parameter	Guideline Used (µg/L)	Total Data Points	Total Exceedances	Exceedance %	Average Magnitude (x Guideline)	Maximum Result	Date of Maximum Exceedance	Risk Category
SW0781	Benzo[a]pyrene	0.01	9	1	11.1%	15.00	0.15	2023-03-10	Moderate
	Pyrene	0.02	9	3	33.3%	4.72	0.24	2023-03-10	Moderate
SW0780	Benzo[a]pyrene	0.01	7	1	14.3%	10.00	0.1	2023-03-10	Moderate
	Pyrene	0.02	7	1	14.3%	7.00	0.14	2023-03-10	Low
SW0742	Pyrene	0.02	5	1	20.0%	5.50	0.11	2021-08-05	Moderate
	Benzo[a]pyrene	0.01	5	1	20.0%	4.80	0.048	2021-08-05	Low
SW0854	Pyrene	0.02	4	2	50.0%	1.05	0.021	2020-06-22	Low
SW0749A	Benzo[a]pyrene	0.01	3	1	33.3%	0.00			Low
	Pyrene	0.02	3	1	33.3%	0.00			Low

(Sites 737, 742, 742B, 744. 744B, 805, 806, 812 had no exceedances).

SITES OF CONCERN

Based on the risk matrix analysis, the following sites were identified as the primary areas of concern due to recurring PAH exceedances: **781, 780 and 742.**

5.2.4 Metals

As shown in **Table 5.5** below, several sampling locations exhibited recurring metals exceedances over multiple years, indicating persistent and ongoing environmental concerns. **Copper and zinc** were the most commonly recurring exceedances across the Township and are frequently associated with roadway runoff and urban drainage influences. Sites **742, 749, 780**, and **806/805**, demonstrated the highest and most concerning recurring metal exceedances throughout the monitoring period.

In addition to exceedance frequency, several locations also demonstrated elevated exceedance magnitudes, suggesting chronic contaminant loading and long-term sediment accumulation within the storm system. The recurrence of metals exceedances at these locations indicates that both stormwater runoff influences and aging infrastructure conditions are likely contributing to degraded stormwater quality.

Table 5.5 below summarizes the metals risk matrix and associated exceedance trends across the Township. Due to the large volume of results for each site, only parameters categorized as Moderate, Severe, or Extreme risk have been included within the table.

5.2.5 Background Influenced Sediment Exceedances

Although several sites exceeded applicable metal guidelines within both the water and sediment quality results, a detailed review of the sediment data indicated that many of the exceedances remained below Vancouver Island regional background concentrations (refer to **Appendix B**). These background concentrations represent naturally occurring metal levels within regional soils and sediments. As a result, some exceedances may reflect naturally elevated regional background conditions rather than anthropogenic contamination.

Where sediment exceedances remained below regional background concentrations (cells highlighted in yellow represent results that exceeded the applicable guideline but remained below background concentrations), the results were interpreted as being of lower relative concern unless:

- Exceedances were recurring,
- Multiple contaminants were present, or
- Evidence of anthropogenic influence was identified.

Table 5.5: Risk matrix results based on Metal exceedances between 2011-2025.

Site	Parameter	Guideline Used ug/L	Total Data Points	Total Exceedances	Exceedance %	Average Magnitude (x Guideline)	Maximum Result	Date of Maximum Exceedance	Risk Category
SW0742-1	Iron	300.	7	6	85.7%	52.27	80700.	2021-08-05	Extreme
SW0812	Nickel	0.5	4	4	100.0%	25.13	45.7	2023-04-26	Extreme
SW0742-1	Aluminum	100.	7	6	85.7%	24.18	8320.	2021-08-05	Extreme
SW0744B	Copper	2.	12	12	100.0%	12.44	175.	2024-08-12	Severe
SW0742-1	Nickel	0.5	7	7	100.0%	10.82	17.7	2021-08-05	Severe
SW0805	Nickel	0.5	9	9	100.0%	7.75	24.7	2023-05-16	High
SW0744B	Aluminum	100.	12	12	100.0%	7.74	4180.	2023-05-05	High
SW0737	Copper	2.	8	7	87.5%	6.38	47.2	2025-01-17	High
SW0744B	Nickel	0.5	12	12	100.0%	5.02	8.24	2023-05-05	High
SW0744A	Zinc	10.	7	6	85.7%	5.71	186.	2023-04-05	High
SW0742-1	Copper	2.	7	5	71.4%	6.78	33.5	2020-12-01	High
SW0737	Zinc	10.	8	4	50.0%	9.53	333.	2024-04-25	High
SW0805	Copper	2.	9	9	100.0%	4.55	19.	2024-07-24	High
SW0814	Copper	2.	5	5	100.0%	4.35	14.5	2023-03-02	High
SW0854	Copper	2.	10	10	100.0%	4.05	12.	2022-03-23	High
SW0780	Copper	2.	10	10	100.0%	4.05	21.9	2024-04-24	High
SW0854	Aluminum	100.	10	5	50.0%	7.95	1630.	2020-06-22	High
SW0781	Copper	2.	11	11	100.0%	3.88	18.3	2023-03-10	High
SW0744B	Iron	300.	12	10	83.3%	4.52	6200.	2023-05-05	High
SW0742	Nickel	0.5	9	9	100.0%	3.68	2.81	2024-07-19	High
SW0737	Aluminum	100.	8	5	62.5%	5.81	1790.	2025-01-17	High
SW0854	Nickel	0.5	10	10	100.0%	3.58	4.51	2022-03-23	High
SW0744	Nickel	0.5	7	7	100.0%	3.55	2.57	2023-03-10	High
SW0742B	Iron	300.	3	3	100.0%	3.45	1650.	2023-04-05	High
SW0812	Copper	2.	4	4	100.0%	3.43	11.4	2024-05-10	High
SW0742B	Copper	2.	3	3	100.0%	3.40	10.8	2024-05-10	High
SW0742-1	Chromium	1.	7	3	42.9%	7.74	13.5	2021-08-05	High
SW0742-1	Mercury	0.016	7	2	28.6%	11.59	0.25	2021-08-05	High

6.0 COMBINED RESULTS

The monitoring results indicate that both chronic low-level contamination and episodic high-magnitude contamination events are occurring within portions of the system.

The most significant risks identified are associated with:

- Public health concerns from bacteriological contamination;
- Long-term accumulation of metals and hydrocarbons within storm sediments;
- Potential impacts to marine receiving environments; and
- Aging storm and sewer infrastructure contributing to cross-contamination and sediment transport.

6.1 ENVIRONMENTAL RISK ASSESSMENT

Recurring exceedances of copper, zinc, nickel, iron, manganese, mercury, and PAHs were identified within both stormwater and sediment samples across the Township. The exceedances are generally consistent with urban runoff influences and are likely associated with roadway runoff, vehicle wear, sediment accumulation, aging storm and sewer infrastructure, industrial/commercial land uses, and historical urban contamination.

6.2 PUBLIC HEALTH RISK ASSESSMENT

Several locations also exhibited persistent E. coli exceedances and elevated bacteriological contamination levels potentially associated with sanitary/storm cross-connections, inflow and infiltration (I&I), failing sewer infrastructure, private lateral defects, combined sewer infrastructure, illicit discharges, and urban wildlife inputs.

Due to the magnitude and persistence of the E. coli exceedances identified at several discharge locations, bacteriological contamination represents the highest overall stormwater quality risk within the Township. In particular, several sites demonstrated E. coli concentrations in the thousands to tens of thousands of times above applicable guidelines, which is more indicative of potential human-related contamination sources rather than typical urban wildlife inputs.

As a result, the highest priority recommendations should focus on identifying and eliminating potential sanitary contamination sources, including investigation of combined sewer infrastructure, inflow and infiltration (I&I), cross-connections, and aging sewer infrastructure contributing to bacteriological loading within the storm system.

6.3 PRIORITY DISCHARGE SITES

Based on the exceedance frequency, exceedance magnitude, environmental concern ratings, and known infrastructure conditions, priority discharge locations and recommended actions were identified and are summarized in **Table 6.1** below.

Table 6.1: Sites identified as concerns based on the risk matrix results, infrastructure condition, and the corresponding priority level for investigation and corrective action.

Discharge ID	Priority Category	Public Health	Environmental	Contaminants	Key Findings
744B (Forshaw)	Priority	High	High	E. coli, Zinc, Copper, PAHs	• Elevated E. coli concentrations suggest likely sanitary cross-connections and significant I&I. • Repeated metals and hydrocarbon exceedances also indicate roadway and infrastructure influences.
749 (Uganda)	Priority	Moderate	High	Zinc, Mercury, Copper, PAHs, E. coli	• Recurring metals and PAH exceedances in both water and sediment data. • Elevated iron and mercury concentrations and aging infrastructure identified within catchment.
806/805 (Kinver)	Priority	High	High	E. coli, Copper, Zinc, Nickel	• Persistent bacteriological contamination • Recurring metals exceedances potentially associated with pump station and infrastructure concerns.
780	Priority	High	Moderate	E. coli, PAHs, Metals	• Persistent E. coli exceedances • Recurring PAHs potentially associated with combined infrastructure and urban runoff influences.
742 (Garthland)	Priority		High	Mercury, Zinc, PAHs	• Elevated mercury and metals exceedances within sediment and stormwater samples.
812 (Grafton)	Priority	High		E. coli	• Persistent bacteriological exceedances
737 (Garthland)	Monitoring	Moderate	Moderate	Zinc, PAHs	• Reoccurring PAHs and metals exceedances associated with aging infrastructure and roadway runoff.
781	Monitoring		Moderate	Lead, PAHs	• Recurring lead and hydrocarbon exceedances identified within sediment samples.
744	Monitoring		Moderate	Zinc, Copper	• Intermittent metals exceedances with localized sediment contamination concerns.
814 (Grafton)	Monitoring	Moderate		E. coli, Metals	• Recurring public health concern ratings with moderate metals exceedances.

7.0 STORMWATER QUALITY IMPROVEMENT RECOMMENDATIONS

The following recommendations have been developed in response to the water quality and sediment quality concerns identified throughout the stormwater quality assessment.

These recommendations are informed by elevated concentrations of:

- **E. coli,**
- **Polycyclic aromatic hydrocarbons (benzo(a)pyrene and pyrene), and**
- **Metals (copper, manganese, nickel, zinc, iron, mercury and cadmium)**

Each of the above were identified in sediments collected from manholes, creeks, and ditches.

The recommendations provided below focus on reducing potential contaminant sources, improving stormwater quality treatment and infrastructure performance, reducing sediment and pollutant accumulation within the drainage system, and supporting long-term watershed health, environmental protection, and public health objectives.

7.1 GREEN INFRASTRUCTURE AND LOW IMPACT DEVELOPMENT (LID)

The monitoring results indicate that increased infiltration, runoff reduction, and distributed stormwater treatment measures would provide long-term water quality benefits throughout the stormwater system. Green infrastructure and Low Impact Development (LID) measures should be prioritized within redevelopment areas, municipal infrastructure renewal projects, roadway upgrades, and catchments with high levels of impervious surfaces and runoff generation. Opportunities should also be pursued to expand urban tree canopy coverage, increase absorbent landscaping, and protect or restore natural drainage features where feasible.

Table 7.1 outlines the key LID options which should be considered during redevelopment and new developments.

Table 7.1: LID options for improving stormwater quality within developed areas and their primary benefits.

BMP	Primary Benefit
Rain gardens	Filtration of metals, sediment and hydrocarbons
Bioswales	Runoff conveyance and treatment
Infiltration swales	Sediment and metals removal
Absorbent landscaping	Runoff reduction and infiltration
Permeable pavement	Reduction in runoff volume
Tree well systems	Roadway runoff treatment
Constructed wetlands	Long-term treatment and sediment removal
Green streets	Distributed runoff treatment
Riparian planting	Sediment stabilization and filtration

Appendix B provides a detailed breakdown of the recommended BMPs, including the primary contaminants each measure is intended to address, overall suitability and effectiveness, and associated maintenance requirements and recommended maintenance schedules.

7.2 INFRASTRUCTURE REHABILITATION

Several high-risk outfalls and monitoring locations appear to be influenced by aging storm and sewer infrastructure, including potential inflow and infiltration (I&I), structural deterioration, sediment accumulation, and possible sanitary cross-connections.

Rehabilitation and renewal of aging infrastructure is expected to reduce infrastructure-derived contamination, improve overall system integrity and hydraulic performance, reduce sediment mobilization within the drainage network, and lower the risk of bacteriological contamination entering the stormwater system.

Priority rehabilitation actions should include:

- Pipe relining and replacement,
- Manhole rehabilitation,
- Repair of structural defects,
- Elimination of combined infrastructure where feasible,
- Abandonment of inactive sewer connections,
- Reduction of Infill and Infiltration pathways, and
- Coordination with municipal asset management programs.

Specific infrastructure targeted for rehabilitation is further prescribed in **Table 7.3** herein.

7.3 UPDATE TO OFFICIAL COMMUNITY GUIDELINES, BYLAWS AND DEVELOPMENT PERMITS

Updated municipal policies, bylaws, and development standards can play an important role in improving long-term stormwater quality and reducing contaminant loading within the drainage network. Integrating stormwater quality objectives into Official Community Plans (OCPs), development permit guidelines, servicing bylaws, and engineering design standards can help ensure that stormwater quality considerations are consistently incorporated into redevelopment and new development projects.

Policy and bylaw updates can support the implementation of source control measures, improve stormwater treatment requirements, and reduce runoff volumes entering the municipal drainage system. These measures are expected to improve overall stormwater quality, reduce sediment and contaminant transport, and support long-term watershed protection objectives.

Potential policy and bylaw considerations may include:

- Requiring Oil Grit Separators (OGS) for high-risk land uses and redevelopment projects,
- Implementing rainwater management and runoff reduction requirements,
- Establishing minimum Low Impact Development (LID) targets for redevelopment and new development,
- Requiring stormwater quality treatment for roadway and parking lot runoff,
- Protecting and restoring riparian corridors and natural drainage features,
- Increasing urban tree canopy and absorbent landscaping requirements,
- Encouraging infiltration and on-site rainwater management where feasible,
- Strengthening erosion and sediment control requirements during construction, and
- Integrating stormwater quality objectives into municipal asset management and infrastructure planning processes (in progress via the Storm Sewer Asset Management Plan).

7.4 BEST MANAGEMENT PRACTICES (BMPS) FOR STORMWATER QUALITY

The following operational and maintenance recommendations are intended to support long-term improvements in stormwater quality throughout the municipal drainage network. These measures focus on reducing contaminant loading, improving sediment and pollutant capture, identifying potential sources of bacteriological contamination, and improving overall stormwater system performance. **Table 7.2** outlines the recommended Best Management Practices (BMPs), including their primary target contaminants, recommended maintenance frequencies, and priority application areas.

Table 7.2: Recommended BMPs for improving stormwater quality, including associated maintenance and inspection schedules.

BMP	Target Contaminants	Purpose	Recommended Frequency / Standard	Recommended Application
Enhanced Street Sweeping Program	Metals PAH Sediment	Removes sediment, metals, hydrocarbons, and roadway contaminants before they enter the stormwater system	• Arterial/commercial roads: bi-weekly • Industrial areas: weekly where feasible • Residential roads: monthly minimum • Additional sweeping prior to fall/winter rainfall season	• Focus on high traffic corridors, • Industrial/commercial catchments and priority outfall drainage areas.
Catch Basin Cleaning and Sediment Removal	Metals PAHs Sediment Bacteria	Removes accumulated sediment and associated contaminants from the storm system	• High-risk catchments: 2–4 times annually • Remaining municipal system: minimum annually • Additional inspections following major storm events	• Prioritize discharge connections: **742, 749, 806, 744B, and 780.**
Oil-Grit Separator (OGS) Maintenance	Metals PAH	Captures and removes oil, sediment, metals, and hydrocarbons from runoff **Most Effective for hydrocarbons**	• Inspection twice annually • Cleaning when sediment/oil storage reaches 50% capacity	• Applicable to municipal and private systems.
Sanitary Cross-Connection Investigations & Upgrades	Bacteria	Identifies and eliminates sources of bacteriological contamination entering the storm system	• Annual investigation program within high-risk catchments • Additional investigations triggered by exceedances	• Include CCTV inspections, smoke testing, and dye testing.
Wet Weather Outfall Monitoring	Bacteria Metals PAHs	Identifies ongoing contaminant sources and tracks stormwater quality trends	• Minimum 5 samples in 30 days (5 in 30) wet weather monitoring events annually • Dry weather screening annually	• Prioritize historically elevated outfalls and receiving environments with recreational use.
Enhanced Street and Parking Lot Spill Management	Metals Hydrocarbons PAHs	Reduces contaminant discharges from spills, leaks, and industrial/commercial activities	• Immediate spill response • Annual business education and inspection program	• Focus on industrial, commercial and transportation-related land uses.
Storm Sewer Flushing Program	Sediment PAHs	Removes accumulated sediment and prevents remobilization of contaminants during storm events	• Every 2-5 years depending on sediment accumulation risk	• Prioritize flat drainage areas and known sediment accumulation zones.
Rain Garden and Bioswale Maintenance	Metals Bacteria PAH	Maintains stormwater treatment performance and infiltration capacity	• Quarterly inspections • Vegetation replacement annually as needed • Sediment removal as required	• Applicable to municipal boulevards, parks and redevelopment areas.
Public Education Program	E.coli PAH Metals	Reduces pollutant inputs through public awareness and source control practices	• Annual outreach campaign	• Include pet waste disposal, illicit discharge awareness and spill prevention.
Riparian and Shoreline Vegetation Enhancement	Metals Sediment	Stabilizes sediments, improves filtration, and reduces runoff impacts to receiving environments	• Ongoing adaptive management and maintenance	• Focus on sensitive marine receiving environments and shoreline outfalls.

7.5 PRIORITIZED RECOMMENDATIONS BASED ON WATER QUALITY RISK

The results of the water quality analysis and risk matrix were compared against previous investigations completed throughout the Township, including historical CRD investigations and infrastructure assessments completed as part of the Storm Sewer Asset Management Plan. This comparison was undertaken to identify recurring areas of concern, confirm potential infrastructure-related sources of contamination, and help prioritize corrective actions and future capital upgrades.

The recommendations and infrastructure priorities outlined within the following reports were reviewed and incorporated into the development of the stormwater quality recommendations and priority actions presented within this assessment:

- Kerr Wood Leidal Associates Ltd. (KWL).
  - *Township of Esquimalt Inflow and Infiltration (I&I) Masterplan – Final Report* (August 24, 2021).
- Urban Systems Ltd. (USL)
  - *Township of Esquimalt Sanitary Sewer Asset Management Plan: Risk Prioritization* (January 29, 2025)
- GeoAdvice Engineering Inc.
  - *Township of Esquimalt Stormwater System Model Update and Calibration-Draft* (March 3, 2026)
  - *Township of Esquimalt Stormwater System Capacity Analysis- Draft* (April 22, 2026)

Table 7.3 summarizes the recommended stormwater quality improvement strategies, associated priority locations, identified infrastructure concerns, and recommended actions based on the combined findings of the water quality assessment and previous infrastructure investigations.

Table 7.3: Recommendations based on priority and actions to improve stormwater quality within the Township.

Proposed Stormwater Quality Improvement Strategy	Priority	Primary Risk Type	Target Outfalls / Areas	Primary Target Contaminants	Key Findings / Identified Infrastructure Issues	Recommended Actions / BMPs	Expected Water Quality Benefit
Investigate and Eliminate Sewage Cross-Connections and I&I at High-Risk Outfalls	**Immediate**	Public Health	**744B, 780, 806/805, 749, 737**	E.coli, Enterococci	• Combined sanitary infrastructure structural pipe defects • Potential sanitary cross-connections • Elevated wet weather bacteriological loading. Prioritize and follow recommendations for: • **744B** - Upgrade gravity mains on Gosper Cresent – SGM0790 and SGM0561 (KWL, USL) • **780** - Upgrade combined manhole SMH0163 (KWL) • **737** – Upgrade level 2 and 3 structural defects and forcemain upgrades identified along Rhoda Lane (USL) • **749** – Upgrade pipe SGM0862 (USL, KWL)	• CCTV inspection of priority sewer mains • Dye and smoke testing • Manhole rehabilitation • Pipe relining or replacement • Disconnect and abandon inactive services • Wet-weather source tracing • Private lateral investigations • Separation of combined infrastructure where feasible	• Significant reduction in bacteriological contamination • Improved marine recreational water quality • Improved long-term infrastructure performance
Enhanced Catch Basin Cleaning, Sediment Removal and Street Sweeping Program	**Immediate**	Environmental	**742, 749, 737, 806/805, 744B** commercial and high traffic corridors	Metals, PAHs and sediment	• Elevated sediment-bound metals • Recurring PAHs and hydrocarbons • Sediment accumulation within the storm system • Results suggest roadway runoff influences Prioritize streets within **Kinver, Uganda, Forshaw and Garthland areas.**	• Increase catch basin cleaning frequency to 2–4 times annually • Vacuum sediment removal • Bi-weekly street sweeping in commercial/high traffic areas • Storm sewer flushing program • Develop sediment disposal protocols	• Reduction in sediment-bound metals and PAHs entering marine receiving environments. • Reduced long-term sediment accumulation
Prioritize Structural Rehabilitation of Aging Storm and Sewer Infrastructure	**Immediate**	Public Health / Environmental	**737, 744B, 749, 780**	Metals and E.coli	Multiple outfalls identified aging gravity mains, force mains, combined infrastructure, and structural defects contributing to infiltration/inflow and sediment accumulation. Prioritize and follow recommendations for: • **812/814** – Grafton pumpstation upgrades (USL) • **744B, 744A & 742, 749 and 737 –** Prioritize pipe upgrades with structural defects. Extreme exceedances of iron, aluminum and copper suggest failing infrastructure. • **Garthland and Forshaw Area.** • **Kinver and Uganda** areas - Prioritize pipes highlighted as flood risk (GeoAdvice)	• Pipe relining/replacement • Manhole rehabilitation • Repair priority structural defects • Abandon inactive sewer connections	• Reduced infrastructure-derived metals and lower contamination risk.
Install Water Quality Structures (Oil-Grit Separators and Hydrodynamic Separators)	Immediate / Short Term	Environmental	**742, 749, 806/805, 780**	Copper, Zinc, Nickel, Benzo(a)pyrene, Pyrene	• High imperviousness and roadway runoff likely contribute significant metals and PAHs. • Recurring metals, hydrocarbon and sediment-related exceedances • Evidence of roadway and commercial runoff influences • Limited stormwater treatment within existing infrastructure Prioritize areas with reoccurring PAH:	• Install OGS units at high-risk areas. • Retrofit deep sump catch basins • Install hydrodynamic separators and filter cartridges • Prioritize commercial, industrial and arterial drainage systems • Implement bylaw requirements for redevelopment and new developments	• Improved capture of sediment, grit, oils, grease, and hydrocarbon-associated contaminants. • Most effective for hydrocarbons.

Proposed Stormwater Quality Improvement Strategy	Priority	Primary Risk Type	Target Outfalls / Areas	Primary Target Contaminants	Key Findings / Identified Infrastructure Issues	Recommended Actions / BMPs	Expected Water Quality Benefit
					• **749, 780, 781 and 737 (Garthland and Uganda)**		
Implement Best Management Practices (BMPs), Low Impact Development (LID), and Green Infrastructure	Short Term	Environmental	Township-wide priority catchments	Metals and PAHs	• Urban runoff, high imperviousness, and limited infiltration opportunities contribute to elevated contaminant loading Prioritize the following: • **780** – Grafton area surrounding outfall has an impervious rating of 60-100% (GeoAdvice) • **747** – outfall has an impervious rating of 60-70% (GeoAdvice). • **Kinver and Uganda** existing storm pipes were highlighted to have potential flood risk due to pipe capacity constraints (GeoAdvice).	• Prioritize LID and BMPs in redevelopment projects as outlined in **Section 7.1 and 7.4.** • Retrofit stormwater outfalls and treatment systems • Implement source control measures • Protect and restore natural drainage features	• Reduced runoff volume • Improved infiltration and filtration • Improved watershed resilience.
Undertake Detailed Industrial / Commercial Source Control Program	Medium Term	Environmental	**742, 749, 806/805**	Copper, Zinc, Nickel, Mercury, PAHs	• Broad suite of metals and hydrocarbon exceedances suggest potential industrial/commercial runoff and spill-related sources. • Prioritize sites which show no improvement after infrastructure upgrades.	• Upstream manhole sediment sampling • Business inspections • Spill prevention and response requirements • Covered storage requirements • Illicit discharge enforcement	• Reduced contaminant loading from high-risk land uses. • Improved source identification and spill prevention
Implement Stormwater Management Bylaws and Rainwater Management Policies	Long Term	Environmental / Public Health	Township-wide priority catchments	All contaminants	• Redevelopment and infrastructure renewal provide opportunities to improve long-term stormwater quality.	• Require Rainwater Management Plans prepared by Qualified Professionals • Require OGS for commercial, industrial, CD, institutional, and multi-family developments • Require treatment of first flush runoff • Establish runoff reduction and infiltration targets • Require LID integration into redevelopment • Require ESC plans and enhanced sediment controls during construction • Implement illicit discharge and spill prevention bylaws	• Long-term reduction in stormwater contaminant loading and improved runoff quality. • Improved runoff quality • Improved watershed protection and stormwater management outcomes
Implement Wet Weather Outfall Monitoring and Source Tracking Program	Medium Term	Public Health / Environmental	**737, 744B, 749, 780, 806/805** and other historically elevated outfalls	All contaminants	• Multiple outfalls demonstrated elevated wet weather bacteriological contamination, recurring metals exceedances, and indications of storm-driven contaminant loading • Prioritize sites which show no improvement after infrastructure upgrades.	• Complete minimum five wet-weather sampling events annually at priority outfalls (include five dry weather samples where possible). • Monitor for E. coli, Enterococci, metals, PAHs, TSS, and field parameters • Undertake source tracing investigations where recurring exceedances occur • Correlate results with rainfall intensity and infrastructure condition data • Prioritize recreational marine receiving environments and historically elevated discharge locations	• Improved identification of contaminant sources and loading patterns • Earlier identification of sanitary cross-connections and infrastructure failures • Improved prioritization of infrastructure rehabilitation projects • Long-term reduction in bacteriological and contaminant loading to receiving environments

8.0 CONCLUSION

The review of available CRD stormwater and sediment quality data identified several recurring stormwater quality concerns throughout the Township associated with bacteriological contamination, metals, hydrocarbons, and sediment accumulation within the drainage network. The assessment identified multiple locations exhibiting persistent or chronic exceedances of applicable water and sediment quality guidelines, particularly at outfalls associated with aging storm and sewer infrastructure, combined systems, and high urban runoff influences.

The recommendations provided within this memorandum are intended to support the Township's Storm Sewer Asset Management Plan, and future infrastructure renewal programs, stormwater quality improvement initiatives, and long-term watershed management objectives. Implementation of targeted infrastructure rehabilitation, wet weather monitoring, stormwater source control measures, and green infrastructure and Low Impact Development (LID) practices are expected to improve stormwater quality, reduce contaminant loading to marine receiving environments, and support long-term environmental and public health protection throughout the Township.

8.1 PRIORITY STORMWATER RISKS

The most significant overall risk identified through the assessment relates to elevated E. coli concentrations and associated public health concerns. Several outfalls demonstrated persistent and extremely elevated bacteriological exceedances that are indicative of human-related contamination sources, such as sanitary cross-connections and combined sewer infrastructure. As a result, investigation and rehabilitation of aging sewer and storm infrastructure should remain the highest priority action item moving forward.

Recurring exceedances of metals and PAHs were also identified within both stormwater and sediment samples, particularly at sites influenced by roadway runoff, urban sediment accumulation and deteriorating infrastructure conditions. While some sediment exceedances may reflect naturally elevated regional background concentrations, the recurrence and spatial distribution of exceedances indicates that urban runoff and infrastructure-related contaminant loading continue to influence stormwater quality throughout the Township.

The highest priority sites and recommendations identified through this assessment are outlined in Table 8.1.

Table 8.1: Priority sites identified for stormwater quality improvements

Priority Category	Priority Sites	Key Concerns	Recommended Actions
Public Health	744B 780 812 749 806/805	• Persistent and extreme E. coli exceedances • Potential sanitary cross-connections and combined infrastructure • Aging infrastructure	• Investigation and elimination of combined infrastructure and potential sanitary cross-connections • Kinver pump station rehabilitation and upgrades
Environmental	742 737 749 781 780	• Recurring metals exceedances Elevated PAHs • Sediment accumulation within storm system • Aging stormwater infrastructure	• Upgrade priority aging infrastructure • Enhanced catch basin cleaning and sediment removal • Increased street sweeping

8.1.1 Priority Areas for Stormwater Infrastructure Upgrades

Based on the findings of this assessment, the following areas should be prioritized for future stormwater infrastructure improvement works:

- **Uganda and Kinver** – Bacteriological contamination
- **Garthland and Forshaw** – Metal contamination
- **Garthland and Uganda** – PAH contamination

8.1.2 Summary of Contamination Risk

Table 8.1 below summarizes the overall risk matrix results for each monitored site, including the total number of exceedances, highest risk contaminant category, and secondary contaminants of concern. The results were used to identify priority sites, recurring contaminant trends, and the primary stormwater quality issues contributing to public health and environmental risk throughout the Township.

Table 8.2: Summary of highest risk parameters for each site and their level of concern.

Site	Parameters Assessed	Total Data Points	Total Exceedances	Highest Risk Parameter	Highest Risk Group	Secondary Risk Category	
SW0744B	13	141	88	**Escherichia Coli**	Bacteria	Copper	Aluminum
SW0780	13	122	50	**Escherichia Coli**	Bacteria	Copper	Benzo[a]pyrene
SW0805	13	109	58	**Escherichia Coli**	Bacteria	Nickel	Copper
SW0812	13	43	22	**Escherichia Coli**	Bacteria	Nickel	Copper
SW0806	13	136	63	**Escherichia Coli**	Bacteria	Nickel	Copper
SW0749	13	68	42	**Escherichia Coli**	Bacteria	n/a	n/a
SW0781	13	136	59	**Escherichia Coli**	Bacteria	Copper	Pyrene
SW0742-1	13	85	39	**Iron**	Metals	Aluminum	Pyrene
SW0744A	13	75	33	**Escherichia Coli**	Bacteria	Zinc	n/a
SW0744	13	83	41	**Escherichia Coli**	Bacteria	Nickel	Copper
SW0814	13	58	25	**Escherichia Coli**	Bacteria	Copper	Nickel
SW0742	13	104	38	**Escherichia Coli**	Bacteria	Nickel	Iron
SW0737	13	95	31	**Copper**	Metals	Aluminum	Zinc
SW0742B	13	34	15	**Escherichia Coli**	Bacteria	Iron	Copper

Extreme	Severe	High	Moderate

Please contact the undersigned should you have any questions or require additional information.

Sincerely,

URBAN SYSTEMS LTD.

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APPENDIX A:

Township of Esquimalt Stormwater and Sediment Quality Analysis

Capital Regional District – Raw Stormwater Quality Data

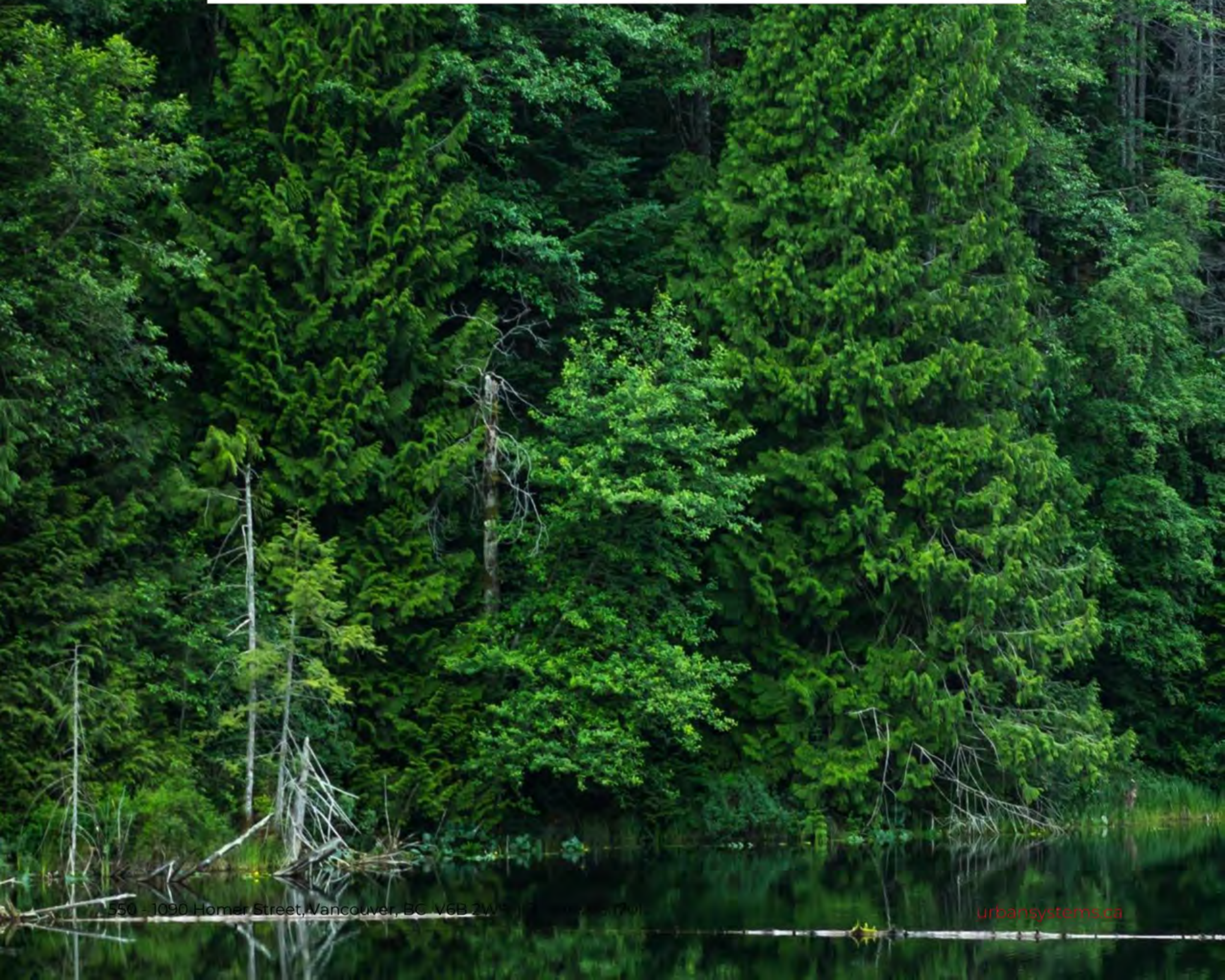


Table 2: Township of Esquimalt Water Quality Analysis - Parameters of Concern

Township of Esquimalt Water Quality Data															
			Bacteriolocical Tests	Total Metals										Polycyclic Aromatic Hydrocarbons	
Parameter			Escherichia Coli	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Zinc	Benzo[a]pyrene	Pyrene
Unit			CFU/100 mL	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
BC Water Quality Guidelines (BCWQG)	Freshwater Aquatic Life (Long Term)		200	--	5		1	2	1000	3		0.5	33	0.01	0.02
	Marine Life (Long Term)			--	12.5	0.12		2		2			10		
Canadian Council of Ministers of the Environment (CCME)	Freshwater Aquatic Life			100	5			2	300	1	0.026			0.015	
	Marine				12.5	0.12					0.016				
Site	Date	Time													
Site 737															
SW0737	2020-03-27	13:39	65												
SW0737	2020-07-09	14:10	190												
SW0737	2021-03-09	12:44	3												
SW0737	2021-03-17	11:13	1	23.7	0.521	0.0074	0.33	2.54	60	0.0322		0.668	3.69	0.005	0.02
SW0737	2021-08-19	13:10	10	24.1	0.682	0.0067	0.24	1.33	82.7	0.0705		0.349	5.16	0.005	0.02
SW0737	2022-07-20	13:25	3	299	0.59	0.0245	0.74	8.48	368	0.662		1	9.6	0.005	0.02
SW0737	2023-04-03	14:00	25	341	0.616	0.0205	1.26	5.39	455	1.39		1.31	10.2	0.0051	0.02
SW0737	2023-06-13	11:00	7	61.2	0.643	0.0079	0.64	3.42	58.5	0.0699		1.69	2.66		
SW0737	2024-04-25	14:20	6	295	0.558	0.0163	0.69	10.9	250	0.347		0.82	333	0.005	0.02
SW0737	2024-08-22	12:25	890	181	0.99	0.0293	0.79	11.4	209	0.315		1.77	15.9		
SW0737	2025-01-17	14:01	17	1790	2.08	0.0232	3.87	47.2	4660	2.25		2.82	22.2	0.005	0.02
Total Data Points			11	8	8	8	8	8	8	8	0	8	8	6	6
Total Exceedences			1	5	0	0	2	7	3	2	0	7	4	0	0
Site 742															
SW0742	2020-03-31	11:10	38												
SW0742	2020-07-09	14:30	5900	53.5	0.897	0.0167	0.34	3.87	822	0.175	0.0276	2.27	5.6		
SW0742	2021-03-17	11:53	4	148	0.52	0.0089	0.49	1.76	1200	0.112	0.0133	2.33	3.6		
SW0742	2021-08-05	12:50	21	67.9	0.636	0.0148	0.33	2.25	1190	0.114	0.0348	1.41	4	0.005	0.02
SW0742	2022-02-17	11:10	3	104	0.372	0.0075	0.34	1.49	859	0.107	0.0134	1.39	2.7	0.005	0.02
SW0742	2022-08-18	13:20	1100												
SW0742	2023-03-10	11:13	43	266	0.426	0.0129	1.02	3.51	760	0.381	0.0111	1.83	9.9		
SW0742	2023-06-13	11:19	900												
SW0742	2024-03-14	14:00	61	79.4	0.275	0.0113	0.3	2.05	433	0.079		1.29	4.4		
SW0742	2024-07-19	13:00	38	52	0.84	0.09	1.53	3.41	559	0.17	0.0187	2.81	19.5		
SW0742	2024-08-21	10:06	74	55.5	0.609	0.0124	0.62	3.23	924	0.076		1.67	10.5		
SW0742	2025-04-30	12:38	40	57.4	0.247	0.01	0.29	1.44	691	0.051	0.0422	1.56	4		
Total Data Points			12	9	9	9	9	9	9	9	7	9	9	2	2
Total Exceedences			3	3	0	0	2	6	9	0	4	9	2	0	0
Site 742 Additional															
SW0742-1	2020-12-01	13:04	32	213	0.507	0.0104	0.57	2.67	872	0.197	0.0077	2.13	2.7	0.005	0.02
SW0742-2A	2020-12-01	13:40		4990	1.64	0.202	8.67	33.5	7140	5.01	0.0044	9.71	76.2		
SW0742-2A	2021-05-12	12:20	7	57.5	0.463	0.0168	0.15	2.37	73	0.0648	0.0025	1.03	2.5	0.005	0.02
SW0742-2B	2020-12-01	13:50		211	0.497	0.0105	0.64	2.51	781	0.196	0.0061	2.33	2.7		
SW0742-2B	2021-05-12	12:50	40	180	0.606	0.0059	0.54	1.24	2050	0.18	0.121	2.11	2.4	0.005	0.02
SW0742-2B	2021-08-05	13:40	440	8320	8.6	0.199	13.5	26.7	80700	9.36	0.25	17.7	80.8	0.048	0.11
SW0742-2C	2021-08-05	14:00	68	596	1.03	0.0178	1.04	1.62	2540	0.537	0.0019	2.86	6.3	0.005	0.02
Total Data Points			5	7	7	7	7	7	7	7	7	7	7	5	5
Total Exceedences			1	6	1	2	3	5	6	2	2	7	2	1	1
Site 0742B															
SW0742B	2020-03-31	11:38	46												
SW0742B	2020-07-07	14:35													
SW0742B	2021-03-17	12:04	1800												
SW0742B	2021-08-05	12:05													
SW0742B	2022-02-17	11:24	1	177	0.347	0.008	0.38	3.61	674	0.158		0.838	3.44	0.005	0.02
SW0742B	2022-08-18	13:30													
SW0742B	2023-04-05	13:30	26	413	0.916	0.0297	1.12	6.01	1650	0.942		1.69	18.6		
SW0742B	2023-06-13	11:31													
SW0742B	2024-03-27	13:30													
SW0742B	2024-05-10	14:02	5	135	1.26	0.0151	0.62	10.8	784	1.76		1.3	17.6		
SW0742B	2024-08-12	12:10													
Total Data Points			5	3	3	3	3	3	3	3	0	3	3	1	1
Total Exceedences			1	3	0	0	1	3	3	1	0	3	0	0	0
Exceedence Rate			20%	100%	0%	0%	33%	100%	100%	33%	#DIV/0!	100%	0%		
Site 0744															
SW0744	2020-01-22	13:40	500												
SW0744	2020-03-31	12:00	260												
SW0744	2020-07-09	13:00	1900												
SW0744	2021-03-09	13:06	870												
SW0744	2021-03-17	11:44	190	131	0.488	0.0111	0.48	2.87	482	0.3	0.0031	1.45	9.18	0.005	0.02
SW0744	2021-08-05	11:20	480	160	1.48	0.0119	0.57	4.57	712	0.683		2.45	9.5	0.005	0.02

Township of Esquimalt Water Quality Data

Parameter			Bacteriolocical Tests	Total Metals										Polycyclic Aromatic Hydrocarbons	
			Escherichia Coli	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Zinc	Benzo[a]pyrene	Pyrene
Unit			CFU/100 mL	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
BC Water Quality Guidelines (BCWQG)	Freshwater Aquatic Life (Long Term)		200	--	5		1	2	1000	3		0.5	33	0.01	0.02
	Marine Life (Long Term)			--	12.5	0.12		2		2			10		
Canadian Council of Ministers of the Environment (CCME)	Freshwater Aquatic Life			100	5			2	300	1	0.026			0.015	
	Marine				12.5	0.12					0.016				
Site	Date	Time													
SW0744	2022-02-17	12:00	630	67	0.493	0.0109	0.3	2.56	398	0.151		1.31	11.8	0.005	0.02
SW0744	2022-08-19	13:15	2400												
SW0744	2023-03-10	11:30	1700	552	0.648	0.0296	2.24	11.7	971	2.27		2.57	125		
SW0744	2023-06-13	11:50	250												
SW0744	2024-03-27	13:18	1400	117	0.465	0.0204	0.48	5.18	373	0.406		1.43	51.1		
SW0744	2024-08-12	12:48	600	65.3	1.12	0.011	0.36	5.39	375	0.176		2.15	8.96		
SW0744	2025-01-16	13:40	1	29.7	0.363	0.0232	0.17	2.19	161	0.102		1.07	18.4		
	Total Data Points		13	7	7	7	7	7	7	7	1	7	7	3	3
	Total Exceedences		11	4	0	0	1	7	6	1	0	7	4	0	0
	Site 0744A														
SW0744A	2020-03-31	12:10	800												
SW0744A	2020-07-09	13:15	170												
SW0744A	2021-03-09	13:09	650												
SW0744A	2021-08-05	11:30													
SW0744A	2022-02-17	12:10	1	37.3	0.369	0.0231	0.16	2.15	227	0.109		1.09	19.9	0.005	0.02
SW0744A	2022-08-19	13:18													
SW0744A	2023-04-05	14:15	12	151	0.979	0.0357	0.55	3.52	2250	0.596		1.59	186		
SW0744A	2023-06-13	11:52													
SW0744A	2024-03-27	13:20													
SW0744A	2024-04-18	13:16	3	26.8	0.57	0.0282	0.17	2.52	1000	0.145		1.27	49.4		
SW0744A	2024-04-25	14:02	20	134	0.338	0.0148	0.36	5.13	312	0.456		0.63	41		
SW0744A	2024-05-08	12:47	16000	93.9	0.952	0.0113	0.4	3.66	255	0.268		1.24	4.9		
SW0744A	2024-08-12	12:52													
SW0744A	2025-01-16	13:32	1200	158	0.476	0.012	0.59	3.6	400	0.335		1.42	13.5		
SW0744A	2025-04-09	13:09	1	208	0.559	0.0285	0.45	3.44	757	0.589		1.28	32.6		
	Total Data Points		10	7	7	7	7	7	7	7	0	7	7	1	1
	Total Exceedences		4	4	0	0	0	7	5	0	0	7	6	0	0
	Site 0744B														
SW0744B	2020-01-22	14:05	2700												
SW0744B	2020-01-29	12:17													
SW0744B	2020-03-03	11:38	110000												
SW0744B	2020-03-31	12:18	160000												
SW0744B	2020-07-09	14:20	760000												
SW0744B	2021-01-06	12:48	47000												
SW0744B	2021-03-09	8:30	2100												
SW0744B	2022-01-28	13:50	300000	110	0.788	0.0193	0.39	8.43	350	0.213		1.6	7.02	0.005	0.02
SW0744B	2022-02-17	12:32	410000	124	0.959	0.0278	0.52	5.56	418	0.237		1.74	9.9	0.005	0.02
SW0744B	2022-03-09	12:10	2200000												
SW0744B	2022-05-04	11:38	4300000												
SW0744B	2022-06-24	10:00	67000												
SW0744B	2022-07-04	13:10	74000												
SW0744B	2022-07-12	11:20	72000												
SW0744B	2022-07-20	14:21	10000												
SW0744B	2022-08-09	10:13	14000												
SW0744B	2022-11-02	11:38	1400												
SW0744B	2022-11-21	13:10	160000												
SW0744B	2022-12-06	14:24	55000												
SW0744B	2023-03-10	11:35	12000	771	0.795	0.03	2.27	12.6	1130	1.78		2.81	40.4		
SW0744B	2023-05-05	13:12	52000	4180	1.5	0.107	10.2	47.4	6200	10.7		8.24	150		
SW0744B	2023-06-13	12:07	14000												
SW0744B	2024-02-07	13:03	110000	324	0.688	0.0123	0.7	5.44	473	0.269		1.58	5.6		
SW0744B	2024-03-27	13:46	70000	207	0.816	0.016	0.43	9.28	322	0.302		1.48	14		
SW0744B	2024-04-18	13:22	65000	192	1.05	0.0397	0.54	14.5	398	0.694		1.9	13.8		
SW0744B	2024-08-12	13:05	59000	1990	2.07	0.1	3.22	175	2920	5.03		4.07	58.9		
SW0744B	2024-11-14	9:22	5500	849	1.06	0.0228	1.62	8.93	954	0.806		2.59	10.4		
SW0744B	2025-01-16	13:20	14000	106	0.689	0.0097	0.33	3.58	249	0.248		1.63	5.9		
SW0744B	2025-04-08	13:18	4200	240	0.668	0.01	0.54	3.75	398	0.389		1.28	6.4		
SW0744B	2025-06-11	13:19	6800	196	0.905	0.007	0.52	4.2	284	0.547		1.21	5.1		
	Total Data Points		29	12	12	12	12	12	12	12	0	12	12	2	2
	Total Exceedences		29	12	0	0	4	12	10	3	0	12	6	0	0
	Site 749														

Township of Esquimalt Water Quality Data

Parameter			Bacteriolocical Tests	Total Metals										Polycyclic Aromatic Hydrocarbons	
Parameter			Escherichia Coli	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Zinc	Benzo[a]pyrene	Pyrene
Unit			CFU/100 mL	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
BC Water Quality Guidelines (BCWQG)	Freshwater Aquatic Life (Long Term)		200	--	5		1	2	1000	3		0.5	33	0.01	0.02
	Marine Life (Long Term)			--	12.5	0.12		2		2			10		
Canadian Council of Ministers of the Environment (CCME)	Freshwater Aquatic Life			100	5			2	300	1	0.026			0.015	
	Marine				12.5	0.12					0.016				
Site	Date	Time													
SW0749	2020-03-31	12:40	72												
SW0749	2020-07-07	10:20													
SW0749	2021-04-27	10:35	240												
SW0749	2021-08-23	12:30													
SW0749	2022-03-04	11:29	800	113	0.7	0.0093	0.57	3.61	101	0.151		1.43	4.25	0.005	0.02
SW0749	2022-08-23	11:05													
SW0749	2023-03-10	11:50	300	552	0.83	0.026	2.39	8.65	723	2.03	0.0025	7.29	12.5	0.005	0.02
SW0749	2023-06-13	12:20	580												
SW0749	2024-03-27	13:04	6100	402	0.876	0.0181	0.81	7	509	1.41		2.08	10.2		
SW0749	2024-09-05	13:30													
SW0749	2025-04-29	13:07	310	1840	2.86	2.07	3.47	29.5	6640	16.2		15	103		
SW0749	2025-07-29	13:45		9300	14.5	0.221	18.7	50.9	21200	25.5	0.054	16.3	208	0.28	0.57
	Total Data Points		15	5	5	5	5	5	5	5	2	5	5	3	3
	Total Exceedences		6	5	1	2	3	5	4	4	1	5	4	1	1
	Site 780														
SW0780	2020-03-03	13:04	1500												
SW0780	2020-06-26	12:50													
SW0780	2020-07-07	12:45													
SW0780	2020-11-20	14:01	1700	218	0.953	0.0168	0.69	8.02	462	0.391		1.15	14.4	0.005	0.02
SW0780	2021-02-24	12:26	2800												
SW0780	2021-04-01	11:30	800	67.9	0.537	0.0108	0.59	3.49	110	0.309		0.59	8.2	0.005	0.02
SW0780	2021-06-18	11:42													
SW0780	2021-08-25	14:30													
SW0780	2022-02-07	12:32	19000	28.6	0.76	0.0123	0.49	3.3	43.7	0.191		0.53	8.2	0.005	0.02
SW0780	2022-07-14	12:06	80												
SW0780	2023-03-10	10:18	9000	773	3.77	0.0312	4.18	19.2	1080	2.93		1.98	57.1	0.1	0.14
SW0780	2023-07-06	12:25	1												
SW0780	2023-12-08	12:15	48000												
SW0780	2024-02-12	14:40	31000	63.4	1.56	0.0129	0.63	6.63	76.9	0.254		0.56	13.4		
SW0780	2024-04-24	13:05	820	109	2.85	0.0191	1.54	21.9	174	0.447	0.0056	1.12	32	0.005	0.02
SW0780	2024-07-24	13:11	7	13	1.04	0.019	0.22	4.25	27.2	0.092	0.0019	1.54	7.5	0.005	0.02
SW0780	2024-09-09	11:38	2100	15	0.509	0.0069	0.18	2.15	52.3	0.121	0.0019	0.62	8.4	0.005	0.02
SW0780	2025-02-04	12:00	5100	99	0.63	0.153	0.8	4.78	319	0.696		1.11	85.3		
SW0780	2025-07-30	13:57	520	90.2	0.374	0.0106	0.36	7.22	277	0.843		1.04	14.3		
	Total Data Points		15	10	10	10	10	10	10	10	3	10	10	7	7
	Total Exceedences		12	3	0	1	2	10	3	1	0	10	6	1	1
	Site 781														
SW0781	2020-03-03	13:04	2000												
SW0781	2020-06-26	13:00													
SW0781	2020-07-09	13:00	47	49.6	0.374	0.0073	0.26	4.11	225	0.282		0.334	7.97	0.005	0.02
SW0781	2020-11-20	14:20	72000	216	1.24	0.0268	1.29	15.6	253	1.41		1.11	21.4		
SW0781	2021-02-24	12:52	320												
SW0781	2021-04-01	11:15	280	103	0.416	0.01	0.72	2.7	361	0.488		0.65	11.2	0.005	0.02
SW0781	2021-06-18	11:50	7												
SW0781	2021-08-25	14:40		108	0.307	0.0145	0.5	4.7	442	0.526		0.47	13.5	0.005	0.02
SW0781	2022-02-07	13:00	460	57.7	0.423	0.0118	0.32	3.39	419	0.143		0.72	6.28	0.005	0.02
SW0781	2022-07-14	12:20	27												
SW0781	2023-03-10	10:27	1400	917	0.891	0.0469	2.89	18.3	1460	3.14		2.35	56.4	0.15	0.24
SW0781	2023-07-06	12:35	79												
SW0781	2024-02-27	13:20	420	67.7	0.47	0.009	0.37	4.31	417	0.13		0.879	7.23		
SW0781	2024-04-24	13:15	9600	132	0.858	0.0207	0.6	17.5	495	0.827	0.005	1.2	25.4	0.005	0.021
SW0781	2024-07-24	13:22	12	47.6	0.218	0.005	0.14	2.46	185	0.19	0.0019	0.32	8.5	0.005	0.02
SW0781	2024-09-09	11:50	5400	130	0.502	0.0184	0.37	4.2	609	0.252	0.0053	0.7	15.8	0.005	0.022
SW0781	2025-07-30	14:10	9400	105	0.348	0.0136	0.45	8.17	413	0.671	0.0136	0.86	18.4	0.005	0.02
	Total Data Points		15	11	11	11	11	11	11	11	4	11	11	9	9
	Total Exceedences		10	7	0	0	2	11	8	2	0	8	7	1	3
	Site 805														
SW0805	2020-03-03	13:15	110000												
SW0805	2020-06-23	9:37	8000												
SW0805	2021-02-24	12:45	13000												
SW0805	2021-06-17	13:58	11000												

Township of Esquimalt Water Quality Data															
			Bacteriolocical Tests	Total Metals										Polycyclic Aromatic Hydrocarbons	
Parameter			Escherichia Coli	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Zinc	Benzo[a]pyrene	Pyrene
Unit			CFU/100 mL	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
BC Water Quality Guidelines (BCWQG)	Freshwater Aquatic Life (Long Term)		200	--	5		1	2	1000	3		0.5	33	0.01	0.02
	Marine Life (Long Term)			--	12.5	0.12		2		2			10		
Canadian Council of Ministers of the Environment (CCME)	Freshwater Aquatic Life			100	5			2	300	1	0.026			0.015	
	Marine				12.5	0.12					0.016				
Site	Date	Time													
SW0805	2021-06-18	13:02	39000												
SW0805	2021-07-28	11:19	170000												
SW0805	2021-08-25	10:32	140000	235	0.534	0.0222	0.47	15	309	0.518		1.09	15		
SW0805	2021-09-23	10:24	280000												
SW0805	2021-11-30	14:14	11000												
SW0805	2022-01-17	13:18	23000												
SW0805	2022-01-28	14:12	120000	130	0.474	0.0171	0.99	9.71	221	0.505		1.05	12	0.005	0.02
SW0805	2022-05-13	14:10	130000												
SW0805	2022-07-14	13:25	520000												
SW0805	2023-01-18	12:30	210												
SW0805	2023-03-02	12:58	2000	479	2.35	0.0665	2.08	7.53	473	0.639		1.42	15		
SW0805	2023-03-10	10:50	33000	348	0.549	0.0201	0.82	7.57	489	1.31	0.0019	1.18	13.6	0.005	0.02
SW0805	2023-05-16	12:47	12000	42.5	0.606	0.0079	5.94	4.21	111	0.217		24.7	5.7		
SW0805	2023-06-19	11:44	180000												
SW0805	2023-12-14	13:22	5000												
SW0805	2024-02-06	14:14	8200	132	0.744	0.0144	0.6	3.16	166	0.182		0.922	3.52		
SW0805	2024-07-24	13:40	390000	99.6	0.874	0.024	0.51	19	231	0.651		1.5	19.4		
SW0805	2024-09-18	14:19	17000	52.3	1.31	0.024	0.77	11.3	81.5	0.229		2.05	8.4		
SW0805	2025-02-04	12:47	5700	176	0.687	0.038	0.68	4.43	264	0.398		0.97	7.1		
	Total Data Points		23	9	9	9	9	9	9	9	1	9	9	2	2
	Total Exceedences		23	6	0	0	2	9	3	1	0	9	5	0	0
	Site 806														
SW0806	2020-03-03	13:16	300												
SW0806	2020-06-23	9:38	50000												
SW0806	2020-07-22	12:15		285	1.75	0.0443	0.85	5.76	317	0.381		1.51	5.2	0.005	0.02
SW0806	2021-02-24	12:44	530												
SW0806	2021-04-01	11:55	1300	194	0.723	0.0174	0.47	3.55	456	0.245		1.23	9.3		
SW0806	2021-06-17	13:50	2400												
SW0806	2021-06-18	13:04	1300												
SW0806	2021-07-28	11:18	32000												
SW0806	2021-08-25	10:33	120000	757	1.7	0.0615	1.43	15.3	903	0.864		2.95	29.5		
SW0806	2021-09-23	10:20	6900												
SW0806	2021-11-30	14:16	190												
SW0806	2022-01-28	14:15	200	126	0.604	0.0188	0.33	3.51	321	0.145		1.25	6.43	0.005	0.02
SW0806	2022-05-13	14:12	2100												
SW0806	2022-07-14	13:23	1300												
SW0806	2023-03-02	13:00	900	235	0.87	0.0304	0.56	3.72	339	0.338		1.07	13.4		
SW0806	2023-03-10	10:52	1100	287	0.624	0.0174	0.75	6.59	425	0.643	0.0026	1.3	17.7	0.005	0.02
SW0806	2023-06-19	11:45	630												
SW0806	2024-02-06	14:16	12000	147	0.546	0.0257	0.44	3.52	368	0.177		1.38	11		
SW0806	2024-04-24	12:25	2500	138	0.505	0.0098	0.44	7.21	262	0.211	0.0044	0.98	7.5	0.005	0.02
SW0806	2024-07-24	13:36	9200	80.9	1.11	0.021	0.26	5.08	169	0.171	0.0019	1.92	6.1	0.005	0.02
SW0806	2024-09-18	14:22	7900	186	0.663	0.016	0.36	4.01	196	0.159	0.0023	1.15	8.3	0.005	0.02
SW0806	2025-02-04	12:40	520	197	0.66	0.059	0.39	3.33	299	0.211		1.15	8.8		
	Total Data Points		21	11	11	11	11	11	11	11	4	11	11	6	6
	Total Exceedences		19	10	0	0	1	11	7	0	0	11	4	0	0
	Site 812														
SW0812	2023-04-26	14:10	110000	114	0.56	0.0133	11.3	5.14	139	0.447		45.7	16.2		
SW0812	2023-05-05	11:15	5500												
SW0812	2023-06-19	12:32	58000												
SW0812	2024-05-10	13:32	12000	324	0.887	0.0611	0.91	11.4	381	1.24		1.76	21.9		
SW0812	2024-06-04	12:40	290	260	1.25	0.0405	0.79	6.62	250	0.734		1.85	29.7		
SW0812	2024-07-24	14:16													
SW0812	2024-11-12	13:09	780												
SW0812	2025-01-16	14:02	9800	134	0.519	0.0166	0.51	4.26	129	0.403		0.95	14.2		
	Total Data Points		7	4	4	4	4	4	4	4	0	4	4	0	0
	Total Exceedences		7	0	0	0	1	4	1	1	0	4	4	0	0
				4											
	Site 814														
SW0814	2020-03-03	13:37	7000												
SW0814	2020-05-25	13:28	1200												

Township of Esquimalt Water Quality Data

Parameter			Escherichia Coli	Aluminum	Arsenic	Cadmium	Chromium	Copper	Iron	Lead	Mercury	Nickel	Zinc	Benzo[a]pyrene	Pyrene
			Bacteriolocical Tests	Total Metals										Polycyclic Aromatic Hydrocarbons	
Unit			CFU/100 mL	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
BC Water Quality Guidelines (BCWQG)	Freshwater Aquatic Life (Long Term)		200	--	5		1	2	1000	3		0.5	33	0.01	0.02
	Marine Life (Long Term)			--	12.5	0.12		2		2			10		
Canadian Council of Ministers of the Environment (CCME)	Freshwater Aquatic Life			100	5			2	300	1	0.026			0.015	
	Marine				12.5	0.12					0.016				
Site	**Date**	**Time**													
SW0814	2020-06-26	13:35													
SW0814	2020-07-09	13:20	250												
SW0814	2021-02-24	13:56	17												
SW0814	2021-06-18	12:40	2300												
SW0814	2022-02-16	14:05	1000	411	0.785	0.017	0.85	5.25	346	0.881		1.28	9.36	0.005	0.02
SW0814	2022-07-14	13:37													
SW0814	2023-03-02	13:24	50	403	1.24	0.0279	2.58	14.5	280	0.82		1.94	12.5		
SW0814	2023-06-19	13:00	400												
SW0814	2024-05-10	13:15	5600	362	1.65	0.0433	6.32	10.2	267	0.973		1.35	8.5		
SW0814	2024-07-24	14:20	41000	158	0.86	0.027	3.03	7.75	167	0.476		1.21	6.6		
SW0814	2025-01-16	14:21	600	179	0.727	0.0125	1.83	5.83	145	0.296		0.89	4.2		
SW0814A	2015-03-06	0:00													
Total Data Points			11	5	5	5	5	5	5	5	0	5	5	1	1
Total Exceedences			9	0	0	0	4	5	1	0	0	5	1	0	0
				5											
Site 854															
SW0854	2018-08-10	9:15	7800000												
SW0854	2019-04-23	12:58	5400												
SW0854	2019-07-03	11:35	25000												
SW0854	2020-04-27	12:15	5600	1260	1.5	0.0224	2.39	10.9	1420	0.868		2.06	12.1	0.005	0.02
SW0854	2020-06-22	12:00	6800	1630	2.61	0.0211	3.86	10	2080	1.53		2.63	14.7	0.0058	0.021
SW0854	2021-03-31	12:20	3000	213	0.634	0.0188	0.84	8.24	334	0.6		1.18	17.9		
SW0854	2021-06-25	11:38	1300	65.4	3.33	0.03	2.1	8.73	973	0.368		1.22	16.1		
SW0854	2022-03-23	13:55	800	732	0.75	0.0178	1.75	12	1240	1.37		4.51	24.1	0.0091	0.021
SW0854	2022-07-14	11:38	44000	62.6	2.03	0.0226	0.46	7.99	672	0.212		1.92	11.7		
SW0854	2023-03-23	12:10	1600	27.2	0.438	0.0091	0.29	3.71	256	0.175		0.778	5.92	0.005	0.02
SW0854	2023-06-19	11:38	100000												
SW0854	2024-04-11	11:14	10000	96.8	0.939	0.0093	0.87	3.99	244	0.223		0.71	6.4		
SW0854	2024-07-22	12:08	7500	141	2.46	0.026	0.5	8.67	171	0.156		2.14	5.5		
SW0854	2025-04-28	11:56	5300	60.1	0.784	0.0137	0.45	6.74	272	0.273	0.0033	0.75	8.4		
Total Data Points			11	10	10	10	10	10	10	10	1	10	10	4	4
Total Exceedences			11	5	0	0	4	10	6	2	0	10	6	0	2

Above BC Water Quality Guideline for Freshwater Aquatic Life
Above BC Water Quality Guideline for Freshwater Marine Life
Above CCME guideline for lowest Freshwater or Marine Life

Table 2: Township of Esquimalt Storm Sediment Analysis – Parameters of Concern

Township of Esquimalt Sediment Water Quality Data														
		General	Metals								Polycyclic Aromatic Hydrocarbons			
Parameter		pH	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Silver	Zinc	Benzo[a]pyrene	Pyrene	Total Heavy PAH's	Total Light PAH's
Unit		[illegible]	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt
Freshwater	CCME ISQG	6.5-9	5.9	0.6	37.3	37.3		0.17		123	0.0319			
	CCME PEL			3.5	90	197		0.486		315	0.782			
Marine	CRD MSQG		57	5.1	260	390	450	0.48	6.1	410			12	5.2
	CCME ISQG		7.24	0.7	52.3	18.7	30	0.13	1	124	0.0888	0.153		
	CCME PEL		42	4.2	160	108	112	0.7	2.2	271	0.763	1.398		
Vancouver Island Background			4	0.95	65	100	40	0.15	1	150				
Site	Date													
Site 737														
SW0737	2011-06-17		5.7	0.16	19	63.3	13.3	0.026	0.11	146				
SW0737-1	2011-06-17		5.3	0.43	2	97.8	38	0.11	0.09	244				
SW0737-2	2011-06-17		8.4	1.64	51	330	95.6	0.57	0.29	590				
SW0737	2013-07-12		25.5	0.441	27.7	110	51.8	0.053	0.22	487	2			
SW0737	2014-06-09	7.59	3.59	0.223	28.1	48.3	18.7	0.044	0.05	125	1.3	2.6	14	2.1
SW0737	2016-09-20		23.6	0.279	31.3	50.3	58.3	0.0505	0.089	196	1.9	4.7	17	5.9
SW0737	2017-12-06		7.95	0.095	17.2	33.9	9.55	0.04	0.1	79.3	0.034	0.072	0.28	0.064
SW0737-1	2017-12-06		9.14	0.291	17.7	73.8	16.9	0.055	0.1	359	13	22.3	87.3	26.5
SW0737	2021-03-17		7.44	0.369	50.7	46.6	8.29	0.067	0.085	63.6	2.2	4.6	18	7.2
SW0737	2022-07-20		5.71	0.103	23.3	50.8	10.6	0.05	0.05	98.7	0.24	0.048		
SW0737	2023-04-03		3.7	0.122	27.8	47.6	11.3	0.082	0.055	126	0.5	0.94		
SW0737	2023-06-13		3.18	0.1	26.4	42.4	16.8	0.05	0.07	92	0.88	1.7		
SW0737	2024-04-25		2.37	0.077	30.5	49	10.2	0.05	0.05	205	1.1	2		
SW0737	2024-08-22		3	0.105	29.6	50	13.6	0.128	0.071	128	0.65	1.1		
SW0737	2025-01-17		3.44	0.112	38.4	52.9	19.9	0.05	0.059	116	0.26	1.1		
Total Data Points		1	15	15	15	15	15	15	15	15	12	11	5	5
Total Exceedences		0	6	1	3	15	4	1	0	10	12	9	4	3
Exceedences below background		n/a	0	0	3	13	1			4	n/a	n/a	n/a	n/a
Site 742														
SW0742-2	2011-06-17		2.7	0.3	37	88.6	22.2	0.699	0.32	196				
SW0742-2	2012-06-25	6.54	3.15	0.279	25.3	36.2	16.3	0.0645	0.067	77.2	0.042	0.077	0.3	0.06
SW0742-4	2012-06-25	7.79	6.02	0.248	35.3	54.9	15.9	0.0398	0.161	201	0.034	0.064	0.19	0.049
SW0742-2	2013-07-08		4.62	0.36	34.5	71.3	21.8	4.4	0.28	200	0.094			
SW0742-2	2014-07-02	7.53	5.94	0.248	28.1	52.7	11.1	2.68	0.07	99.6	0.0092	0.028	0.12	0.01
SW0742-4	2014-07-02	7.36	9.21	0.586	27.9	33	18.4	0.079	0.126	248	0.042	0.082	0.5	0.045
SW0742	2017-10-04		4.98	0.174	23.5	33.5	14.8	2.3	0.1	108	0.11	0.238	0.909	0.17
SW0742-2A	2020-12-01		2.36	0.271	34.3	55.3	8.39	0.07	0.06	143	0.028	0.044	0.18	0.033
SW0742-2B	2020-12-01		5.18	0.094	27	25.9	8.71	29.8	0.05	69.6	0.018	0.025	0.1	0.015
SW0742-2A	2021-08-05		3.6	0.437	36.6	81.3	10.8	0.182	0.178	274	0.024	0.071		
SW0742-2B	2021-08-05		26.3	0.291	25.3	38.4	12.3	22.2	0.103	122	0.032	0.055		
Total Data Points		4	11	11	11	11	11	11	11	11	10	9	7	7
Total Exceedences		0	4	0	0	11	0	7	0	6	6	1	0	0
Exceedences below background		n/a	0	0	0	11	0	0	0	1	n/a	n/a	n/a	n/a
Site 744														
SW0744	2011-10-06		3.4	0.68	41	52.6	68.1	0.07	0.08	222				
SW0744	2012-06-25	7.28	6.2	1.09	53.8	115	89.7	0.175	0.302	569	0.74	1.4	5.1	0.81
SW0744	2014-06-16	7.29	3.49	0.473	31	40	30.5	0.154	0.686	187	0.53	1.2	6.6	1.2
SW0744	2015-06-22		3.07	0.138	19.4	50.8	19.2	0.0295	0.436	210	0.072	0.13	0.19	0.016
SW0744	2020-07-09		4.84	0.574	48.7	78.7	51.8	0.115	0.881	375	0.63	0.72	4.5	0.94
SW0744	2021-03-31		2.65	0.182	29.1	38.3	26.6	0.05	0.322	164	0.087	0.17	0.64	0.12
Total Data Points		2	6	6	6	6	6	6	6	6	5	5	5	5
Total Exceedences		0	1	2	3	6	4	2	0	6	5	4	0	0

Township of Esquimalt Sediment Water Quality Data

Parameter		General	Metals								Polycyclic Aromatic Hydrocarbons			
		pH	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Silver	Zinc	Benzo[a]pyrene	Pyrene	Total Heavy PAH's	Total Light PAH's
Unit:		pH	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt
Freshwater	CCME ISQG	6.5-9	5.9	0.6	37.3	37.3		0.17		123	0.0319			
	CCME PEL			3.5	90	197		0.486		315	0.782			
Marine	CRD MSQG		57	5.1	260	390	450	0.48	6.1	410			12	5.2
	CCME ISQG		7.24	0.7	52.3	18.7	30	0.13	1	124	0.0888	0.153		
	CCME PEL		42	4.2	160	108	112	0.7	2.2	271	0.763	1.398		
Vancouver Island Background			4	0.95	65	100	40	0.15	1	150				
Site	Date													
Exceedences below background		n/a	0	1	3	5	1	0	0	0	n/a	n/a	n/a	n/a
Site 749														
SW0749	2011-06-17		12.4	0.24	24	122	33.4	0.038	0.11	292				
SW0749-2	2011-06-17		32.3	1.49	29	187	51.9	0.08	0.16	252				
SW0749	2012-06-20	7.56	5.17	0.41	24.7	62.2	45.3	0.017	0.089	201	1.4	3.7	14	5.1
SW0749-2	2012-06-20	6.35	13.6	0.629	160	348	43.7	4.27	2.71	231	0.23	0.38	0.88	0.31
SW0749-2	2013-07-08		34.6	0.569	20.1	206	55.3	0.18	0.387	234	0.3			
SW0749	2014-07-09	6.99	5.3	1.69	44.4	136	87	0.063	0.241	510	3.7	7.7	43	4.7
SW0749	2015-06-29		3.89	0.568	37.5	79.9	51.9	0.0875	0.124	308	0.7	1.7	6.1	0.91
SW0749-3	2015-06-29		7.03	1.33	32.8	126	52.3	0.196	0.359	425	0.27	0.53	2	0.35
SW0749	2017-06-28		3.36	0.299	37	73.9	30.5	0.407	0.2	222	0.434	0.991	3.62	0.578
Total Data Points		3	9	9	9	9	9	9	9	9	7	6	6	6
Total Exceedences		0	5	4	3	9	9	4	1	9	7	6	2	0
Exceedences below background		n/a	0	1	2	3	2	0	0	0	n/a	n/a	n/a	n/a
Site 780														
SW0780	2011-06-17		4.4	0.74	46	321	93.1	0.042	0.18	441				
SW0780	2012-06-20	7.65	9.68	1.37	39.9	111	77.9	0.0133	0.241	337	0.17	0.34	1.2	0.28
SW0780-1	2012-06-20	8.47	5.67	0.587	54	61.2	173	0.0347	0.11	175	0.42	0.94	3.4	0.61
SW0780	2014-06-17	8.16	2.32	0.219	49.8	48	41	0.015	0.05	166	0.51	0.98	6	0.7
SW0780	2015-06-22		2.21	0.138	24.1	63.5	35.9	0.0272	0.05	185	0.44	1	3.6	1
SW0780	2020-11-20													
Total Data Points		3	5	5	5	5	5	5	5	5	4	4	4	4
Total Exceedences		0	1	2	4	5	5	0	0	5	4	4	0	0
Exceedences below background		n/a	0	1	4	3	1	0	0	0	n/a	n/a	n/a	n/a
Site 781														
SW0781	2015-06-22		7.47	0.414	118	123	372	0.137	0.05	171	0.32	0.69	2.5	0.59
SW0781	2018-12-11													
Total Data Points		0	1	1	1	1	1	1	1	1	1	1	1	1
Total Exceedences		0	1	0	1	1	1	1	0	1	1	1	0	0
Exceedences below background		n/a	0	0	0	0	0	1	0	0	n/a	n/a	n/a	n/a
Site 805														
Site 806														
SW0806	2012-06-20	6.38	10.6	1.22	46	124	92.6	0.0793	0.257	364	0.86	2	7.9	1.6
SW0806-3	2012-06-20	7.91	5.19	0.27	37.5	71.4	25.8	0.0242	0.07	229	0.038	0.066	0.25	0.043
SW0806-2	2013-07-08		9.26	1.98	49.5	362	77	0.184	0.901	472	0.38			
SW0806-3	2013-07-08		7.18	0.401	27.8	94.7	37.8	0.031	0.111	235	0.095			
SW0806-4	2014-06-23	6.66	9.79	1.33	48.9	216	52.2	0.088	0.314	372	2.5	6	32	6.1
SW0806-4	2015-11-30	6.35	21.9	1.17	46.9	166	165	0.23	0.333	591	0.55	1	4	0.65
Total Data Points		4	6	6	6	6	6	6	6	6	6	4	4	4
Total Exceedences		0	5	4	5	6	5	2	0		6	3	1	1

Township of Esquimalt Sediment Water Quality Data

Parameter		General	Metals								Polycyclic Aromatic Hydrocarbons			
		pH	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Silver	Zinc	Benzo[a]pyrene	Pyrene	Total Heavy PAH's	Total Light PAH's
Unit		pH	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt	mg/kg dry wt
Freshwater	CCME ISQG	6.5-9	5.9	0.6	37.3	37.3		0.17		123	0.0319			
	CCME PEL			3.5	90	197		0.486		315	0.782			
Marine	CRD MSQG		57	5.1	260	390	450	0.48	6.1	410			12	5.2
	CCME ISQG		7.24	0.7	52.3	18.7	30	0.13	1	124	0.0888	0.153		
	CCME PEL		42	4.2	160	108	112	0.7	2.2	271	0.763	1.398		
Vancouver Island Background			4	0.95	65	100	40	0.15	1	150				
Site	Date													
Exceedences below background		n/a	0	0	5	2	1	0	0	0	n/a	n/a	n/a	n/a
Site 812														
Site 814														
Site 854														
SW0854	2013-08-08	6.77	5.49	0.883	60.8	113	90.2	0.0334	0.222	529	0.14	0.85	3	0.71
Total Data Points		1	1	1	1	1	1	1	1	1	1	1	1	1
Total Exceedences		0	0	1	1	1	1	0	0	1	1	1	0	0
Exceedences below background		n/a	0	1	1	0	0	0	0	0	n/a	n/a	n/a	n/a

Above the lowest BC Water Quality Guideline for Freshwater Aquatic Life
Above the lowest BC Water Quality Guideline for Marine Life
Above CCME guideline, but below reported Vancouver Island Background level

CCME ISQG Canadian Council of Ministers of the Environment Interim Sediment Quality Guideline
CCME PEL Canadian Council of Ministers of the Environment Probable Effect Level
CRD MSQG Capital Regional District Marine Sediment Quality Guideline

APPENDIX B:

Recommended Low Impact Development (LID) and Stormwater Best Management Practices (BMP's)

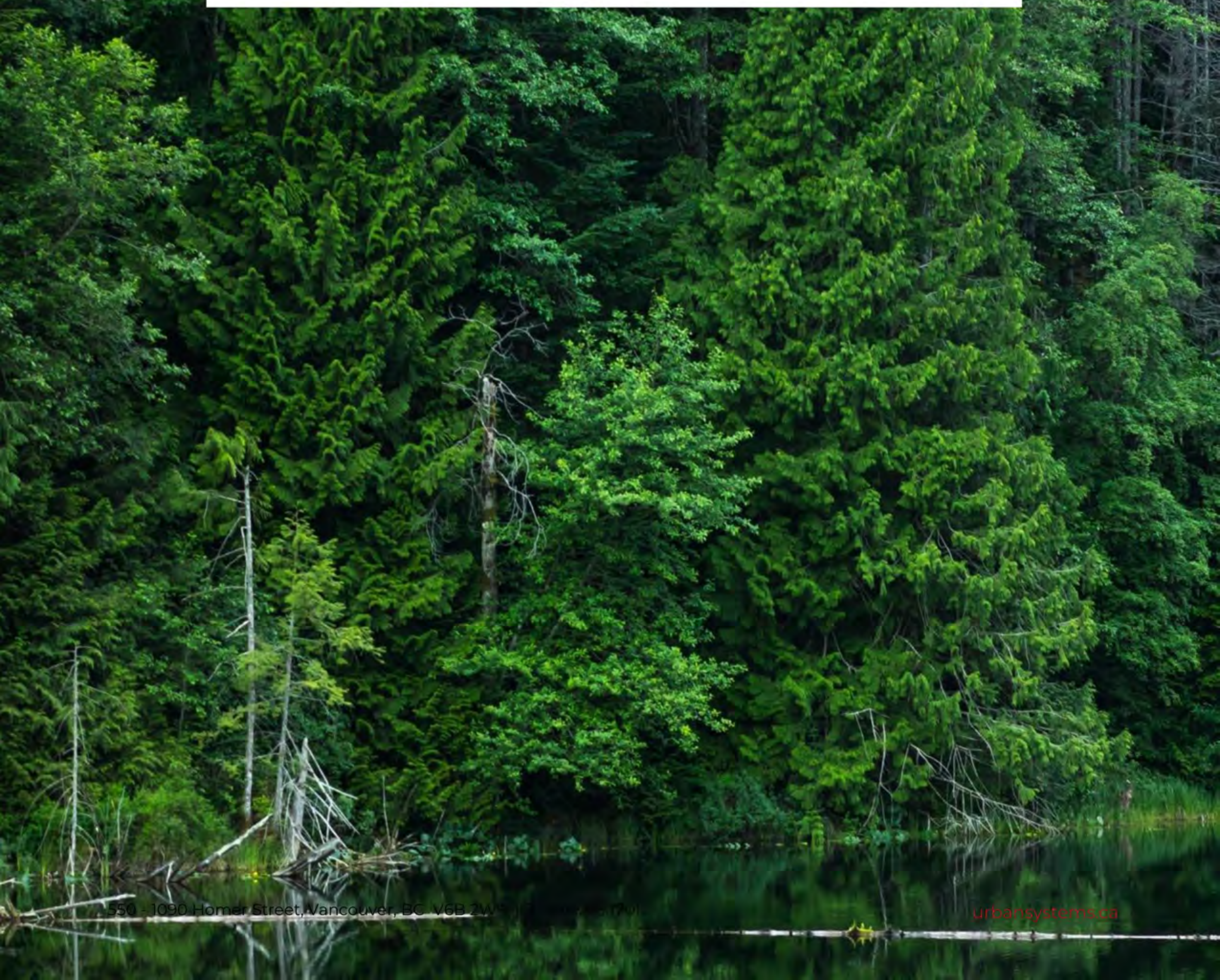
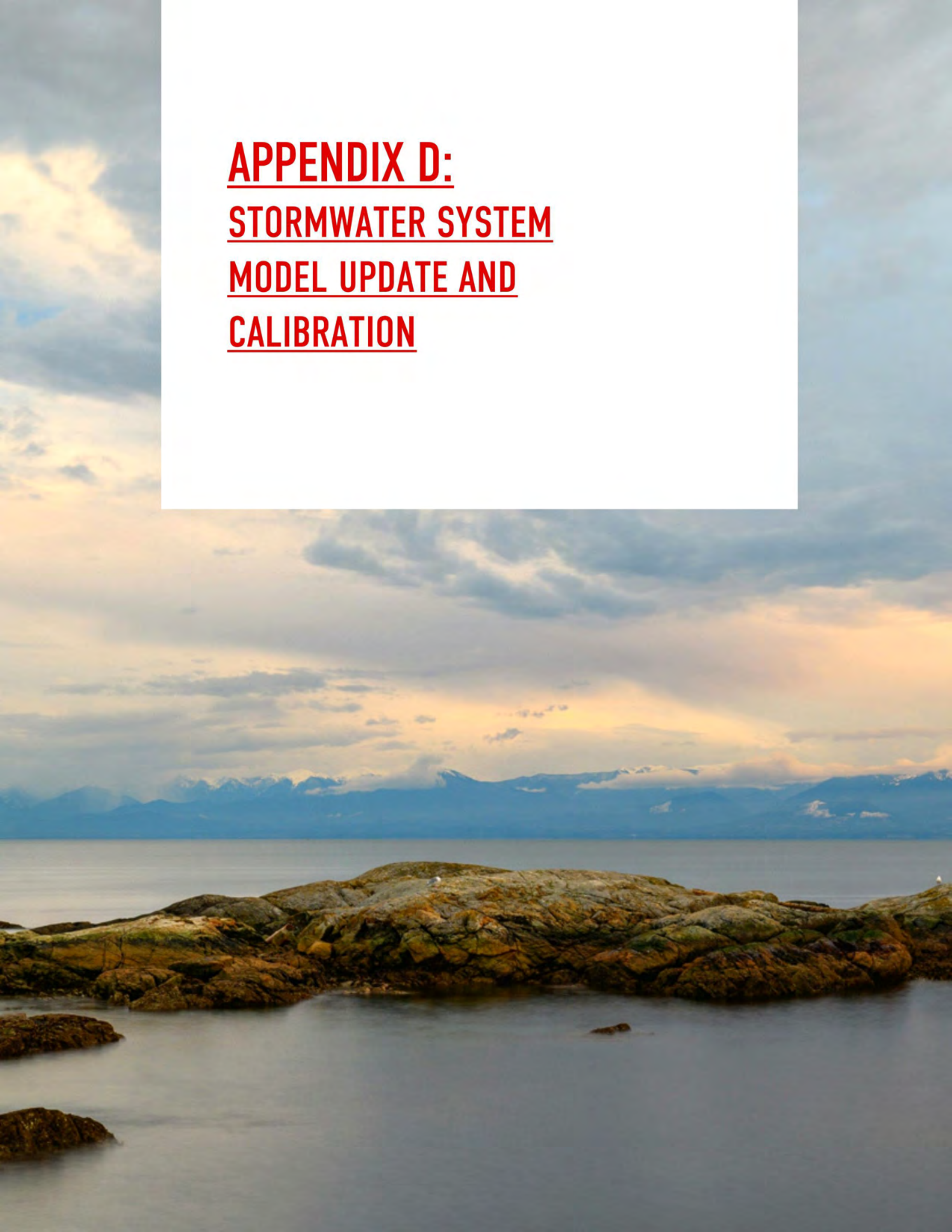


Table 1: Recommended Low Impact Development (LID) and stormwater Best Management Practices (BMPs), including primary treatment purpose, suitable applications, maintenance requirements, and relative effectiveness for addressing stormwater quality concerns identified within the Township of Esquimalt.

BMP Type	Primary Purpose	Suitable Land Uses	Maintenance Schedule (BMPs)	Relative Effectiveness for Esquimalt Results
		Primary Measures (best for water quality treatment)		
Rain Gardens & Infiltration Bulges	Capture and filter runoff from roofs, roads and parking lots	All	• Inlet cleaning twice annually • Vegetation maintenance annually • Mulch replacement every 3 years · Sediment and erosion inspection after major storms	**Primary -** Dissolved and sediment-bound metals and PAHs. **Secondary** - E.coli reduction
Absorbent Landscapes	Reduce runoff from impervious surfaces through infiltration	All	• Core aeration annually in spring • Weed management annually • Mulch replacement every 3 years • Inspect for ponding and soil compaction	**Primary -** Copper, Zinc, Nickel, Iron and Manganese **Secondary** - PAHs.
Infiltration Swales	Capture, infiltrate and treat urban and road runoff	All	• Inlet inspection/cleaning twice annually • Annual aeration and vegetation maintenance • Mulch replacement every 3 years • Sediment cleanout as needed	**Primary -** Copper, Zinc, Nickel, Iron, Manganese, Benzo(a)pyrene and Pyrene due to sediment filtration. **Secondary** - E.coli reduction
Pervious Paving	Infiltrate and treat runoff while maintaining a hard surface	• Not suitable for industrial/ heavy use activities	• Vacuum sweeping minimum twice annually • Weed management annually • Aggregate replacement every 3 years • Inspect for clogging	**Primary -** Copper, Zinc, Iron, Nickel and PAHs from parking lots and roadways. **Secondary** -E.coli
Water Quality Structures (OGS, Separators, Filters)	Treat runoff for sediment, oil, grit and hydrocarbons	• Local streets and arterial roads.	• Inspect annually minimum • Vacuum clean sediment and oil as required • Replace filter media per manufacturer recommendations	**Primary -** Benzo(a)pyrene, Pyrene, and hydrocarbons. **Secondary -** Copper, Zinc and sediment-bound contaminants.
		Secondary Measures		
Green Roofs	Reduce peak runoff and stormwater volume	• Commercial mixed use Institutional.	• Intensive maintenance first 2 years • Annual weeding and inspection • Aeration as needed • Vegetation replacement if required	• Moderate effectiveness for reducing runoff volume and associated contaminant transport. • Limited direct treatment benefit for metals and bacteria. • Useful supplementary BMP.
Tree Well Structures	Managing runoff from adjacent hard surfaces	• Medium/high density • Commercial mixed use • Institutional • Arterial roads	• Inlet inspection twice annually • Mulch replacement every 3 years • Vegetation and grate adjustments as trees mature	• Moderate-high effectiveness for roadway metals (Copper, Zinc, Nickel) and runoff reduction. • Limited direct benefit for E.coli and PAHs.
Rainwater Harvesting	Reduce runoff volume and potable water demand	• Commercial mixed use • institutional	• Gutter and diverter cleaning twice annually • Tank cleaning every 3 years • Regular inspection for algae and cross-connections	• Moderate effectiveness by reducing runoff volume and contaminant transport. • Limited direct contaminant treatment capability.
Infiltration Trenches	Reduce runoff volume and promote infiltration	• Commercial mixed use • Industrial • Institutional • Local streets.	• Annual sump inspection and sediment cleanout • Inspect overflow structures · • Pretreatment maintenance required	• High effectiveness for metals and PAHs when pretreatment is provided. • Limited suitability for untreated roadway runoff with high sediment loads.
Detention Tanks	Reduce downstream flooding and peak flows	• Commercial mixed use • Industrial, institutional	• Annual sediment inspection and cleanout • Inspect pumps, restrictors and overflow systems • Pretreatment sump maintenance required	• Moderate effectiveness for runoff attenuation but • limited direct contaminant treatment. • Best used alongside treatment BMPs.
Constructed Wetlands	Treat runoff through detention, sedimentation and biological uptake	• Parks, institutional • Large developments • Downstream treatment systems.	• Vegetation management annually • Sediment removal every 5-10 years • Mosquito/vector monitoring • Outlet maintenance	• Highest overall treatment effectiveness for metals, sediment, hydrocarbons and some bacterial reduction.

APPENDIX D:

STORMWATER SYSTEM MODEL UPDATE AND CALIBRATION



Township of Esquimalt
Stormwater System Model Update and Calibration

Technical Memorandum #1

FINAL

Prepared for:
Township of Esquimalt
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And

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Submission Date: April 15, 2026

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Project ID: 2025-133-ESQ

1.0 Introduction

The Township of Esquimalt (Township) retained Urban Systems Ltd. (Urban Systems) and GeoAdvice Engineering Inc. (GeoAdvice) to update and calibrate the existing hydraulic and hydrologic model of the Esquimalt stormwater system. The existing model was originally developed by GeoAdvice in 2018, as summarized in *Township of Esquimalt Stormwater System Modeling* (GeoAdvice, 2020).

The existing model was updated to align with 2025 GIS network data, calibrated to 2025-2026 flow monitoring data, and converted from InfoSWMM (AutoDesk) to AquaTwin Sewer (Aquanuity Inc.). This memo summarizes the network update and calibration results.

An overview of the Esquimalt stormwater system is provided in **Figure 1.1** on the following page.

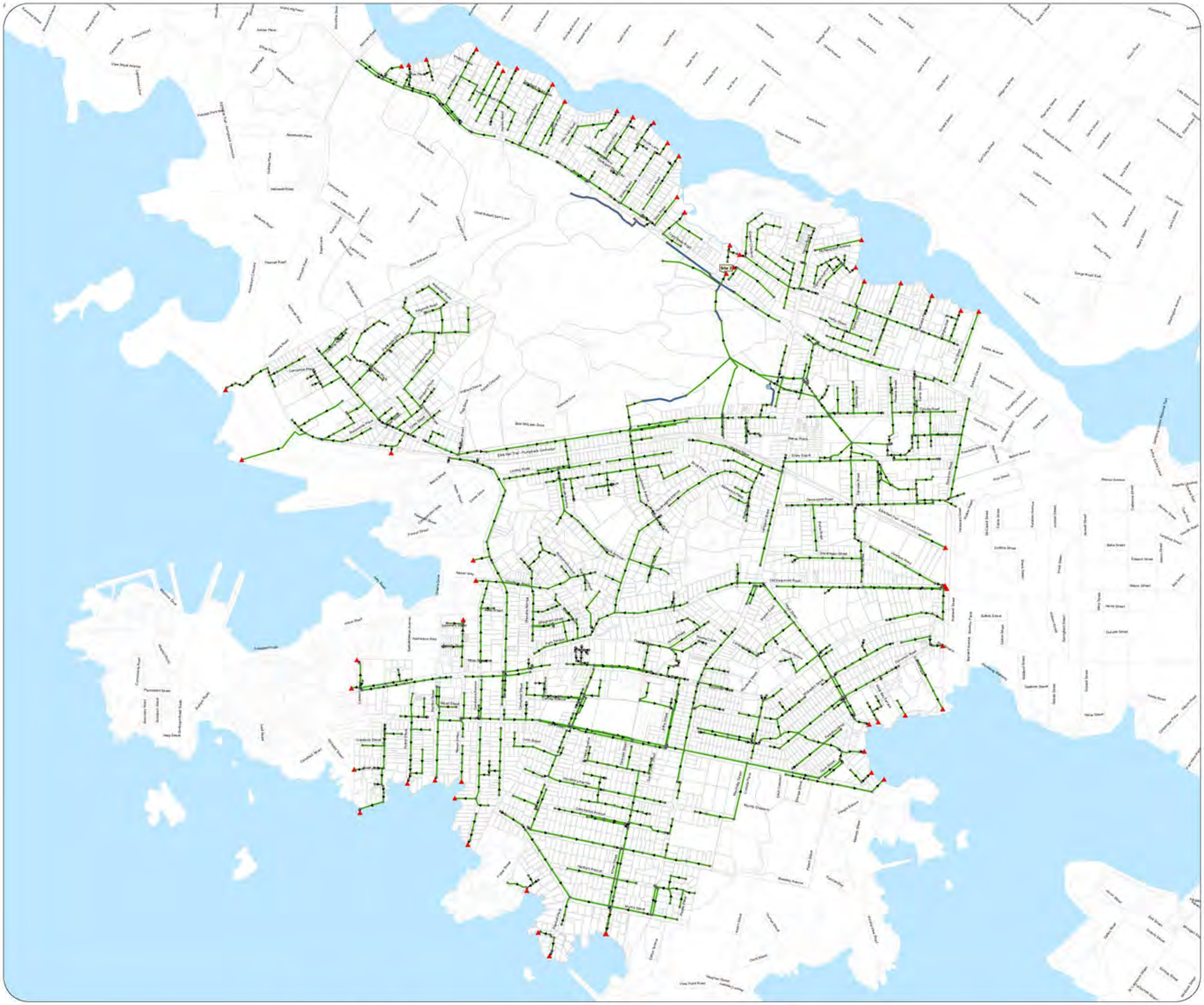
The main components of the stormwater system model are summarized in **Table 1.1**.

Table 1.1: Model Statistics of Current System

Component	Total
Study Area	602 ha
Subcatchments	4,564
Storm Conduits	Open Channels: • 20 (0.98 km) Gravity Mains: • 1,183 (64.05 km)
Junctions	1,188
Outfalls	58
Detention Ponds	1

In the preparation of this memo, GeoAdvice would like to acknowledge the support of the following Township Staff:

- Joel Clary, P.Eng., PMP
- Charles Davie, AScT, MMCD CCA
- Braylon Lumb



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Junction
- Open Channel
- Gravity Main
- Subcatchment

Note: Site labels indicate flow monitoring locations.

Esquimalt Stormwater System Overview

Township of ESQUIMALT

Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
Client: **Township of Esquimalt, BC**
Date: **April 2026**
Created by: **SZ**
Reviewed by: **WdS**

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.25 0.5 1
Kilometers

N W E S

Figure 1.1

2.0 Stormwater Model Update

2.1 Data Collection and Review

Prior to updating the model, information on the Township sewer system was compiled, collected and reviewed. This included reviewing the following pertinent information, in addition to the information provided in the 2018 model development project, as summarized in *Township of Esquimalt Stormwater System Modeling* (GeoAdvice, 2020):

- Original InfoSWMM hydraulic and hydrologic model (maintained by GeoAdvice)
- GIS database (November 6, 2025)
- Aerial imagery (November 20, 2025)
- LiDAR data (November 25, 2025)
- As-built drawings (November 27, 2025)
- City of Victoria GIS database (December 5, 2025)
- Victoria Harbour tidal data (January 27, 2026)
- Flow monitoring and rainfall data (February 10, 2026)
- Gorge Vale Golf Course Storm Drainage and Infrastructure Map (March 16, 2026)
- Model Question Responses (March 16, 2026)
- Updated Pipe Materials from Video Investigation (March 23, 2026)
- Resolved Pipe Diameter Discrepancies (March 26, 2026)

2.2 Hydraulic Model Development

2.2.1 Network Update

The Township's latest GIS data, as-built drawings, and additional storm network information were compared against the 2018 GIS and 2018 stormwater model to identify necessary model updates.

To summarize, the model update consisted of:

- Adding 62 pipes
- Removing 9 pipes
- Splitting 4 pipes
- Renaming 16 pipes

In addition, pipe diameters, materials, and roughness coefficients (which correspond to materials) were updated based on the GIS data. In total, 28 pipe diameters, 60 pipe materials, and 936 pipe roughness coefficients were updated. In addition, pipe inverts and manhole ground elevations were updated as needed using GIS data, as-built drawings, and interpolation.

2.2.2 Model Conversion

The 2018 stormwater model was developed in the InfoSWMM software (Autodesk). As InfoSWMM has been retired, the model was converted to AquaTwin Sewer (Aquanuity Inc.), a supported platform that utilizes the same simulation engine and input structure. AquaTwin Sewer was selected to align with the Township's sanitary model, which was recently converted to the same software, maintaining a consistent modeling platform for both systems.

2.2.3 Gravity Main & Culvert Data

GIS gravity mains and culverts are named using the Township's GIS identifier, in the format "DGMXXXX" (Esquimalt Storm Drain Gravity Main), where "XXXX" is a unique 4-digit identifier number for each pipe. The format "GA-DGMXXXX" is used for conduits included in the model for connectivity with no GIS identifier, where "GA" indicates 'GeoAdvice' and "XXXX" is a sequential numeric identifier. These conduits represent assumed connections included to maintain hydraulic connectivity in the model where GIS conduit data is unavailable (e.g., gaps where pipes are missing and connections near outfalls or open channels not represented in the GIS). However, they are based on the best available information (e.g., field observations, record drawings, and LiDAR data) and are expected to represent the actual system configuration well.

Manning's 'n' roughness coefficients were assigned to the gravity mains and culverts, based on the material type identified in the Township GIS data, according to **Table 2.1**.

Table 2.1: Gravity Main and Culvert Roughness Coefficients

Material Name	Manning's Roughness Coefficient*
Asbestos Cement	0.013
Clay Tile	0.015
Concrete	0.015
Corrugated Steel	0.024
High-Density Polyethylene	0.013
Polyvinyl Chloride	0.013
Relined	0.013
Vitrified Clay	0.014
Unknown	0.015

***Roughness coefficients based on average value for a range of materials and ages (http://www.fsl.orst.edu/geowater/FX3/help/8_Hydraulic_Reference/Mannings_n_Tables.htm)**

Minor losses were applied to all sharp pipe bends in which high velocities could result in significant hydraulic grade line (HGL) changes. The loss coefficients, applied to the model as a pipe exit loss, assumed that all manholes in the Township system are fully benched. The minor losses and associated bend angle are summarized in **Table 2.2**.

Table 2.2: Gravity Main Bend Minor Loss Coefficients

Bend Angle	Minor Loss Coefficient (K_L)*
0° – 14°	0.00
15° – 29°	0.25
30° – 44°	0.45
45° – 59°	0.65
60° – 74°	0.80
75° – 89°	0.90
90° +	1.00

***Maple Ridge Design Criteria Manual, Section D:**
https://www.mapleridge.ca/DocumentCenter/View/6033/Part-1?bidId=

Modeled gravity mains and culverts with an inlet or outlet were assigned an entrance loss coefficient of 0.5 (averaged from typical entrance loss values) and a theoretical exit loss coefficient of 1.0. Specific details on each inlet and outlet structure were not confirmed.

2.2.4 Manhole and Model Junction Data

GIS manholes are named using the Township's GIS identifier, in the format "DMHXXXXX" (Esquimalt Storm Drain Manhole), where "XXXX'' is a unique 4-digit identifier number for each manhole. The format "GA-DMHXXXX" is used for new junctions and junctions without a GIS identifier, where "GA" indicates 'GeoAdvice' and "XXXX" is a sequential numeric identifier.

Junctions were used in the model to provide connectivity where transitions between different physical attributes, such as size and slope, occur and to represent manholes, headwalls, catch basins and catchment load points. Missing ground elevations for junctions were extracted from the LiDAR data.

2.2.5 Outfall Data

The Township stormwater system has downstream connections to the Department of National Defence (DND) and City of Victoria stormwater system, as well as outfalls to the Strait of Juan de Fuca and Gorge Waterway. All downstream connections to external systems were modeled as outfalls.

Connections to the DND and City of Victoria stormwater systems were modeled as "free" outfalls, which means that the downstream network does not influence the HGL at the boundary condition.

Outfalls to the Strait of Juan de Fuca and Gorge Waterway were modeled as fixed outfalls, where the downstream boundary condition is defined by a constant HGL. In the model, this was implemented by assigning a constant water level value to these outfalls equal to the highest recorded tide elevation from recent historical data.

Tidal elevation data was obtained from the *Marine Environmental Data Section* (*MEDS*) of the *Government of Canada* website (https://www.isdm-gdsi.gc.ca/isdm-gdsi/twl-mne/inventory-inventaire/sd-ds-eng.asp?no=7120&user=isdm-gdsi&region=PAC). The Victoria Harbour station (Station #7120) was selected, since it is the closest permanent station to the Esquimalt stormwater system outfalls. The station's hourly tidal elevation data was reviewed and analyzed for the years 2024 and 2025. The highest tide between 2024 and 2025 happened on December 14, 2024 at 11:05, and had a recorded value of 3.69 m. Since Station #7120 uses a different elevation datum than the model, the CGVD28 datum offset of -1.868 m provided for the station was applied to the water elevations for the years 2024 and 2025. Therefore, a fixed outfall head of 1.822 was applied for these outfalls. For the scenarios with climate change, a sea level rise of 0.5 m was used, as recommended by the Capital Regional District (CRD) in their 2021 study (https://www.crd.ca/media/file/coastal-flood-inundation-mapping-project-summary).

2.3 Hydrologic Model Development

2.3.1 Subcatchment Delineation

For this study, the model subcatchments were updated to improve model accuracy and better reflect current site conditions. Subcatchments were delineated based on surface topography and the Township's cadastral GIS layer. Four (4) distinct subcatchment types were included in the updated model:

- Urban
    - The urban area consists of the more densely developed areas with a dense storm main network. These subcatchments were modeled using parcel boundaries.
- Road/Railway
    - The road and railway subcatchments were delineated using Thiessen polygons around manholes and catch basins on roads and railways. Thiessen polygons assign the surrounding surface area to the nearest drainage structure, representing the area that would most likely drain to that inlet based on proximity. This provides a simplified and reasonable approach for delineating road and railway subcatchments in the absence of detailed allocation methods.
- Natural
    - The natural area consists of less densely developed areas with little to no storm main network, particularly in the Gorge Vale Golf Club and large parks across the Township. These were modeled using natural catchment boundaries based on LiDAR data.
- Special Case
    - The special cases include areas from the from DND, Songhees Nation, and City of Victoria lands which drain into the Township's stormwater system. The DND and Songhees Nation areas had no available stormwater system GIS, so natural catchment boundaries based on LiDAR data were used to delineate subcatchments in these areas. For the City of Victoria area, available stormwater GIS pipe and catchment layers were used to delineate subcatchment boundaries.

Subcatchment slopes, the average slope over each catchment area in the direction of the expected flow path, were determined using the LiDAR data. Subcatchment widths were estimated using the following formula:

$$Width = \frac{Area}{Length}$$

$$\text{where } Length = 1.7 * \sqrt{Area}$$

While width is the primary model input, it may be easier to understand width in terms of how it impacts the length of the subcatchment. Subcatchment length affects the time of concentration of a subcatchment and, in turn, the time available for infiltration processes to occur.

2.3.2 Subcatchment Runoff Routing Parameters – Existing Land Use

The Township's 2023 aerial imagery was processed using a pre-trained deep learning model in ArcGIS Pro for land cover classification. This model analyzed the imagery to categorize land into various classifications. The results were reviewed for accuracy, and the verified classifications were used to estimate the impervious percentage for each subcatchment. During model calibration, these impervious percentages were adjusted by up to ±10% to improve agreement between modeled and observed flows. **Figure 2.1** illustrates how the aerial imagery was used to determine impervious areas.

Figure 2.1: Impervious Areas From Aerial Imagery

The Township's property parcel data with existing land use were sorted into high-level land use categories that generally maintain similar properties. Subcatchment areas were then overlaid with the Township's existing land use categories to determine the composition within each subcatchment. These categories were used to assign hydrologic parameters, such as existing runoff routing percentage and pervious/impervious depression storage, to each subcatchment, independent of the aerial imagery-derived impervious percentages. The existing runoff routing percentage, pervious depression storage, and impervious depression storage for each subcatchment for each land use type are defined in **Table 2.3**.

Table 2.3: Subcatchment Surface Parameter Estimates

Land Use Category	Impervious Runoff Routed to Pervious Area (%)	Pervious Depression Storage (mm)	Impervious Depression Storage (mm)
Commercial	25	5	3
Comprehensive Development	25	5	2
Golf Course	100	8	2
Industrial	25	5	3
Institutional	70	5	2
Multi-Family Residential	25	5	2
Parks/Open Space	100	8	2
Railway	100	8	2
Road	40	5	2
Single Family Residential	85	5	2

Note that "impervious runoff routed to pervious area" refers to the percentage of the runoff from the impervious area of a given subcatchment that is routed to the pervious area of that subcatchment. The remaining runoff from the impervious area of the subcatchment is routed directly to the outlet node of the subcatchment. This is different from "impervious percentage", which refers to the percentage of the total area of a given subcatchment that is impervious, with the remaining area being pervious.

Subcatchment roughness values are summarized in **Table 2.4**.

Table 2.4: Subcatchment Roughness Coefficients

Hydrologic Parameter	Value
Manning's "n" Overland Roughness Coefficient	
Pervious Area "n"	0.200
Impervious Area "n"	0.013

2.3.3 Subcatchment Runoff Routing Parameters – Future Land Use

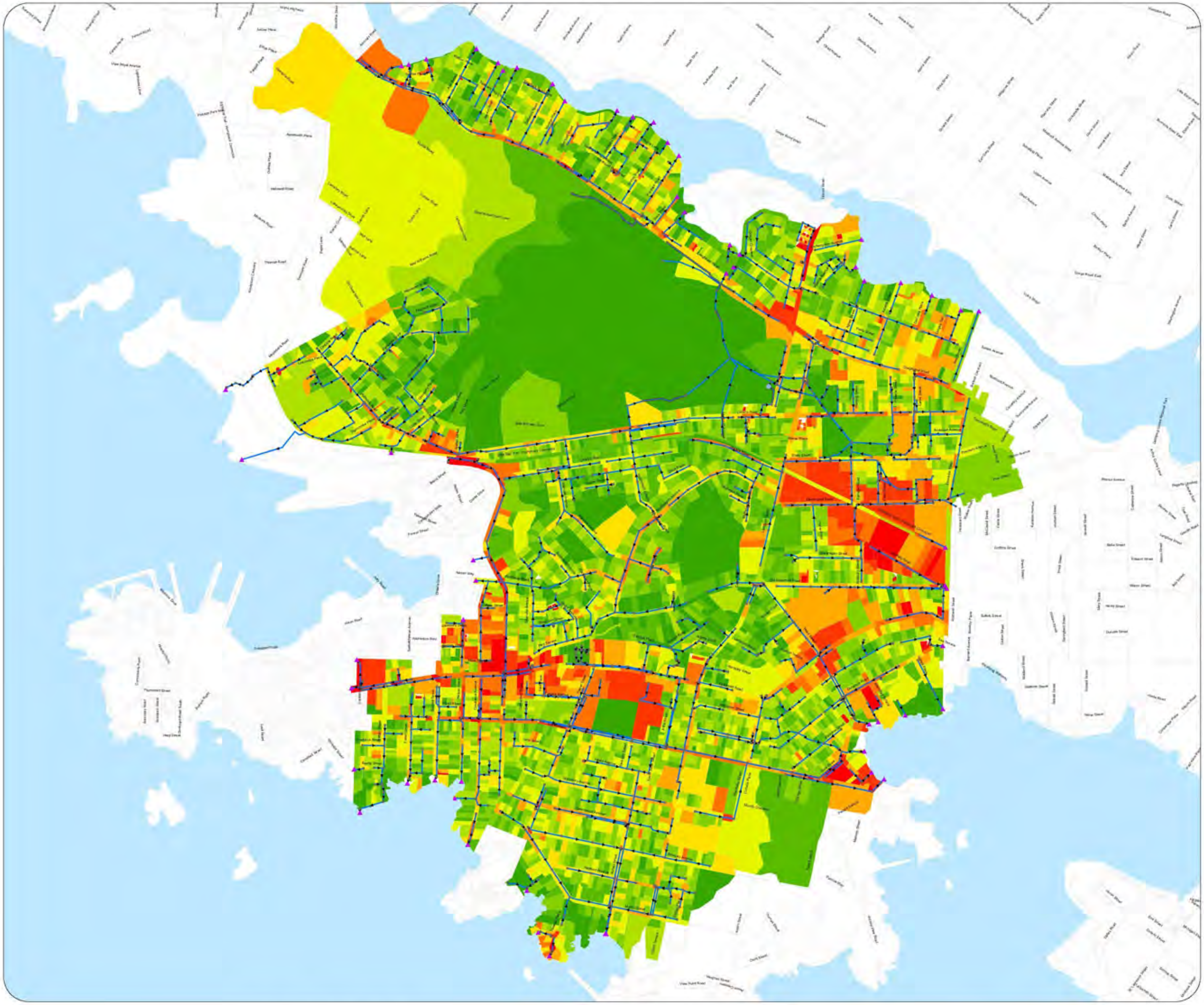
Existing land use designations were compared against the proposed land use designations from the Township's OCP. Consistent with the assumptions used to develop the Township's *Sanitary Sewer Asset Management Plan* (Urban Systems, April 2025), only parcels where a land use change is proposed in the OCP or where there is a development application were updated with increased impervious values.

The OCP subcatchment parameters for each OCP land use category are defined in **Table 2.5**, based on the calibrated values in **Table 2.3**. For development applications, the OCP land use designation was assumed.

Table 2.5: OCP Subcatchment Surface Parameter Estimates

OCP Land Use Category	Percent Impervious (%)	Runoff Routed to Pervious Area (%)	Pervious Depression Storage (mm)	Impervious Depression Storage (mm)
Business	80	25	5	3
Commercial/Commercial Mixed-Use	80	25	5	3
English Inn Mixed-Use	80	25	5	3
Esquimalt Town Square	80	25	5	3
Federal Land	70	70	5	2
High Density Residential	80	25	5	2
Institutional	70	70	5	2
Low Density Residential	55	85	5	2
Medium Density Residential	70	50	5	2
Neighbourhood Commercial Mixed-Use	80	25	5	3
Parks and Open Space	10	85	8	2
Townhouse Residential	70	50	5	2

The existing land use percent impervious is shown in **Figure 2.2**, and the future OCP land use percent impervious is shown in **Figure 2.3**. On average, the existing subcatchments are 35.0% impervious, and the future OCP subcatchments are 41.7% impervious, indicating a moderate increase across the study area.



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Junction
- Open Channel
- Gravity Main

Percent Impervious

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100

Esquimalt Stormwater
Existing Percent Impervious

Township of Esquimalt

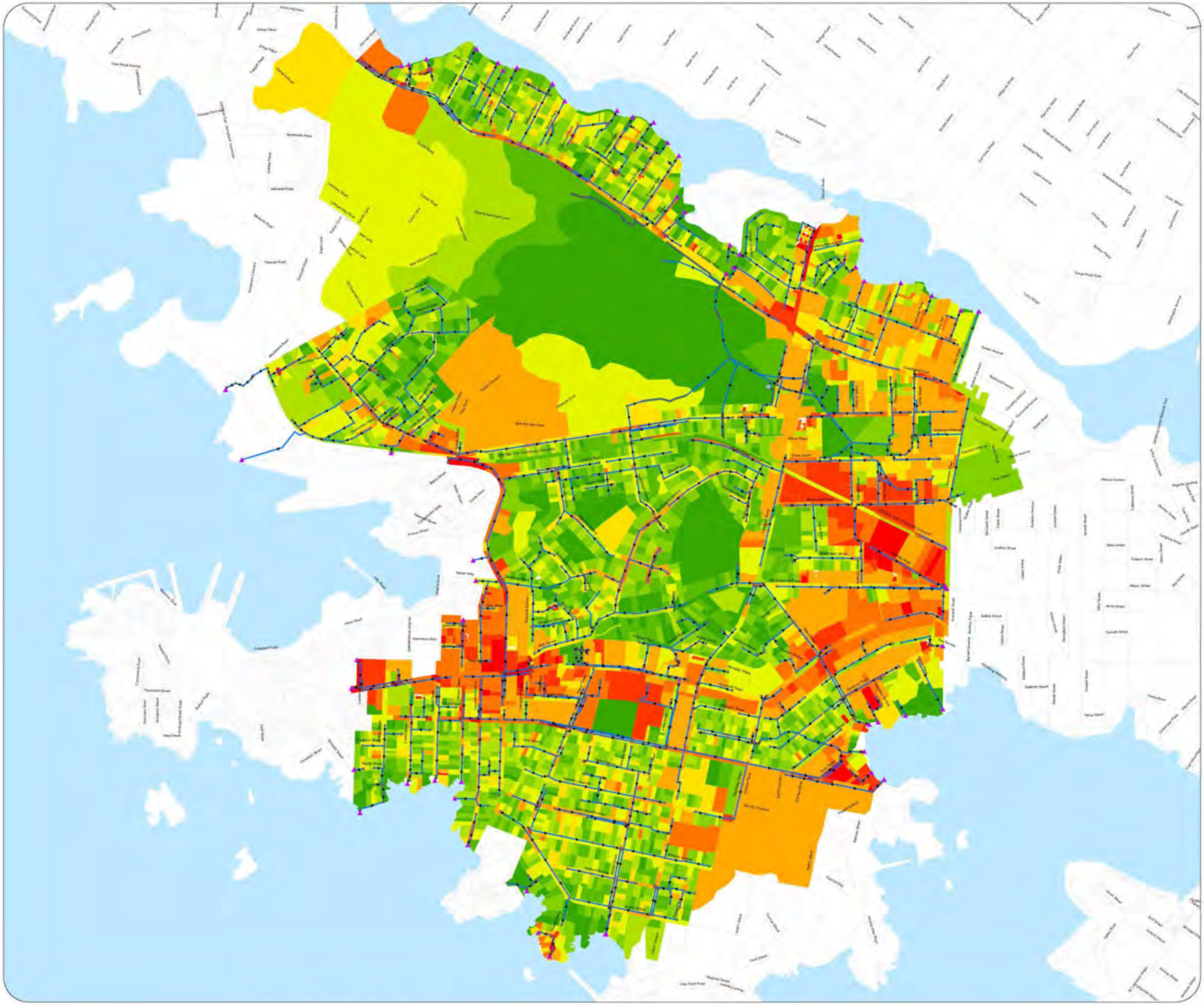
Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
Client: **Township of Esquimalt, BC**
Date: **April 2026**
Created by: **SZ**
Reviewed by: **WdS**

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.25 0.5 1
Kilometers

N W E S

Figure 2.2



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Junction
- Open Channel
- Gravity Main

Percent Impervious

- 0 - 10
- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100

Esquimalt Stormwater
Future OCP Percent Impervious

Township of ESQUIMALT

Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
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Date: **April 2026**
Created by: **SZ**
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0 0.25 0.5 1
Kilometers

N W E S

Figure 2.3

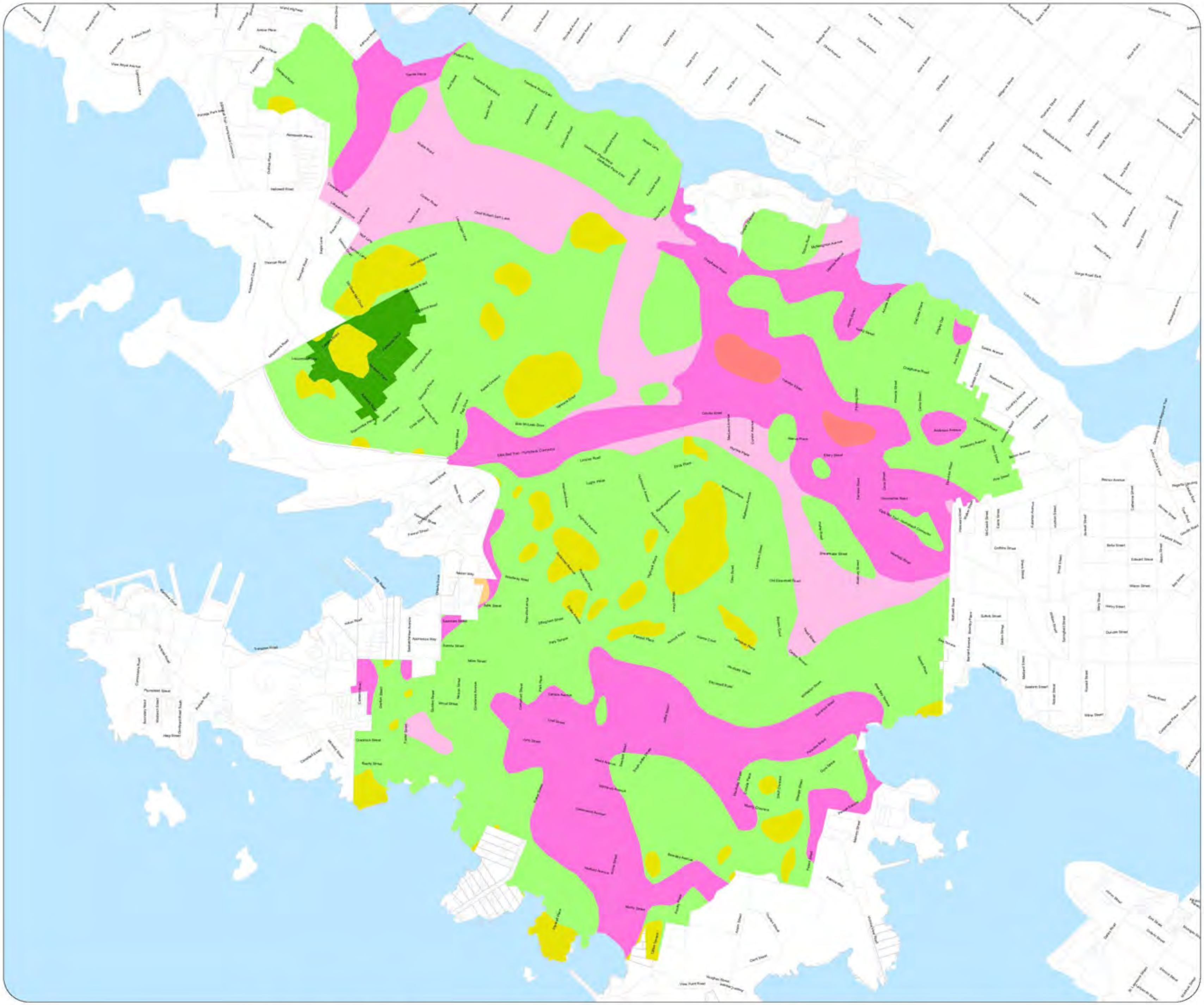
2.3.4 Subcatchment Soil Properties

Subcatchment soil and infiltration parameters were defined in accordance with the soil type(s) contained in each subcatchment. Soil data was obtained from the BC Ministry of Energy and Mines *Quaternary Geological Map of Greater Victoria*. The Green-Ampt infiltration method was used to characterize soil infiltration characteristics in the model. The calibrated Green-Ampt infiltration parameters are summarized in **Table 2.6**.

Table 2.6: Calibrated Green-Ampt Infiltration Parameters

Unit Code	Description	Suction Head (mm)	Conductivity (mm/hr)	Initial Deficit (/)
C1	Mixed clay and shallow deposits, transitional	316.3	2.00	0.385
C2	Thick soft Victoria clay >3 m	316.3	0.05	0.385
FC2	Fill over clay (Unit C2), anthropogenic fill	316.3	3.00	0.385
O1	Peat over Victoria clay, wetland <60 m	166.8	34.00	0.486
R1	Exposed bedrock	0.001	0.01	0.001
R2 (a)	Bedrock with thin soil <5 m (Southeast Esquimalt)	0.001	10.00	0.001
R2 (b)	Bedrock with thin soil <5 m (Northwest Esquimalt)	0.001	0.50	0.001

Soil classification is shown on **Figure 2.4**.



GeoAdvice Engineering Inc.

Legend

- Ocean
- Parcel

Soil Classification

C1	*Mixed clay and shallow deposits, transitional*
C2	*Thick soft Victoria clay >3 m*
FC2	*Fill over clay (Unit C2), anthropogenic fill*
O1	*Peat over Victoria clay, wetland <60 m*
R1	*Exposed bedrock*
R2a	*Bedrock with thin soil <5 m (Southeast)*
R2b	*Bedrock with thin soil <5 m (Northwest)*

Soil Classification

Township of ESQUIMALT

Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
Client: **Township of Esquimalt, BC**
Date: **March 2026**
Created by: **SZ**
Reviewed by: **WdS**

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0 0.25 0.5 1
Kilometers

N W E S

Figure 2.4

2.3.5 Subcatchment Groundwater

The flow monitoring data used to calibrate the model (see **Section 3.0**) showed that groundwater interflow is present in the system. The groundwater flow was modeled using the following equation:

$$Groundwater\ flow = A_1(D_1 - BC)^{B_1},$$

Where:

- A_1 is the groundwater flow coefficient
- B_1 is the groundwater flow exponent
- BC is the channel bottom elevation above bottom of surficial aquifer
- D_1 is the average water table elevation above bottom of surficial aquifer taken midway between channel and edge of sub-basin

The calibrated groundwater parameters A_1 and B_1 are shown in **Table 2.7**.

Table 2.7: Calibrated Groundwater Parameters

Parameter	Value
A_1	0.1
B_1	2.0

The groundwater module in the SWMM engine requires that a surficial aquifer be defined. The aquifer parameters used in the Township model are presented in **Table 2.8**.

Table 2.8: Calibrated Aquifer Parameters

Aquifer Parameter (Unit)	Calibrated Value
Porosity (Fraction)	0.45
Wilting Point (Fraction)	0.08
Field Capacity (Fraction)	0.16
Conductivity (mm/hr)	100.00
Conductivity Slope	10.00
Tension Slope	15.00
Upper Evaporation Fraction	0.35
Lower Evaporation Depth (mm/day)	14.00
Lower GW Loss Rate (mm/hr)	0.00/0.11*
Bottom Elevation (m)	0.00
Water Table Elevation (m)	0.00
Unsaturated Zone Moisture (Fraction)	0.20

***Adjusted during model calibration such that Site 5 and Site 6 catchments have no loss rate and all other areas have a loss rate of 0.11 mm/hr.**

3.0 Model Calibration and Validation

Flow monitoring data was collected from November 9, 2025 through March 10, 2026 as part of a temporary flow monitoring plan developed by GeoAdvice, Urban Systems, and Bot Corp. The model calibration results discussed herein are based on the comparison of continuous-simulation model results to flow monitoring for the 10-year storm event between December 14-19, 2025. The locations of the flow monitors and corresponding catchments are provided in **Figure 1.1** in **Section 1.0**.

Continuous simulation offers a few advantages over single event-based calibration in that:

- Statistical measures of goodness-of-fit provide a single and non-subjective measure of model calibration.
- The entire flow record period can be calibrated at once, ensuring both small and large events are considered.
- Continuous calibration can provide a reasonable match for all events rather than good matches for only one or two specific events.

Model calibration was conducted using both tabular/visual comparisons of model and field data in addition to the integral square error (ISE) and Nash-Sutcliffe Efficiency (NSE) continuous calibration guidelines. Both statistical methods are based on the square of the error between observed and modeled data, punishing large discrepancies more harshly than small discrepancies. Typical ISE and NSE calibration guidelines are summarized in **Table 3.1**.

Table 3.1: ISE and NSE Goodness-of-Fit Ratings for Model Calibration

ISE Range	NSE Range	Calibration Rating	Model Application
0 - 3	0.50 – 1.00	Excellent	Planning, Preliminary Design, Final Design
3 - 6	0.40 – 0.49	Very Good	Planning, Preliminary Design, Final Design
6 - 10	0.30 – 0.39	Good	Planning, Preliminary Design
10 - 25	0.20 – 0.29	Fair	Planning
>25	<0.20	Poor	Screening

Calibration was achieved by adjusting subcatchment hydrologic parameters (impervious percentage, runoff routing, depression storage, width, etc.) and soil infiltration parameters (suction head, conductivity, initial deficit) to mimic the conditions captured by the temporary flow monitor. The ISE and NSE results of the model calibration at the flow monitoring sites are provided in **Table 3.2**. Plots of the calibrated model flows against field and rainfall data are provided in **Appendix A**.

Table 3.2: ISE and NSE Calibration Results

Flow Monitoring Site	Manhole ID	Location	ISE Score	NSE Score	Calibration Rating
Site 1	DMH0798	1180 Colville Rd	4.18	0.88	Excellent
Site 2	DMH0625	1060 Craigflower Rd	3.84	0.85	Excellent
Site 3a	DMH0833	537 Head St	13.05	0.60	Good
Site 3b	DMH0532	537 Head St	11.18	0.23	Fair
Site 4	DMH0056	1000 Lyall St	4.78	0.85	Excellent
Site 5	DMH0349	405 Kinver St	3.59	0.89	Excellent
Site 6	DMH0215	905 Admirals Rd	5.08	0.81	Very Good

Overall, the calibration results for the captured flow monitoring period are very good or excellent, with Site 3a and Site 3b showing only a good and fair agreement, respectively. The lower ratings at these sites are influenced by noise in the field data, potentially due to backwater effects, and the limited groundwater contribution observed at Site 3a during this event. Despite this, the modeled and observed peaks align well, which is the primary focus of this study. Overall, the ISE and NSE scores indicate that the model is well calibrated for master planning and preliminary design purposes.

Lastly, model validation was completed using the <2-year storm event between November 22–28, 2025 and the 2-year storm event between January 4–17, 2026. For both events, the modeled flows aligned well with the field data.

4.0 Summary

GeoAdvice Engineering Inc. was retained by the Township of Esquimalt to update and calibrate the Esquimalt stormwater model. The following is a summary of the tasks and findings from the study:

- The Township's latest GIS and as-built drawings were used to update the existing InfoSWMM hydraulic model of the Township's stormwater system.
- The Township's InfoSWMM model was converted to AquaTwin Sewer (Aquanuity).
- The model covers a total area of 602 ha with varying subcatchments sizes, land uses, and soil types.
- The model was calibrated to temporary flow monitoring data collected at six (6) locations in between November 2025 and March 2026. Overall the model shows a very good agreement with the field data.
- Parcels with land use changes between the existing and OCP were updated with increased imperviousness to represent future conditions. Changes were only made to parcels with identified land use changes.

Submission

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Reviewed and Approved by:

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2026-04-15

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Senior Modeling Review

Document History and Version Control

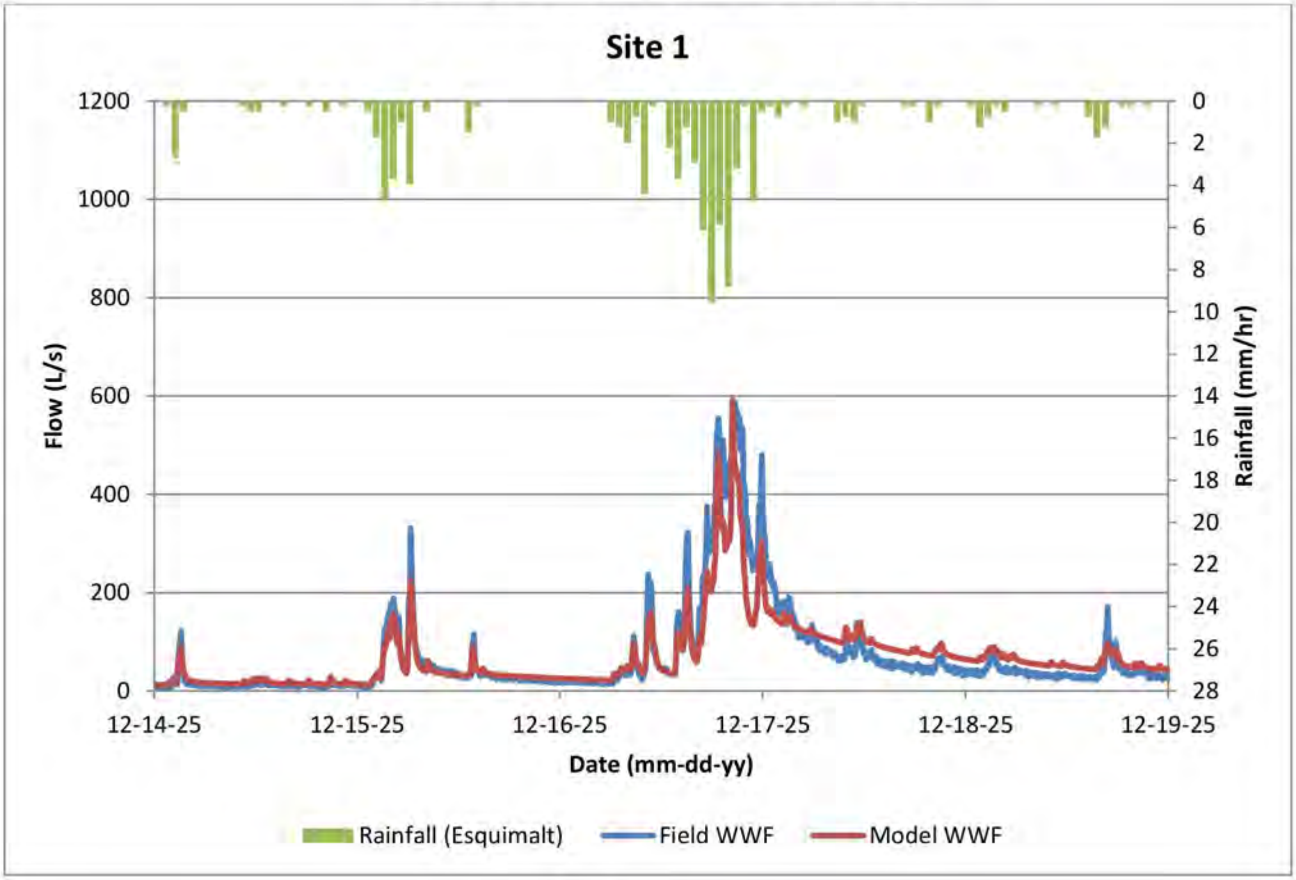
Revision No.	Date	Document Description	Revised By	Reviewed By
R0	March 16, 2026	Draft	Sean Zoschke	Werner de Schaetzen
R1	April 15, 2026	Final	Sean Zoschke	Werner de Schaetzen

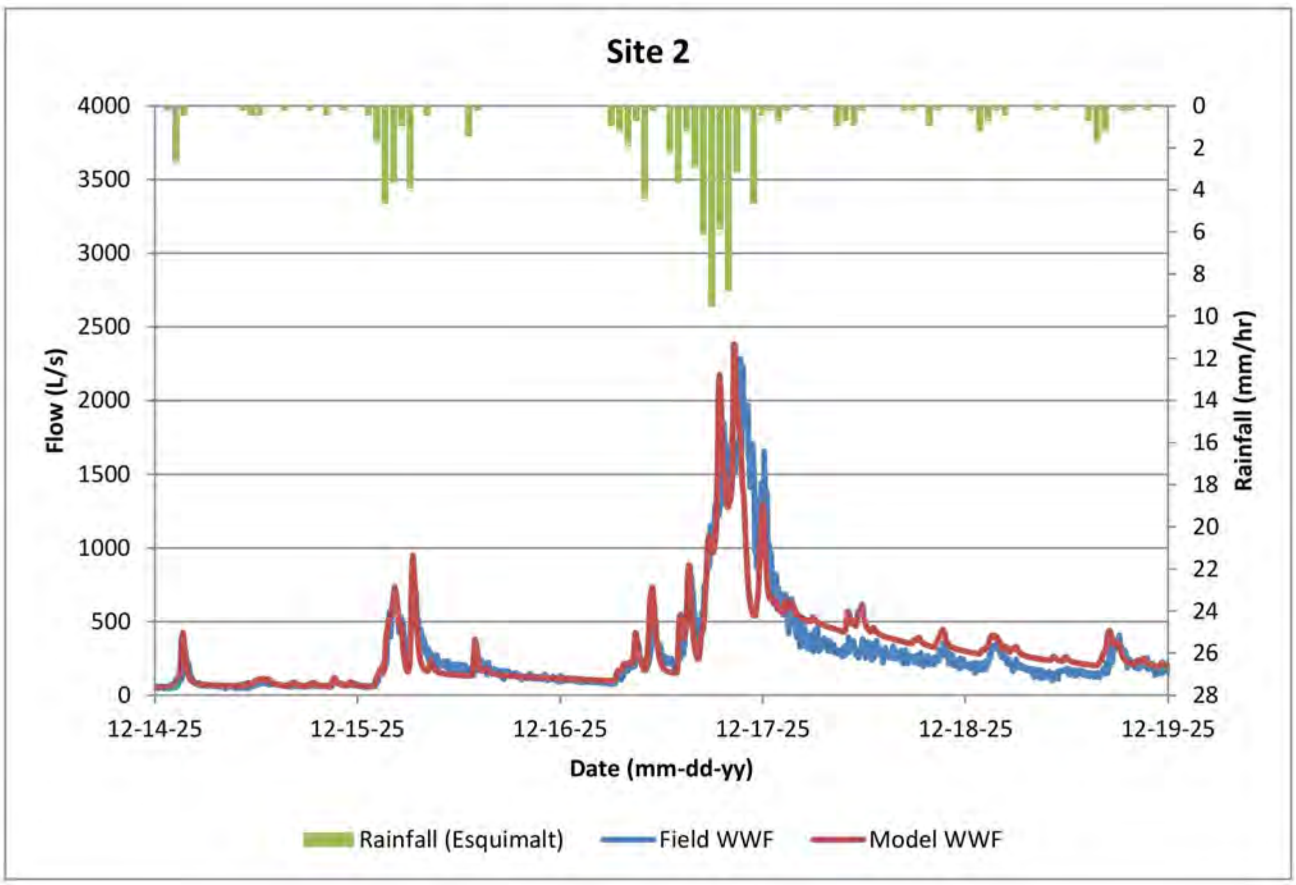
Statement of Qualifications and Limitations

This document represents GeoAdvice Engineering Inc. best professional judgment based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by a member of the engineering profession currently practicing under similar conditions. No warranty, express or implied is made.

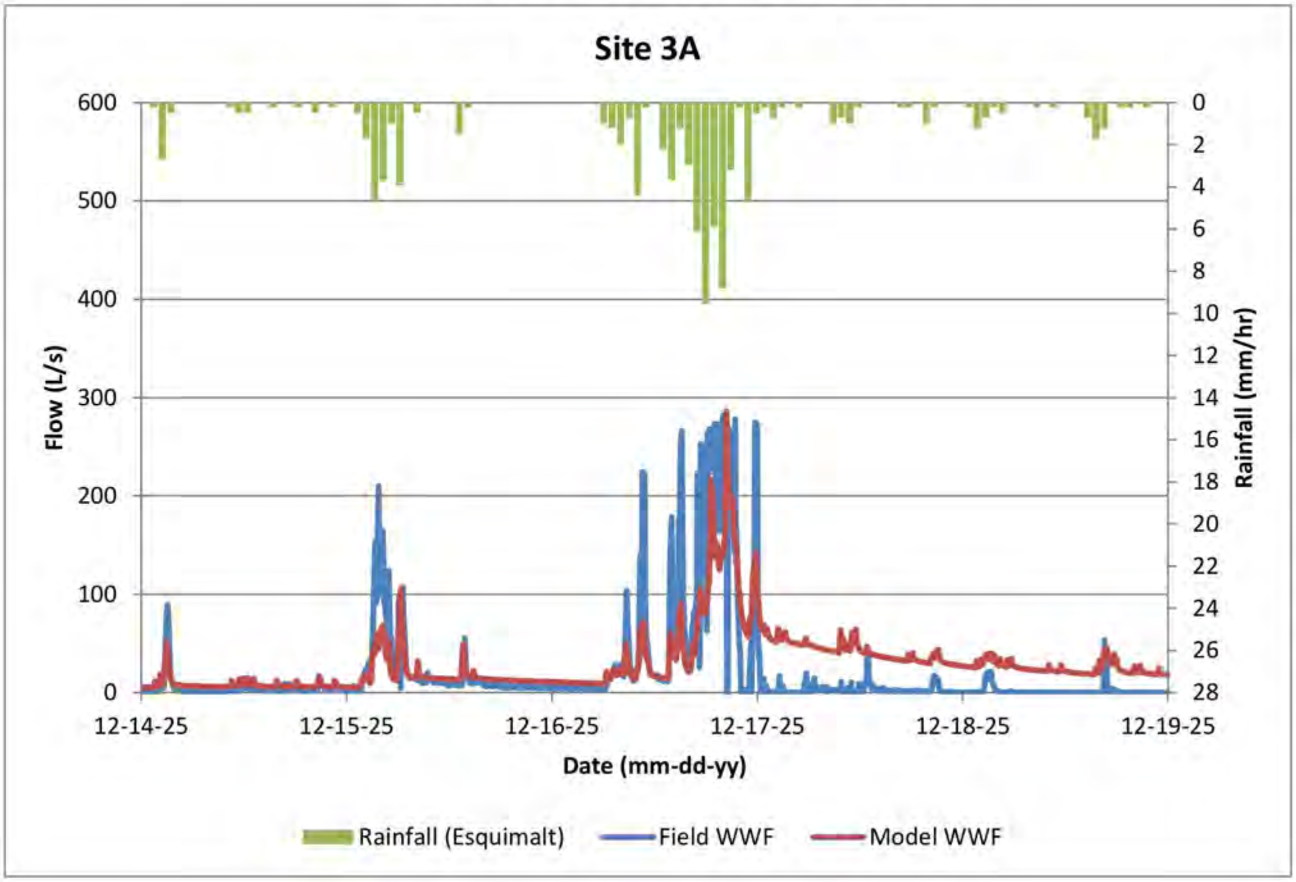
Appendix A Calibration Plots

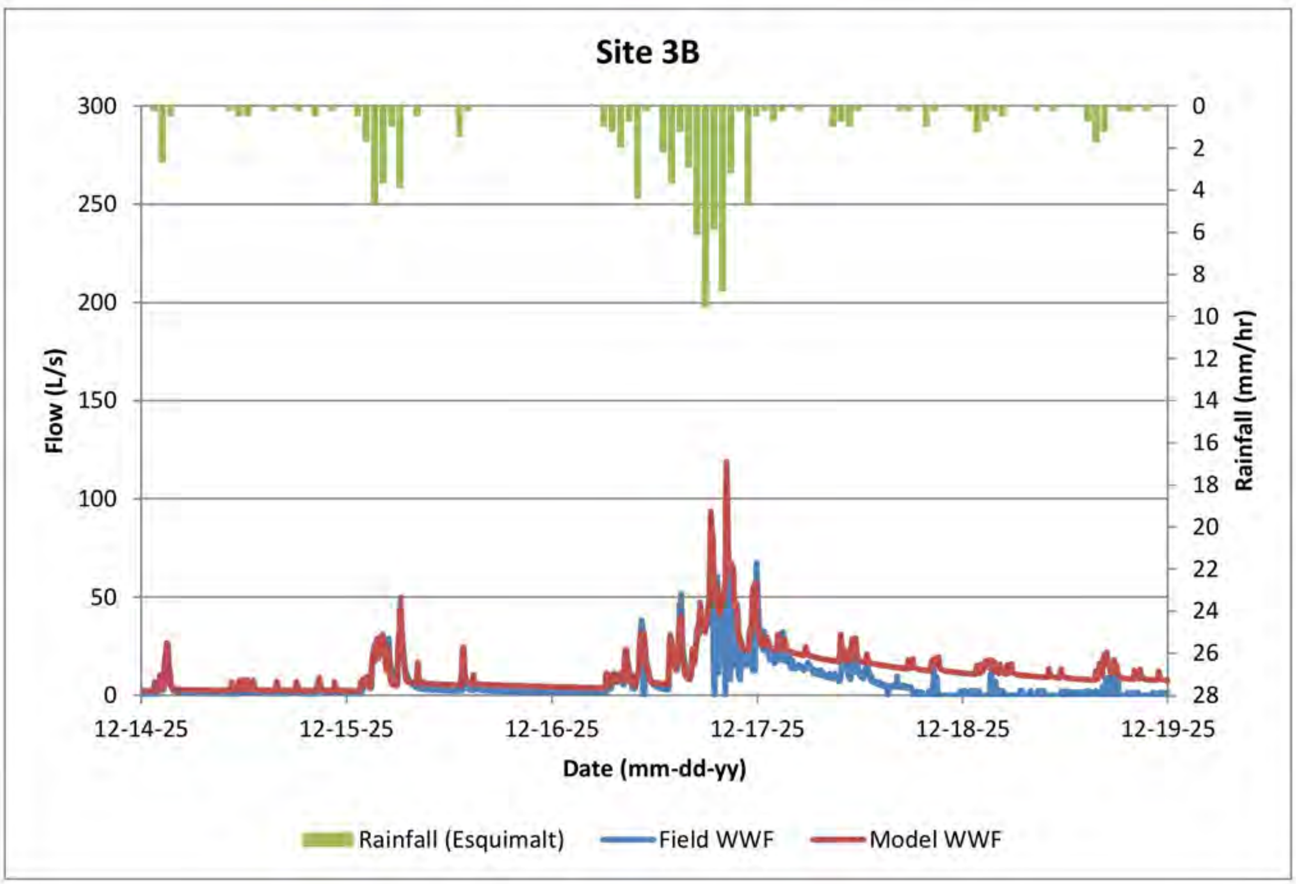
Township of Esquimalt Drainage Model
Calibration Graphs (December 14–19, 2025)



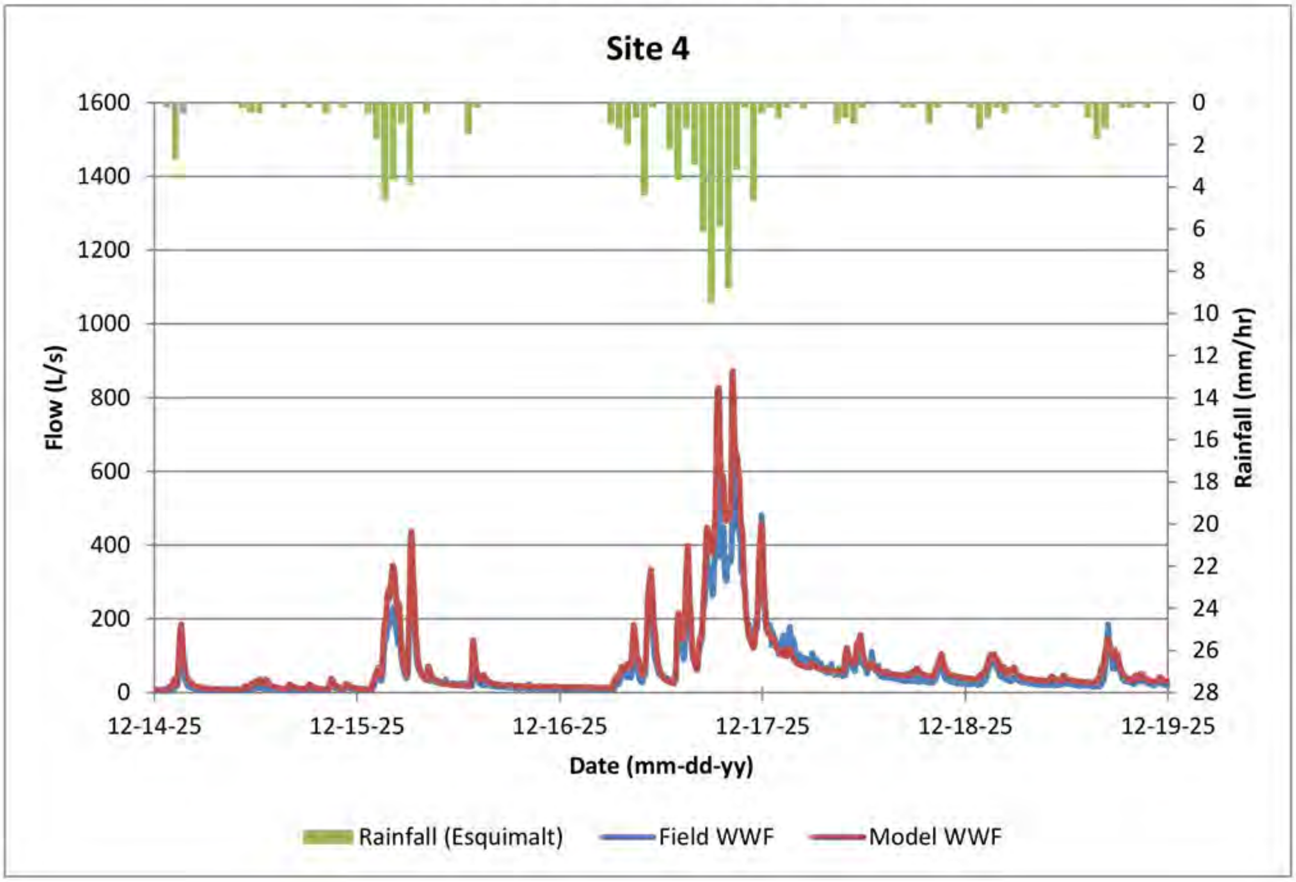


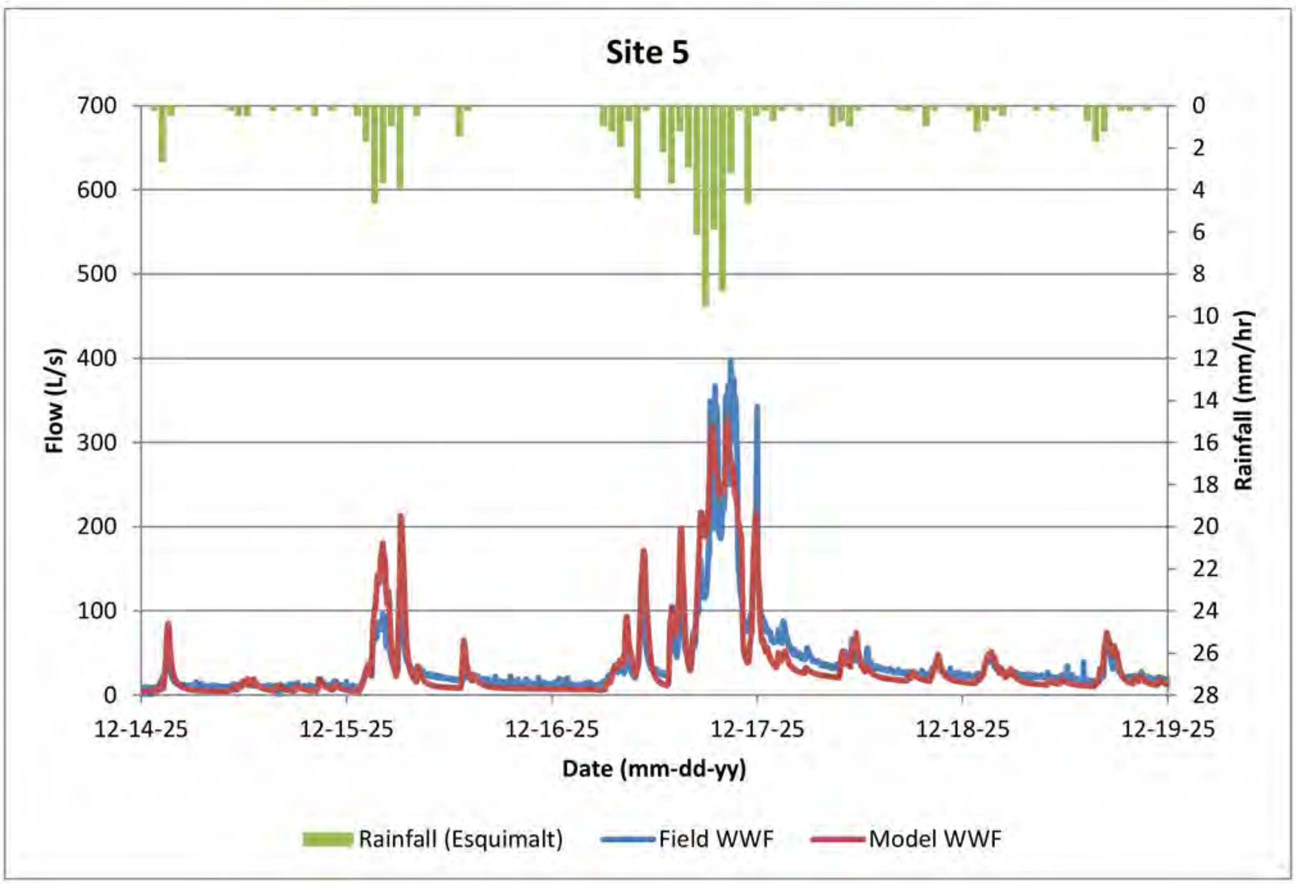
Township of Esquimalt Drainage Model
Calibration Graphs (December 14–19, 2025)



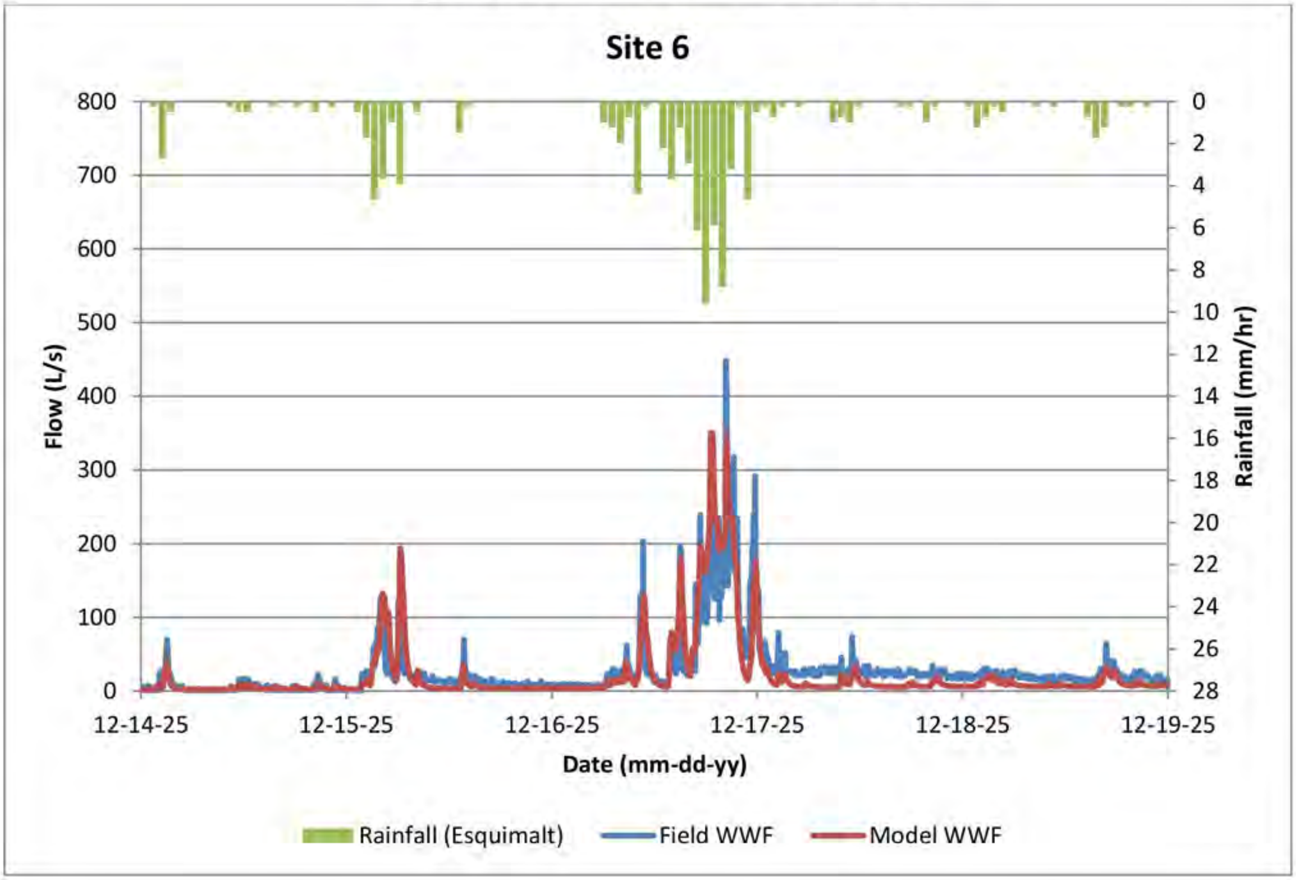


Township of Esquimalt Drainage Model
Calibration Graphs (December 14–19, 2025)



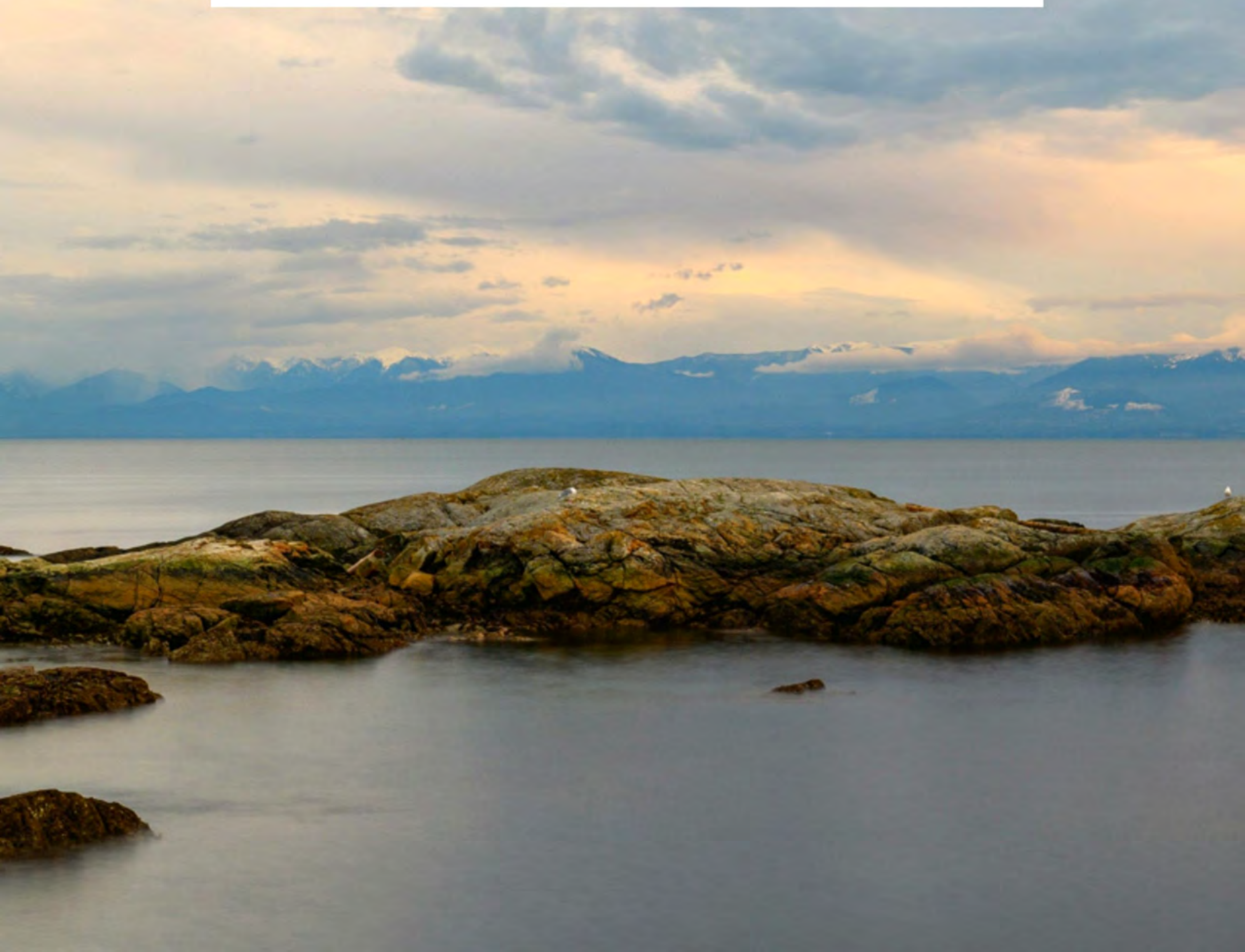


Township of Esquimalt Drainage Model
Calibration Graphs (December 14–19, 2025)



APPENDIX E:

STORMWATER SYSTEM CAPACITY ANALYSIS



Township of Esquimalt
Stormwater System Capacity Analysis

Technical Memorandum #2
FINAL

Prepared for:
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And

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Submission Date: August 31, 2026

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Project ID: 2025-133-ESQ

1.0 Introduction

The Township of Esquimalt (Township) retained Urban Systems Ltd. (Urban Systems) and GeoAdvice Engineering Inc. (GeoAdvice) to complete the Storm Sewer Asset Management Plan. As part of this work, the hydraulic performance of the Township's stormwater collection system was assessed under existing and future conditions using the updated Esquimalt stormwater model. The recent model update and calibration are summarized in *Tech Memo #1: Stormwater System Model Update and Calibration* (GeoAdvice, March 2026), and a previous system-wide analysis is documented in *Township of Esquimalt Stormwater System Modeling* (GeoAdvice, 2020).

This technical memorandum describes the assumptions and results of the hydraulic modeling and capacity analysis using AquaTwin Sewer software program (Aquanuity Inc.). AquaTwin Sewer is a sewer collection system modeling and management software application of Aquanuity Inc.

In the preparation of this memo, GeoAdvice would like to acknowledge the support of the following Township Staff:

- Joel Clary, P.Eng., PMP
- Charles Davie, AScT, MMCD CCA
- Braylon Lumb

2.0 System Capacity Analysis

This section summarizes the Township stormwater system capacity analysis under existing and future OCP conditions.

2.1 Design Storms

Historical IDF curves for use in the model were obtained from the IDF-CC tool (https://www.idf-cc-uwo.ca/) with historical data sourced from the Environment Canada *Victoria Gonzales CS* weather station.

Climate change was accounted for by using the IDF-CC tool to develop climate change-adjusted IDF curves based on historical data from the *Victoria Gonzales CS* weather station and an ensemble of global, bias corrected, climate change models. Projections were developed for the OCP planning horizon assuming a planning horizon of 50 years, developing climate change projections for 2075 assuming a 'moderate' climate change scenario corresponding to RCP 4.5 (https://www.ipcc-data.org/guidelines/pages/glossary/glossary_r.html). This scenario assumes that global greenhouse gas emissions peak mid-century and then decline due to the implementation of mitigation measures, resulting in a stabilization of warming trends rather than continued acceleration under a high-emissions pathway. RCP 4.5 was selected as the primary planning scenario as it is generally considered more representative of current policy trajectories and is commonly used in infrastructure planning guidance.

As the Township does not have a specific design storm distribution defined, GeoAdvice recommended the use of the AES design storm distribution, consistent with the approach adopted in the adjacent City of Victoria and Town of View Royal stormwater master plans. The AES distribution is derived from historical rainfall records and represents a temporally distributed design storm corresponding to a given return period. This synthetic distribution reflects typical local rainfall patterns and provides a realistic representation of how storm intensity varies over the duration of an event.

Design storm durations used for the modeling analysis include 1-hour, 2-hour, 6-hour, 12-hour, and 24-hour durations for 10-year and 100-year return periods. Consistent with regional practice, the AES 30th percentile distribution was applied to short-duration storms (2 hours or less), and the AES 50th percentile distribution was applied to longer-duration storms (greater than 2 hours).

The design storms used in the model are summarized in **Table 2.1** and **Table 2.2**.

Table 2.1: Design Storms (Existing IDF)

Return Period	Distribution	Duration (hours)	Total Rainfall (mm)	Average Intensity (mm/hr)	Peak Intensity (mm/hr)
10-year	AES Type 1 30% Percentile	1	10.1	10.1	15.9
	AES Type 1 30% Percentile	2	16.1	8.1	12.7
	AES BC Coast 50% Percentile	6	34.2	5.7	9.4
	AES BC Coast 50% Percentile	12	53.7	4.5	7.4
	AES BC Coast 50% Percentile	24	74.7	3.1	5.2
100-year	AES Type 1 30% Percentile	1	13.9	13.9	21.9
	AES Type 1 30% Percentile	2	22.2	11.1	17.5
	AES BC Coast 50% Percentile	6	51.9	8.6	14.3
	AES BC Coast 50% Percentile	12	84.0	7.0	11.6
	AES BC Coast 50% Percentile	24	127.9	5.3	8.8

Table 2.2: Design Storms (Climate Change 2075 Moderate IDF)

Return Period	Distribution	Duration (hours)	Total Rainfall (mm)	Average Intensity (mm/hr)	Peak Intensity (mm/hr)
10-year	AES Type 1 30% Percentile	1	11.0	11.0	17.4
	AES Type 1 30% Percentile	2	17.6	8.8	13.9
	AES BC Coast 50% Percentile	6	37.2	6.2	10.3
	AES BC Coast 50% Percentile	12	58.5	4.9	8.1
	AES BC Coast 50% Percentile	24	81.1	3.4	5.6
100-year	AES Type 1 30% Percentile	1	15.0	15.0	23.6
	AES Type 1 30% Percentile	2	24.0	12.0	18.9
	AES BC Coast 50% Percentile	6	55.5	9.3	15.4
	AES BC Coast 50% Percentile	12	90.3	7.5	12.5
	AES BC Coast 50% Percentile	24	135.7	5.7	9.4

2.2 Hydraulic Level of Service (HLoS) Criteria

Capacity HLoS for the Township's minor system was determined using the hydraulic capacity (q/Q), hydraulic grade line (HGL), surcharge time and flood rate/volume model results under peak conditions. **Table 2.3** and **Table 2.4** summarize the criteria used to define the capacity HLoS ratings and will be used in the risk assessment completed by Urban Systems.

Table 2.3: Gravity Main Hydraulic Level of Service Criteria Scoring

Criteria	Score
Hydraulic Capacity (q/Q*)	
q/Q < 1.0	1
q/Q ≥ 1.0	2
Hydraulic Grade Line (HGL)	
HGL < Crown	1
Crown ≤ HGL < Rim Elevation	2
HGL ≥ Rim Elevation	3
Surcharge	
Minor: Surcharge Time ≤ 5 minutes	1
Major: Surcharge Time > 5 minutes	2
Flood	
Minor: Peak Flood Rate < 0.05 m^3/s OR Flood Volume < 15 m^3**	1
Major: Peak Flood Rate ≥ 0.05 m^3/s AND Flood Volume ≥ 15 m^3**	2

***q/Q = peak flow/full pipe flow.**
****Flood volume requirement is the equivalent of a 0.05 m^3/s flood lasting for 5 minutes.**

The surcharge and flood criteria were chosen to filter out flooding caused by model instabilities, as well as differentiate between deficiencies caused by short-duration, high-intensity events (shorter than 5 minutes) and those resulting from longer duration events (longer than 5 minutes). Addressing deficiencies identified under short-duration events through pipe capacity upgrades may not always be the most practical or cost-effective solution, especially when the major system would carry the burden of these events. The minor and major flood thresholds (0.05 m^3/s and 15 m^3) were based on the estimated conveyance capacity of a standard road cross section at a 1% grade.

Each individual criterion from **Table 2.3** is categorized into an HLoS ranking in accordance with the criteria summarized in **Table 2.4**.

Table 2.4: Gravity Main Hydraulic Level of Service Ratings

HLoS Rating	Capacity	HGL	Surcharge	Flood
A	1	1	1	1
B	1	2	1	1
	1	3	1	1
C	1	2	2	1
	1	3	2	1
	1	3*	2	2
D	2	1	1	1
	2	2	1	1
	2	3	1	1
E	2	2	2	1
	2	3	2	1
F	**2**	**3**	**2**	**2**
F'	**1**	**3****	**2**	**1**

***Applies when the downstream node HGL is rated as a '3', with no consideration for upstream conditions.**

****Applies only when the downstream node HGL is rated '1', while the upstream node HGL is also rated as a '3'.**

Detailed descriptions of how each HLoS category relates, in practical terms, to the performance of the Township's minor system are presented in **Table 2.5**.

Table 2.5: Gravity Main Hydraulic Level of Service Descriptions

HLoS Rating	Code	Description
A	1-1-1-1	Gravity Main performing as designed
B	1-2-1-1	Adequate capacity; Minimal backwater caused by downstream condition
	1-3-1-1	Adequate capacity; Minimal backwater caused by downstream condition (potential for small flood event)
C	1-2-2-1	Adequate capacity; Significant backwater caused by downstream condition
	1-3-2-1	Adequate capacity; Significant backwater caused by downstream condition (potential for small flood event)
	1-3-2-2	Adequate capacity; Significant backwater caused by downstream condition (potential for large flood event)
D	2-1-1-1	Marginal capacity
	2-2-1-1	Marginal capacity; Minor surcharge event < 15 minutes
	2-3-1-1	Marginal capacity; Minor surcharge event < 15 minutes (potential for minor flood event)
E	2-2-2-1	Capacity exceeded; Major surcharge (> 15 minute) event likely
	2-3-2-1	Capacity exceeded; Major surcharge (> 15 minute) event likely (potential for minor flood event)
F	**2-3-2-2**	Capacity exceeded; Major flood event likely
F'*	**1-3-2-1**	Discharge restriction; Major flood event likely

***Considers the case when a downstream manhole configuration (sharp bends under high velocities, lack of benching, etc.) or outlet creates backwater conditions without an existing downstream backwater condition.**

For minor system networks, pipe upgrades are typically not recommended for HLoS ratings of 'A', 'B', 'C' or 'D' as these ratings indicate that capacity is available in the gravity mains to convey flows or that the capacity deficiency is not predicted to be detrimental to overall system operation. Gravity mains receiving an HLoS rating of 'B', 'C' or 'D' may show surcharging or flooding on connected nodes; however, these cases would indicate that the surcharged condition is due to downstream hydraulic deficiencies (cases 'B' or 'C') or is not significant enough to be of concern (case 'D').

For the 10-year event, it is recommended that only gravity mains receiving an HLoS rating of 'F' or 'F-prime' (F'), are considered for upgrade. Rectifying all 'E' pipes is not recommended as surcharge is not necessarily detrimental to the system performance, unless the predicted surcharge condition coincides with areas of known catch basin backup or other observed performance issues. For a gravity main receiving an 'E' rating, its hydraulic capacity has been exceeded and is likely causing surcharging or minor flooding to occur; however, this flood volume has been deemed acceptable for the sake of this analysis. A gravity main receiving an 'F' rating indicates that significant flooding is likely. To eliminate an 'F' pipe, it will likely be required to also improve downstream 'E' pipes.

2.3 Hydraulic Capacity Analysis

To provide the Township with the clearest possible understanding of system performance, a number of scenarios were simulated representing combinations of existing and future land use conditions and climate change assumptions.

Future land use conditions were based on the Township's Official Community Plan (OCP), with only parcels identified for redevelopment or development applications updated to reflect increased imperviousness consistent with OCP designations. No onsite stormwater controls (e.g. detention or infiltration measures) were included in the modeling scenarios as a conservative assumption, with the system assessed on the basis that no onsite flow reduction measures are implemented.

Existing Land Use without Climate Change:

- 10-Year Existing System Performance with Existing Land Use
- 100-Year Existing System Performance with Existing Land Use

Future OCP Land Use without Climate Change:

- 10-Year Existing System Performance with Future OCP Land Use
- 100-Year Existing System Performance with Future OCP Land Use

Future OCP Land Use with Climate Change:

- 10-Year Existing System Performance with Future OCP Land Use
- 100-Year Existing System Performance with Future OCP Land Use

The gravity main HLoS results under each scenario are summarized in **Table 2.6** and **Table 2.7**.

Table 2.6: 10-Year Gravity Main HLoS Results (Number of Mains)

HLoS Rating	Existing Land Use No Climate Change	Future Land Use No Climate Change	Future Land Use With Climate Change
A	1,008	943	875
B	60	78	73
C	62	90	139
D	5	12	11
E	44	56	74
F	**4**	**4**	**11**
F'	**0**	**0**	**0**

Table 2.7: 100-Year Gravity Main HLoS Results (Number of Mains)

HLoS Rating	Existing Land Use No Climate Change	Future Land Use No Climate Change	Future Land Use With Climate Change
A	727	665	593
B	86	76	70
C	200	237	280
D	21	14	10
E	125	150	167
F	**24**	**41**	**63**
F'	**0**	**0**	**0**

Maps depicting model results for all scenarios have been provided in **Appendix A**.

The majority of the modeled network is comprised of minor system components. Minor systems are typically intended to convey runoff from a 10-year event. As such, the 10-year results were used to determine if any upgrades were required on the Township stormwater system, and the 100-year results are informational purposes only. No analysis was completed to determine how the overland flow paths would convey the 100-year flows.

With respect to the results, under both existing and future conditions, the Township's minor stormwater system performs relatively well, with deficiencies concentrated in a few general areas:

- **Greenwood Avenue:** The model is predicting large flooding locations due to bottlenecks in the 200 mm mains on Greenwood Ave and the adjacent 250 mm main on private property between Greenwood Ave and Wychbury Ave.
- **Viewfield Road:** The model is predicting significant flooding due to a bottleneck in the 200 mm main on Viewfield Rd.
- **Grenville Avenue:** The model is predicting significant flooding due to a bottleneck in the 150 mm main on Grenville Ave at Esquimalt Rd.
- **Dead-End Pipes:** The model predicts localized flooding at dead-end storm mains.
- **Tidally Influenced Pipes:** The model predicts flooding at several locations near the shoreline that are influenced by tidal conditions. These issues are considered lower priority due to their proximity to the ocean and the influence of boundary conditions.

Outside of these areas, the system does exhibit surcharging and some minor flooding under the 10-year storms. In general, these are not expected to cause significant issues, as the overland system will likely convey the minor flood volumes (defined as peak flood rate < 0.05 m^3/s or flood volume < 15 m^3).

Under the 100-year scenarios, model results show widespread surcharging and flooding. No overland flow analysis was completed to assess how critical these overland flows are and whether the overland flow paths convey these flows without creating a hazard to property. This approach is consistent with typical municipal stormwater planning studies, and aligns with practices commonly applied in other communities, where detailed overland flow analysis is often deferred due to the additional data requirements, model complexity, and computational effort associated with 2D or dual drainage modeling. As such, this analysis has been identified as a potential next step and is included in the recommendations for a future model update, particularly if flooding becomes a concern for the Township.

It is important to note that there is a reduction in identified deficiencies in the 10-year and 100-year results compared to the previous system-wide analysis in *Township of Esquimalt Stormwater System Modeling* (GeoAdvice, 2020). This difference is primarily attributed to updates in model calibration, revised IDF data and methodology, and the use of revised design storm distributions and durations of 1-hour, 2-hour, 6-hour, 12-hour, and 24-hour (as opposed to the previous analysis using Chicago and SCS storm distributions with only 24-hour durations). The updated results are therefore expected to provide a more representative indication of current system performance.

3.0 Capital Improvements Plan

This section identifies the required capacity-based improvement projects along with their associated priority from a capacity perspective. Urban Systems will incorporate these results into their risk assessment alongside other prioritization factors (e.g., asset condition, social and financial impact, etc.).

Capacity-based deficiencies were identified using the Existing and Future OCP Land Use scenarios, under the 10-year design storm. Storm mains with HLoS ratings of either 'F' or 'F-prime' were considered "deficient" and proposed upgrades were considered to eliminate these deficiencies. All capacity-based system improvement recommendations were sized such that they could convey the climate change 10-year design storm without surcharging (i.e. $d/D < 1.0$) under the future land use conditions.

Storm mains by the ocean with flooding driven by tidal boundary conditions were not considered for capacity upgrades, as increasing pipe capacity would not materially reduce flooding. These areas are considered lower relative risk due to limited consequence compared to inland deficiencies.

Based on the MMCD guidelines, the design and sizing criteria shown in **Table 3.1** were used.

Table 3.1: Hydraulic Design Criteria

Criterion	Parameter Value
Design Flow	Future OCP Land Use with 10-Year Climate Change Storm
Max. depth/Diameter ratio	$d/D \leq 1.0$
Min. Pipe Diameter	D = 250 mm
Manning Roughness Coefficient	n = 0.013

The $d/D \leq 1.0$ criterion was applied as a design control to prevent surcharge, while hydraulic performance was also confirmed using $q/Q \leq 1.0$ under the design storm conditions.

The recommended gravity main upgrade projects are summarized in **Table 3.2**.

Table 3.2: Summary of the Gravity Main Upgrade Projects

Horizon	Project ID*	Project Description	Quantity
Existing	**1**	Upgrade three (3) pipes along Greenwood Avenue by Kinver Street to 300 mm.	192 m
	2	Upgrade three (3) pipes along Esquimalt Road from Grenville Avenue to Admirals Road to 250 mm.	112 m
	3	Upgrade three (3) pipes along Viewfield Road by Old Esquimalt Road to 250 mm and 300 mm.	170 m
	4	Upgrade two (2) pipes along Wychbury Avenue near Kinver Street to 300 mm and 450 mm, and cap the pipe extending south from the existing flow split on Wychbury Avenue west of Kinver Street, with manhole rebenching as required.	138 m
Future	**5**	Upgrade one (1) pipe along Bewdley Avenue by Lampson Street to 300 mm.	83 m
	6	Upgrade two (2) pipes along Glengarry Place by Kindersley Road to 250 mm.	87 m
		Total	**782 m**

***Project ID represents the project priority.**

Four (4) gravity main upgrade projects with a total length of 612 m are recommended under the existing horizon, and two (2) gravity main upgrade projects with a total length of 170 m are recommended under the future horizon. Both future projects are triggered by climate change rather than growth-related land use changes.

The total number of pipes upgraded (14) exceeds the number of HLoS 'F' deficiencies (11) due to inclusion of diameter continuity upgrades, which were HLoS 'E' both before and after upstream 'F' deficiencies were resolved and were classified as capacity-related upgrades.

Gravity main upgrade details and locations are provided in the table and map in **Appendix B**.

4.0 Summary and Recommendations

4.1 Summary

GeoAdvice Engineering Inc. was retained by the Township of Esquimalt to assess the hydraulic performance of the Township's stormwater collection system under existing and future conditions using the updated Esquimalt stormwater model:

- The existing system hydraulic capacity was assessed with 10-year and 100-year design storms under the following scenarios:
    - Existing Land Use (Existing IDF)
    - Future OCP Land Use (Existing IDF)
    - Future OCP Land Use (Climate Change IDF)
- Capacity deficiencies were identified using a hydraulic level of service (HLoS) methodology. The 10-year results were used to determine whether upgrades are required for the Township stormwater system. Under existing and future OCP land use with the existing IDF, four (4) deficiencies were identified. Under future OCP land use with the climate change IDF, eleven (11) deficiencies were identified.
- System flooding is primarily driven by localized conveyance constraints in undersized storm mains, including bottlenecks in key corridors, dead-ends, and tidally influenced constraints along shoreline areas.
- Four (4) gravity main upgrade projects with a total length of 612 m are recommended under the existing horizon, and two (2) gravity main upgrade projects with a total length of 170 m are recommended under the future horizon.

4.2 Recommendations

1. **Verification of Stormwater Collection Network Data**
   Prior to undertaking capacity-related capital improvements, the Township should verify stormwater system data through a combination of as-built drawing review and targeted field surveys. The model development included a detailed review of available records and consultation with Township staff to resolve data gaps where possible; however, some assumptions were required where information was unavailable or uncertain. Verification should focus on pipe diameters, invert elevations, rim elevations, and other key attributes, particularly in areas where model inputs are assumed, records are uncertain, or capacity issues have been identified. Any discrepancies between drawings, field conditions, and the model should be resolved and incorporated into model updates to confirm the need, timing, and sizing of proposed upgrades and to ensure the model accurately reflects current system conditions.

2. **Overland Flow Analysis**
If the Township is interested in understanding the potential hazards to property associated with overland flows from the modeled flood locations, an overland flow analysis is recommended. This analysis can be completed via 2D modeling, 1D dual drainage modeling, or assessment of downstream flow routes using LiDAR data. An evaluation of the feasibility and benefits of these approaches can be completed, particularly in areas prone to surface flooding or complex flow patterns, to inform selection of the most appropriate modeling approach for the Township's needs. Assessing the potential impact on computational resources, data requirements, and model complexity will inform the decision-making process regarding the appropriate approach to meet the Township's objectives.

   If 2D modeling or 1D dual drainage modeling is the selected approach, an updated hydraulic and hydrological model will be developed using the chosen methodology. This updated model will incorporate the latest data, parameters, and techniques identified during the evaluation process, ensuring that it reflects the most accurate representation of the Township's hydraulic and hydrologic dynamics.

3. **Additional Flow Monitoring**
Model calibration was completed as part of this study and the calibration results were very good; however, the Township should consider undertaking additional flow monitoring to support future model refinement and validation. Additional monitoring would help capture a broader range of catchment conditions and system responses under different rainfall events and ensure the model remains representative as land use and infrastructure conditions evolve. Longer-term monitoring is also recommended to increase the likelihood of capturing a wider range of rainfall events and conditions, which improves confidence in model validation and supports more robust future calibration efforts.

4. **Permanent Township-Owned Rain Gauge**
The Township should consider installing a permanent, high-resolution rain gauge within the study area to support ongoing stormwater analysis and future model applications. As part of this study, a temporary rain gauge was installed between November 9, 2025 and March 10, 2026 by Bot Corp, which provided short-term local rainfall data to support model calibration efforts. However, there would be value in maintaining long-term local rainfall records through a permanent installation to better capture site-specific rainfall variability, particularly for short-duration, high-intensity events. While regional Environment Canada stations are suitable for general design use, a local gauge would improve representation of site-specific rainfall variability, particularly for short-duration, high-intensity events. Locally recorded rainfall data would support future updates to Intensity-Duration-Frequency (IDF) curves and provide a basis for ongoing model validation and verification of system response during extreme events, strengthening the long-term robustness and defensibility of the model.

5. **Maintenance of Stormwater System Model**
   Ongoing development, zoning and infrastructure changes dictate that model updates should be completed every year. Piping capacities should be updated where investigations indicate discrepancies from assumptions used in the model development.

6. **Modeling User's Guide for Land Development Applications**
   A Modeling User's Guide will be a key tool for optimizing infrastructure planning and decision-making processes in the Township. It is recommended that a guide is developed to assist the Township in performing development application impact reviews for their stormwater system.

   This specialized document would streamline decision-making by providing clear methodologies and guidelines for assessing the impact of proposed developments on the Township stormwater system, including common hydrologic inputs and consideration for both major and minor system flows. It will empower stakeholders to identify potential drainage challenges early on and implement targeted measures to mitigate risks and ensure long-term resilience.

   It is recommended that the guide includes a template report to ensure that all consultants are using the model in the same way to assess developments (i.e. standard practice for implementing development into model and analyzing infrastructure).

7. **Hydraulic Modeling of Storm Sewer Systems Training Course**
   A customized hands-on training course on the new storm sewer model and modeling software can be provided in alignment with the Asset Management Plan. The Township has not received training on the updated AquaTwin Sewer model, and as stormwater management practices advance over time in the Township, this may provide value. This would support an improved understanding of the model framework, assumptions, and outputs, which may be beneficial when the model is used to support ongoing investigations or future updates. Customized training manuals with hands-on tutorials would be prepared, and exercises would be run on the new model during training.

8. **Development Of Customized Standards And Conventions**
   A customized Modeling Standards and Conventions document can be developed to establish the modeling rules for the Township to observe when analyzing or updating the storm model, in alignment with the Asset Management Plan. The Township does not currently have a formal modeling standards document for the storm system model, and as stormwater management practices advance over time in the Township, this will support consistency in modeling applications. Modeling Standards and Conventions typically include good modeling techniques, naming conventions, calibration tolerances, standard practices and procedures, and model management practices, which help inform model updates, development reviews, and future system assessments.

Submission

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Project Engineer

Reviewed and Approved by:

PROFESSIONAL PROVINCE OF BRITISH COLUMBIA Dr. W. DE SCHAETZEN # 30059 ENGINEER 2026-08-31

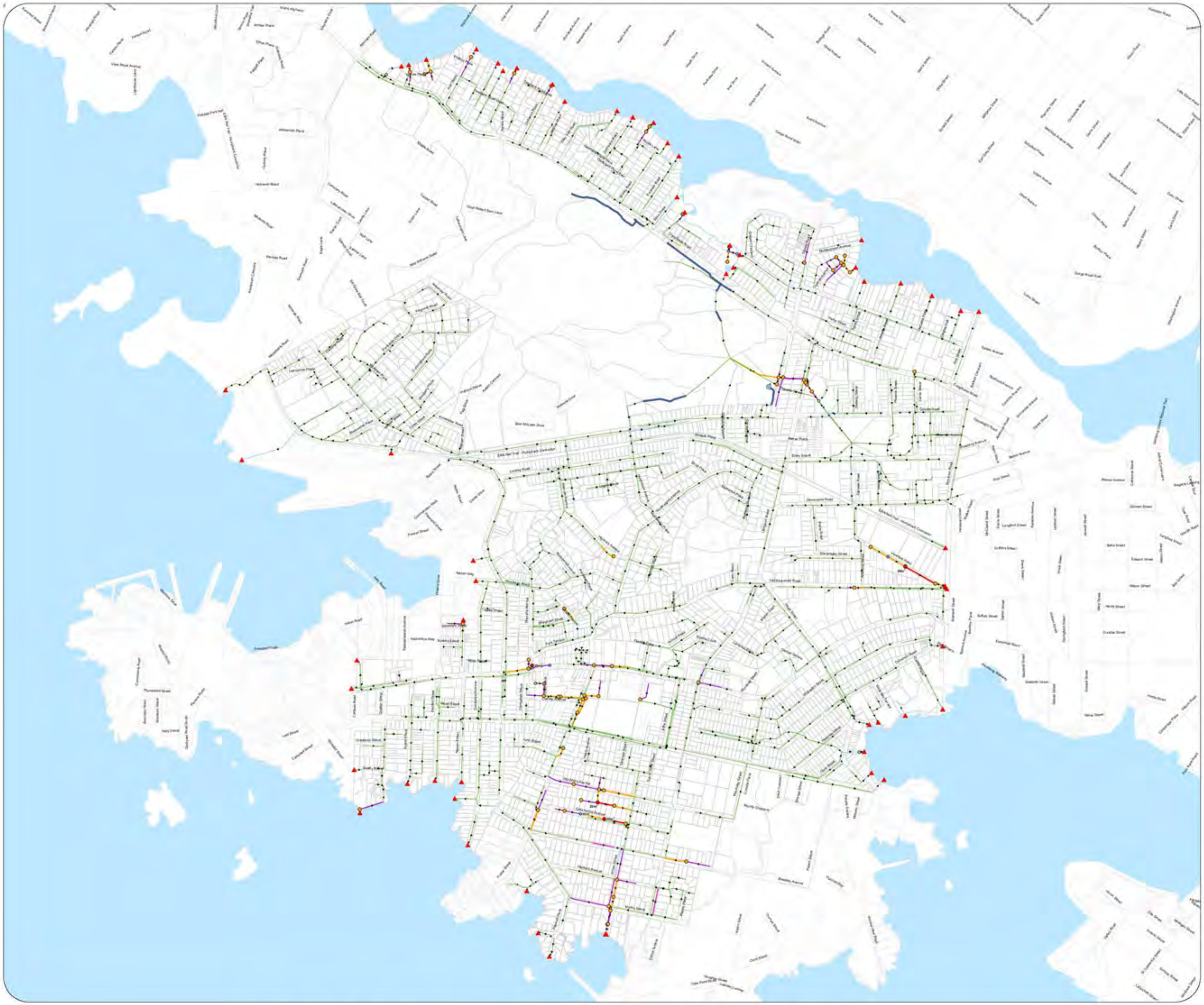
Werner de Schaetzen, Ph.D., P.Eng.
Senior Modeling Review

Document History and Version Control

Revision No.	Date	Document Description	Revised By	Reviewed By
R0	April 23, 2026	Draft	Sean Zoschke	Werner de Schaetzen
R1	May 22, 2026	Draft	Sean Zoschke	Werner de Schaetzen
R2	August 31, 2026	Final	Sean Zoschke	Werner de Schaetzen

Statement of Qualifications and Limitations
This document represents GeoAdvice Engineering Inc. best professional judgment based on the information available at the time of its completion and as appropriate for the project scope of work. Services performed in developing the content of this document have been conducted in a manner consistent with that level and skill ordinarily exercised by a member of the engineering profession currently practicing under similar conditions. No warranty, express or implied is made.

Appendix A Hydraulic Level of Service Figures



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Open Channel
- Subcatchment

Junction

Note: Predicted flood volume defined on map

- Minor Flood Event (6)
- Major Flood Event (4)
- Minor Surcharge - No Flooding (4)
- Major Surcharge - No Flooding (66)

Gravity Main HLoS

- A (1,008) *Gravity main performing as designed*
- B (60) *Adequate capacity; Minimal backwater caused by downstream condition (potential for <5 min. flood event)*
- C (62) *Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*
- D (5) *Marginal capacity; Surcharge event < 5 min. likely (potential for < 5 min. flood event)*
- E (44) *Capacity exceeded; Significant surcharge event likely (potential for < 5 min. flood event)*
- F (4) *Capacity exceeded; Large flood event likely*
- F' (0) *Discharge restriction; Significant backwater caused by downstream manhole configuration (large flood event likely)*

Existing Land Use
Existing IDF 10-Year Storm
Modeling Results

Township of ESQUIMALT

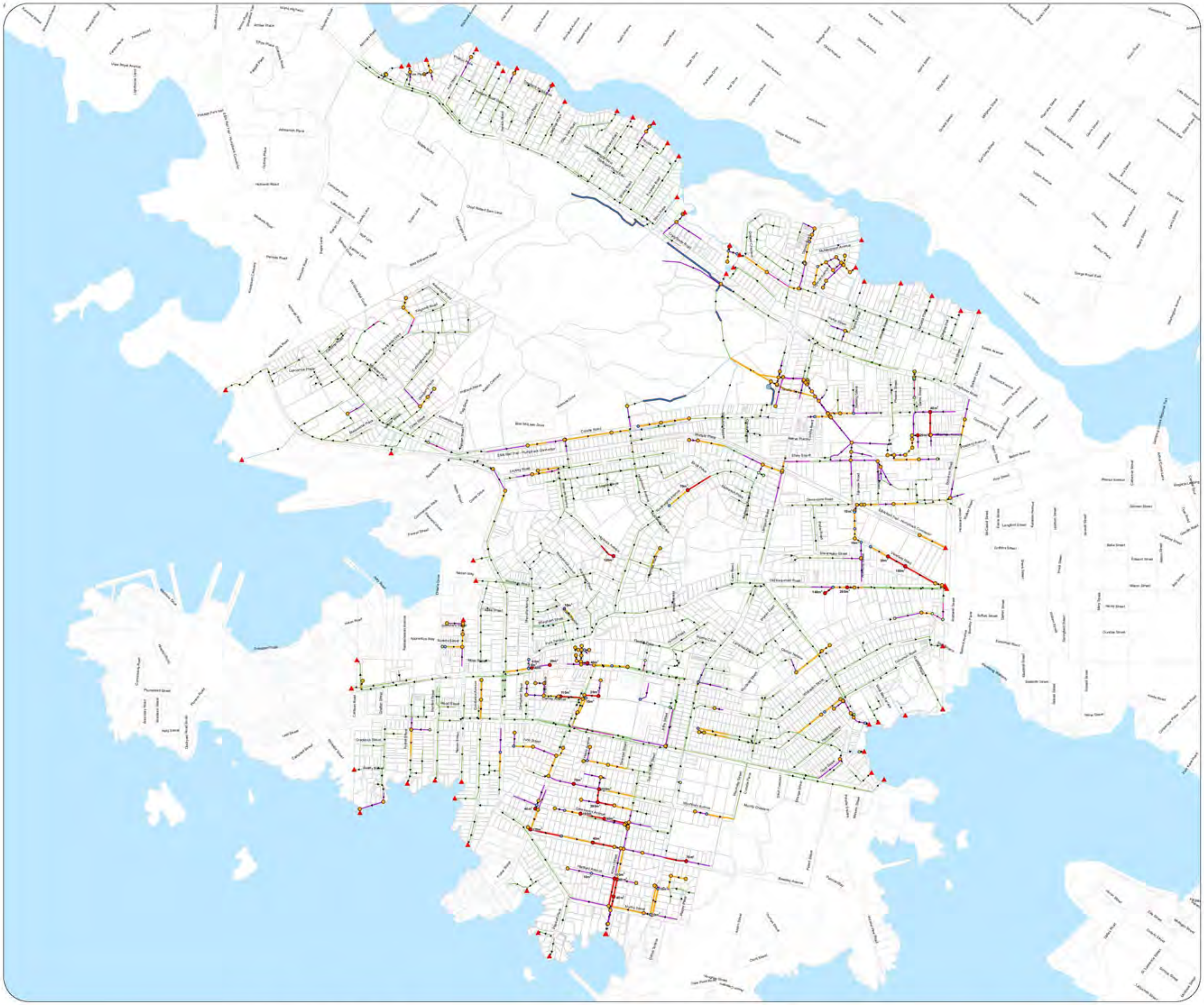
Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
Client: **Township of Esquimalt, BC**
Date: **April 2026**
Created by: **SZ**
Reviewed by: **WdS**

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.25 0.5 1
Kilometers

N W E S

Figure A.1



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Open Channel
- Subcatchment

Junction

Note: Predicted flood volume defined on map

- Minor Flood Event (36)
- Major Flood Event (26)
- Minor Surcharge - No Flooding (18)
- Major Surcharge - No Flooding (196)

Gravity Main HLoS

A (727)	*Gravity main performing as designed*
B (86)	*Adequate capacity; Minimal backwater caused by downstream condition (potential for <5 min. flood event)*
C (200)	*Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*
D (21)	*Marginal capacity; Surcharge event < 5 min. likely (potential for < 5 min. flood event)*
E (125)	*Capacity exceeded; Significant surcharge event likely (potential for < 5 min. flood event)*
F (24)	*Capacity exceeded; Large flood event likely*
F' (0)	*Discharge restriction; Significant backwater caused by downstream manhole configuration (large flood event likely)*

Existing Land Use
Existing IDF 100-Year Storm
Modeling Results

Township of ESQUIMALT

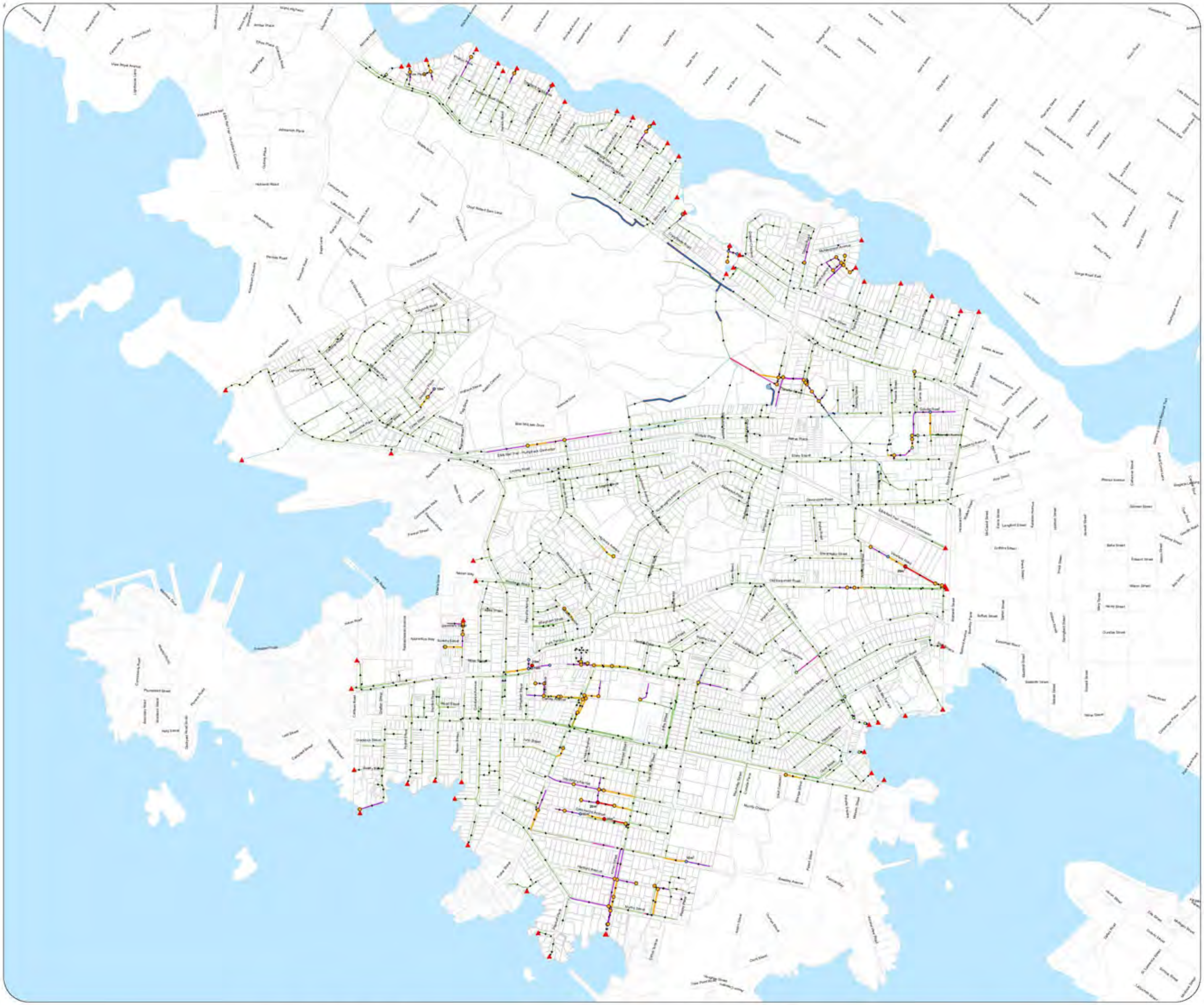
Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
Client: **Township of Esquimalt, BC**
Date: **April 2026**
Created by: **SZ**
Reviewed by: **WdS**

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.25 0.5 1
Kilometers

N W E S

Figure A.2



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Open Channel
- Subcatchment

Junction

Note: Predicted flood volume defined on map

- Minor Flood Event (11)
- Major Flood Event (4)
- Minor Surcharge - No Flooding (9)
- Major Surcharge - No Flooding (85)

Gravity Main HLoS

A (943)	*Gravity main performing as designed*
B (78)	*Adequate capacity; Minimal backwater caused by downstream condition (potential for <5 min. flood event)*
C (90)	*Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*
D (12)	*Marginal capacity; Surcharge event < 5 min. likely (potential for < 5 min. flood event)*
E (56)	*Capacity exceeded; Significant surcharge event likely (potential for < 5 min. flood event)*
F (4)	*Capacity exceeded; Large flood event likely*
F' (0)	*Discharge restriction; Significant backwater caused by downstream manhole configuration (large flood event likely)*

Future Land Use
Existing IDF 10-Year Storm
Modeling Results

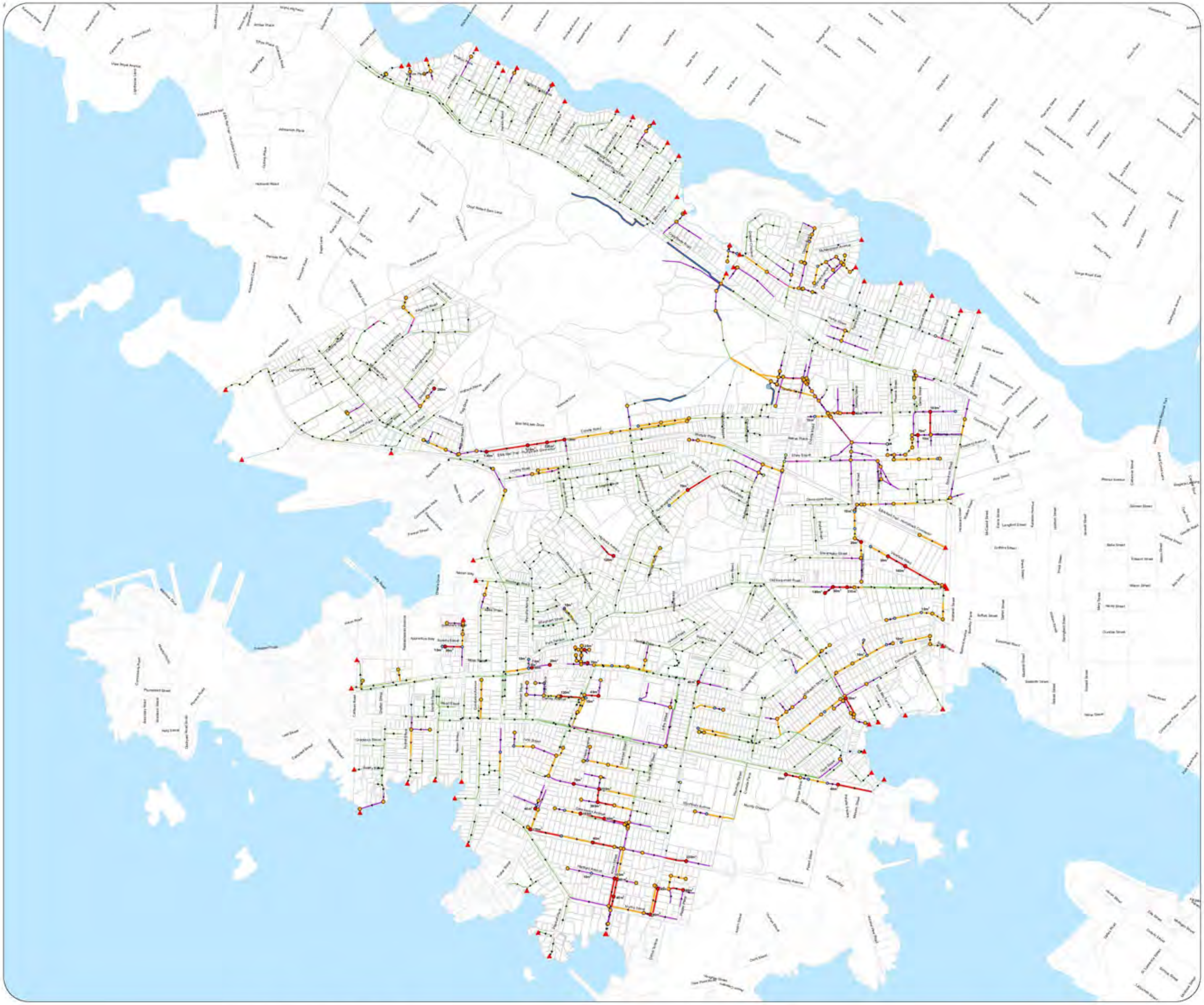
Township of ESQUIMALT

Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
Client: **Township of Esquimalt, BC**
Date: **April 2026**
Created by: **SZ**
Reviewed by: **WdS**

0 0.25 0.5 1
Kilometers

N W E S

Figure A.3



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Open Channel
- Subcatchment

Junction

Note: Predicted flood volume defined on map

- Minor Flood Event (48)
- Major Flood Event (43)
- Minor Surcharge - No Flooding (8)
- Major Surcharge - No Flooding (236)

Gravity Main HLoS

A (665)	*Gravity main performing as designed*
B (76)	*Adequate capacity; Minimal backwater caused by downstream condition (potential for <5 min. flood event)*
C (237)	*Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*
D (14)	*Marginal capacity; Surcharge event < 5 min. likely (potential for < 5 min. flood event)*
E (150)	*Capacity exceeded; Significant surcharge event likely (potential for < 5 min. flood event)*
F (41)	*Capacity exceeded; Large flood event likely*
F' (0)	*Discharge restriction; Significant backwater caused by downstream manhole configuration (large flood event likely)*

Future Land Use
Existing IDF 100-Year Storm
Modeling Results

Township of ESQUIMALT

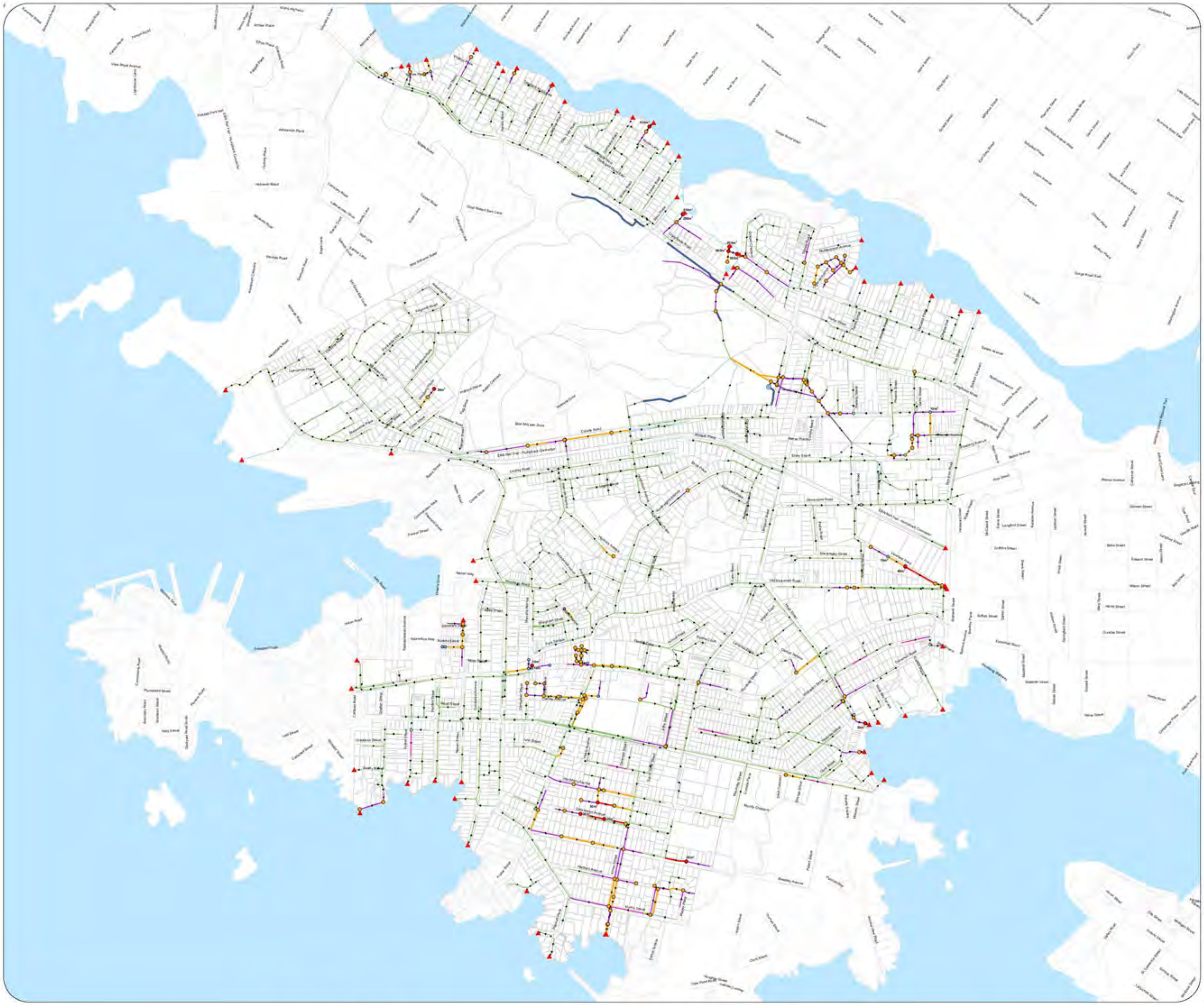
Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
Client: **Township of Esquimalt, BC**
Date: **April 2026**
Created by: **SZ**
Reviewed by: **WdS**

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.25 0.5 1
Kilometers

N W E S

Figure A.4



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Open Channel
- Subcatchment

Junction

Note: Predicted flood volume defined on map

- Minor Flood Event (13)
- Major Flood Event (14)
- Minor Surcharge - No Flooding (8)
- Major Surcharge - No Flooding (122)

Gravity Main HLoS

A (875)	*Gravity main performing as designed*	
B (73)	*Adequate capacity; Minimal backwater caused by downstream condition (potential for <5 min. flood event)*	
C (139)	*Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*	
D (11)	*Marginal capacity; Surcharge event < 5 min. likely (potential for < 5 min. flood event)*	
E (74)	*Capacity exceeded; Significant surcharge event likely (potential for < 5 min. flood event)*	
F (11)	*Capacity exceeded; Large flood event likely*	
F' (0)	*Discharge restriction; Significant backwater caused by downstream manhole configuration (large flood event likely)*	

Future Land Use
Climate Change IDF 10-Year Storm
Modeling Results

Township of Esquimalt

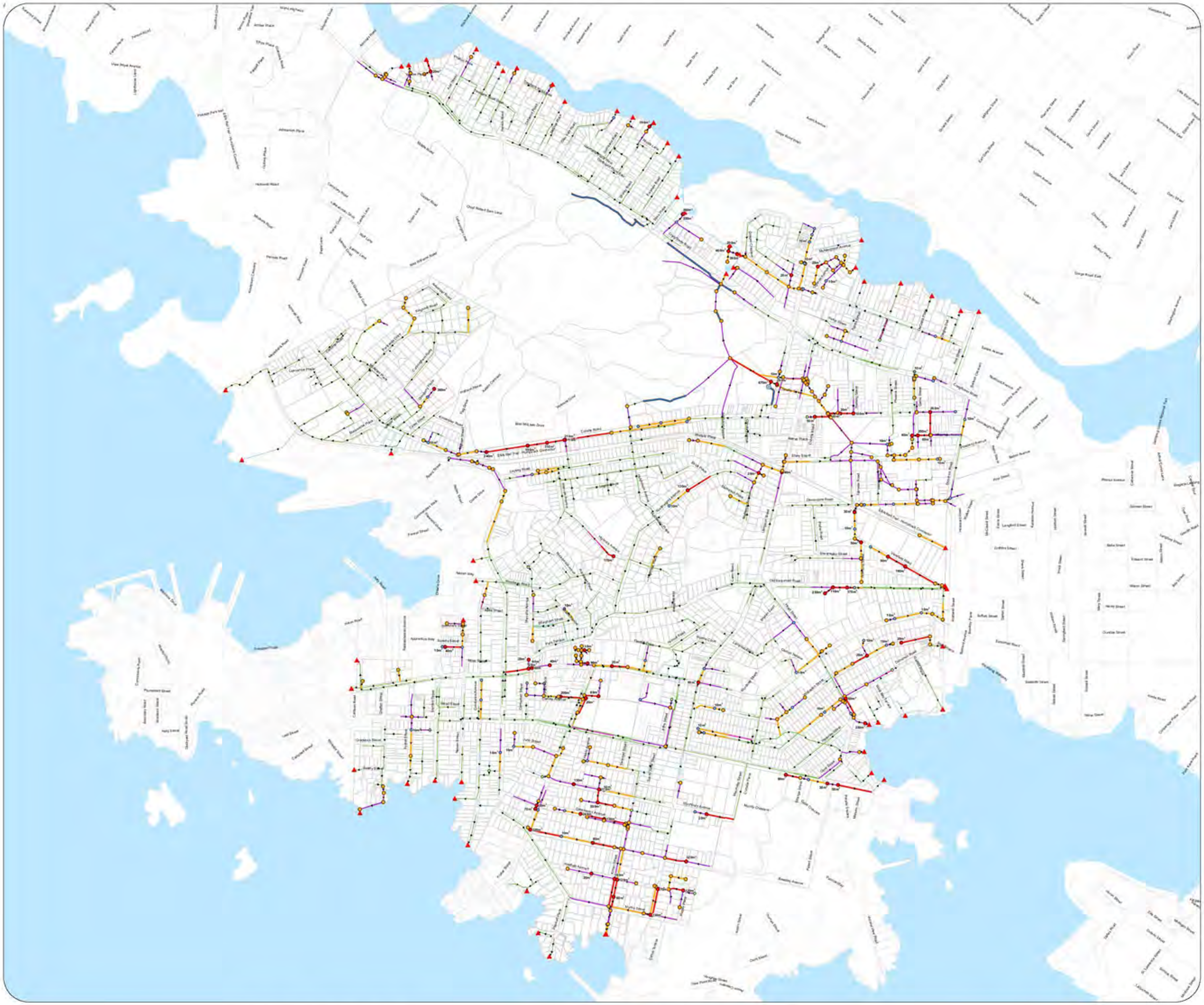
Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
Client: **Township of Esquimalt, BC**
Date: **April 2026**
Created by: **SZ**
Reviewed by: **WdS**

DISCLAIMER: GeoAdvice does not warrant in any way the accuracy and completeness of the information shown on this map. Field verification of the accuracy and completeness of the information shown on this map is the sole responsibility of the user.

0 0.25 0.5 1
Kilometers

N W E S

Figure A.5



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Open Channel
- Subcatchment

Junction

Note: Predicted flood volume defined on map

- Minor Flood Event (66)
- Major Flood Event (74)
- Minor Surcharge - No Flooding (10)
- Major Surcharge - No Flooding (253)

Gravity Main HLoS

A (593)	*Gravity main performing as designed*
B (70)	*Adequate capacity; Minimal backwater caused by downstream condition (potential for <5 min. flood event)*
C (280)	*Adequate capacity; Significant backwater caused by downstream condition (potential for flood event)*
D (10)	*Marginal capacity; Surcharge event < 5 min. likely (potential for < 5 min. flood event)*
E (167)	*Capacity exceeded; Significant surcharge event likely (potential for < 5 min. flood event)*
F (63)	*Capacity exceeded; Large flood event likely*
F' (0)	*Discharge restriction; Significant backwater caused by downstream manhole configuration (large flood event likely)*

Future Land Use
Climate Change IDF 100-Year Storm
Modeling Results

Township of ESQUIMALT

Project: **Storm System Modeling**
Project ID: **2025-133-ESQ**
Client: **Township of Esquimalt, BC**
Date: **April 2026**
Created by: **SZ**
Reviewed by: **WdS**

0 0.25 0.5 1
Kilometers

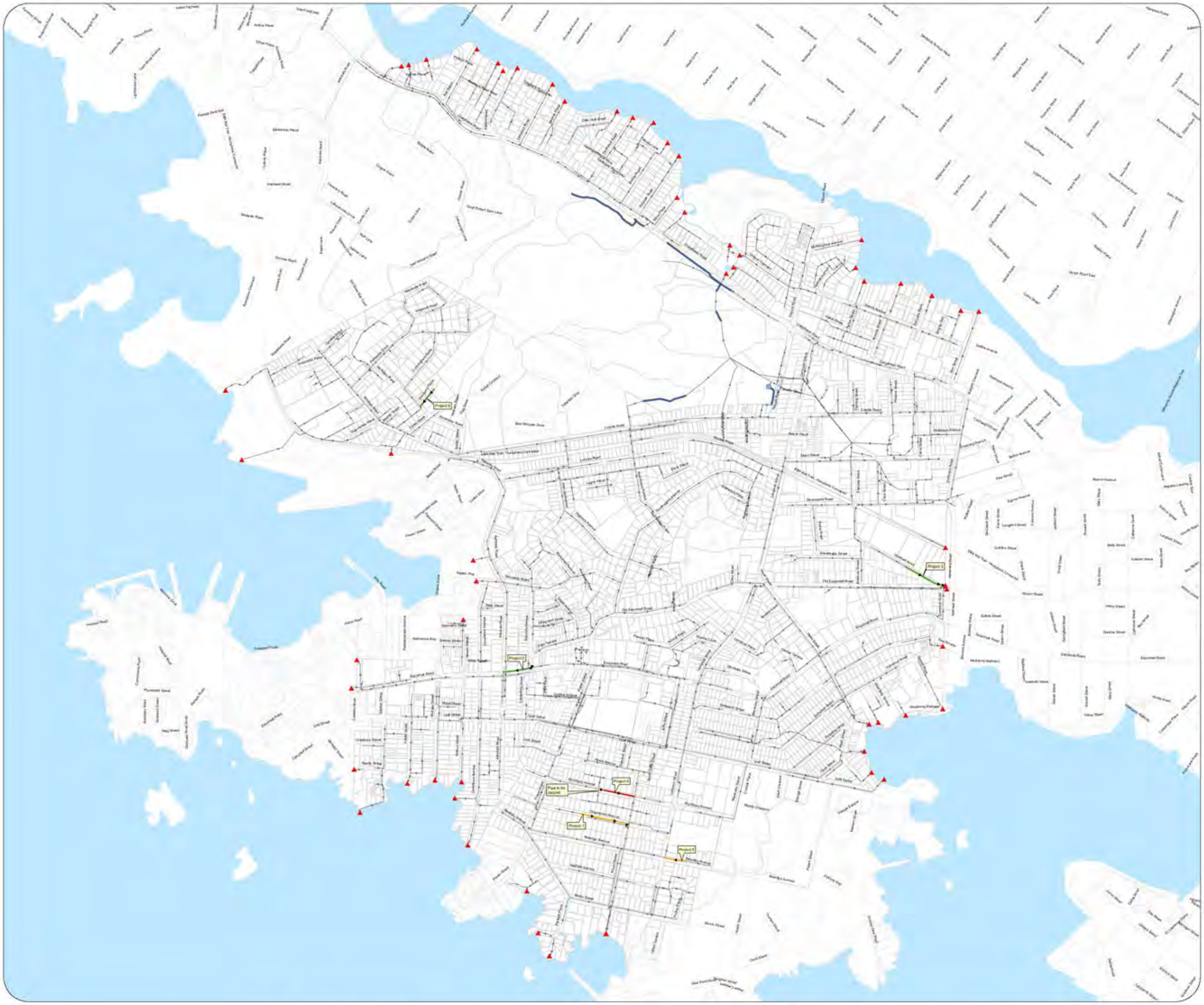
N
W E
S

Figure A.6

Appendix B Detailed Capital Improvement Plan

Recommended Gravity Main Improvements

Horizon	Project	Gravity Main ID	Upstream Manhole ID	Downstream Manhole ID	Length (m)	Slope (/)	Existing Diameter (mm)	Future OCP Land Use with 10-Year CC Storm		
								Recommended Upgrade Diameter (mm)	Upgrade d/D	Upgrade q/Q
Existing	1	DGM0617	DMH0084	DMH0757	15.5	0.010	200	300	0.65	0.58
		DGM0618	DMH0353	DMH0084	84.1	0.005	200	300	0.67	0.81
		DGM0734	DMH0115	DMH0353	92.7	0.005	200	300	0.61	0.71
	2	DGM0774_1	DMH0235	GA-DMH0034	13.9	0.009	150	250	0.49	0.33
		DGM0774_2	GA-DMH0034	DMH0621	88.7	0.010	150	250	0.59	0.64
		DGM1251	DMH0978	DMH0235	9.4	0.010	150	250	0.22	0.01
	3	DGM0467	DMH0200	GA-DO0010	12.2	0.006	200	300	0.71	0.90
		DGM0568	DMH0343	DMH0684	131.2	0.011	200	250	0.78	0.94
		DGM0570	DMH0684	DMH0200	26.4	0.016	200	250	0.78	0.82
	4	DGM0502	DMH0284	DMH0632	18.3	0.018	200	300	0.82	0.96
		DGM1069	DMH0632	DMH0875	119.6	0.006	200	450	0.59	0.62
Future	5	DGM0934	DMH0839	DMH0920	83.0	0.007	200	300	0.64	0.74
	6	DGM0152	DMH0206	DMH0795	46.7	0.017	150	250	0.61	0.65
		DGM1157	DMH0709	DMH0206	39.8	0.066	150	250	0.52	0.33



GeoAdvice Engineering Inc.

Legend

- Detention Pond
- Outfall
- Storm Main
- Open Channel
- Subcatchment

Storm Main Upgrade Diameter

- 250 mm
- 300 mm
- 450 mm

System Improvement Recommendations

Township of ESQUIMALT

Project:	**Storm System Modeling**
Project ID:	**2025-133-ESQ**
Client:	**Township of Esquimalt, BC**
Date:	**May 2026**
Created by:	**SZ**
Reviewed by:	**WdS**

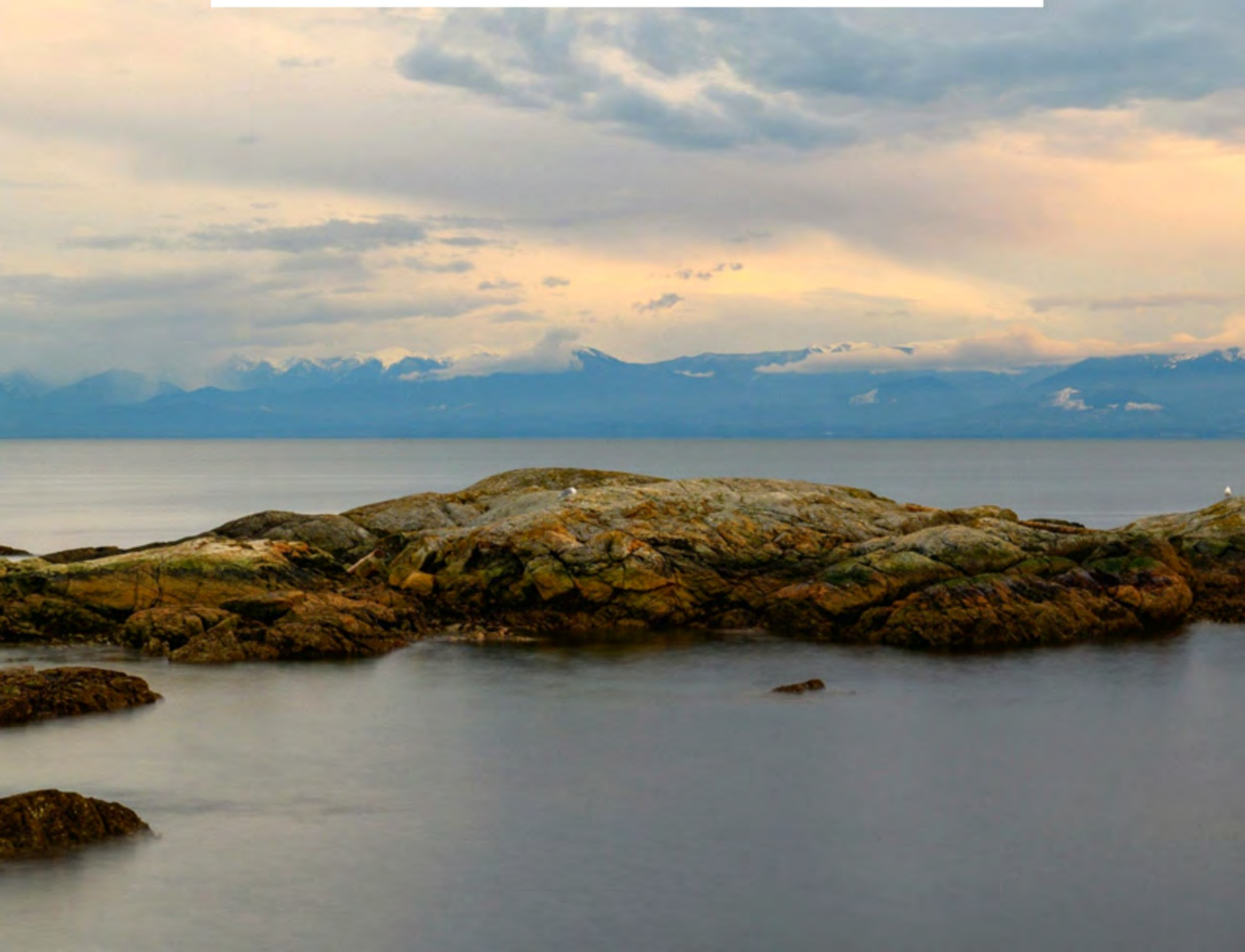
0 0.25 0.5 1
Kilometers

N W E S

Figure B.1

APPENDIX F:

STORM SEWER ASSET MANAGEMENT PLAN - UNIT COST ESTIMATING



MEMORANDUM

DATE: June 17, 2026
TO: Joel Clary, P.Eng.
FROM: Alex Kempa, Dan Todd – Urban Systems
FILE: 1688.0013.01
SUBJECT: Storm Sewer Asset Management Plan Unit Cost Estimating

1.0 INTRODUCTION

Urban Systems has been working with the Township of Esquimalt (the Township) to develop a Storm Sewer Asset Management Plan (SSAMP). The scope of work includes identifying upgrade projects required within the Township's storm sewer system and preparing Class D cost estimates for these projects. The following technical memorandum details the unit rate costs to be applied in developing these estimates.

2.0 COST DERIVATIONS AND BACKGROUND INFORMATION

Storm sewer construction costs have been developed for gravity collection sewers, assuming full replacement ($/m). These unit rate estimates were developed using unit rates from comparable communities and existing cost estimates by Urban, adjusted for inflation, based on construction cost indices published by the Engineering News Record for nearby markets. These unit rates are used in the SSAMP to estimate the average annual life cycle investment for the Township's storm sewer system. This life-cycle planning approach evenly distributes capital investments over the expected service life of linear assets to determine an annual investment rate. These unit rates are also used to estimate the cost of infrastructure upgrade projects (e.g., capacity driven projects) and inform full pipe replacement needs due to condition. Note, in some cases, full pipe replacement may not be needed, and other strategies such as lining or point repairs may be feasible, however, additional review of CCTV records is needed to determine suitable renewal actions.

2.1 INCLUSIONS AND ASSUMPTIONS

The following section introduces inclusions and assumptions related to the development of the storm sewer unit costs proposed herein. These unit rates are intended to include all of the typical scope and components that are required for linear stormwater construction such as:

- Site preparation (asphalt milling, common excavation, rock excavation);
- Road restoration (granular base/subbase, asphalt pavement, trench backfill);
- Stormwater gravity works (pipe works, service connections, catchbasins, manholes); and

The scope items listed above are normalized and combined into a per-metre unit-rate and added to typical per-metre pipe supply and installation costs for varying pipe diameters. To provide reliable cost estimates, we have made the following assumptions:

- Trenches for pipe depths less than 1.5m will have an unsupported vertical excavation height of 1.2m, with upper trench section constructed at 1H:1V side slopes. This results in a paving width of approximately 2.1m;
- Trenches for pipe depths greater than 1.5m will be constructed with near-vertical sidewalls (supported by excavation as required), result in consistent surface disturbance and pavement restoration width of 2m;

- Rock excavation to be encountered for 20% of the excavated volume;
- A 7% allowance for traffic control; and
- A 40% contingency allowance has been applied to the estimated capital cost, and an additional 10% engineering allowance.

Additionally, as gravity mains are typically installed within road right-of-ways, cost multipliers have been introduced for the different cross-sectional road types utilized by the Township to account for increases or decreases in costs based on their classification and associated level of complexity (such factors include removal and replacement of more substantial road structure to accommodate larger traffic, removal and replacement of medians, curb & gutter or sidewalk, electrical conduit crossings, etc.):

- RSV Service Road, RLN Road Lane, RRT Restricted Road → 0.85x multiplier from base;
- RLO Local Road, RST Strata Road → Base cost scenario;
- RC1 RC2 Major & Minor Collectors, RRC Recreation Road, RYL Yield Lane → 1.25x multiplier from base;
- RA1 Major Arterial → 1.50x multiplier from base;

Finally, since gravity mains are required to maintain downward grade along the collection system, installation depth ranges have been discretized and costed out individually to provide a high-accuracy cost estimate:

- Minimum (<1.5m) installation depth;
- Moderate (1.5m~3m) installation depth; and
- Deep (3m~6m) installation depth.

The cost derivation is structured such that the volume of earthworks (excavation and backfill) required at each depth interval is factored into the unit-cost estimate.

Table 1 below summarizes the estimated gravity main construction cost at a shallow installation depth, 0-1.5m, (inclusive of manholes, service connections, roadworks, tie-ins and 40% contingency and 10% engineering) for local and strata roads, rounded to the nearest $5.

Table 1: Gravity Main Unit Costs in Local and Strata Roads

Pipe Size	Costs ($/m) Including E&C
150	$2,705
200	$2,780
250	$2,825
300	$2,975
350	$3,035
375	$3,060
400	$3,275
450	$3,585
525	$3,740
600	$4,100
675	$4,535
750	$4,725
900	$5,100
1050	$5,475
1200	$5,900
1350	$6,275
1500	$6,655

Table 2 below summarizes the multipliers used to estimate costs for the different road classifications.

Table 2: Road Classification Multipliers

Road Classification	Cost Multiplier
RA1 Major Arterial	1.50x
RC1 RC2 Major & Minor Collectors, RRC Recreation Road, RYL Yield Lane	1.25x
RLO Local Road, RST Strata Road	1.00x
RSV Service Road, RLN Road Lane	0.85x

Table 3 below shows the proposed derived unit cost rates for installation of a gravity main at various depths within a local road, including 40% contingency and 10% engineering allowances – a detailed summary for each depth scenario is appended to this memo.

Table 3: Gravity Main Unit Costs at Various Depths (Local and Strata Roads)

Pipe Size (mm)	Costs ($/m) Including E&C		
	0-1.5m Depth	1.5-3m Depth	3-6m Depth
150	$2,705	$3,685	$5,565
200	$2,780	$3,760	$5,645
250	$2,825	$3,810	$5,695
300	$2,975	$3,970	$5,850
350	$3,035	$4,035	$5,915
375	$3,060	$4,060	$5,945
400	$3,275	$4,225	$6,105
450	$3,585	$4,540	$6,425
525	$3,740	$4,770	$6,695
600	$4,100	$5,145	$7,065
675	$4,535	$5,620	$7,650
750	$4,725	$5,820	$7,850
900	$5,100	$6,210	$8,240
1050	$5,475	$6,605	$8,635
1200	$5,900	$7,055	$9,105
1350	$6,275	$7,450	$9,500
1500	$6,655	$7,840	$9,895

Sincerely,

URBAN SYSTEMS LTD.

A Kempa

Alex Kempa, P.Eng.
Project Engineer

Dan Todd, P.Eng.
Civil Engineer

/ak

U:\Projects_VIC\1688\0013\01\R-Reports-Studies-Documents\R1-Reports\Unit Cost\2026-06-17-SSAMP Unit Cost Estimating_FINAL.docx

Estimated Stormwater Project Unit Costs, 2025

Storm Sewer Main (0-1.5m depth)	Road Classification	150mm	200mm	250mm	300mm	350mm	375mm	400mm	450mm	525mm	600mm	675mm	750mm	900mm	1050mm	1200mm	1350mm	1500mm	Assumptions and Inclusions
	RSV Service Road, RLN Road Lane, RRT Restricted Road (0.85x)	$2,301	$2,362	$2,401	$2,529	$2,579	$2,600	$2,782	$3,046	$3,177	$3,487	$3,853	$4,014	$4,334	$4,655	$5,014	$5,335	$5,655	
	RLO Local Road, RST Strata Road (1x)	$2,707	$2,779	$2,824	$2,975	$3,034	$3,059	$3,273	$3,583	$3,738	$4,102	$4,533	$4,723	$5,099	$5,477	$5,899	$6,277	$6,653	All road classes include mains, appurtenances, tie-ins, service connections, pavement restoration, engineering (10%), contingency (40%)
	RC1 RC2 Major & Minor Collectors, RRC Recreation Road, RYL Yield Lane (1.25x)	$3,383	$3,474	$3,530	$3,719	$3,793	$3,824	$4,091	$4,479	$4,672	$5,128	$5,666	$5,903	$6,373	$6,846	$7,374	$7,846	$8,316	
	RA1 Major Arterial (1.5x)	$4,060	$4,168	$4,236	$4,463	$4,551	$4,589	$4,909	$5,375	$5,607	$6,153	$6,799	$7,084	$7,648	$8,215	$8,848	$9,415	$9,979	

Storm Sewer Main (1.5-3m depth)	Road Classification	150mm	200mm	250mm	300mm	350mm	375mm	400mm	450mm	525mm	600mm	675mm	750mm	900mm	1050mm	1200mm	1350mm	1500mm	Assumptions and Inclusions
	RSV Service Road, RLN Road Lane, RRT Restricted Road (0.85x)	$3,131	$3,197	$3,241	$3,374	$3,428	$3,452	$3,590	$3,859	$4,056	$4,373	$4,778	$4,947	$5,280	$5,615	$5,996	$6,331	$6,665	
	RLO Local Road, RST Strata Road (1x)	$3,684	$3,762	$3,812	$3,969	$4,033	$4,061	$4,224	$4,540	$4,772	$5,144	$5,621	$5,819	$6,212	$6,606	$7,054	$7,448	$7,841	All road classes include mains, appurtenances, tie-ins, service connections, pavement restoration, engineering (10%), contingency (40%)
	RC1 RC2 Major & Minor Collectors, RRC Recreation Road, RYL Yield Lane (1.25x)	$4.605	$4,702	$4,766	$4.961	$5.042	$5,077	$5.280	$5.675	$5.964	$6.430	$7.027	$7.274	$7.765	$8.258	$8.817	$9.310	$9.801	
	RA1 Major Arterial (1.5x)	$5,526	$5,642	$5,719	$5,954	$6,050	$6,092	$6,335	$6,810	$7,157	$7,716	$8,432	$8,729	$9,318	$9,910	$10,581	$11,172	$11,761	

Storm Sewer Main (3-6m depth)	Road Classification	150mm	200mm	250mm	300mm	350mm	375mm	400mm	450mm	525mm	600mm	675mm	750mm	900mm	1050mm	1200mm	1350mm	1500mm	Assumptions and Inclusions
	RSV Service Road, RLN Road Lane, RRT Restricted Road (0.85x)	$4,732	$4,798	$4,841	$4,975	$5,029	$5,053	$5,191	$5,460	$5,689	$6,005	$6,503	$6,671	$7,005	$7,340	$7,741	$8,076	$8,410	
	RLO Local Road, RST Strata Road (1x)	$5,567	$5,645	$5,696	$5,852	$5,917	$5,945	$6,107	$6,423	$6,693	$7,065	$7,651	$7,849	$8,241	$8,636	$9,107	$9,501	$9,894	All road classes include mains, appurtenances, tie-ins, service connections, pavement restoration, engineering (10%), contingency (40%)
	RC1 RC2 Major & Minor Collectors, RRC Recreation Road, RYL Yield Lane (1.25x)	$6,959	$7,056	$7,120	$7,316	$7,396	$7,431	$7,634	$8,029	$8,366	$8,831	$9,563	$9,811	$10,302	$10,795	$11,383	$11,876	$12,367	
	RA1 Major Arterial (1.5x)	$8,351	$8,467	$8,544	$8,779	$8,875	$8,917	$9,160	$9,635	$10,039	$10,598	$11,476	$11,773	$12,362	$12,953	$13,660	$14,252	$14,841	

STORMWATER PIPE COST PER METRE (0-1.5m depth) DERIVATION

Based on 8.5m / 11.0m Residential Road scenario

Average trench width of 2m straight down (utilize 6' trench box)

Top trench width: 2.1 m

Inflation Rate (Jan 2021 - Dec 2024)

17.24%

			Manhole:	1050mm		1200mm		1500mm		1500mm		1800mm	
			Pipe Size:	100mm to 375mm		400mm to 600mm		675mm to 750mm		900mm to 1050mm		1200mm to 1575mm	
Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total**	**Unit Price**	**Total**	**Unit Price**	**Total**	**Unit Price**	**Total**	**Unit Price**	**Total**
A.	**SITE PREPARATION**												
1.01	Asphalt cutting	lin.m.	2.00	$ 8	$ 16	$ 8	$ 16	$ 8	$ 16	$ 8	$ 16	$ 8	$ 16
1.02	Common excavation and off site disposal (roads)	cu.m.	2.34	$ 35	$ 82	$ 35	$ 82	$ 35	$ 82	$ 35	$ 82	$ 35	$ 82
1.03	Rock breaking (20%)	cu.m.	0.47	$ 450	$ 211	$ 450	$ 211	$ 450	$ 211	$ 450	$ 211	$ 450	$ 211
	SUBTOTAL - SECTION A				**$ 309**		**$ 309**		**$ 309**		**$ 309**		**$ 309**
B.	**ROAD WORK RESTORATION**												
2.01	Trench Backfill (0.6~1.6m depth)	cu.m	1.65	$ 63	$ 104	$ 63	$ 104	$ 63	$ 104	$ 63	$ 104	$ 63	$ 104
2.02	Granular subbase (200mm depth)	sq.m.	2.10	$ 26	$ 54	$ 26	$ 54	$ 26	$ 54	$ 26	$ 54	$ 26	$ 54
2.03	Granular base (150mm depth)	sq.m.	2.10	$ 40	$ 84	$ 40	$ 84	$ 40	$ 84	$ 40	$ 84	$ 40	$ 84
2.04	Asphalt (50mm)	sq.m.	2.10	$ 72	$ 151	$ 72	$ 151	$ 72	$ 151	$ 72	$ 151	$ 72	$ 151
	SUBTOTAL - SECTION B				**$ 393**		**$ 393**		**$ 393**		**$ 393**		**$ 393**
C.	**STORMWATER SEWERS**												
3.01	Manhole complete (1 per 50m)	ea.	0.02	$ 6,300	$ 126	$ 7,900	$ 158	$ 15,125	$ 303	$ 15,125	$ 303	$ 16,500	$ 330
3.02	100mm Lot service connection c/w 200mm IC (1 per 10m)	ea.	0.10	$ 3,400	$ 340	$ 3,400	$ 340	$ 3,400	$ 340	$ 3,400	$ 340	$ 3,400	$ 340
3.03	Catch basin c/w 150mm PVC lead (1 per 50m)	ea.	0.02	$ 6,448	$ 129	$ 6,448	$ 129	$ 6,448	$ 129	$ 6,448	$ 129	$ 6,448	$ 129
3.04	Tie-in existing main to manhole (1 per 400m)	ea.	0.0025	$ 2,000	$ 5	$ 2,000	$ 5	$ 2,000	$ 5	$ 2,000	$ 5	$ 2,000	$ 5
	SUBTOTAL - SECTION C				**$ 600**		**$ 632**		**$ 776**		**$ 776**		**$ 804**
	SUMMARY OF EXTRA COSTS				**$ 1,302**		**$ 1,334**		**$ 1,478**		**$ 1,478**		**$ 1,506**

Pipe Size (mm)	150	200	250	300	350	375	400	450	525	600	675	750	900	1050	1200	1350	1500
Pipe Cost (supply and install)	**$250**	**$280**	**$300**	**$375**	**$390**	**$400**	**$485**	**$650**	**$725**	**$920**	**$1,010**	**$1,100**	**$1,280**	**$1,460**	**$1,640**	**$1,820**	**$2,000**
Service Junction (1 per 10m)	**$60**	**$73**	**$80**	**$95**	**$115**	**$120**	**$130**	**$150**	**$167**	**$189**	**$211**	**$234**	**$278**	**$323**	**$367**	**$412**	**$456**
Extra Costs	$1,302	$1,302	$1,302	$1,302	$1,302	$1,302	$1,334	$1,334	$1,334	$1,334	$1,478	$1,478	$1,478	$1,478	$1,506	$1,506	$1,506
Traffic Control	$113	$116	$118	$124	$126	$128	$136	$149	$156	$171	$189	$197	$213	$228	$246	$262	$277
Subtotal	$1,725	$1,771	$1,800	$1,896	$1,933	$1,949	$2,085	$2,283	$2,382	$2,614	$2,888	$3,009	$3,249	$3,490	$3,759	$3,999	$4,239
Inflation Rate (Dec 2024 - 2025)	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%
Total Cost w/ Inflation	$1,758	$1,804	$1,834	$1,932	$1,970	$1,987	$2,125	$2,327	$2,427	$2,664	$2,943	$3,067	$3,311	$3,556	$3,830	$4,076	$4,320
Contingency (40%)	$703	$722	$734	$773	$788	$795	$850	$931	$971	$1,065	$1,177	$1,227	$1,324	$1,422	$1,532	$1,630	$1,728
Engineering (10%)	$246	$253	$257	$270	$276	$278	$298	$326	$340	$373	$412	$429	$464	$498	$536	$571	$605
TOTAL UNIT COST (ROUNDED)	**$2,705**	**$2,780**	**$2,825**	**$2,975**	**$3,035**	**$3,060**	**$3,275**	**$3,585**	**$3,740**	**$4,100**	**$4,535**	**$4,725**	**$5,100**	**$5,475**	**$5,900**	**$6,275**	**$6,655**

STORMWATER PIPE COST PER METRE (1.5-3m depth) DERIVATION

Based on 8.5m / 11.0m Residential Road scenario
Average trench width of 2m with 8' trench box
Top Trench Width 2 m

Inflation Rate (Jan 2021 - Dec 2024)
17.24%

Item	Description	Unit	Quantity	Unit Price	Total	Unit Price	Total	Unit Price	Total	Unit Price	Total	Unit Price	Total
			Manhole:	1050mm		1200mm		1500mm		1500mm		1800mm	
				100mm to 375mm		400mm to 600mm		675mm to 750mm		900mm to 1050mm		1200mm to 1575mm	
A.	**SITE PREPARATION**												
1.01	Asphalt cutting	lin.m.	2.00	$ 8	$ 16	$ 8	$ 16	$ 8	$ 16	$ 8	$ 16	$ 8	$ 16
1.02	Common excavation and off site disposal (roads)	cu.m.	6.00	$ 35	$ 210	$ 35	$ 210	$ 35	$ 210	$ 35	$ 210	$ 35	$ 210
1.03	Rock breaking (20%)	cu.m.	1.20	$ 450	$ 540	$ 450	$ 540	$ 450	$ 540	$ 450	$ 540	$ 450	$ 540
	SUBTOTAL - SECTION A				**$ 766**		**$ 766**		**$ 766**		**$ 766**		**$ 766**
B.	**ROAD WORK RESTORATION**												
2.01	Trench Backfill (1.6~3.6m depth)	cu.m	5.20	$ 63	$ 328	$ 63	$ 328	$ 63	$ 328	$ 63	$ 328	$ 63	$ 328
2.02	Granular subbase (200mm depth)	sq.m.	2.00	$ 26	$ 52	$ 26	$ 52	$ 26	$ 52	$ 26	$ 52	$ 26	$ 52
2.03	Granular base (150mm depth)	sq.m.	2.00	$ 40	$ 80	$ 40	$ 80	$ 40	$ 80	$ 40	$ 80	$ 40	$ 80
2.04	Asphalt (50mm)	sq.m.	2.00	$ 72	$ 144	$ 72	$ 144	$ 72	$ 144	$ 72	$ 144	$ 72	$ 144
	SUBTOTAL - SECTION B				**$ 603**		**$ 603**		**$ 603**		**$ 603**		**$ 603**
C.	**STORMWATER SEWERS**												
3.01	Manhole complete (1 per 50m)	ea.	0.02	$ 8,100	$ 162	$ 10,300	$ 206	$ 19,250	$ 385	$ 19,250	$ 385	$ 21,000	$ 420
3.02	100mm Lot service connection c/w 200mm IC (1 per 10m)	ea.	0.10	$ 3,400	$ 340	$ 3,400	$ 340	$ 3,400	$ 340	$ 3,400	$ 340	$ 3,400	$ 340
3.03	Catch basin c/w 150mm PVC lead (1 per 50m)	ea.	0.02	$ 6,448	$ 129	$ 6,448	$ 129	$ 6,448	$ 129	$ 6,448	$ 129	$ 6,448	$ 129
3.04	Tie-in existing main to manhole (1 per 400m)	ea.	0.0025	$ 2,000	$ 5	$ 2,000	$ 5	$ 2,000	$ 5	$ 2,000	$ 5	$ 2,000	$ 5
	SUBTOTAL - SECTION C				**$ 636**		**$ 680**		**$ 859**		**$ 859**		**$ 894**
	SUMMARY OF EXTRA COSTS				**$ 2,005**		**$ 2,049**		**$ 2,228**		**$ 2,228**		**$ 2,263**

Pipe Size (mm)	150	200	250	300	350	375	400	450	525	600	675	750	900	1050	1200	1350	1500
Pipe Cost (supply and install)	**$250**	**$280**	**$300**	**$375**	**$390**	**$400**	**$485**	**$650**	**$725**	**$920**	**$1,010**	**$1,100**	**$1,280**	**$1,460**	**$1,640**	**$1,820**	**$2,000**
Service Junction (1 per 10m)	**$60**	**$73**	**$80**	**$95**	**$115**	**$120**	**$130**	**$150**	**$167**	**$189**	**$211**	**$234**	**$278**	**$323**	**$367**	**$412**	**$456**
Traffic Control	$32	$39	$44	$54	$60	$63	$71	$88	$99	$120	$133	$146	$172	$198	$224	$251	$277
Extra Costs	$2,005	$2,005	$2,005	$2,005	$2,005	$2,005	$2,005	$2,005	$2,049	$2,049	$2,228	$2,228	$2,228	$2,228	$2,263	$2,263	$2,263
Subtotal	$2,347	$2,397	$2,429	$2,529	$2,570	$2,588	$2,691	$2,893	$3,040	$3,278	$3,582	$3,708	$3,958	$4,209	$4,495	$4,746	$4,996
Inflation Rate (Dec 2024 - 2025)	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%
Total Cost w/ Inflation	$2,392	$2,443	$2,476	$2,577	$2,619	$2,637	$2,743	$2,948	$3,098	$3,340	$3,650	$3,779	$4,034	$4,290	$4,580	$4,837	$5,091
Contingency (40%)	$957	$977	$990	$1,031	$1,048	$1,055	$1,097	$1,179	$1,239	$1,336	$1,460	$1,512	$1,614	$1,716	$1,832	$1,935	$2,037
Engineering (10%)	$335	$342	$347	$361	$367	$369	$384	$413	$434	$468	$511	$529	$565	$601	$641	$677	$713
TOTAL UNIT COST (ROUNDED)	**$3,685**	**$3,760**	**$3,810**	**$3,970**	**$4,035**	**$4,060**	**$4,225**	**$4,540**	**$4,770**	**$5,145**	**$5,620**	**$5,820**	**$6,210**	**$6,605**	**$7,055**	**$7,450**	**$7,840**

STORMWATER PIPE COST PER METRE (3-6m depth) DERIVATION

Based on 8.5m / 11.0m Residential Road scenario

Average trench width of 2m with 8' and 6' trench boxes

Top Trench Width 2 m

Inflation Rate (Jan 2021 - Dec 2024)

17.24%

			Manhole:	**1050mm**		**1200mm**		**1500mm**		**1500mm**		**1800mm**	
				100mm to 375mm		**400mm to 600mm**		**675mm to 750mm**		**900mm to 1050mm**		**1200mm to 1575mm**	
Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total**	**Unit Price**	**Total**	**Unit Price**	**Total**	**Unit Price**	**Total**	**Unit Price**	**Total**
A.	**SITE PREPARATION**												
1.01	Asphalt cutting	lin.m.	2.00	$ 8	$ 16	$ 8	$ 16	$ 8	$ 16	$ 8	$ 16	$ 8	$ 16
1.02	Common excavation and off site disposal (roads)	cu.m.	12.00	$ 35	$ 420	$ 35	$ 420	$ 35	$ 420	$ 35	$ 420	$ 35	$ 420
1.03	Rock breaking (20%)	cu.m.	2.40	$ 450	$ 1,080	$ 450	$ 1,080	$ 450	$ 1,080	$ 450	$ 1,080	$ 450	$ 1,080
	SUBTOTAL - SECTION A				**$ 1,516**		**$ 1,516**		**$ 1,516**		**$ 1,516**		**$ 1,516**
B.	**ROAD WORK RESTORATION**												
2.01	Trench Backfill (3.6~5.6m depth)	cu.m	11.20	$ 63	$ 706	$ 63	$ 706	$ 63	$ 706	$ 63	$ 706	$ 63	$ 706
2.02	Granular subbase (200mm depth)	sq.m.	2.00	$ 26	$ 52	$ 26	$ 52	$ 26	$ 52	$ 26	$ 52	$ 26	$ 52
2.03	Granular base (150mm depth)	sq.m.	2.00	$ 40	$ 80	$ 40	$ 80	$ 40	$ 80	$ 40	$ 80	$ 40	$ 80
2.04	Asphalt (50mm)	sq.m.	2.00	$ 72	$ 144	$ 72	$ 144	$ 72	$ 144	$ 72	$ 144	$ 72	$ 144
	SUBTOTAL - SECTION B				**$ 981**		**$ 981**		**$ 981**		**$ 981**		**$ 981**
C.	**STORMWATER SEWERS**												
3.01	Manhole complete (1 per 50m)	ea.	0.02	$ 11,700	$ 234	$ 15,100	$ 302	$ 27,500	$ 550	$ 27,500	$ 550	$ 30,000	$ 600
3.02	100mm Lot service connection c/w 200mm IC (1 per 10m)	ea.	0.10	$ 3,400	$ 340	$ 3,400	$ 340	$ 3,400	$ 340	$ 3,400	$ 340	$ 3,400	$ 340
3.03	Catch basin c/w 150mm PVC lead (1 per 50m)	ea.	0.02	$ 6,448	$ 129	$ 6,448	$ 129	$ 6,448	$ 129	$ 6,448	$ 129	$ 6,448	$ 129
3.04	Tie-in existing main to manhole (1 per 400m)	ea.	0.0025	$ 2,000	$ 5	$ 2,000	$ 5	$ 2,000	$ 5	$ 2,000	$ 5	$ 2,000	$ 5
	SUBTOTAL - SECTION C				**$708**		**$776**		**$1,024**		**$1,024**		**$1,074**
	SUMMARY OF EXTRA COSTS				**$3,205**		**$3,273**		**$3,521**		**$3,521**		**$3,571**

Pipe Size (mm)	150	200	250	300	350	375	400	450	525	600	675	750	900	1050	1200	1350	1500
Pipe Cost (supply and install)	**$250**	**$280**	**$300**	**$375**	**$390**	**$400**	**$485**	**$650**	**$725**	**$920**	**$1,010**	**$1,100**	**$1,280**	**$1,460**	**$1,640**	**$1,820**	**$2,000**
Service Junction (1 per 10m)	**$60**	**$73**	**$80**	**$95**	**$115**	**$120**	**$130**	**$150**	**$167**	**$189**	**$211**	**$234**	**$278**	**$323**	**$367**	**$412**	**$456**
Traffic Control	$32	$39	$44	$54	$60	$63	$71	$88	$99	$120	$133	$146	$172	$198	$224	$251	$277
Extra Costs	$3,205	$3,205	$3,205	$3,205	$3,205	$3,205	$3,205	$3,205	$3,273	$3,273	$3,521	$3,521	$3,521	$3,521	$3,571	$3,571	$3,571
Subtotal	$3,547	$3,597	$3,629	$3,729	$3,770	$3,788	$3,891	$4,093	$4,264	$4,502	$4,875	$5,001	$5,251	$5,502	$5,803	$6,054	$6,304
Inflation Rate (Dec 2024 - 2025)	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%
Total Cost w/ Inflation	$3,615	$3,666	$3,699	$3,800	$3,842	$3,860	$3,966	$4,171	$4,346	$4,588	$4,968	$5,097	$5,352	$5,608	$5,913	$6,170	$6,424
Contingency (40%)	$1,446	$1,466	$1,479	$1,520	$1,537	$1,544	$1,586	$1,668	$1,738	$1,835	$1,987	$2,039	$2,141	$2,243	$2,365	$2,468	$2,570
Engineering (10%)	$506	$513	$518	$532	$538	$540	$555	$584	$608	$642	$696	$714	$749	$785	$828	$864	$899
TOTAL UNIT COST (ROUNDED)	**$5,565**	**$5,645**	**$5,695**	**$5,850**	**$5,915**	**$5,945**	**$6,105**	**$6,425**	**$6,695**	**$7,065**	**$7,650**	**$7,850**	**$8,240**	**$8,635**	**$9,105**	**$9,500**	**$9,895**