INTEGRATED RAINWATER MANAGEMENT PLAN

PHASE 2 REPORT AND RECOMMENDATIONS TO GUIDE NEXT STEPS

CITY OF
COURTENAY

DECEMBER 4, 2020 *FINAL REPORT*

INTEGRATED RAINWATER MANAGEMENT PLAN

FINAL REPORT

City of Courtenay

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Executive Summary

OVERVIEW

The City of Courtenay (the City) is developing an Integrated Rainwater Management Plan (IRMP). The IRMP will include a long-term capital plan and recommendations to manage current and potential future rainwater management issues in a way that helps achieve the community's goals for growth and development, flood protection, and environmental health. An IRMP aims to help the community achieve, at minimum, a "no net loss" in watershed health due to development but strives for betterment in watershed health where practically achievable. The IRMP is being developed for 13 catchments that span municipal boundaries, including those of the Tsolum River, Puntledge River, Courtenay River, and their tributaries.

The IRMP is being developed in three (3) phases: Phase 1 (conducted in 2018) included preliminary hydraulic modelling of the City's trunk drainage trunk system. Phase 2 (currently underway) included a hydrogeological assessment, geotechnical assessment, and environmental assessment conducted in 2019 and early 2020. These involved desktop methods, field reconnaissance, and environmental data collection.

Phase 3 has yet to begin, but will include refining performance analysis of the existing storm sewer system, completing the environmental assessment, defining future infrastructure needs, developing a management strategy tailored to each watershed, and laying out an implementation plan and adaptive management program.

This report is a summary of the Phase 1 and 2 efforts to date that set the stage for Phase 3.

SUMMARY OF KEY FINDINGS

The following is a summary of the key findings from the work completed to date:

1. **Preliminary performance analysis of the trunk storm sewer system suggests that numerous capacity deficiencies exist, particularly when considering future climate change.**

   Early indications show that to satisfy current performance criteria, the capital reinvestment in system upgrades will significantly exceed the City's recent funding levels for drainage infrastructure. It will be important in future phases of the IRMP to consider the acceptable level of service for existing infrastructure, make risk-based decisions, and develop a sustainable funding program to suit.

   Analysis to date has been done in the absence of real performance data. Flow monitoring data at several locations throughout the City was collected in 2019 and will be used in Phase 3 to prepare an expanded, calibrated hydraulic model to refine the capacity assessment results and capital improvement priorities.

2. **The City's watersheds are ecologically diverse and provide an important habitat for terrestrial, aquatic, and estuarine/marine species. As is the case in all urban centers, historic development has impacted watershed health.**

   Further urban densification can occur without additional harm provided that: Green Infrastructure of various forms is applied; watercourse riparian corridors are protected / restored; and the City continues to protect and expand its urban tree canopy. Impacts of future development and the application of management techniques to address them will be further explored in Phase 3 of the IRMP.

3. **Water quality in most creeks has been compromised; some sources of pollution are known, others are not.**

    Analysis of metals and coliforms in water quality samples showed exceedances in most watercourses. Of particular concern is the Courtenay River, which showed total coliforms exceeding 8,000 times the allowable limit for recreational purposes. Overall, the Courtenay River, Puntledge River, and Morrison Creek demonstrated high coliform concentrations and the sources of contamination should be further investigated.

    There are also elevated concentrations of copper, iron, and zinc which is typical in urban settings and is most likely associated with motor vehicle use. Best management practices of various types can be used to prevent or remove pollutants from entering receiving natural watercourses. Basic street sweeping, landscape based "biofilters", and end-of-the-pipe engineering treatment devices are the most common approaches. Such practices will be further defined in Phase 3 of the IRMP.

4. **Recharge of rainwater to ground (infiltration) may be appropriate in some areas and not in others. The variability of ground conditions across the City will influence management techniques and their designs. Therefore, criteria and standards need to be flexible to suit the location.**

    The hydrogeological (groundwater) assessment indicates the infiltration potential within the City spans from "good" to "marginal" and may not be appropriate in all areas due to underlying aquifer vulnerability. Where aquifer contamination risk exists, there is heightened need for water quality treatment. Source controls and area-specific recommendations for infiltration-based rainwater management techniques will be considered as part of the Phase 3 IRMP process.

RECOMMENDATIONS

The following recommendations are intended to guide the next steps in the development of the IRMP. They are consistent with the original scope of the phased IRMP.

1. Use process flow monitoring data collected in 2019, to calibrate and expand the Phase 1 hydraulic model of the municipally owned rainwater management infrastructure. This will solidify a capital program for the City's drainage services.

2. Complete the remaining components of the environmental assessment, including a natural hazard assessment, ecological health analysis, and assessing the unmitigated impacts of future land use.

3. Engage external stakeholders for supplemental input on issues. It is recommended that engagement focus on environmental stewardship groups and adjacent government jurisdictions.

4. Engage internal stakeholders to discuss management options, acceptable levels of service, refined criteria and standards, and implementation plan. Ongoing operations and maintenance, future asset replacement, cost implications and existing funding levels are important considerations in this process.

5. Compile a comprehensive IRMP, including a prioritized capital plan and recommendations, which may include but are not necessarily limited to additional study, ongoing monitoring, education, coordination with other authorities, and regulatory changes and enforcement.

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1.0 Introduction

1.1 PURPOSE OF AN INTEGRATED RAINWATER MANAGEMENT PLAN

The City of Courtenay (the City) is developing an Integrated Rainwater Management Plan (IRMP). The IRMP will include a long-term capital plan and recommendations to manage current and potential future rainwater management issues in a way that helps achieve the community's goals for growth and development, flood protection, and environmental health. An IRMP aims to help the community achieve, at minimum, a "no net loss" in watershed health due to development but strives for betterment in watershed health where practically achievable. The IRMP is being developed for 13 catchments that span municipal boundaries, including those of the Tsolum River, Puntledge River, Courtenay River, and their tributaries.

An IRMP comprehensively explores the strategic linkages between land use, environment, and infrastructure as they relate to rainwater runoff, conveyance, and quality. They describe current and potential future rainwater issues that may be influenced by changes in land use and climate change. They also establish a plan for how these issues will be addressed through integrated rainwater management practices. Such practices may include the development and enforcement of policies and regulations related to land use and rainwater management techniques; new capital projects and upgrades to existing capital infrastructure; improved maintenance and operations; monitoring; and sustainable funding.

An IRMP is developed through a "watershed lens". This means that issues and needs are assessed holistically, from source to discharge point and with consideration for everything in between. An IRMP is not required in all watersheds – it is typically developed for a single watershed or grouping of watersheds in which the combination of existing issues and development pressures warrants a comprehensive, integrated plan to address them. Areas in which isolated issues exist and/or in which development pressures are limited can often be guided by more focused solutions such as a Master Drainage Plan, site assessment, feasibility study, or other appropriate solution.

1.2 STUDY AREA

The study area is shown in Figure 1. The IRMP is being developed for 13 catchments that span municipal boundaries, including those of the Tsolum River, Puntledge River, Courtenay River, and their tributaries. While lands beyond the City boundary are identified, technical study and development of strategy is limited to within the City's boundary. It's important to engage with other authorities such as K'ómoks First Nation, the Town of Comox, and the Comox Valley Regional District when moving forward with the IRMP process.

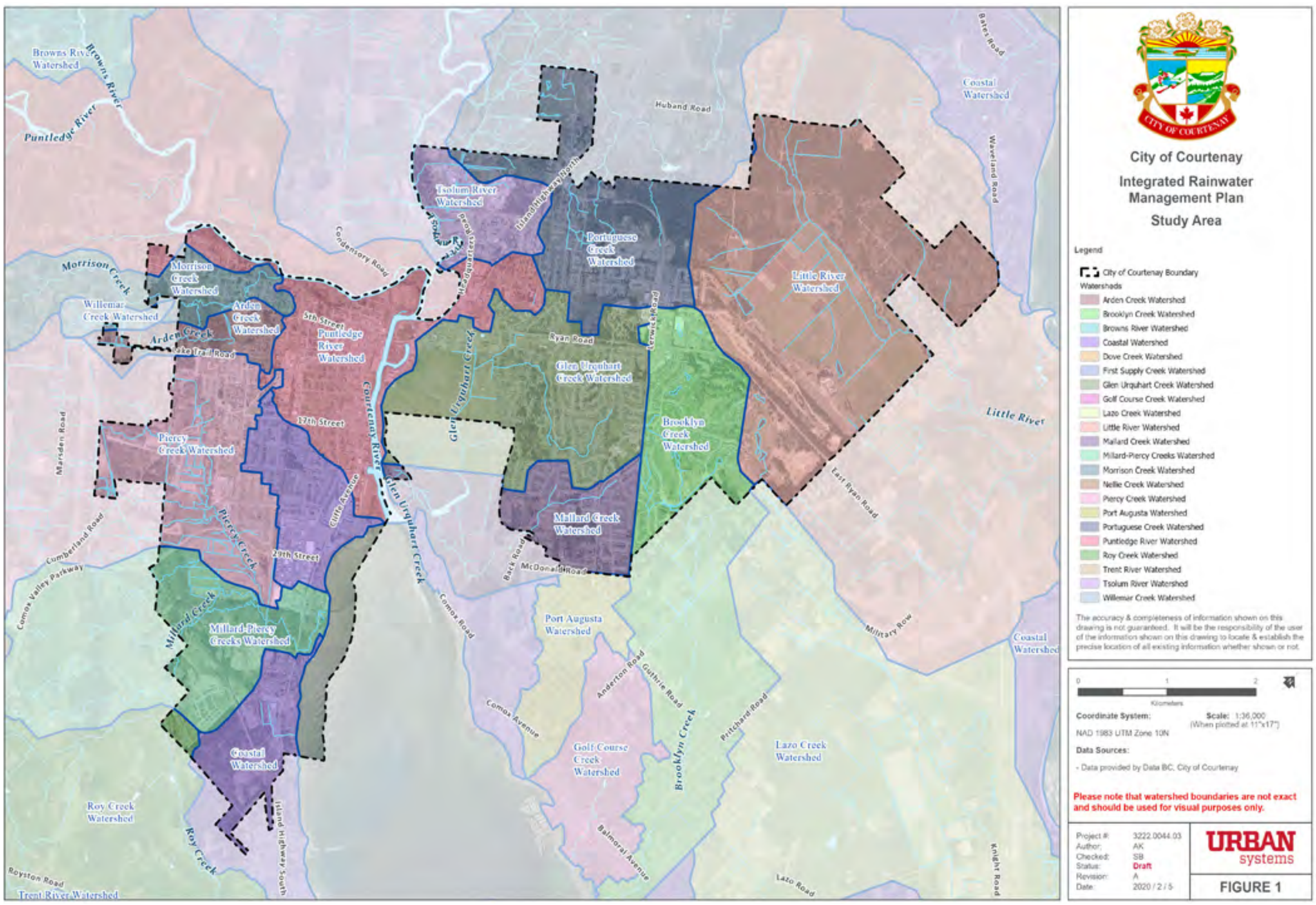

FIGURE 1: STUDY AREA

In general, topography of the City comprises a relatively flat floodplain to the north of the Puntledge River and Tsolum River, and gently sloping lowlands and uplands. Steeper terrain is concentrated along the rivers, several major creeks, and the escarpments along the portions of Back Road and Ryan Road.

1.3 PROCESS TO DEVELOP THE IRMP

The City's IRMP is being developed in phases as outlined in Table 1.

TABLE 1: PROCESS TO DEVELOP THE INTEGRATED RAINWATER MANAGEMENT PLAN

PHASE	STATUS	DESCRIPTION	OUTPUT
Phase 1	Complete (2018-2019)	• Involved a high-level assessment of rainwater conveyance and potential capacity-based capital upgrades, along with anticipated capital planning priorities. • The high-level assessment was based on modelling the City's drainage trunk system only (pipes 600m and larger).	• Phase 1 report • Preliminary capital plan and program
Phase 2	Underway (2019-2020)	• Includes data collection and analysis to better understand the current state of the watersheds health within City boundaries and the state of the City's drainage infrastructure system. • Integrate data on land use, environment and habitat, soils and groundwater, and climate change to provide the City with information on current and potential future watershed health.	• Current conditions report • Future conditions report
Phase 3	To be initiated	• Expected to include an expanded analysis of the Phase 1 drainage system model • Assess natural hazards • Assess ecological health • Evaluate management options • Define the management strategy • Define a capital program • Prepare an implementation plan • Prepare an adaptive management program	• Management options report • Final IRMP and capital plan

1.4 PURPOSE OF THIS REPORT

This Phase 2 interim report aims to:

- provide a summary of "what we know to date" about current and potential future issues as they relate to integrated rainwater management in Courtenay, and recommendations for next steps.
- help Council decide what direction to give staff regarding major next steps in the process to develop the IRMP.

This report serves as a compilation of information from numerous technical reports. This report is meant to provide a summary, while additional detail can be obtained from each technical report appended.

1.5 STAKEHOLDER ENGAGEMENT

Input from stakeholders is important – while not always quantitative, stakeholder input still point to issues to be addressed and opportunities to be leveraged. Furthermore, stakeholder buy-in is important to the long-term success of the IRMP.

To date, internal City stakeholders were engaged at a June 4, 2019 workshop to gather input on what form the IRMP should take and how it will be used. This was an important step not only for ensuring the IRMP, as a deliverable, meets the City's needs and expectations, but also building ownership of the IRMP by its end users. Some examples of end users include Engineering, Public Works, Planning, and Finance.

Both internal and external stakeholders will be engaged in 2020 to discuss rainwater management issues and management options. Their input will inform the development of the Management Options report and the final IRMP.

2.0 Completed Assessments

2.1 OVERVIEW

To date, four core assessments have been completed. Each component and the methodology by which it was assessed are summarized in Table 2.

TABLE 2: OVERVIEW OF COMPLETED ASSESSMENTS

COMPONENT	RATIONALE	METHODOLOGY
Drainage system performance assessment	• Built infrastructure is designed to meet defined criteria and level of service. Its performance is influenced by land use change, asset condition, and climate change. The City has a responsibility to operate and maintain this infrastructure.	• Trunks-only hydraulic modelling (pipe 600 mm in diameter and larger). • High-level assessment of condition based largely on asset age and material type as proxy data.
Hydrogeological (groundwater) assessment	• The ability of water to penetrate into the ground is important to the selection and design of management techniques, and also has a direct effect on infrastructure sizing. • Vulnerability of underlying aquifers to pollution is important to understand when promoting infiltration of urban runoff.	• Hydrogeological assessment and soils mapping.
Geotechnical assessment	• Increased runoff and stream flows can lead to erosion and slope failure. Watercourse and slope stability are indicators of overall watershed health.	• Hydrometric data collection. • Geotechnical assessment through desktop study and field reconnaissance.
Environmental assessment	• Water quality and the benthic index of biological integrity (B-IBI) are two key indicators of watershed health.	• Environmental data collection and analysis.

The outcomes of these assessments provide an overall understanding of the current state of the built and natural systems, and insights as to their vulnerability to future influences of land use change and climate change.

2.2 DRAINAGE SYSTEM PERFORMANCE

A preliminary assessment of hydraulic performance of the City's drainage system was conducted by Urban Systems in collaboration with GeoAdvice in 2018 as part of Phase 1 of the IRMP. The Phase 1 report is provided in Appendix A. The analysis to date was completed in absence of real monitoring data in which to calibrate the model. Flow monitoring data was collected at numerous locations through the study are in 2019. This data will be processed and applied to supplemental analysis in 2020. As such, the findings below are preliminary and only represent a likely indicator of performance.

Objectives

- Assess the hydraulic performance of the City's trunk rainwater conveyance system.
- Develop a near-term capital plan based on identified high priority deficiencies.

Capacity Assessment Methodology

- Modelling was conducted using InfoSWMM software. Models were developed using best available data provided by the City. A number of data gaps existed for which assumptions or estimates were made to complete the Phase 1 analysis. A list of data gaps was provided to the City, who has since spent considerable effort collecting new data to fill in the gaps. The additional data will be integrated into the 2020 modeling efforts.
- To date, the assessment has focused on trunks only (pipes 600m in diameter or greater and culvert crossings within trunk watercourses). Insufficient geometric data was available for open watercourses so analysis was limited to pipes.
- The hydraulic model does not account for asset condition; therefore, it is assumed that all pipes are in good operating condition. This may not be the case in practice, which highlights the importance of considering asset condition when identifying priorities.
- Imperviousness for existing land use was estimated using the City's Zoning Bylaw assigning values to each zoning type in general accordance with the Master Municipal Construction Documents (MMCD) guidelines. In subsequent iterations of modelling, existing total imperviousness values should be refined through GIS analysis of air photos, along with identifying the effective imperviousness values through model calibration.

- Design storm events modelled included a range of durations for 1:2-year, 1:10-year, and 1:100-year return periods. According to the City's Subdivision and Development Servicing Bylaw, the minor conveyance system is required to accommodate 1:10-year flows. Road crossing culverts and overland routes are intended to convey 1:100-year flows. The 1:2-year event is most critical to watercourse health.

- Analysis was also conducted to represent a preliminary future condition by applying a 15% increase in precipitation intensity to account for climate change. The OCP Land Use Map was used to estimate potential future land use, to which the same MMCD-based imperviousness values were assigned. For Phase 1, no source controls were applied to limit the impacts of future development.

- Pipes and culverts were assessed using the criteria outlined in Table 3.

TABLE 3: HYDRAULIC PERFORMANCE ASSESSMENT CRITERIA

CAPACITY LIKELIHOOD OF FAILURE (LOF)	HYDRAULIC CONDITION	HYDRAULIC GRADE LINE (HGL) CONDITION	DESCRIPTION
1	q/Q < 1	HGL < Crown Elevation	Conduit performing as designed
2	q/Q < 1	Crown Elevation ≤ HGL < Ground Elevation, or HGL ≥ Ground Elevation	Adequate capacity, downstream condition causing backwater
3	q/Q ≥ 1	HGL < Crown Elevation	Marginal capacity
4	q/Q ≥ 1	Crown Elevation ≤ HGL < Ground Elevation	Capacity exceeded and surcharging likely
5	q/Q ≥ 1	HGL ≥ Ground Elevation	Capacity exceeded and flooding likely

*where q/Q = peak flow / full flow in pipe

Capacity Assessment Preliminary Findings

- Numerous deficiencies in the storm sewer network were predicted. The extent and magnitude of deficiencies is expected to increase into the future, mostly due to the influence of climate change, but also due to land use change, if not sufficiently managed.

- Preliminary results suggest that culvert performance under the existing 1:10-year and 1:100-year events are good to moderate; however, the inventory of culverts is poor, therefore the assessment of culverts is generally lacking, at this time. This is to be expanded in 2020.

- Four systems were identified as highest priority in the near term. These priority systems are likely to involve design and construction improvements over the long term but are subject to condition assessment. All systems, high-priority or not, are subject to further investigation and monitoring. The location and the pertinent storm sewer length is:
  - Woods Avenue (1.0 km)
  - Willemar Avenue (2.7 km)
  - 19th Street (1.8 km)
  - 26th Street, 29th Street, Cliffe Avenue (1.5 km)

Condition Assessment Methodology

- The City has some understanding of infrastructure condition, but not completely. In the absence of field data, age and material type is commonly used as a proxy for condition. For the purpose of this preliminary assessment, such proxy data was applied.
- The following table summarizes the inventory of the City's trunk pipe material and the assigned age based on typical historical construction practices. Generally, the older the age, the poorer the condition is assumed.

PIPE MATERIAL	TOTAL TRUNK LENGTH	% OF TOTAL	TYPICAL AGE
Asbestos Cement (AC)	1,500 m	9	50-60 years
Wood	1,000 m	5	60-70 years
Corrugated Metal / Steel Pipe (CMP or CSP)	7,300 m	40	40-50 years
Concrete	800 m	4	30-40 years
Plastic (PVC or HDPE)	7,500 m	41	15-30 years
Unknown	200 m	1	n/a
Total	**18,300 m**	**100**	

Condition Assessment Findings

Approximately 55% (roughly $20M in capital value) of the trunk infrastructure was found to be over 40 years of age and of a material type that may be nearing the end of its expected service life – AC, Wood, and Corrugated Metal.

Overall Capital Program

Given the potential enormity of capital reinvestment required within the City, a preliminary near-term capital program (1-5 years) was developed for infrastructure that meets the following conditions:

1. Known condition and known performance issue
2. Anticipated condition issue based on age and material type
3. Theoretical hydraulic performance deficiency against established criterion.

The preliminary near-term (2019-2023) infrastructure capital program is summarized as follows.

TABLE 4: PRELIMINARY ESTIMATED INFRASTRUCTURE CAPITAL PROGRAM

YEAR	CONSTRUCTION VALUE	APPROXIMATE LENGTH OF WORKS
2019	$1.5M	500m
2020	$1.5M	500m
2021	$2.0M	670m
2022	$2.0M	670m
2023	$2.0M	670m

Figures 2 and 3 illustrate the overall preliminary recommended infrastructure capital program.

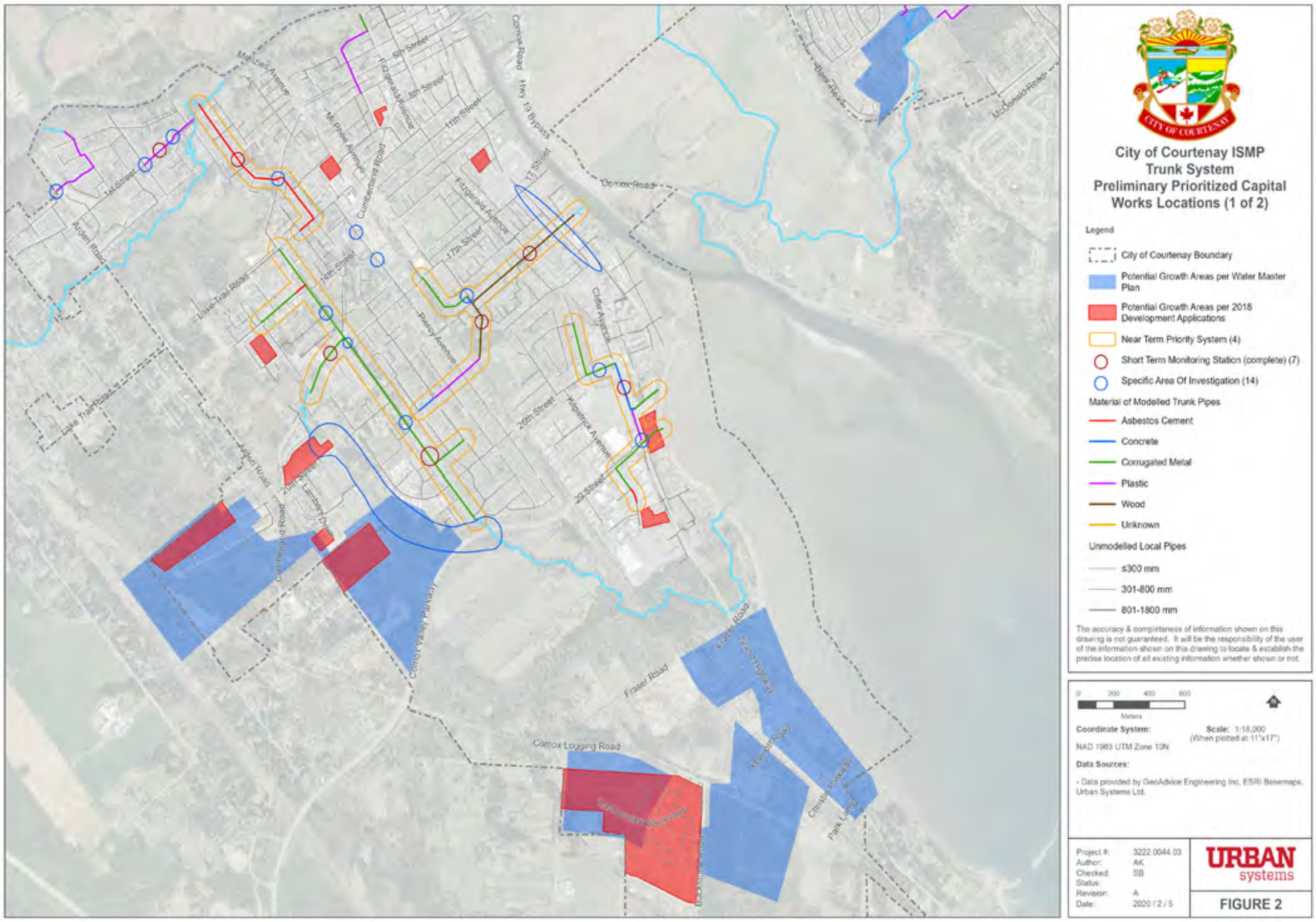

FIGURE 2: PRIORITIZED CAPITAL WORKS LOCATIONS

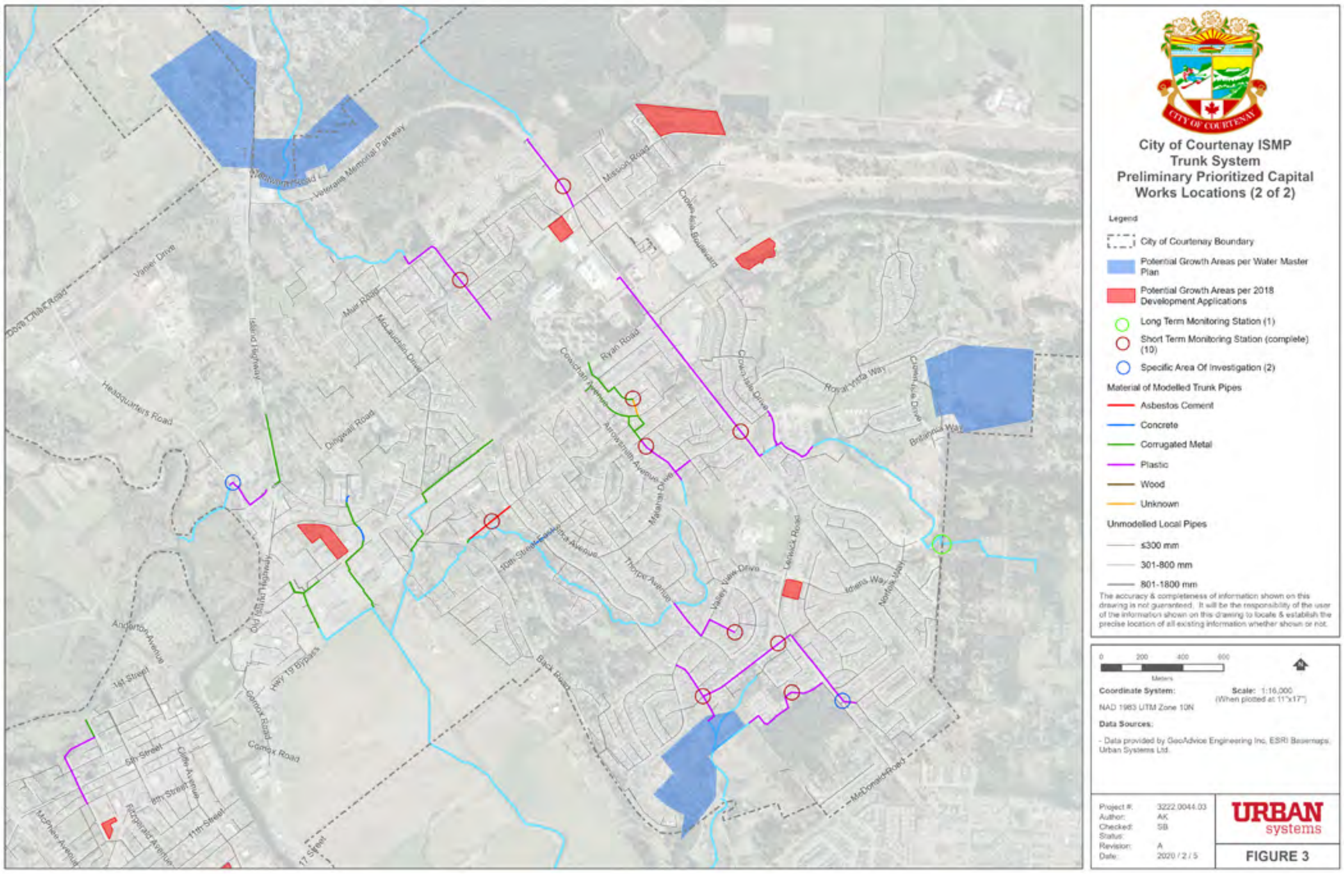

FIGURE 3: PRIORITIZED CAPITAL WORKS LOCATIONS

To improve upon the preliminary results presented herein, recommendations were made in Phase 1 for:

- Hydrometric monitoring
- Resolving data gaps
- Field reconnaissance
- CCTV inspections and flushing

As part of the Phase 2 scope of work for the IRMP, some hydrometric data was gathered. Recommendations are provided in Section 4 for next steps in the Phase 2 scope of work to further develop the IRMP.

2.3 HYDROGEOLOGICAL ASSESSMENT

A hydrogeological assessment was completed by Waterline Resources (Waterline) in 2019. A detailed description of Waterline's methodology and findings is provided in their technical report in Appendix B.

Objectives

- Estimate soil infiltration potential based on surficial geology mapping, land use data, and a conceptual groundwater model, to identify areas where rainwater infiltration may be possible.
- Characterize risk to groundwater quality in mapped aquifers based on interpreted soil infiltration potential, to identify areas where risks to groundwater quality should be considered in any infiltration-based stormwater management techniques.

Methodology

- Waterline used its own GIS Web application tool, Enviro Web Services™ to develop the conceptual model, which includes two- and three-dimensional hydrogeological images constructed using publicly available data and data directly from the City's database. Data included surficial and bedrock geology mapping, terrain mapping, hydrometric data, water well records, and aquifer mapping, where available. A significant amount of groundwater and surface water data exists within the City, which was beneficial for model development.
- Waterline characterized the relative infiltration potential across the City by assignment of a permeability range to mapped surficial geology units based on their descriptions (gravel, sand, silt or clay) and depositional environment (alluvial, fluvial, marine, glacio-marine, etc.). Generally, granular sediments such as sands and gravels are highly transmissive and allow surface water to infiltrate freely through the unsaturated zone. These zones were generally assigned a good infiltration capacity. Conversely, cohesive sediments such as silts and clays are less transmissive and can restrict the ability of surface water to infiltrate the unsaturated zone. These zones were generally assigned a poor infiltration capacity. A marginal infiltration capacity was assigned where both cohesive and granular sediments were mapped within the same geological unit, and where a cohesive soil was mapped underlying a granular soil.
- The infiltration layer was superimposed on layers representing land cover, topography, and bedrock exposures, as well as the extent of mapped aquifers. This information was used to interpret potential risk to groundwater quality associated with infiltration.

Key Findings

The key findings from the mapping of soil infiltration potential and aquifer vulnerability assessment are illustrated on Figures 4, 5 and 6 and summarized below.

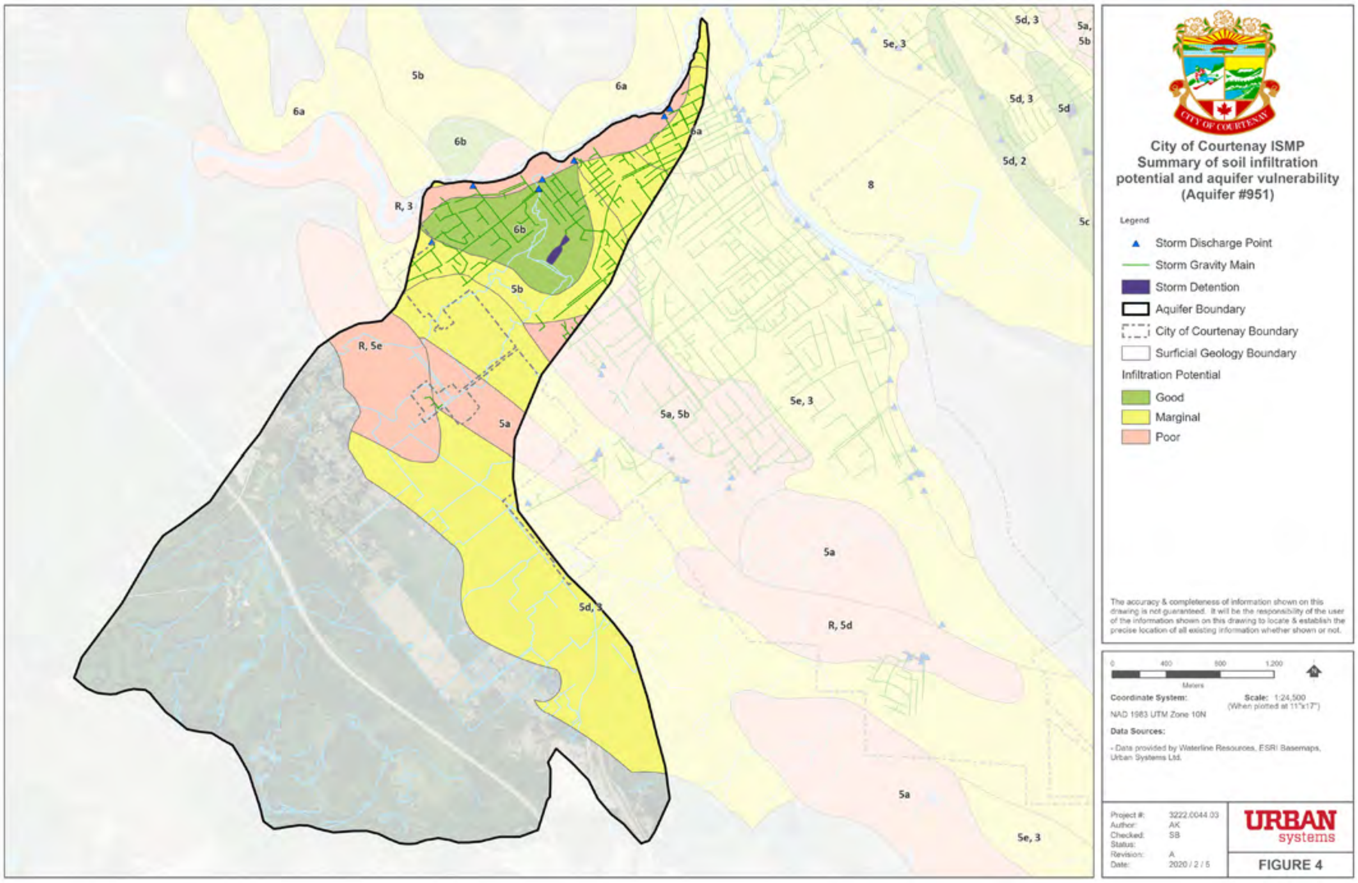

FIGURE 4: INFILTRATION POTENTIALS AND VULNERABILITY FOR AQUIFER #951

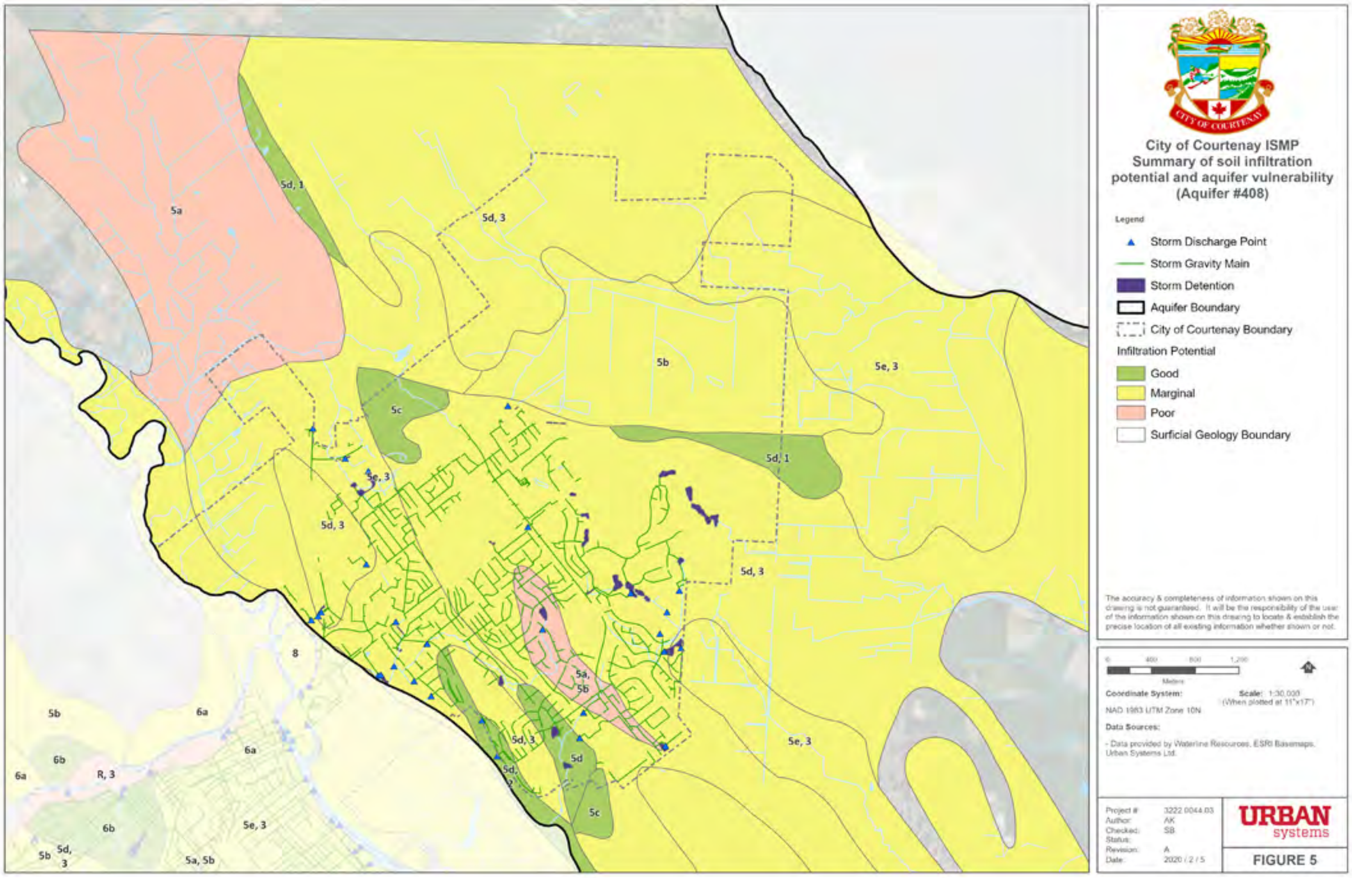

FIGURE 5: INFILTRATION POTENTIALS AND VULNERABILITY FOR AQUIFER #408

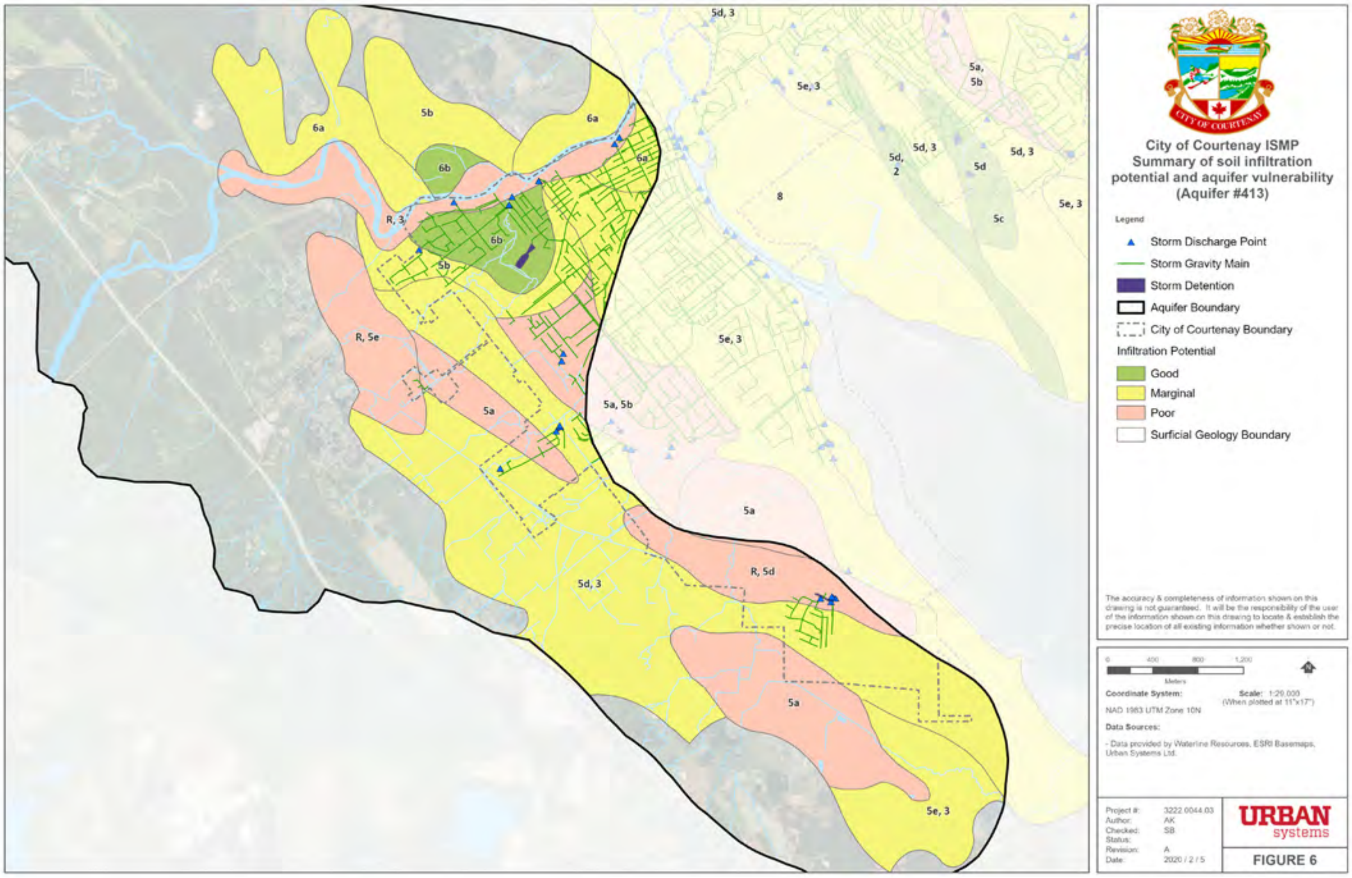

FIGURE 6: INFILTRATION POTENTIALS AND VULNERABILITY FOR AQUIFER #413

Soil infiltration potential

Table 5 includes a summarized list of areas for rainwater infiltration potential.

TABLE 5: SUMMARY OF INFILTRATION POTENTIAL

PRIORITY	OVERLYING AQUIFER #	LOCATION	INFILTRATION POTENTIAL
1	408	The north zone transected by the Veterans Memorial Parkway	Good
2	408	The south zone at Hawk Glen Park	Good
3	408	The Little River Valley	Marginal
4	408	Little River South Valley Wall	Good
5	951	West side of Roy Morrison Park and adjacent Lake Trail School	Marginal
6	951	North area bounded by Anderton Avenue, 8th Street, Johnston Avenue and Puntledge River Valley	Marginal
7	408	Courtenay River Northeast Valley Wall	Good
8	951	East side of Roy Morrison Park and adjacent Puntledge Park Elementary	Good
9	none	Tsolum and Courtenay River Valleys	Marginal

Aquifer vulnerability

Table 6 summarizes the aquifers that span City boundaries.

TABLE 6: SUMMARY OF AQUIFER VULNERABILITY

INFORMATION	CAPILANO AQUIFER (AQUIFER #951)	QUADRA SAND (AQUIFER #408)	BEDROCK (AQUIFER #413)
Type	Unconfined	Confined, small portions of aquifer are exposed at grade	Partially confined
Area (km^2)	12.7	147.7	35.2
Vulnerability	High	Low	Moderate
Comments	Contamination from surface activities is high due to the shallow unconfined nature of the aquifer. There are no well licenses within the City boundary.	Generally, a confining layer exists about the aquifer (mean thickness is 25m). There are no well licenses issued within the City boundary.	Bedrock exposures have been observed within the City. The mean thickness of the confining layer is 6m. There are no well licenses within the City boundary.

Considerations for Rainwater Management

Following are high-level considerations for rainwater management in Courtenay based on the findings from the hydrogeological assessment.

- Many of the City's rainwater detention ponds are in areas of marginal and good infiltration potential. It is assumed that these storm detention ponds are designed to be impermeable and do not allow exfiltration to the subsurface. Designing rainwater detention ponds in areas of marginal or good infiltration potential to allow exfiltration to the subsurface could allow in-situ subsurface contaminant attenuation to occur prior to discharge to surface waterbodies. Allowing exfiltration at detention ponds will also reduce the rainwater flows discharged adjacent surface waterbodies, thereby reducing the potential for contaminant loading to the receiving waterbody.

- At rainwater collection points, enhanced contaminant attenuation can be explored by having rainwater into bioswale that can remove low-level hydrocarbon, pesticides, salts, trace metals and organics concentrations from the rainwater prior to discharge into surface waterbodies.

- In areas where high levels of hydrocarbons have been detected in rainwater consider installation of an oil-water separator.

- Installation of head-controlled sediment traps upstream of rainwater discharge points will allow suspended sediment to fall out of the rainwater prior to discharge to a fish-bearing stream. These sediment traps would require periodic removal of sediment collected in the trap. Such traps should be located upstream of detention ponds to maximize exfiltration potential of the ponds and minimize maintenance.

2.4 GEOTECHNICAL ASSESSMENT

A geotechnical assessment was completed by Thurber Engineering (Thurber) in 2019. A detailed description of Thurber's methodology and findings is provided in their technical report in Appendix C.

Objective

- Identify significant risks related to slope stability and erosion in the study area.

Methodology

The geotechnical assessment included a review of historical air photographs (1949 to 1996) and field reconnaissance of the Puntledge and Tsolum Rivers, and selected creeks and culverts within City boundaries on October 23 and 24, 2019. The assessment of risk did not include potential environmental impacts where these result from natural processes, unless these appeared to be exacerbated by development or infrastructure. Very low-risk areas were not typically logged in the field reconnaissance as the objective was to identify significant risks.

The following hazards were considered when assessing risk:

- Erosion
- Landslides (not associated with earthquakes)
- Obstruction leading to debris
- Fill embankments
- Culverts and other structures (erosion, undermining, function,
- Earthquakes
- Steep slopes

Key Findings

Key findings from the geotechnical assessment are summarized below:

- No large-scale slope failures were observed in the air photographs. Observed slope failures were generally small bank failures along the Puntledge and Tsolum Rivers which were likely initiated by undercutting or trees toppling. The meanders of the Tsolum River upstream of the confluence with the Puntledge were slowly shifting with time and have been locally stabilized with rip-rap at various locations.

- During the field reconnaissance, Thurber observed 28 locations of interest. Of these, 1 was assessed as very high risk, 3 as high risk, 12 as moderate risk, and 12 as low or very low risk. Of the 28 locations, 7 were natural features and 21 were engineered. Locations of interest are shown on Figure 7.

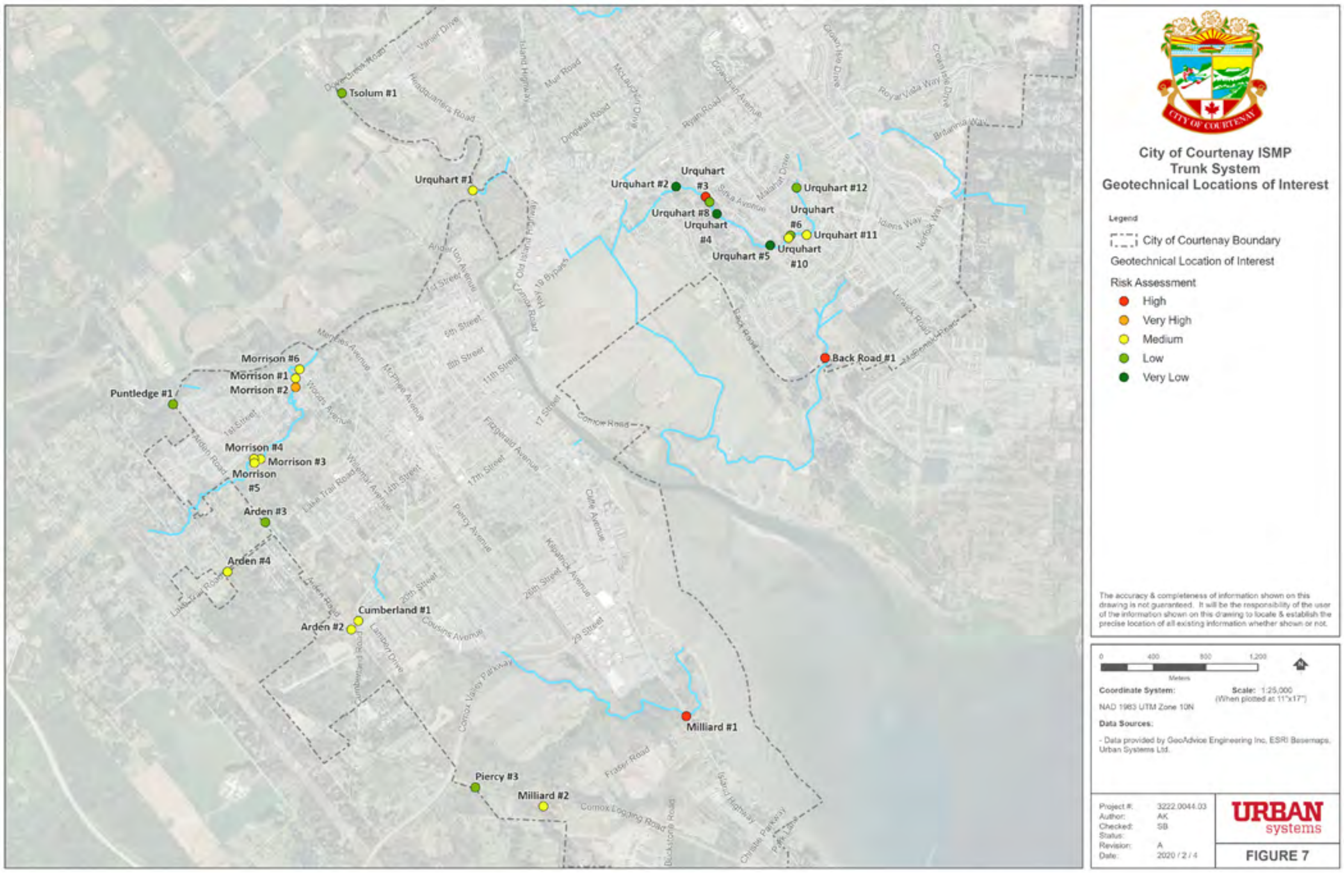

FIGURE 7: LOCATIONS OF INTEREST

Findings from Thurber's field reconnaissance and risk assessment are summarized in Table 7. Results are presented according to level of risk, from very high to very low.

TABLE 7: SUMMARY OF GEOTECHNICAL RISK ASSESSMENT

WATERCOURSE	ISSUE	RISK RATING
Morrison Creek	Culvert	Very high
Mallard Creek	Culvert	High
Millard Creek	Culvert	High
Glen Urquhart Creek	Culvert	High
Piercy Creek	Culvert	Medium
Arden Creek	Retaining Wall	Medium
Piercy Creek	Culvert	Medium
Millard Creek	Culvert	Medium
Morrison Creek	Culvert	Medium
Morrison Creek	Erosion	Medium
Morrison Creek	Erosion	Medium
Morrison Creek	Erosion	Medium
Morrison Creek	Storm Outfall	Medium
Glen Urquhart Creek	Culvert	Medium
Glen Urquhart Creek	Pedestrian Bridge	Medium
Glen Urquhart Creek	Pedestrian Bridge	Medium
Arden Creek	Culvert	Low
Piercy Creek	Culvert	Low
Puntledge River	Erosion	Low
Tsolum River	Erosion	Low
Glen Urquhart Creek	Culvert	Low
Glen Urquhart Creek	Obstruction	Low
Glen Urquhart Creek	Obstruction	Low
Glen Urquhart Creek	Obstruction	Low
Glen Urquhart Creek	Culvert	Very low
Glen Urquhart Creek	Culvert	Very low
Glen Urquhart Creek	Culvert	Very low
Glen Urquhart Creek	Culvert	Very low

Thurber's technical report in Appendix C includes a data sheet for each of the areas of interest, including the specific location, details of the hazards identified, their likelihood and consequence, an overall risk rating, and possible remedial options. Risk ratings and possible remedial options will be considered in the development of Management Options as a next step in the process to develop the IRMP.

2.5 ENVIRONMENTAL ASSESSMENT

An environmental assessment was initiated by Current Environmental (Current) in 2019 and will be completed in early 2020. A detailed description of Current's methodology and findings is provided in their technical report in Appendix D.

Objectives

- Understand the current environmental health of the City's watersheds and potential current and future risks, based on both desktop and field data.

Methodology

- The assessment included the components summarized in Table 8 below.

TABLE 8: ENVIRONMENTAL ASSESSMENT METHODOLOGY

COMPONENT	STATUS	METHODOLOGY
Information gathering and mapping	Complete	• Desktop review using various online and printed resources available from municipal, provincial, and federal databases and libraries.
Impervious area assessment	Complete for existing condition; future condition to be completed in Phase 3	• Desktop analysis to calculate percent total impervious area (%TIA) within each watershed and in riparian areas.
Fish presence assessment	Complete	• Desktop analysis based on fish presence, availability of stream channel for fish migration, and percent impervious area.
Water quality assessment	Complete	• Field data collection of hand-meter data and samples submitted for laboratory analysis from six locations across the City.
Benthic community assessment	Complete	• Field data collection from six locations across the City • Samples collected between September and October 2019 in accordance with Metro Vancouver's Monitoring and Adaptive Management Framework and submitted for laboratory analysis.

COMPONENT	STATUS	METHODOLOGY
Aquatic species and habitat inventory (freshwater and estuarine/marine)	Complete	• Desktop review and field reconnaissance based on published standards, City of Courtenay Environmental Development Permit Areas, and professional experience.
Terrestrial species and habitat assessment	Complete	• Desktop review and field reconnaissance based on published standards and professional experience.
Species at risk	Complete	• Desktop review based on published standards and professional experience.
Natural hazard assessment	To be completed in Phase 3	• n/a
Environmental parameters and ecological health analyses	To be completed in Phase 3	• n/a

Key Findings

Key findings from the environmental assessment conducted to date are summarized in Table 9.

Impervious Area

- Overall, the City contains approximately 30% impervious cover at slightly over 1,000 hectares (ha). The area within riparian corridors (30 m from stream bank) contains approximately 16% impervious cover or 70 ha. A summary of impervious area by watershed is provided in Table 9.

TABLE 9: IMPERVIOUS AREA COVER WITHIN CITY WATERSHEDS

WATERSHED	WATERSHED AREA		RIPARIAN CORRIDOR	
	Area Within City of Courtenay (ha)	Percent Total Impervious Area (%)	Area Within City of Courtenay (ha)	Percent Total Impervious (%)
Brooklyn Creek	162	51	29	52
Courtenay River	836	39	37	24
Glen Urquhart Creek	568	44	43	24
Little River	646	11	93	3
Millard-Piercy Creek	476	8	126	14
Morrison Creek	135	34	27	12
Portuguese Creek	230	26	40	13
Puntledge River	227	37	16	12
Tsolum River	353	25	26	20
City of Courtenay (overall)	3,376	30	437	16

The Little River and Millard-Piercy Creek watersheds demonstrate high watershed health, at least as indicated by %TIA (total impervious area) within the overall watershed and within the riparian corridor. The watershed with the highest TIA is Brooklyn Creek, which exceeds 50% TIA, demonstrating impacted watershed health.

Based on these findings, all watersheds within Courtenay except for Millard Piercy Creek are considered impacted by development and stream quality is expected to be impacted and potentially non-supporting.

Fish Presence

- The following table shows the percentage of availability of urban stream channels within City boundaries to fish migration. This is an indicator of watershed health, whereby the higher the percent availability, the higher the watershed health.

TABLE 10: FISH PRESENCE IN URBAN STREAMS

WATERCOURSE	TOTAL LENGTH (M) BASED ON SENSITIVE HABITAT ATLAS	CONFIRMED FISH PRESENCE LENGTH (M)	PERCENT FISH BEARING (%)
Brooklyn Creek	5,680	0	0
Courtenay River	7,222	7,222	100
Glen Urquhart Creek	7,247	4,047	56
Little River	16,593	13,705	83
Millard-Piercy Creek	24,983	22,832	91
Morrison Creek	5,533	4,825	87
Portuguese Creek	7,394	866	12
Puntledge River	3,271	3,271	100
Tsolum River	5,146	3,485	68

As shown in Table 10, there is fish presence in all watercourses except for Brooklyn Creek, which has heavily modified headwaters channels on Crown Isle. The percent fish bearing length of the watercourses is generally moderately high to high, except for Glen Urquhart Creek (56%) and Portuguese Creek (12%). A perched culvert installation was observed on Glen Urquhart Creek, which acts as a barrier to fish migration and likely contributes to limited fish productivity in the channel.

Water Quality

- Hand-meter water quality data indicate that chronically high turbidity conditions may exist at the stormwater outlet into Morrison Creek. Acute (single event) elevated temperature and turbidity events were observed periodically at all sites, apart from Piercy Creek which remained within water quality guidelines for all parameters. These findings align with the results of the impervious area analysis previously discussed.
- Water quality samples submitted for laboratory analysis of dissolved metals indicate that all measured water quality sites contain chronically high concentrations of copperin both the summer and winter seasons (with the exception of Brooklyn Creek, which had just one summer exceedance for copper). . The Courtenay River site measured from outfall flows at the eastern terminus of 19th Street showed a chronic exceedance of iron, while the Piercy Creek site at the southern terminus of Marsden Road showed chronically elevated zinc concentrations.
- Total coliform counts in water quality samples were chronically in exceedance of recreational limits for all six sites, with Piercy Creek showing the lowest average and the Courtenay River showing the highest average, at over 8,000 times the allowable limit. Average E.coli counts exceeded recreational limits for the Courtenay River, Puntlege River, and the highest observed at Morrison Creek, which was nearly 32 times the allowable chronic condition.
- None of the water quality sampling sites showed either acute or chronic exceedances of nitrate above recreational guidelines under either summer or winter conditions, pointing to minimal influence of agricultural runoff and pesticide use.

Benthic community assessment

The benthic index of biological integrity (B-IBI) combines the relative abundance and taxa richness of benthic invertebrates and is intended to be used as an indicator of stream condition. The B-IBI is a 10-metric score that is used to rate a stream's biological condition. Stream condition classification as based on B-IBI score is summarized in Table 11.

TABLE 11: STREAM CONDITION CLASSIFICATION BASED ON B-IBI SCORE

10 METRIC B-IBI SCORE	STREAM CONDITION
46-50	Excellent
38-44	Good
28-36	Fair
18-26	Poor
10-16	Very Poor

Field samples of benthic invertebrates were collected in October 2019 from six sites and submitted to the laboratory for analysis. Based on the B-IBI score from each sampling site, the resulting predictions for stream condition are summarized in Table 12.

TABLE 12: BENTHIC INDEX OF BIOTIC INTEGRITY SCORES

WATERCOURSE	B-IBI SCORE	STREAM CONDITION
Brooklyn Creek	16	Very Poor
Courtenay River	12	Very Poor
Glen Urguhart Creek	20	Poor
Little River	n/a	n/a
Millard Piercy Creek	na	n/a
Morrison Creek	18	Poor
Portuguese Creek	14	Very Poor
Puntledge River	18	Poor
Tsolum River	n/a	n/a

These results generally align with the results of the impervious area analysis and water quality analysis and are reflective of typical watersheds that have experienced significant development.

Species and Habitat Inventory

- There is a high diversity of marine invertebrate species in the Comox Harbour, including species at risk. These are summarized in Appendix D.

Summary of Environmental Assessment

The results of the environmental assessment are summarized in Table 13. Based on the results, watersheds were identified as being low, moderate, or high priority in terms of implementing management practices to address the issues that have been identified.

TABLE 13: SUMMARY OF ENVIRONMENTAL ASSESSMENT RESULTS

WATERSHED		COURTENAY RIVER	GLEN URQUHART CREEK	LITTLE RIVER	MILLARD/ PIERCY CREEK
% Fish Bearing Stream Channels (w/n City limits)		100	56	83	91
% Watershed Covered in Impervious Surfaces and Predicted Stream Quality (Scheuler 1994)		Non-supporting	Non-supporting	Impacted	Sensitive
Benthic index of biological integrity (B-IBI) Stream Health Score (Page et al. 2008)		Very Poor	Poor	n/a	Very Poor
Water Quality Handmeter Exceedance of BC Standards (Summer)	Acute	Temp./ Turbidity	Temp./ Turbidity	n/a	No
	Chronic	No	No	n/a	No
Water Quality Handmeter Exceedance of BC Standards (Winter)	Acute	Turbidity	No	n/a	Turbidity
	Chronic	No	No	n/a	No
Water Quality Laboratory Exceedance of BC Standards (Summer)	Acute	Copper, Iron, Zinc, E. coli, Ttl. Coliform	Copper, Iron, E. coli, Ttl. Coliform	n/a	Copper, Iron, Zinc, E. coli, Ttl. Coliform
	Chronic	Copper, Iron, Zinc, E. coli, Ttl. Coliform	Copper, Zinc, Ttl. Coliform	n/a	Copper, Zinc, Ttl. Coliform
Water Quality Laboratory Exceedance of BC Standards (Winter)	Acute	Copper, Iron Zinc, E. coli, Ttl. Coliform	Copper, Iron, E. coli, Ttl. Coliform	n/a	Copper, Iron, Zinc, E. coli, Ttl. Coliform
	Chronic	Copper, Zinc, Ttl. Coliform	Copper, Zinc, E. coli, Ttl. Coliform	n/a	Copper, Zinc, E. coli, Ttl. Coliform
Management Priority		MODERATE	HIGH	MODERATE	HIGH

SITES LABELLED “N/A” WERE NOT ASSESSED FOR HANDMETER OR LABORATORY WATER QUALITY PARAMETERS ACCORDING TO

MORRISON CREEK	PORTUGUESE CREEK	PUNTLEDGE RIVER	BROOKLYN CREEK	TSOLUM RIVER	CITY OF COURTENAY
87	12	100	0	68	74.6 (Average)
Non-supporting	Non-supporting	Non-supporting	Non-supporting	Impacted	Majority Non-supporting
Poor	n/a	Poor	Very Poor	n/a	Very Poor/ Poor
Temperature	n/a	Temp./ Turbidity	Temperature	n/a	Temp./ Turbidity
Turbidity	n/a	No	No	n/a	Turbidity
Turbidity	n/a	No	Turbidity	n/a	Turbidity
No	n/a	No	No	n/a	No
Copper, Iron, Zinc, E. coli, Ttl. Coliform	n/a	Copper, Iron, Zinc, E. coli, Ttl Coliform	Copper, Iron, E. coli, Ttl. Coliform	n/a	Copper, Iron, Zinc, E. coli, Ttl. Coliform
Copper, Zinc, E. coli, Ttl. Coliform	n/a	Copper, Zinc, E. coli, Ttl. Coliform	Ttl. Coliform	n/a	Copper, Iron, Zinc, E. coli, Ttl. Coliform
Copper, Iron, Ttl. Coliform	n/a	Copper, Iron, Zinc, E. coli, Ttl. Coliform	Copper, Iron, Ttl. Coliform	n/a	Copper, Iron, Zinc, E. coli, Ttl. Coliform
Copper, Zinc, Ttl. Coliform	n/a	Copper, Zinc, E. coli, Ttl. Coliform	Copper, Zinc, Ttl. Coliform	n/a	Copper, Zinc, E. coli, Ttl. Coliform
HIGH	LOW	MODERATE	LOW	LOW	

BUDGET/SCOPE OF STUDY.

3.0 Synthesis of Key Findings

The following is a summary of the key findings from the work completed to date on current and potential future conditions:

1. **Preliminary performance analysis of the trunk storm sewer system suggests that numerous capacity deficiencies exist, particularly when considering future climate change.**

   The trunks-only hydraulic model showed that the value of high-priority capital works may be in the order of $9M in the next five years. This excludes non-infrastructure capital works (studies, monitoring, other programs) and the rest of the City's drainage network, such as ponds and pump stations. This work to date has been done in absence of real flow monitoring data. The existing model will be expanded upon in 2020 to include the all City-owned rainwater management infrastructure and be calibrated to flow data collected. This new work may somewhat change the recommendations for capital improvements, so we recommend initiating preliminary planning for capital works, but not act upon them until 2021.

   It will be necessary to develop clear prioritization criteria and a sustainable funding model so that the most important works and other management responses can be carried out when needed. This will be considered in the continued development of the IRMP.

2. **The City's watersheds are ecologically diverse and provide important habitat for terrestrial, aquatic, and estuarine/marine species. As is the case in all urban centers, historic development has impacted watershed health.**

   The results of the environmental assessment showed that development has impacted the City's watersheds from what would be their health under a natural condition. This is to be expected and not something unique to the City of Courtenay. Most impact is caused by a loss of riparian forest and anthropogenic influences.

   Analysis has not yet been conducted on the future conditions. Further urban densification can occur without additional harm provided that Green Infrastructure of various forms are applied, watercourse riparian corridors are protected / restored, and the City continues to protect and expand its urban tree canopy. Impacts of future development and the application of management techniques to address them will be further explored in Phase 3 of the IRMP.

3. **Water quality in most creeks has been compromised; some sources of pollution are known, others not.**

As described, analysis of metals and coliforms in water quality samples showed chronic exceedances in most watercourses. Of particular concern is the Courtenay River, which showed total coliforms exceeding 8,000 times the allowable limit for recreational purposes. Overall, the Courtenay River, Puntledge River, and Morrison Creek demonstrated high coliform concentrations and the sources of contamination should be investigated further.
Elevated concentrations of copper, iron, and zinc may be associated with vehicle pollutants entering rainwater systems and suggests that a heightened responsibility may exist between the City and private landowners/developers to improve treatment facilities and best management practices to better remove/detain heavy metals from runoff before they are allowed to enter natural waters. Similar efforts would also benefit elevated turbidity levels, such as those entering Morrison Creek, at an outfall with effluent entering into a notable salmon spawning reach.

4. **Recharge of rainwater to ground (infiltration) may be appropriate in some areas and not in others. The variability of ground conditions across the City will influence management techniques and their designs. Therefore, criteria and standards need to be flexible to suit the location.**

The hydrogeological (groundwater) assessment indicates the infiltration potential within the City spans from “good” to “marginal” and may not be appropriate in all areas due to underlying aquifer vulnerability. Where aquifer contamination risk exists, there is heightened need for water quality treatment. Source controls and area-specific recommendations for infiltration-based rainwater management techniques will be considered as part of the Phase 3 IRMP process.

4.0 Phase 2 Recommendations

The following recommendations are intended to guide the next steps in the development of the IRMP. They are consistent with the original scope of the phased IRMP.

1. Use process flow monitoring data collected in 2019, to calibrate and expand the Phase 1 hydraulic model of the municipally owned rainwater management infrastructure. This will solidify a capital program for the City's drainage services.

2. Complete the remaining components of the environmental assessment, including a natural hazard assessment, ecological health analysis, and assessing the unmitigated impacts of future land use.

3. Engage external stakeholders for supplemental input on issues. It is recommended that engagement focus on environmental stewardship groups and adjacent government jurisdictions.

4. Engage internal stakeholders to discuss management options, acceptable levels of service, refined criteria and standards, and implementation plan. Ongoing operations and maintenance, future asset replacement, cost implications and existing funding levels are important considerations in this process.

5. Compile a comprehensive IRMP, including a prioritized capital plan and recommendations, which may include but are not necessarily limited to additional study, ongoing monitoring, education, coordination with other authorities, and regulatory changes and enforcement.