SANITARY SEWER MASTER PLAN

FINAL REPORT

DECEMBER 2021

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Project No. 3222.0019.03

Report to:
The City of Courtenay
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SANITARY SEWER MASTER PLAN

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EXECUTIVE SUMMARY

The *Sanitary Sewer Master Plan* (SMP) provides a review of the performance of the City of Courtenay's sanitary sewer system by characterizing sewer flows, assessing gaps in levels of service and identifying deficiencies and recommended upgrades over the next 20 years. The technical analysis centers on capacity issues in particular as it relates to infrastructure sizing to service both current customers, growth and inflow and infiltration.

Overall, the final SMP addresses the following study objectives:

- **To assess the performance of the system against desired levels of service for the sanitary system including issues and ideas that stem from operations, engineering, and planning departments.**
- **To prioritize capital projects over the short- and medium-tern to determine expenditure planning and prioritize design-to-construction assignments; and,**
- **To update the hydraulic model for use in the performance assessment and for all other future assessments for system capacity e.g., development reviews, preliminary design projects.**
- **To identify projects for inclusion in the Development Cost Charges Bylaw.**

Various information sources provide the current context for existing sanitary system capacity conditions such as interviews with City staff, flow monitoring during the Summer of 2019, flow records from the Comox Valley Regional District (who are responsible to treat wastewater and dispose of the effluent), local historical rainfall records, service complaints (via staff insights), and previous hydraulic models. Future capacity conditions are based on considerations from the Official Community Plan, growth projections from planning staff, the Subdivision and Development Servicing Bylaw, industry practices for adapting to climate change and water-sewer flow generation by means of population growth and potential water conservation. These inputs establish a comprehensive account of the conditions to provide input to Courtenay's sewer utility to develop a customized, practical and prioritized capital plan for the next 5 years.

The SMP and implementation plan recommends **phasing in priority projects based on sewer capacity and other municipal drivers for capital planning.** Modelling scenarios at 2019, 2024 and 2039 allow for assessment of each pipe and lift station to accommodate the projected flows. Recommended projects are categorized into Primary, Secondary, and Tertiary based on relative necessity and overall benefit to the system. **Table A** summarizes the projects. Further to this, it is recommended that the City develop an infrastructure risk evaluation matrix for evaluation of future sewer projects. The Matrix should include both risk and consequence evaluation criteria for prioritizing potential projects.

Table A: Summary of Capital Projects – Sanitary Sewer Master Plan

Project Name	Timing	Budget
City Projects Related to Past System Performance Issues		
Puntledge Catchment Redirection (SEW 002)	*Short-term* ***(Initiated 2021)***	**$ 1,700,000**
1st Street Lift Station & Forcemain Upgrades (SEW 007)	*Short-term* ***(Initiated 2021)***	**$2,500,000**
Mansfield Lift Station and Forcemain Upgrades	*Short-term*	**$1,800,000**
City Projects Related to Short-term Growth-Related System Performance Issues		
Cliffe Ave – Trunk Sewer (26th St. to 21st St.) (SEW 003)	*Short-term*	**$ 2,300,000**
Cliffe Ave – Sewer Force Main (S. Courtenay to 26th St.) (SEW 004)	*Short-term*	**$2,000,000**
Fitzgerald Ave – Trunk Sewer (4th St. to 21st St.) (SEW 005)	*Short-term*	**$3,900,000**
Arden Central – Trunk Sewer (Lake Trail Rd. to Cumberland Rd.) (SEW 006)	*Short-term*	**$800,000**
City Projects Related to Medium- to Long-Term Growth-Related System Performance Issues		
South Courtenay Area Servicing (SEW 011)	*Medium-term* ***(Initiated 2021)***	**TBD**
North Courtenay Area Servicing (SEW 010)	*Medium-term*	**TBD**
Arden North – Trunk Sewer (Arden Rd. - 1st St. to Lake Trail Rd.) (SEW 012)	*Medium-term*	**$2,000,000**
East Courtenay Lift Station & Forcemain (SEW 008)	*Medium-term*	**$2,100,000**
Veterans Memorial Pkwy Lift Station and Forcemain (SEW 009)	*Medium-term*	**$1,600,000**
City Projects Related to Growth-Related System Performance Issues Already Underway		
Greenwood – Trunk Sewer Extension (SEW 001)	*Ongoing* ***(Completed 2021)***	**$ 7,950,000**

The Sewer Master Plan includes an implementation plan which includes the following recommendations:

- Update the Development Cost Charges (DCC) bylaw for the eligible projects. This Sewer Master Plan identifies nine (9) DCC-eligible growth-driven projects. Municipalities are advised to update their DCC bylaw when better information is available and also to be mindful that comprehensive updates (i.e., having the outcomes from most technical service areas) can provide for administrative efficiencies. An update to the DCC Bylaw is scheduled and the results from this study can be incorporated following additional analysis (e.g., planning considerations such as growth projections and development equivalencies) alongside City staff. Normally a DCC program includes the full 20-year plan and so as part of the update it is recommended that the full 20-year time period be considered, and additional projects be added as appropriate. Table B summarizes the DCC-eligible projects.

It is recommended that the City spend approximately $3.0M per year for the next 5 Years on upgrades to address hydraulic deficiencies identified in this report. In addition, a minimum forecast of $2.0M to $2.5M in spending is also recommended in current in-service asset replacement per year for assets at or near the end of their useful life.

- Identify sources of inflow and infiltration (I&I) over the next five years and then use business case analyses to determine the feasibility of rehabilitation projects to reduce inflow and infiltration.
- Conduct and to coordinate, on an ongoing basis with CVRD (Comox Valley Regional District), select initiatives including regular meetings to improve data quality and information sharing at major facilities e.g., regional pump station.
- Continue to consult with K’omoks First Nation (KFN) to support the servicing agreements in place among participating governments. The sewer hydraulic model and recommended capital plan incorporates new flows from KFN in the next 20 years.
- Integrate this plan with the City’s long term flood protection strategy to ensure critical infrastructure is adequately protected.
- Integrate this plan with condition-based assessments being completed as part of the City’s asset management program as well as concurrent planning for other City infrastructure, such as roads and all other buried utilities.

1.0 BACKGROUND

1.1 INTRODUCTION

The City of Courtenay is expected to undergo significant growth over the next 20 years with early signs of rapid growth already occurring. Generally, the existing sanitary infrastructure can accommodate a range of sanitary flow conditions yet there are multiple pipes that do not meet a standard level of service and require upgrades; in the future, more and more pipes will not meet levels of service and incremental upgrades are needed. These are common conditions to plan for with respect to sewer utilities in growing communities. The Courtenay Sanitary Sewer Master Plan (SMP) will provide a schedule of prioritized capital projects over the next 20 years including considerations and impacts to the DCC bylaw for eligible projects. Overall the outcomes from the sewer master plan are:

- To create an accurate sewer model that integrates with City of Courtenay's GIS system for the 2019 scenario, which also allows for flow projections into the future scenarios of 2024 and 2039;
- To identify and confirm existing and future capacity deficiencies,
- To develop a prioritized list of capacity-based projects for short-term and long-term capital planning and servicing,
- To provide a foundation for preliminary sanitary sewer design including technical findings with respect to project locations, upgrade bundling for project efficiencies, flow and slope considerations, and
- To identify source-factors and priorities for infiltration and inflow including a list of proposed flow monitoring locations for ongoing review and analysis.

1.2 STUDY AREA

The study area is comprised of catchments throughout the City of Courtenay. Generally, the study area comprises the City boundary including lands serviced by the sewer utility, with a few exceptions to servicing small areas outside the boundary (given their apparent development feasibility). Figure 2.1 in **Appendix A** illustrates the parcels currently serviced by the City sewer system.

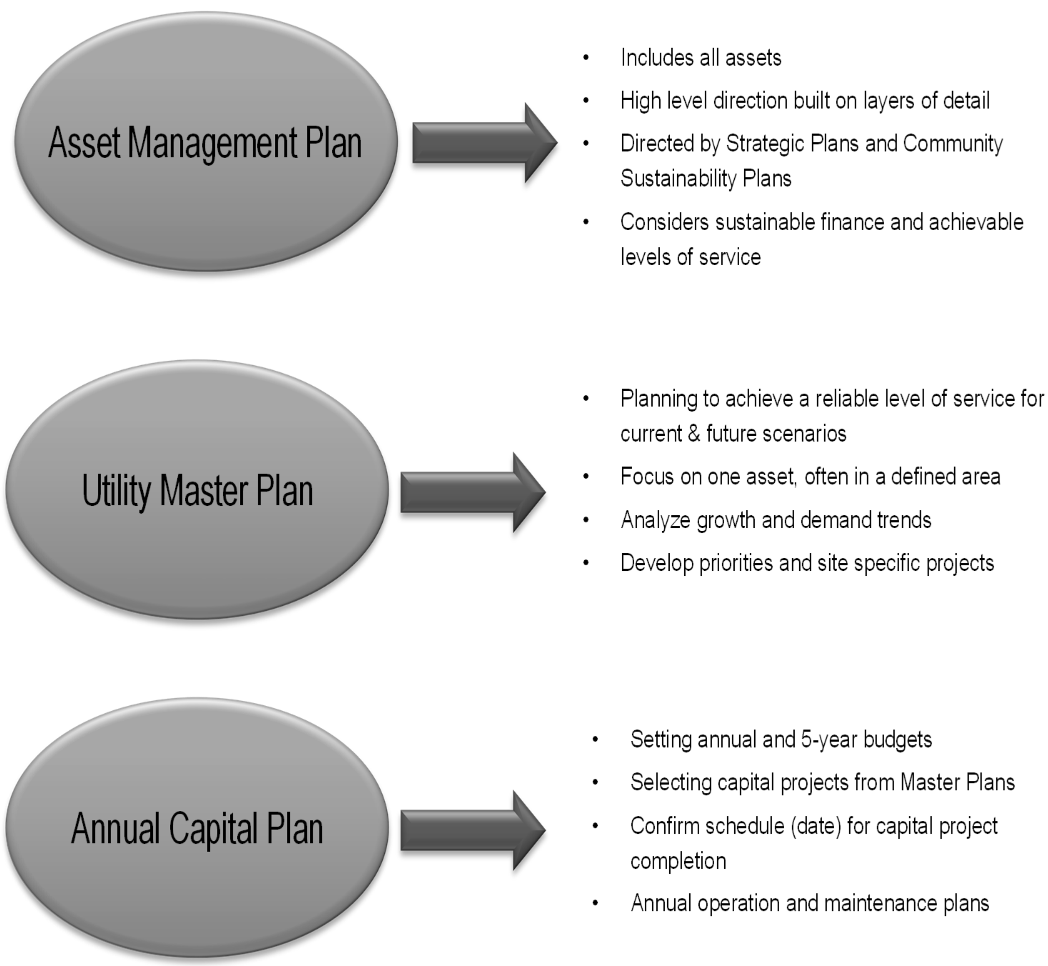
1.3 SUPPORTING DOCUMENTATION

GeoAdvice has prepared a technical report that documents the analysis completed to update and calibrate the City sewer model and the capacity analysis undertaken. This report is located in **Appendix A**.

The City has prepared project sheets for each of the major projects and also developed cost estimates for each project. These are contained in **Appendix B**.

1.4 INFRASTRUCTURE HIERARCHY AND GOVERNANCE

Levels of service, utility policy, asset management, master planning, capital planning, and annual programs are all related; however, they should be evaluated as their own focus areas then integrated to provide clarity and overall effectiveness. The conventional infrastructure hierarchy is summarized below.



Using this hierarchy for infrastructure planning, it becomes clear that establishing service levels is a priority for any Sanitary Sewer Master Plan. The process of evaluating system-performance against targeted service levels is described in the following section, prefaced by a brief description of assets in the catchment as well as a performance summary from hydraulic analyses.

2.0 SYSTEM PERFORMANCE

System performance is the cornerstone of a sewer master plan, including current and future conditions. This section summarizes the infrastructure, presents summary results of hydraulic analyses, and defines the risk methodology for the analysis. Selecting levels of service to determine capital priorities and funding requirements is a key outcome of the SMP.

2.1 SANITARY INFRASTRUCTURE OVERVIEW

The City of Courtenay sanitary system is comprised of approximately 159 km of gravity mains, approximately 6 km of force mains, and 10 lift stations owned and operated by the City situated throughout 11 sanitary sewer catchments. The entire service area drains to the Comox Valley Regional District where the flows are collected and treated prior to return to the environment.

Pipe Material: Sanitary sewer main installations have been ongoing for many decades which naturally results in a mix of materials, diameters and construction standards. Asbestos cement and polyvinyl chloride (PVC) pipe comprise the majority of all sewer mains; the latter material is almost exclusively installed in new developments and upgrade projects.

Construction Depth: most sewer mains are situated at depths less than 3 metres (m) with only a select few pipes extending below 6m.

Pipe Diameter: Approximately 80 percent of the pipes in the system are 200 millimeter (mm) diameter or less. The remaining 20 percent of pipes are 250 mm diameter or greater, and generally comprise the sewer main conveyance system including trunks.

Lift Stations: There are 10 sanitary lift stations located throughout the City to convey flows from localized low-points and up-gradient to specific locations to proceed again with gravity flows. The stations range in size, capacity and complexity. Two of the largest stations, Anderton and First Street, are also the oldest stations with an original construction date of 1961 (albeit there have been multiple upgrades since that time).

2.2 HYDRAULIC MODELING SUMMARY

Section 2.2 provides an overview of the hydraulic modeling methodology, including the type of model used for the assessment as well as how flows are characterized and under what scenarios. Results of the performance assessment are provided as part of the capital plan development.

2.2.1 HYDRAULIC MODEL FLOW METHODOLOGY

Daily flow conveyed in a sanitary system can be generally divided into five components:

- Groundwater infiltration (GWI), which is a function of pipe condition and location with respect to the saturated soil zone
- Base sanitary flow (BSF), which is a function of per-capita water consumption
- Dry weather flow (DWF) which is the summation of GWI and BSF – when averaged over 24 hours this is referred to as Average Dry Weather Flow (ADWF)
- Rainfall-dependent inflow and infiltration (RDI&I)
- Wet weather flow (WWF) which is the summation of DWF and RDI&I and the peak hourly value is referred to as Peak Wet Weather Flow (PWWF)

The relationship between these components is illustrated in the diagram below:

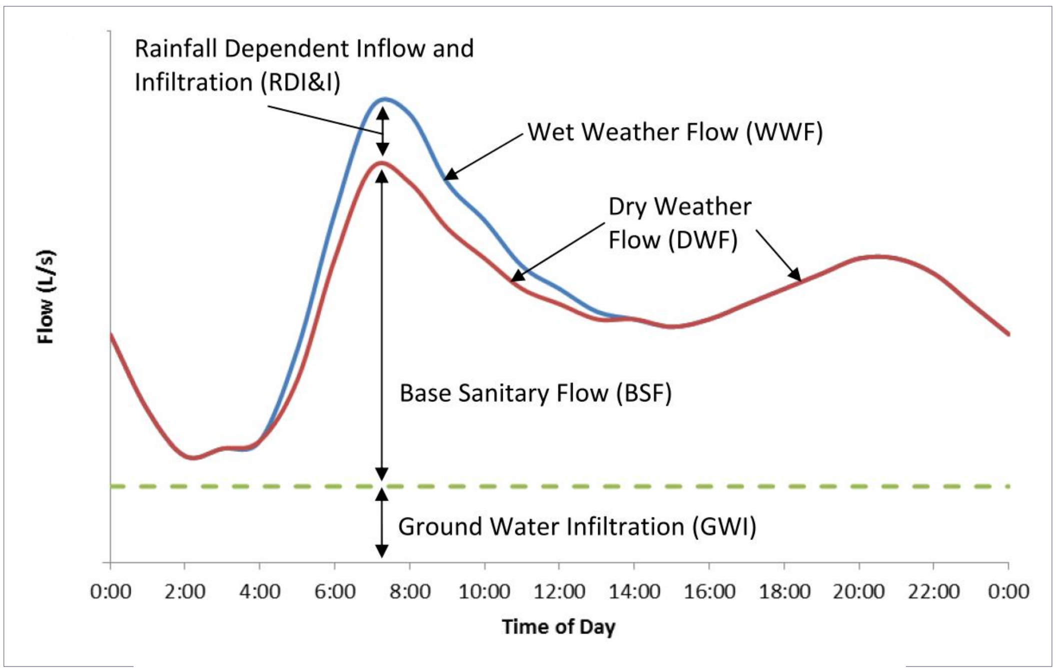


Figure 2 - Relationship Between Components of Sanitary Flow

The hydraulic model incorporates each flow component based on a thorough review and analysis of each component part so as to create a model that is representative of actual conditions. In particular, the model was developed using the City's geospatial information system (GIS) database, land use and zoning maps, as-built drawings, pump curves, operational controls and staff inputs.

There are many benefits in taking the time to create an accurate hydraulic model so that it can provide a practical and reliable account of the performance of the system including its operations, servicing issues, asset renewal needs, flow management e.g. inflow and infiltration and for considering new growth and development. The information developed from the model will lead to confident capital planning. Accuracy starts with field-verified asset inventories and flow data.

Further information on the methodology and results of the flow characterization is provided in **Appendix A**. Summary results are presented later in this section.

Sanitary Loading Data

Field data reviews are essential to developing accurate flow projections for the 2019 modelling scenario. During rainfall events in 2019, 12 flow monitors were installed throughout all catchments to collect field data. Two of the locations are permanent flow monitors while the remainder were installed as temporary flow monitoring sites. Overall, collected flow information was used to:

- Estimate Base Sanitary Flow (BSF)
- Estimate Groundwater Infiltration (GWI)
- Estimate Average Dry Weather Flow (ADWF)
- Develop 24-hour diurnal flow patterns
- Estimate Rainfall Dependent Inflow and Infiltration (RDI&I)
- Estimate Peak Wet Weather Flow (PWWF)
- Calibrate the model

Sub-catchment flows were further characterized because of the need to develop an accurate model throughout the City. The relationship between the data source (flow monitoring station) and applicable sub-catchments is illustrated in Figure 2.2 in **Appendix A**.

Preparing for the Impacts of Climate Change

It is widely accepted that capital planning must now consider the impacts of climate change and its derivatives on infrastructure including changes in precipitation, temperature, and sea level rise. Being cognizant of these changes and adapting the capital planning process accordingly, including engineering standards and design parameters, will help ensure that infrastructure is resilient, and our communities vibrant, over the long term. There are also major economic consequences of ignoring these impacts, as unanticipated infrastructure failure places significant stress on public finances, restricting the capacity of the government to respond and adapt.

By means of rainfall dependent inflow and infiltration (RDI&I), precipitation and snowmelt are most likely to impact sewer flows. At the time of completing the modeling for this Master Plan the City hadn't completed a local assessment of the potential future increase in inflow and infiltration associated with climate change. As such the City elected to follow the 2008 work completed by Metro Vancouver[1] to evaluate the potential increase in inflow and infiltration associated with climate change. These values are location specific as rainfall patterns can change dramatically between regions. When considering preliminary design, the City is encouraged to allocate a 17% increase in RDI&I loadings in order to anticipate potential climate change impacts. This design parameter has been applied when designing new upgrades. This value should be reviewed and considered in conjunction with the design of each project and local flow monitoring as this area of science is ever evolving.

Modeling Scenario Development

Three modelling scenarios provide a comprehensive picture of system performance issues in 2019, 2024 and 2039 (the current, 5-year and 20-year planning horizons): Existing 2019 Extended Period Simulation, and 2039 Extended Period Simulation.

Two common analytical approaches in sanitary sewer modelling are extended period simulation and steady state simulation. An extended period simulation reflects the system performance over 24 hours or longer and models the variation in demands over time. This allows for system storage and pump operation to reflect real world conditions. The steady state simulation is a more conservative approach that takes a snap shot in time and applies a peaking factor to flows assuming all peak flows occur at the same time. For this master plan the extended period simulation method has been used since it is more reflective of real-world conditions.

Population growth forecasts were developed by staff based on land use considerations as well as market forces and ongoing development projects. Growth was separated into 5-and 20-year increments to support the modelling scenarios described herein. The summary results of population include 7,004 new persons by 2024 and a total increase of 9,623 by 2039. The location of growth is illustrated on a catchment by catchment basis in Figure 4.1 in **Appendix A**.

[1] Metro Vancouver, Vulnerability of Vancouver Sewerage Area Infrastructure to Climate Change, 2008, http://www.metrovancouver.org/services/air-quality/AirQualityPublications/Vulnerability_climate_change.pdf.

Utility master plans often include conservative population estimates so as to remain prudent with respect to the timing and risk (of under sizing) related to pipe upgrades. As more detailed information comes forward as to the population growth, the City can conduct further analysis under separate cover to inform applicants and to guide sewer system planning.

All developments located outside the existing serviced areas (e.g., greenfield developments) include an estimate for the combination of groundwater infiltration and rain derived inflow and infiltration of 10,368 L/ha/day.

Current conditions, population projections and future flow estimates provide the foundation for all three modelling scenarios as summarized below.

Existing 2019 Peak Wet Weather Flow: Existing flows were characterized for eleven sub-catchments and were based on the flow monitoring data at the City's flow monitoring stations.

Future 2024 Peak Wet Weather Flow: This scenario is used to forecast gravity main and lift station capacity issues that the current system is susceptible to have during short-term growth over a 5-year period. For the 2024 Extended Period Scenario, the following assumptions were made:

- Assessed the capacity of pipes based on 2024 population and flows
- Assumed 360 liters per capita per day (L/ca/day) based sanitary flows for new population growth

Future 2039 Peak Wet Weather Flow: This scenario is used to identify any gravity main or lift station capacity issues during the 20-year build out condition.

From the above scenarios, the technical report in **Appendix A** provides in-depth analysis for each pipe, lift station and wet well by a Likelihood of Failure (LoF) rating, creating an easily understandable translation of the capacity-performance of sanitary infrastructure.

2.2.2 FLOW CHARACTERIZATION: RESULTS

The first step of the analysis was to estimate the sewer loads of the proposed areas defined above. The existing sanitary sewer model was used to determine initial base sanitary and I&I flows. These flows were adjusted to match the observed field values. The results of the capacity assessment with the hydraulic model for the existing 2019 scenario are summarized in Table 1.

Table 1: Flow characterization based on existing (2019) scenario

Flow Type	Flow (L/s)
Base sanitary flow	68
5-year 24-hour I&I	347
5 year 24-hour Average Wet Weather Flow	415

An accurate hydraulic model can represent the sum of flows at key points of confluence but it also must show strong alignment at select, distributed nodes throughout the system. During technical analysis, it became evident that the sanitary sewer hydraulic model shows strong agreement between modeled and monitored flows. Further, both calibration sites show *excellent* agreement. As with any other model however, it is recommended to update the model regularly, especially as notable flow data is received that likely affects the peak wet weather flow conditions in the model.

2.2.3 EXTRANEOUS FLOW CHARACTERIZATION

By understanding how I&I affects flows within the City's sanitary sewer network, the City can focus its efforts on addressing key areas of concern and possibly defer capacity-driven upgrades by reducing these extraneous flows.

Groundwater Infiltration

The contribution of GWI and I&I was allocated in the model according to the loading in the previous PCSWMM model. In order to perform a dry weather calibration, a separate GWI load was added to the model, determined as a percentage of minimum nightly flows (MNF) recorded by flow monitoring data. The following conversion rates were used:

- MNF conversion rate of 70% for residential areas.
- MNF conversion rate of 40% for industrial, commercial and institutional (ICI) areas

Table 2 summarizes GWI calculated for each flow monitoring site.

Table 2: Groundwater infiltration rates per catchment

Catchment	Area (ha)	GWI (L/d/ha)	GWI Rate (L/s)
Comox Road	714	1,800	15.1
20th Street	789	1,400	13.0
Total/Average	1,503	1,590	28.1

As shown in this table, both sites fall within acceptable rates (industry convention) of between 1,000 L/ha/day and 3,000 L/ha/day.

Elevated GWI rates tend to be correlated with pipe age and groundwater: where system integrity and high-water tables are found so too is there high incidences of GWI. However, without a detailed systematic assessment of GWI, pipe age and condition, and groundwater elevation across the network, it is difficult to isolate exact sources of GWI. As the City collects more empirical and anecdotal information including sewer flow data, the sources of GWI can be better determined: for example, it may be found that areas that are underlain by a confining clay layer exhibit greater GWI.

Rainwater Dependent Inflow and Infiltration

Rainfall dependent I&I contributes a significantly greater percent of flows to overall I&I than GWI. The following table illustrates the approximate RDII rates based on the analysis outlined in **Appendix A** and the total design inflow and infiltration rate.

Table 3: Inflow and infiltration rates per catchment

Catchment	Area (ha)	GWI (L/d/ha)	RDII 5-year 24 hour (L/d/ha)	Climate Change Allowance (L/d/ha)	Design I&I Rates (L/d/ha)
Comox Road	714	1,800	16,100	2,800	20,700
20th Street	789	1,400	19,400	3,300	24,100

2.2.4 PIPE PERFORMANCE SUMMARY

Criteria for Capacity Analysis and Design of Upgrades

Likelihood of pipe failure based on the hydraulic modeling was assessed by the following criteria, which were developed in conjunction with staff and with reference to industry best practices in Table 4.

Table 4: Likelihood of Failure Ratings (Gravity Main)[2]

Likelihood of Failure (LoF)	Hydraulic Capacity	HGL	Velocity	Description
1 (Rare)	q/Q < 0.7	HGL < Crown	V ≥ 0.6 m/s	Gravity main performing as designed
2 (Unlikely)	q/Q < 0.7	HGL < Crown	V< 0.6 m/s	Adequate capacity, low velocity indicated potential sedimentation
3 (Possible)	q/Q < 0.7	Crown ≤ HGL < Rim Elevation or HGL > Ground Elevation	n/a	Adequate capacity, downstream condition causing backwater
	0.7 ≤ q/Q < 1.0	n/a	n/a	Marginal Capacity
	q/Q ≥ 1.0	HGL < Crown	n/a	
4 (Likely)	q/Q ≥ 1.0	Crown < HGL < Rim Elevation	n/a	Capacity exceeded and surcharging likely
5 (Almost Certain)	q/Q ≥ 1.0	HGL ≥ Ground Elevation	n/a	Capacity exceeded and flooding likely

Likelihood of lift station, wet well and forcemain failure based on the hydraulic modeling was determined by the following criteria in Table 5.

[2] *q = peak flow, Q = full pipe flow, HGL = hydraulic grade line, Crown = top of pipe*

Table 5: Lift Station, Wet Well, and Forcemain Ratings[4]

Likelihood of Failure (Lof)	Pump Capacity	Wet Well Capacity	Forcemain Velocity	Description
1 (Rare)	PWWF ≤ Firm Capacity[5]	Max Operating Level < Inlet Pipe Invert	0.9 m/s ≤ V ≤ 3.5 m/s	Lift station performing as designed
2 (Unlikely)	PWWF < Firm Capacity	Max Operating Level < Inlet Pipe Invert	V < 0.9 m/s, V > 3.5 m/s	Forcemain velocity outside of design range
3 (Possible)	PWWF ≤ Firm Capacity	Max Operating Level ≥ Inlet Pipe Invert	n/a	Inlet pipe invert within pump operating range and backup likely (submerged inlet)
4 (Likely)	PWWF > Firm Capacity	Max Operating Level < Inlet Pipe Invert	n/a	Pump capacity exceeded
	PWWF > Firm Capacity	Max Operating Level ≥ Inlet Pipe Invert	n/a	Pump capacity exceeded
5 (Almost Certain)	PWWF > Firm Capacity	Max Operating Level ≥ Max. Physical Depth	n/a	Pump capacity exceeded and wet well capacity and overflow capacity

A detailed overview of the capacity analysis methodology is described in **Appendix A**. Two primary takeaways from this table is a) that stating performance targets is crucial to selecting works to be upgraded and b) that performance must be contextual to the function of the infrastructure e.g. downstream forcemain.

[3] PWWF = peak wet weather flow; V=flow velocity
[5] q/Q = peak flow / full pipe flow

Pipe performance (likelihood of failure) was modeled as a function of hydraulic capacity, HGL, and velocity. The connection between *performance* and *project scoping* (if required) relates to two terms: assessment and design. The 2019, 2024 and 2039 scenarios were used to assess the performance of infrastructure, while design flow/sizing (i.e., proposed upgrades) were based on the 2039 flows with an additional contingency for climate change. Overall, infrastructure is rated as deficient as explained in the tables below, categorized for the 2019 (existing) and 2024 and 2039 (future) scenarios.

Table 6 summarizes the hydraulic performance results for gravity mains across the first 3 design horizons. For full complete LoF ratings, see **Appendix A**. To be deemed deficient, sanitary infrastructure needs a LoF of 4 or 5.

Table 6: Summary of hydraulic capacity analysis for gravity mains

Likelihood of Failure (LoF)	2019	2024	2039
1	668	692	725
2	1366	1389	1416
3	153	125	90
4	20	13	17
5	13	11	4

Two important considerations in regards to the results in Table 6 and with respect to potentially deficient pipes that don't actually require an upgrade:

- the number of pipes with within LoF of 4 or 5 decreases over time due to the implementation of the City planned projects. These projects don't eliminate all issues but address a number of them.
- exceeding capacity (q/Q ≥ 1.0) in a given asset does not automatically trigger an upgrade because in select circumstances this does not pose a risk as upstream and downstream infrastructure could operate safely and there is no anticipated surcharge (i.e. there is rarely a 1:1 correlation to the number of pipes exceeding q/Q =1 and the number of projects).

Table 7 summarizes the number of deficient pumps, force mains and wet wells, under all of the modelling scenarios.

Table 7: Number of Deficient Lift Station in 2019, 2024, and 2039 Scenarios

	2019			2024			2039		
Likelihood of Failure	3	4	5	3	4	5	3	4	5
Number of Lift Stations	0	3	0	0	2	0	0	1	0

In response to the LoF ratings and deficiencies above, an improvement work plan was created that identifies the required capital work projects along with their recommended project schedule.

Also note that the number of deficiencies is higher than the number of projects: the cause for the difference is that during hydraulic analysis, it was determined that many of the system bottlenecks create multiple back-flow conditions causing deficiencies upstream. As a result, when the identified upgrades were installed in the future scenarios, most of the deficiencies were eliminated. A detailed summary of the projects is contained in **Appendix B**.

Discharges to the CVRD

The City of Courtenay sewer system discharges into the CVRD system at three locations. The following Table 8 summarizes the locations and peak discharge flow rates.

Table 8: CVRD Discharge Flow Rates

CVRD Discharge Location	2019 Peak Wet Weather 5-yr 24-hr I&I	2024 Peak Wet Weather Flow 5-yr 24-hr I&I	2039 Peak Wet Weather Flow 5-yr 24 hr I&I
3: Courtenay Lift Station on Comox Road	465 L/s	474 L/s	457 L/s
4: Hudson Trunk Lift Station	11 L/s	16 L/s	16 L/s
5: Greenwood Trunk Lift Station	-	22 L/s	76 L/s

2.2.5 ADAPTIVE INFLOW AND INFILTRATION MANAGEMENT

Given the need to strategically address I&I in the City of Courtenay catchment, it is recommended that the City implement an Adaptive I&I Management Strategy to target sources of I&I in the catchment and strive to defer capacity-driven upgrades where possible. An Adaptive I&I Management Strategy will require coordinated efforts between City staff and dedicated annual funding. Guidance on how to approach the strategy and how the City can feasibly afford to do so is provided in the following section. In broad terms, the strategy will involve:

- Prioritizing sub-catchments for targeting I&I
- First, utilize operator knowledge of known locations of I&I; emphasis should be placed on rainfall-dependent inflows given its proportional share of the flow issue
- Second, utilize the ongoing data collection from flow monitoring locations (identified in Table 8 above) during rainfall periods
- Identifying sources of I&I then identifying possible reduction strategies
- Summarize the results of recent (if any) smoke testing, CCTV or inspection video that has identified sources of RDI&I
- Consider conducting RTK (a 3-parameter assessment based on variables, R = fraction of rainfall volume entering the sanitary sewer, T = time from the onset of rainfall to the peak flow, K = ratio of time to recession of the unit hydrograph from the time to peak.) method using the hydraulic model coupled with up-to-date flow data from the field to the sub-components to RDI&I such as rapid inflows which are sourced to roof leaders, cross connections from storm systems and manhole lids; intermediate inflow & infiltration which come from a variety of sources which are typically closely related to sources of infiltration such as connected foundation drains and can be more difficult to identify or fix; slow infiltration which typically comes from pipe and service connection defects.
- Using business cases to select, scope, and prioritize projects for I&I reduction
- Review and update rainfall gauge stations so that rainfall-dependent responses in the sanitary system can be assessed accurately
- Increase the priority/risk level for conditions ratings for sanitary pipes that are known to exhibit high levels of inflow or infiltration on account of pipe deterioration so that asset management continues to contribute towards capacity-based levels of service
- Condition-driven upgrades are typically strong candidates for pipe relining and other trenchless rehabilitation methods which lower the overall replacement cost

Strategically addressing I&I issues begins with understanding the general source of I&I in each sub-catchment (of which the RTK analysis results provide preliminary indications) and taking steps to prioritize the sub-catchments based on those with the most serious issues.

3.0 CAPITAL PLAN DEVELOPMENT

3.1 CAPITAL PLAN OVERVIEW

A Sanitary Sewer Master Plan incorporates multiple inputs and utility factors so as to identify new policies, programs or projects to maintain adequate levels of service into the future. Key elements of the implementation plan provided in Section 3.4 outline recommendations for programs such as extraneous flow management, financial considerations and tactics to further integrate asset renewal and capacity-driven level of service. Section 3.2 provides a list of improvement projects identified by the City that will alleviate deficiencies identified in the hydraulic analysis. Further to this Section 3.3 includes projects references that could be included is a development cost charge (DCC) capacity.

The combination of major capital projects, flow management programs and the overall implementation plan (Section 3.4) comprises the overall SMP.

Overall, the number of infrastructure upgrades and the scale of financial resources needs to be reviewed against City available resources in order to confirm project timing. The budgets noted in Table A represent Class D cost estimates based on the expected extents of the required upgrades.

3.2 CAPITAL PLAN

Projects selected for the SMP Capital Plan are determined based on the hydraulic capacity analysis which provided a projected likelihood of failure as well as a municipal drivers including:

- Operational improvements such as improved flow and reduced maintenance flushing;
- Feasibility of Construction such as avoiding construction in sensitive areas;
- Expansion of Service to areas previously underserviced by sewer;
- Future expected growth and increased density; and
- Asset renewal and risk mitigation.

Based on a combination of these factors each project is assigned to one of three categories ranked in terms of impact to the sanitary system: Primary Core projects, Secondary projects, and Tertiary projects.

Table A: Summary of Capital Projects – Sanitary Sewer Master Plan

Project Name	Timing	Justification / Benefit	Category	Budget
City Projects Related to Past System Performance Issues				
Puntledge Catchment Redirection (SEW 002)	*Short-term (Initiated 2021)*	A sewer crossing under the Puntledge River is no longer feasible combined with an under-capacity lift station requires an improved route to the East Courtenay Trunk Main that runs along with Hwy 19A bypass.	**Primary Core Project**	**$ 1,700,000**
1st Street Lift Station & Forcemain Upgrades (SEW 007)	*Short-term (Initiated 2021)*	Replacing the aging 1st Street Lift Station and Forcemain will improve capacity in the 1st Street catchment and meet asset management renewal requirements.	**Secondary Project**	**$2,500,000**
Mansfield Lift Station and Forcemain Upgrades	*Short-term*	Past and imminent growth in the Mansfield Lift Station catchment, coupled with new operational and pumping capacity data has accelerated the need for an upgrade to the lift station and forcemain.	**Primary Core Project**	**$1,800,000**
City Projects Related to Short-term Growth-Related System Performance Issues				
Cliffe Ave – Trunk Sewer (26th St. to 21st St.) (SEW 003)	*Short-term*	Rerouting of flows from the Riverway Trunk to the 20th St CVRD connection will allow for expanded capacity in South Courtenay.	**Primary Core Project**	**$ 2,300,000**
Cliffe Ave – Sewer Force Main (S. Courtenay to 26th St.) (SEW 004)	*Short-term*	A forcemain from South Courtenay to the Cliffe Ave Trunk Sewer connection at 26th St will bypass the under-capacity Mansfield Lift Station and forcemain.	**Primary Core Project**	**$2,000,000**

URBAN SYSTEMS

Project Name	Timing	Justification / Benefit	Category	Budget
Fitzgerald Ave – Trunk Sewer (4th St. to 21st St.) (SEW 005)	*Short-term*	A Trunk Main along Fitzgerald Ave will create a route for West Courtenay upper catchment flows to the 20th St CVRD Connection and allow capacity in the Riverway Trunk main allowing for expanded growth in West Courtenay.	**Primary Core Project**	**$3,900,000**
Arden Central – Trunk Sewer (Lake Trail Rd. to Cumberland Rd.) (SEW 006)	*Short-term*	A Trunk Main from Lake Trail Rd to Cumberland Rd will create capacity for growth in 13th St / Lake Trail Rd corridor and avoid costly upgrades along the Willemar Ave through the roundabout.	**Secondary Project**	**$800,000**

City Projects Related to Medium- to Long-Term Growth-Related System Performance Issues

Project Name	Timing	Justification / Benefit	Category	Budget
South Courtenay Area Servicing (SEW 011)	*Medium-term (Initiated 2021)*	Meeting commitments for an expanded level of service in the un-serviced portion of South Courtenay and allowing for growth in the area.	**Secondary Project**	**TBD**
North Courtenay Area Servicing (SEW 010)	*Medium-term*	Meeting commitments for an expanded level of service in the un-serviced portion of North Courtenay and allowing for growth in the area.	**Secondary Project**	**TBD**
Arden North – Trunk Sewer (Arden Rd. - 1st St. to Lake Trail Rd.) (SEW 012)	*Medium-term*	Improving capacity in the 1st St. catchment by re-routing upper catchment flows to the Arden Central trunk. Increased capacity at the 1st St. Lift Station could render this project redundant.	**Tertiary Project**	**$2,000,000**

Project Name	Timing	Justification / Benefit	Category	Budget
East Courtenay Lift Station & Forcemain (SEW 008)	*Medium-term*	Re-routing flows from NIC, Costco, Home Depot catchment to the Greenwood Trunk would allow capacity in the East Courtenay catchments that flow to the Courtenay Regional Sewer Pump Station.	**Tertiary Project**	**$2,100,000**
Veterans Memorial Pkwy Lift Station and Forcemain (SEW 009)	*Medium-term*	Re-routing flows from the expanding area in the hospital catchment to the Greenwood Trunk would allow capacity in the East Courtenay catchments that flow to the Courtenay Regional Sewer Pump Station.	**Tertiary Project**	**$1,600,000**

City Projects Related to Growth-Related System Performance Issues Already Underway

Greenwood – Trunk Sewer Extension (SEW 001)	*Short-term (Completed 2021)*	Population growth in East Courtenay requires expanded capacity via a new route to the Treatment Plant.	**Primary Core Project**	**$ 7,950,000**
Short and Medium Term Capital Projected Total (Excluding North and South Courtenay Servicing)				**$28,650,000**
Total Short Term				*$22,950,000*
Total Medium to Long Term				*$5,700,000*

The City of Courtenay's Sanitary Collection system has a replacement cost of $259M in 2019 dollars[6], using industry standard life cycle replacement data it is recommended that an annual $3.0M investment in the renewal of existing infrastructure be spent. Using alternate extended life scenarios where replacement is based on complete failure, not including Risk costs it would be $2.0M[7]. Based on the extensive asset inventory and using asset management principals it has been determined the Sanitary system has a $4.5M infrastructure deficit and as a whole has approximately 73% remaining life.

Asset deterioration is not a linear process and as such while the next 5 year investment plan for renewal projects is less than the average noted above this will need to be evaluated and updated every year as budgets are set in order to align with ongoing condition assessment work. Prioritizing capacity-based upgrades to align with condition priorities further reduces the overall burden on the utility.

3.3 DEVELOPMENT COST SHARE REVIEW

Development cost charges are permitted under BC legislation to enable local governments to collect levies at the development permit stage so that the costs for adding capacity for new customers from development can be collected and applied to a list of eligible projects. Courtenay recently updated the DCC bylaw as an interim step to a complete Bylaw overhaul. To facilitate any future bylaw updates, the list of proposed capital projects from the SMP was assessed for eligibility toward DCC collections. While most projects include new capacity for growth, only the projects that are *driven* by new growth and not existing deficiencies are included at this time. The projects with at least some potential for DCC eligibility and partial cost allocations are summarized in Table B. The DCC project costs will be required to be adjusted based on the timeframe and year of the DCC bylaw update, and/or projected project timing. The specific DCC portion and allocation can be also determined in conjunction with the updating of the DCC Bylaw.

[6] 2019 dollars are based on contracted projects over the last 5 years, the City may not have had obtained the best pricing available due budget cycles and Contract windows. (Reduced pricing may be possible through releasing RFP's beginning of the year or developing additional in-house resources) – Source: City of Courtenay.
[7] Higher risk changes end of life of asbestos cement pipe from 60 to 80 years, & PVC pipe from 100 to 120 years – Source: City of Courtenay

Table B: DCC-eligible projects and their proposed cost-sharing method

Project Name	Timing	Category	Cost Sharing Approach	Budget
Greenwood – Trunk Sewer Extension (SEW 001)	*Short-term (Completed 2021)*	**Primary Core Project**	*Completely Growth-Driven*	**$7,950,000**
Mansfield Lift Station and Forcemain Upgrades	*Short-term*	**Primary Core Project**	*Population-Ratio*	$**1,800,000**
Cliffe Ave – Trunk (26th St. to 21st St.) Sewer (SEW 003)	*Short-term*	**Primary Core Project**	*Population-Ratio*	**$2,300,000**
Cliffe Ave – Sewer (S. Courtenay to 26 St) Force Main (SEW 004)	*Short-term*	**Primary Core Project**	*Population-Ratio*	**$2,000,000**
Fitzgerald Ave – Trunk Sewer (SEW 005)	*Short- term*	**Primary Core Project**	*Population-Ratio*	**$3,900,000**
Arden Central – Trunk Sewer (SEW 006)	*Short-term*	**Secondary Project**	*Population-Ratio*	**$800,000**
1st Street Lift Station & Forcemain Upgrades (SEW 007)	*Short-term (Initiated 2021)*	**Secondary Project**	*Population-Ratio*	**$2,500,000**
East Courtenay Lift Station & Forcemain (SEW 008)	*Medium-term*	**Tertiary Project**	*Population-Ratio*	**$2,100,000**
Veterans Memorial Pkwy Lift Station and Forcemain (SEW 009)	*Medium-term*	**Tertiary Project**	*Population-Ratio*	**$1,600,000**
Arden North – Trunk Sewer (SEW 012)	*Medium-term*	**Tertiary Project**	*Population-Ratio*	**$2,000,000**
Total DCC-Eligible Projects				**$26,950,000**

3.4 IMPLEMENTATION PLAN AND RECOMMENDATIONS

The City of Courtenay Sanitary Sewer Master Plan funding strategy and implementation plan includes the following recommendations:

- **Phase in priority projects based on their projected likelihood of failure and capacity performance score, and recommended order in this plan, in tandem with other municipal drivers for capital planning.** Modelling scenarios at 2019, 2024 and 2039 allow for assessment of each pipe and lift station to accommodate the projected flows. Recommended projects are categorized into Primary, Secondary, Tertiary based on relative necessity and overall benefit to the system. Table A summarizes the projects.
- **Develop an infrastructure risk evaluation matrix for evaluation of future sewer projects. The Matrix should include both risk and consequence evaluation criteria for prioritizing potential projects.**
- Financial and design preparations should begin in the next budget year to ensure adequate resources exist for the works required over the next 20 years but in particular for the upcoming five-year planning horizon. Consideration to reserve building in addition to borrowing should begin in the next budget year to prepare the utility for both capacity-based projects and asset renewal.
- **Update the Development Cost Charges (DCC) bylaw for the eligible projects.** This Sewer Master Plan identifies nine (9) DCC-eligible growth-driven projects. Municipalities are advised to update their DCC bylaw when better information is available and also to be mindful that comprehensive updates (i.e., having the outcomes from most technical service areas) can provide for administrative efficiencies. An update to the DCC Bylaw is scheduled and the results from this study can be incorporated following additional analysis (e.g., planning considerations such as growth projections and development equivalencies) alongside City staff. Normally a DCC program includes the full 20-year plan and so as part of the update it is recommended that the full 20-year time period be considered and additional projects be added as appropriate. Table B summarizes the DCC-eligible projects.
- **Identify sources of inflow and infiltration (I&I) over the next five years and then use business case analyses to determine the feasibility of rehabilitation projects to reduce inflow and infiltration.**
- **Conduct and to coordinate, on an ongoing basis with CVRD (Comox Valley Regional District), select initiatives including regular meetings to improve data quality and information sharing at major facilities e.g., regional pump station.**
- **Continue to consult with K'omoks First Nation (KFN) to support the servicing agreements in place among participating governments.** The sewer hydraulic

model and recommended capital plan incorporates new flows from KFN in the next 20 years.

- **Integrate this plan with the City's long term flood protection strategy to ensure critical infrastructure is adequately protected.**
- **Integrate this plan with condition-based assessments being completed as part of the City's asset management program as well as concurrent planning for other City infrastructure**, such as roads and all other buried utilities.

A

MODEL DEVELOPMENT CALIBRATION AND CAPACITY ANALYSIS

City of Courtenay Sanitary Sewer Collection System Model Development, Calibration, and Capacity Analysis

Report

Prepared for:
City of Courtenay
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Submission Date: April 22, 2020

Contact: Mr. Werner de Schaetzen, Ph.D., P.Eng.
Project ID: 2019-051-COU

Document History and Version Control

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R0	November 1, 2019	Draft	Adrien d'Andrade	Werner de Schaetzen
R1	November 20, 2019	Updated Draft	Adrien d'Andrade	Werner de Schaetzen
R2	January 8, 2020	Updated Draft	Adrien d'Andrade	Werner de Schaetzen
R3	April 22, 2020	Final	Adrien d'Andrade	Werner de Schaetzen

Table of Contents

1.0 Introduction

GeoAdvice Engineering Inc. (GeoAdvice) was retained by the City of Courtenay, BC (City) to build a hydraulic model of the City's sanitary sewer collection system and use the model to analyze the capacity of the system.

This report describes the methodology, assumptions and results of the hydraulic model development, calibration, capacity analysis, and system improvement recommendations.

The sewer model was built using the InfoSWMM software program (Innovyze). InfoSWMM is a sanitary sewer system modeling and management software application.

In the preparation of this report, GeoAdvice would like to acknowledge the support of the following City Staff:

- Mr. Rod Armstrong
- Mr. Chris Thompson
- Ms. Julia Machin

2.0 Model Development

The hydraulic network model build was divided into multiple tasks as follows:

- Task 1: Data collection and review
- Task 2: Model development
- Task 3: Data gaps and connectivity analysis
- Task 4: Primary system components
- Task 5: Node elevation extraction
- Task 6: Existing base sanitary flow (BSF) calculation and allocation
- Task 7: Field data review and analysis
- Task 8: Inflow & infiltration

2.1 Data Collection and Review

Prior to developing the model, information on the City sanitary sewer system was compiled, collected and reviewed. This included reviewing the following pertinent information:

- Previous InfoSewer hydraulic model
- Updated GIS database
- Lift station operation
- Flow monitoring and rainfall data
- Land-use and zoning maps
- As-built drawings
- Population growth projections
- Development application reviews
- Planned future infrastructure

2.2 Model Development

The City's GIS data was the primary source of up-to-date information on the system to build the pipe and node network topology model. Attributes of the sewer mains, such as nominal diameter, material and age were extracted from the GIS database. Nominal diameters were used to build the model. The coordinate system used in the model is UTM NAD 83 Zone 10.

2.3 Data Gaps and Connectivity Analysis

The next task involved reviewing the GIS sanitary sewer data, identifying data gaps (e.g. missing diameter, material, invert etc.) and checking system connectivity (e.g. orphan node). All data gaps and connectivity issues were addressed and resolved as part of this task. GeoAdvice worked together with the City to create a one-to-one relationship between the model and GIS data to facilitate future model updates.

2.4 Primary System Components

The City operates and maintains nine (9) sanitary lift stations throughout the sanitary network. **Table 2.1** and **Table 2.2** summarize the pump and wet well hydraulic modeling data, respectively.

Table 2.1: Pump Hydraulic Modeling Data

Lift Station Name	Model ID	Firm Capacity* (L/s)	Pump On Level** (m)	Pump Off Level (m)
1st Street	PMP-1STSTREET-1	16.4	1.02	0.39
	PMP-1STSTREET-2		1.17	0.39
Anderton	PMP-ANDERTON-1	21.6	1.12	0.50
	PMP-ANDERTON-2		1.38	0.50
Cascara	PMP-CASCARA-1	1.0	0.75	0.55
	PMP-CASCARA-2		1.25	0.55
Klanawa	PMP-KLANAWA-1	7.8	1.29	0.67
	PMP-KLANAWA-2		1.79	0.67
Majestic	PMP-MAJESTIC-1	10.9	1.00	0.38
	PMP-MAJESTIC-2		1.50	0.38
Mansfield	PMP-MANSFIELD-1	22.7	1.00	0.70
	PMP-MANSFIELD-2		1.50	0.70
Mission Road	PMP-MISSIONRD-1	12.4	1.29	0.67
	PMP-MISSIONRD-2		1.79	0.67
Puntledge	PMP-PUNTLEDGE-1	23.8	0.84	0.48
	PMP-PUNTLEDGE-2		1.34	0.48
Sandpiper	PMP-SANDPIPER-1	24.8	0.95	0.40
	PMP-SANDPIPER-2		1.45	0.40

***Firm capacity based on the calculated lift station flows provided by the City on July 19, 2019.**
****Lag pump on level was assumed to be 0.5 m above the lead pump on level unless further information was available.**

Table 2.2: Wet Well Hydraulic Modeling Data

Lift Station Name	Model ID	Dimensions	Bottom Elevation (m)	Volume Between Lead Pump On/Off Level (m^3)
1st Street	WW-1STSTREET	1.69 m x 3.46 m	9.10	3.69
Anderton	WW-ANDERTON	1.71 m x 3.48 m	-2.89	3.69
Cascara	WW-CASCARA	Ø 1.50 m	82.86	0.35
Klanawa	WW-KLANAWA	3.05 m x 3.05 m	53.09	5.76
Majestic	WW-MAJESTIC	Ø 1.80 m	71.57	1.57
Mansfield	WW-MANSFIELD	2.44 m x 2.44 m	-0.37	1.78
Mission Road	WW-MISSIONRD	Ø 1.83 m	41.56	1.63
Puntledge	WW-SANDPIPER	2.44 m x 1.52 m	-1.67	1.34
Sandpiper	WW-1STSTREET	Ø 2.44 m	0.16	2.57

There is one critical flow split in the City's network with a diversion structure at Old Island Highway and Puntledge Road. The weir diversion was modeled as per as-built drawings provided by the City. Based on the diversion structure set-up, approximately 1/3 of the incoming flow is diverted towards the Anderton Lift Station, while the remainder is directed to the Comox Road trunk main. The location of the diversion structure is shown in **Figure 2.2**.

2.5 Node Elevation Extraction

The City's GIS data was the primary source of up-to-date information for the manhole rim elevations. Manhole rim elevations provided in the City's GIS were primarily obtained using GPS, with some supplemented using LIDAR data. For those elevations not provided by the City, a Digital Elevation Model (DEM) was used to determine missing node elevations. Ground elevations were assigned to the nodes in the model, where elevation data was missing. The DEM was also used to validate node elevations in the model.

2.6 Existing Base Sanitary Flow (BSF) Calculation and Allocation

The next step was to import sewer loads into the model. Existing base sanitary flows (BSF) were determined on a per parcel basis using estimated parcel population, 2018 water meter records, and 2018 bulk water consumption data.

Sewer loads were estimated from water demands using conversion rates for each load type. These conversion rates were initially derived from past experience with other B.C. municipalities and then further adjusted during the calibration process.

Table 2.3 summarizes the existing BSF loading.

Table 2.3: Calibrated Existing BSF Load Summary

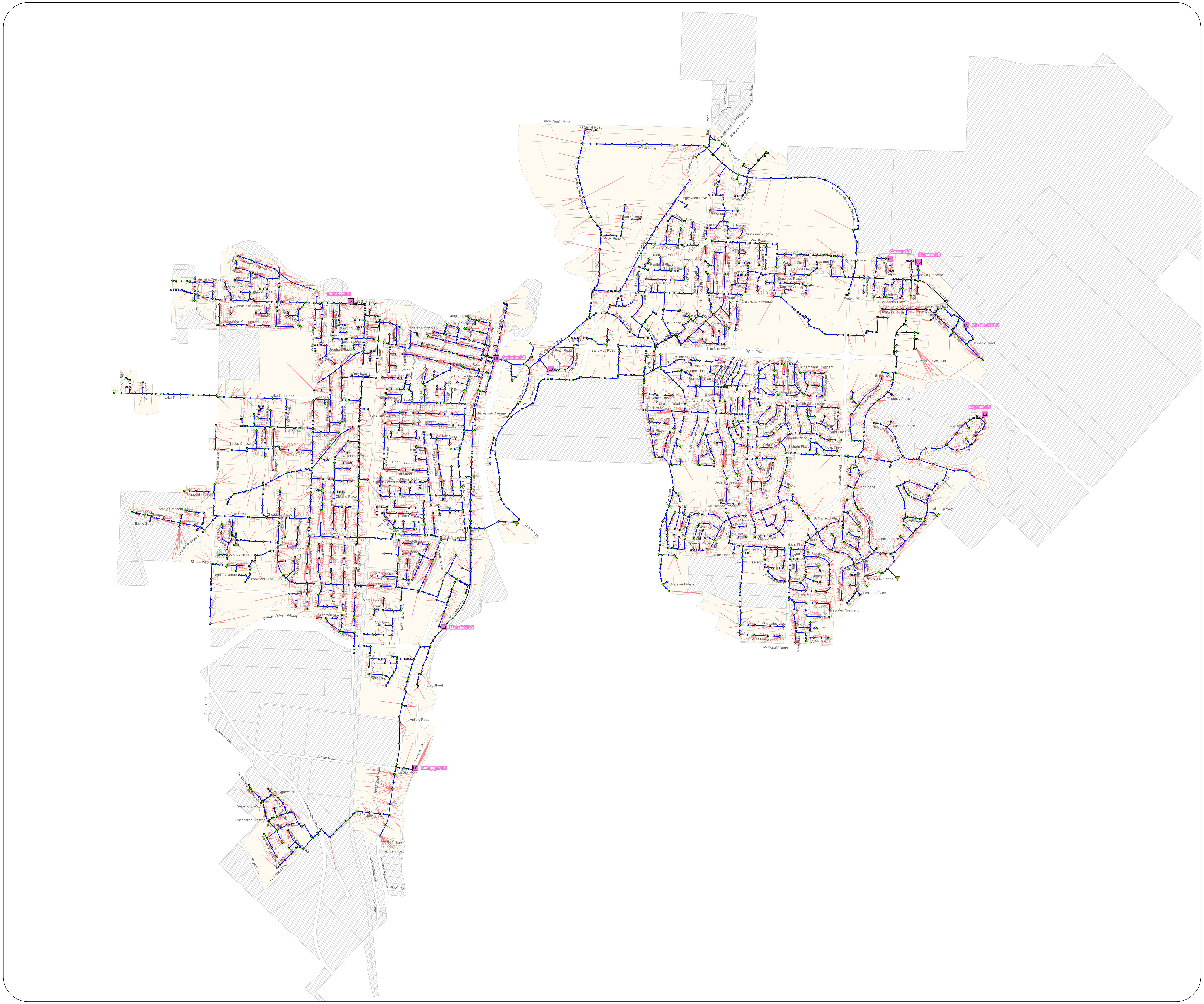
Land Use	Estimated Sewer Serviced Population*	Water Consumption (L/s)	Conversion Rate (%)	Base Sanitary Flow (L/s)
Single Family	23,697	108.4	42%	45.5
Multi-Family	4,155	13.6	56%	7.6
Institutional		5.9	50%	3.0
Commercial		24.0	50%	12.0
Industrial		0.7	50%	0.4
Agricultural		0.0	50%	0.0
Total	**27,852**	**152.7**		**68.5**

***Sewer serviced area was determined to be less than the water serviced area. As such, the sewer serviced population (27,852) is smaller than the water serviced population (28,049).**

Note that in order to get a good match between the observed data at the flow monitors and the model results, the residential conversion rates were separated between metered and unmetered users. For unmetered users, the conversion rate determined during calibration is lower than metered users, as it was assumed that there would be more irrigation demands that would not be converted into sewer loads. Based on the calibrated sewer loads, the metered residential BSF rate is 167 L/cap/day and the unmetered residential BSF rate is 164 L/cap/day.

The next step was the allocation of sewer loads in the model. This step consisted of initially spatially allocating loads using the “Closest Pipe – Upstream Manhole” method. The spatial allocation was then verified against the service lines provided in the City’s GIS and updated to ensure that loads were being directed along the correct flow path. **Figure 2.1** shows the existing serviced parcels and their modeled load allocation.

Diurnal patterns were used to characterize the BSF loads over time and include multipliers or peaking factors (e.g. 24 multipliers) that are applied to the BSF load to estimate the actual load for a given time period (e.g. 1 hour). A 24-hour extended period simulation (EPS) was set up for evaluating the hydraulic capacity of the City sewer system over time. The modeled diurnal patterns can be found in **Appendix A**.



GeoAdvice Engineering Inc.

Legend

- Not Sewer Serviced
- Sewer Serviced
- Sewer Load Allocation
- Outfall
- Lift Station
- Manhole
- Gravity Main
- Forcemain

Existing Load Allocation

COURTENAY 1915 2015

Project: **Sewer Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **April 2020**
Created by: **Ad'A**
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 0.5 1 2
Kilometers

Figure 2.1

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2.7 Field Data Review and Analysis

Field data from twelve (12) flow monitoring sites were provided by the City. **Table 2.4** lists the flow monitoring locations. The flow monitoring locations and corresponding catchments are shown in **Figure 2.2**.

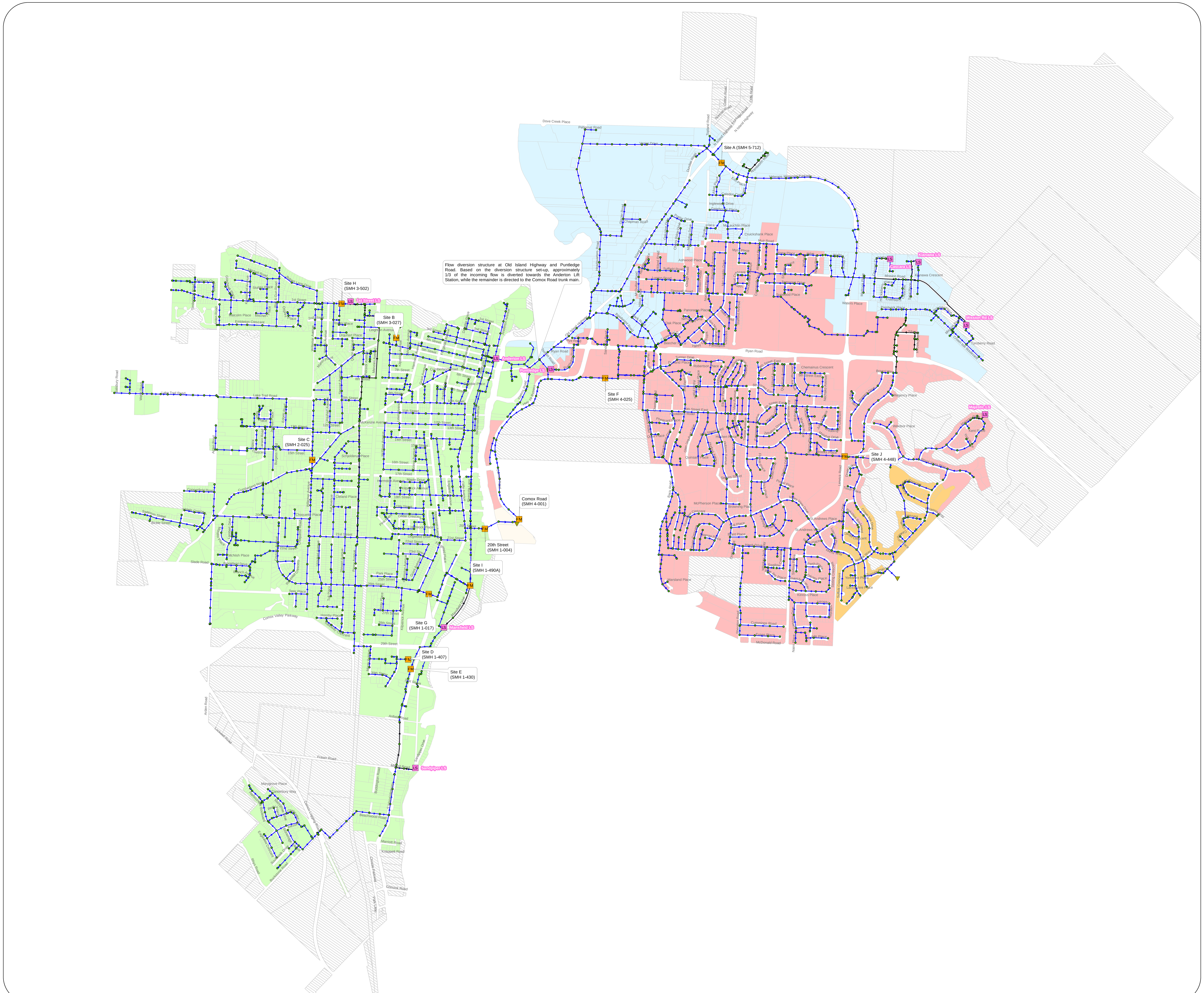
Table 2.4: Flow Monitor Locations

Flow Monitoring Site	Manhole ID
Comox Road Flodar	4-001
20th Street Flodar	1-004
Site A	5-712
Site B	3-027
Site C	2-025
Site D	1-407
Site E	1-430
Site F	4-025
Site G	1-017
Site H	3-502
Site I	1-490A
Site J	4-448

The two (2) flodar sites at Comox Road and 20th Street are permanent monitors that collect the majority of the flow from east Courtenay and west Courtenay, respectively. The remaining sites were installed with temporary monitors in August 2019. The permanent monitors were used for the purposes of dry weather flow calibration and inflow & infiltration calculations, and the temporary monitors were used as a validation.

The only area not captured by the Comox Road and 20th Street flodars is the Hudson Trunk catchment. This catchment is monitored by the Comox Valley Regional District (CVRD).

Field data from the flow monitoring locations were used to determine dry weather flows and estimate inflow & infiltration loads.



GeoAdvice Engineering Inc.

Legend

- Not Sewer Serviced
- Sewer Serviced
- Outfall
- Lift Station
- Manhole
- Gravity Main
- Forcemain
- Flow Monitoring Site

Flow Monitoring Catchment

- 20th Street Flodar Catchment
- Comox Road Flodar Catchment
- Split Catchment
- Hudson Trunk Catchment

Flow Monitoring Sites and Catchments

COURTENAY 1915 2015

Project: **Sewer Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **April 2020**
Created by: **Ad'A**
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 0.5 1 2
Kilometers

Figure 2.2

Document Path: W:\2019-051-COU\02\Mapping\2019-051-COU_F22_FlowMonitoringSites.mxd

2.8 Inflow & Infiltration Allocation

Inflow and Infiltration (I&I) represent additional loading on the sanitary sewer system during dry and wet weather. They are categorized into the following:

- Ground Water Infiltration (GWI)
- Rainfall Dependent Inflow and Infiltration (RDI&I)

Since only the Comox Road Flodar and 20th Street Flodar monitoring sites have been monitoring over an extended duration, GWI and RDI&I were only calculated at these two sites. This provides I&I estimates for east and west Courtenay independently.

2.8.1. Ground Water Infiltration

In order to perform the average dry weather flow (ADWF) calibration, GWI loads were calculated for each catchment. The rates used to convert minimum nightly flow (MNF) to GWI are standard values, derived from typical system performance in B.C. The GWI contribution was estimated for each flow monitoring catchment as follow:

- 80% of the minimum nightly flow (MNF) from residential areas during a period free from RDI&I influence (typically after five dry days with no rainfall); and
- 50% of the MNF from industrial, commercial and institutional (ICI) areas during a period free from RDI&I influence (typically after five dry days with no rainfall).

Based on the model calibration, the conversion factors were adjusted to 70% and 40% for residential areas and ICI areas, respectively.

Table 2.5 summarizes the GWI allocated to each sanitary catchment.

Table 2.5: GWI Allocation per Flow Monitoring Catchment

Flow Monitoring Catchment	MNF (L/s)	GWI Conversion Rate	GWI (L/s)	Catchment Area (ha)	GWI (L/ha/day)
Comox Road	23.9	63%	15.1	713.6	1,800
20th Street	20.9	62%	13.0	788.6	1,400

Note that the catchment upstream of the diversion structure at Old Island Highway and Puntledge Road contributes flow to both catchments. As such, an area weighted average GWI of 1,700 L/ha/day was applied to this catchment.

2.8.2. Rainfall Dependent Inflow and Infiltration

The City model uses area-based RDI&I rates to represent the rainfall dependent I&I. The "Envelope Method" was used to quantify the RDI&I.

For this study, under existing and future load conditions, the modeling analysis will use a 5-year return period I&I (24-hour storm) for capacity assessments. A 25-year return period I&I (1-hour storm) was also determined using the "Envelope Method"; however, was not used as part of this current study.

The "Envelope Method" is a graphical analysis method that involves plotting rainfall against RDI&I to develop a relationship between the two parameters. A line representing the best fit of the measured RDI&I response vs. corresponding rainfall amount is first drawn on the graph. The RDI&I design flow is determined by intersecting the line of best fit with the corresponding design rainfall amount.

By analyzing flows from the Comox Road Flodar and 20th Street Flodar monitoring sites in conjunction with the rainfall data from the Airport (Comox) Elementary and Courtenay Elementary raingages, thirteen (13) and sixteen (16) storm events were identified, respectively. Intensity-duration-frequency (IDF) curves were determined using the IDF-CC tool (https://www.idf-cc-uwo.ca/) for the nearby Comox Airport rain gauge.

Table 2.6: Design Storm Rainfall (Comox Airport IDF Curves)

Design Storm	Rainfall Intensity (mm/hr)
5-year 24-hour	3.1
25-year 1-hour	19.4

Graphical representations of the RDI&I envelopes are shown in **Figure 2.3** to **Figure 2.6**.

Figure 2.3: Comox Road Flodar 5-year 24-hour RDI&I Envelope

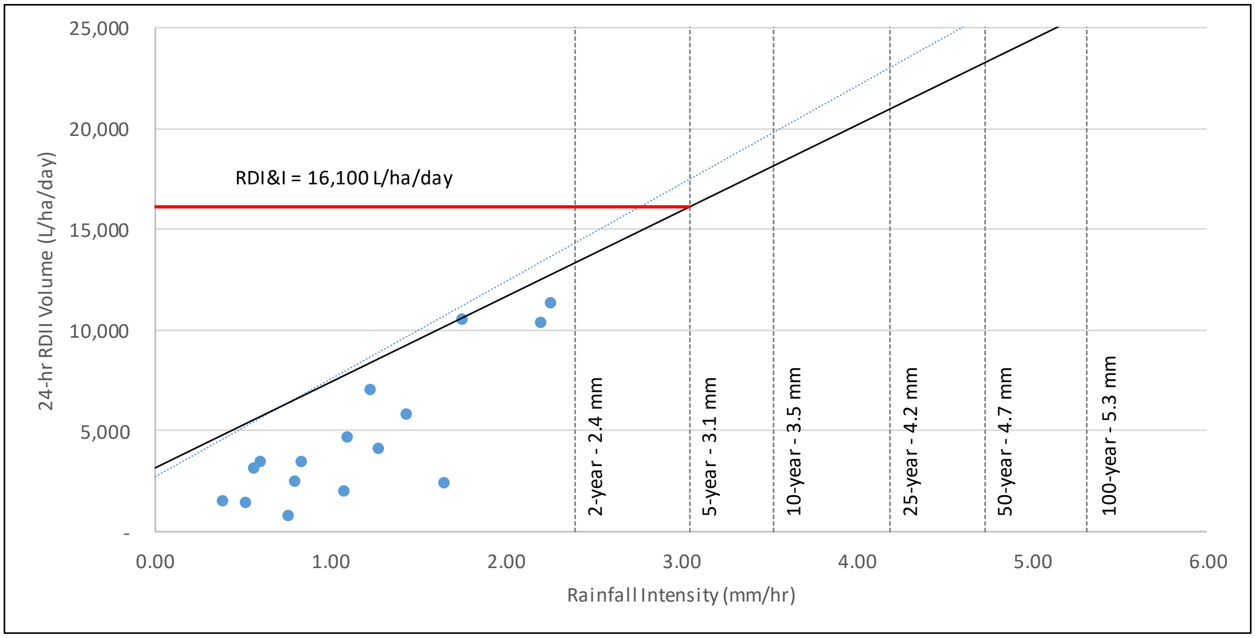


Figure 2.4: Comox Road Flodar 25-year 1-hour RDI&I Envelope

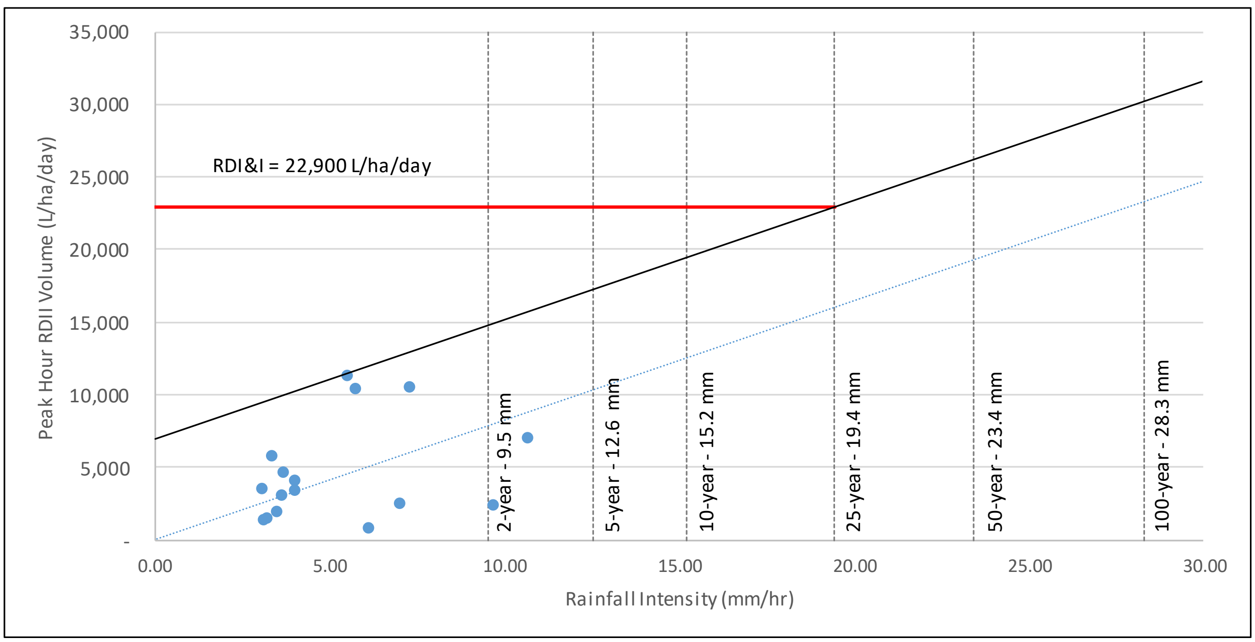


Figure 2.5: 20th Street Flodar 5-year 24-hour RDI&I Envelope

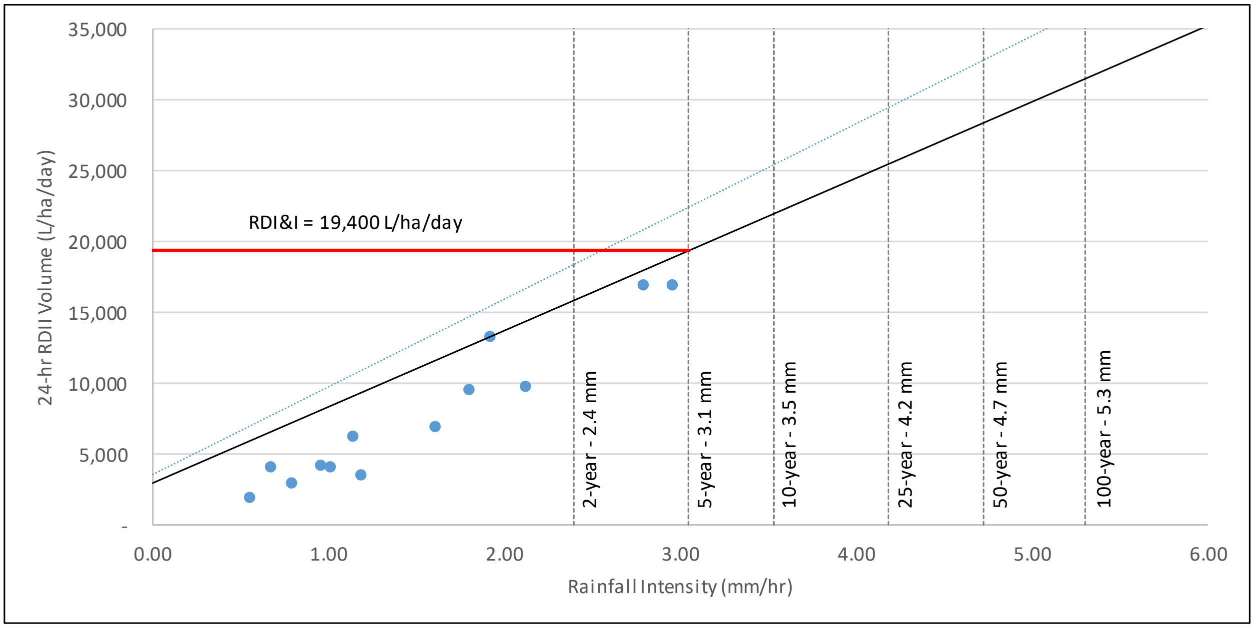
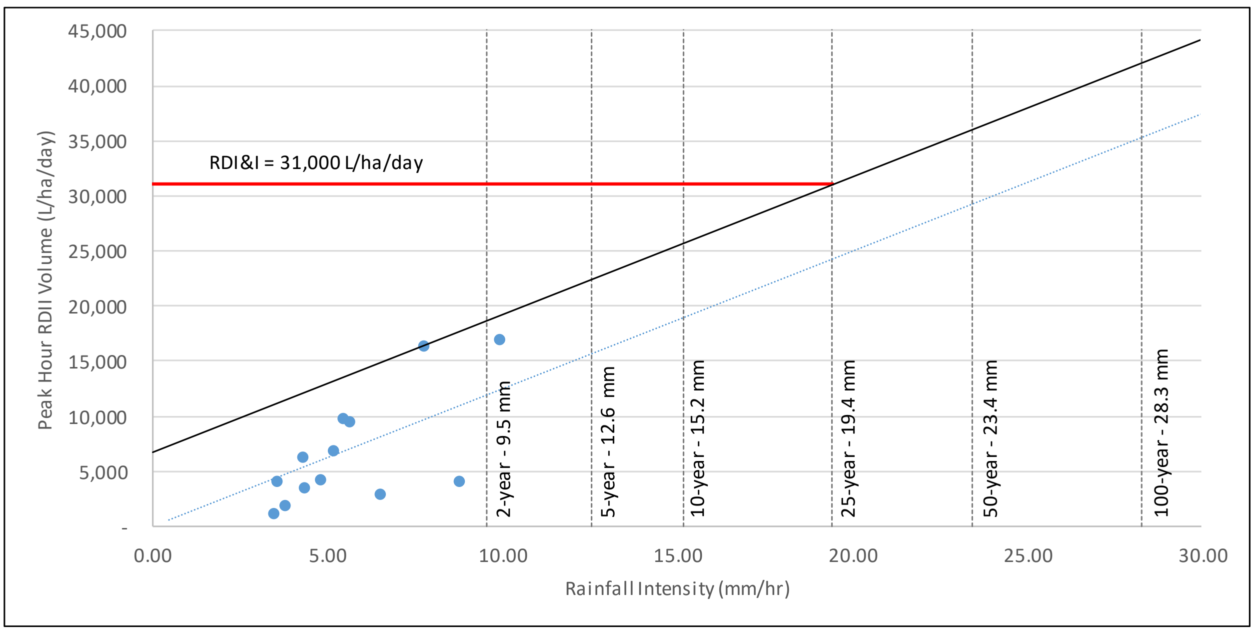


Figure 2.6: 20th Street Flodar 25-year 1-hour RDI&I Envelope



The design RDI&I rates as calculated by the "Envelope Method" are summarized in **Table 2.7**.

Table 2.7: Design RDI&I Rates (Envelope Method)

Flow Monitoring Catchment	5-Year 24-hour RDI&I Rate (L/ha/day)	25-Year 1-hour RDI&I Rate (L/ha/day)
Comox Road	16,100	22,900
20th Street	19,400	31,000

The design I&I rates are the sum of the GWI and I&I for each catchment, and are summarized in **Table 2.8**.

Table 2.8: Design I&I Rates (Envelope Method)

Flow Monitoring Catchment	5-Year 24-hour I&I Rate (L/ha/day)	25-Year 1-hour I&I Rate (L/ha/day)
Comox Road	17,900	24,700
20th Street	20,800	32,400

Again, note that the catchment upstream of the diversion structure at Old Island Highway and Puntledge Road contributes flow to both catchments. As such, an area weighted average 5-year 24-hour I&I rate of 18,900 L/ha/day, and a 25-year 1-hour I&I rate of 27,300 L/ha/day were applied to this catchment.

Based on discussions with the City, it was determined that a scenario for sizing new infrastructure would be developed using the 5-year 24-hour I&I rate, accounting for the impacts of climate change. The report *Climate Projections for Metro Vancouver (June 2016)* predicts the wettest single day of the year will see 17% more rain by the 2050s. To account for climate change in the model, RDI&I rates were increased by 17%. The modeled climate change I&I rates are shown in **Table 2.9**.

Table 2.9: Design I&I Rates with 17% Climate Change

Flow Monitoring Catchment	5-Year 24-hour I&I Rate (L/ha/day)
Comox Road	20,700
20th Street	24,100

Note that the climate change I&I rates are only used for sizing new infrastructure.

3.0 Model Calibration

Before describing how the model was calibrated, it is useful to examine why a hydraulic model may not match the field data. Most of the sources of errors or mismatches are:

- Input data errors
- System loading errors
- Operational control errors
- Poorly calibrated measuring equipment
- Outdated data

The cumulative effect of these areas of uncertainty or "approximation" is that, without verification and validation of the model's ability to recreate known conditions, it is likely that the modeling results would be grossly misleading.

The main reasons for and benefits of a well calibrated model are listed below:

- Confidence: Demonstrate the model's ability to reproduce existing conditions.
- Understanding: Confirm the understanding of the performance of the system.
- Troubleshooting: Uncover missing information and misinformation or anomalies about the system.

3.1 Dry Weather Flow Calibration Results

Modeling results were first reviewed, and then key modeling parameters were adjusted until the model results closely matched the field results. A summary of the calibration changes is shown in **Table 3.1**.

Table 3.1: Calibration Adjustments

Parameter	Adjustment
GWI	MNF conversion rate of 70 % for residential areas MNF conversion rate of 40 % for ICI areas
BSF	Adjusted water consumption to sanitary load conversion for all load types (see **Table 2.3**)
Pattern	Calibrated diurnal patterns (see **Appendix A**)

Figure 3.1 and **Figure 3.2** show the dry weather flow calibration hydrographs at the Comox Road and 20th Street flow monitors, respectively.

Figure 3.1: Comox Road Flodar Dry Weather Flow Calibration Hydrograph

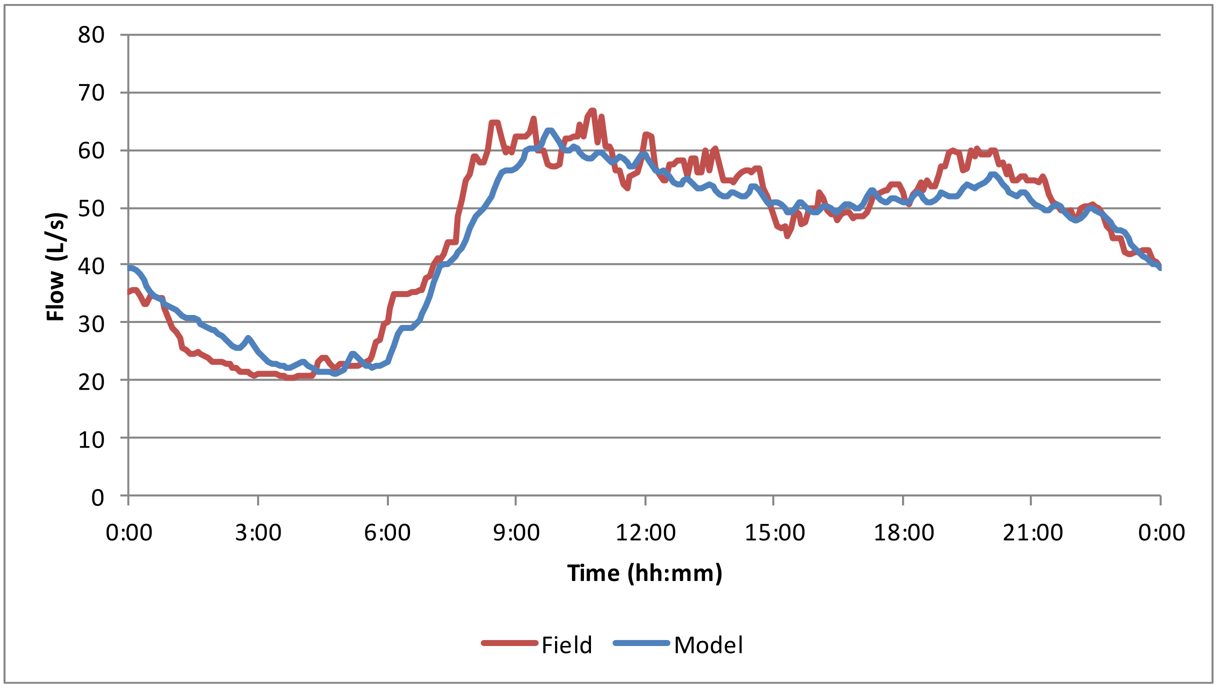


Figure 3.2: 20th Street Flodar Dry Weather Flow Calibration Hydrograph

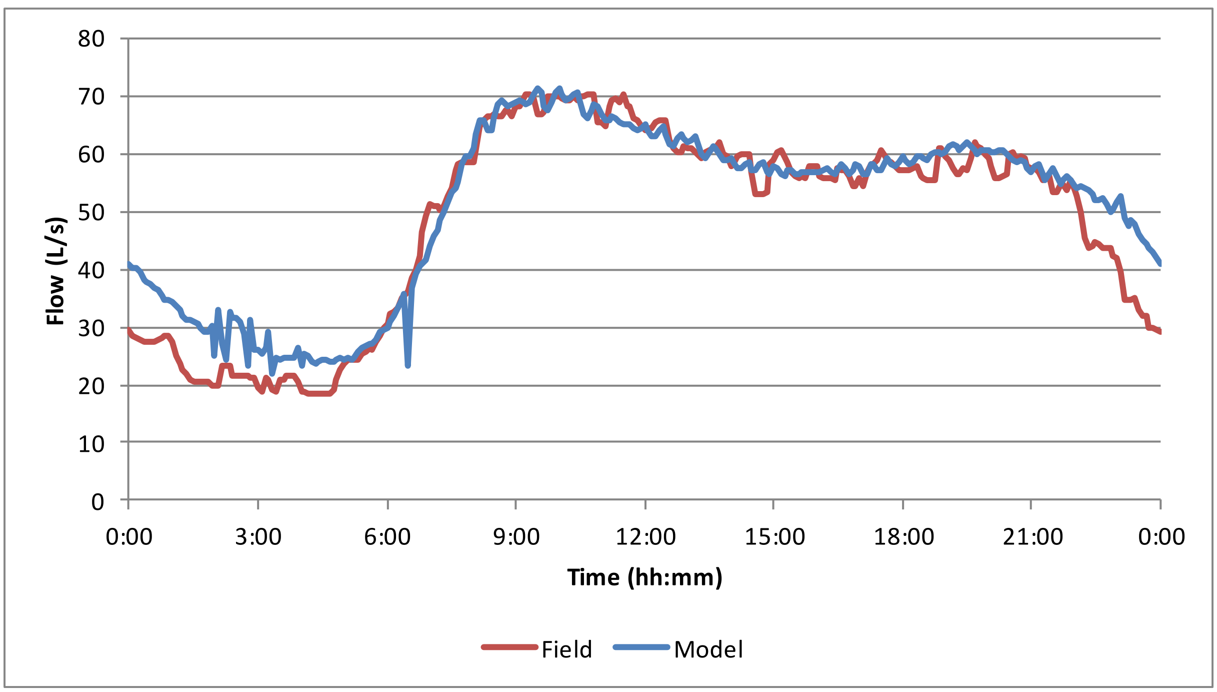


Table 3.2 summarizes the dry weather flow calibration results.

Table 3.2: Dry Weather Flow Calibration Results Summary

Flow Monitoring Catchment	Average Difference	Peak Flow Difference	Time to Peak Difference	Shape Agreement	Overall Agreement
Comox Road	- 1.2 L/s (- 3%)	+ 1.0 L/s (+ 1%)	<1 hr	Excellent	Excellent
20th Street	+ 2.4 L/s (+ 5%)	- 3.5 L/s (- 5%)	<2 hrs	Excellent	Excellent

Overall the calibrated model shows an excellent agreement with the observed dry weather field data at the 2 permanent flow monitoring sites. Validation graphs for the ten (10) temporary flow monitors can be found in **Appendix B**.

4.0 Future Scenario Development

4.1 Future Population and Load Growth

This study considered population for the 5-year and 20-year growth outlooks. In consultation with the City, anticipated development population was collated with the City's projected population growth over the next five years and over the next twenty years to develop the two future modeling scenarios. **Table 4.1** provides a summary of the scenarios to be modeled.

Table 4.1: Summary of Modeling Scenarios

Scenario	Serviced Population	Description
2019	Existing (27,852)	Identify existing system deficiencies.
2024	Existing (27,852) + 5-Year Growth (+ 7,004)	Identify timing of upgrades.
2039	Existing (27,852) + 20-Year Growth (+ 9,623)	Identify future system deficiencies. Size all upgrades for 20-year growth flows.

4.1.1. Development Applications

Recent development applications were reviewed to determine the population and load growth associated with specific development applications. The total population growth projected for specific development applications is summarized in **Table 4.2**.

Table 4.2: Population Growth – Development Applications

Growth Type	Population Growth		Area Growth	
	5-Year	20-Year*	5-Year	20-Year*
Development Applications	+ 2,580	+ 2,830	+ 2.4 ha	+ 2.4 ha

***The 20-Year population growth is inclusive of the 5-Year population growth.**

A complete list of the development applications is outlined in **Appendix C**, including the population growth for each development application and the allocation manhole ID.

4.1.2. Other Specific Development Areas

In addition to the development applications, the City also provided other specific anticipated development areas, as summarized in **Table 4.3**.

Table 4.3: Population Growth – Other Specific Development Areas

Development Area	Manhole ID	Population Growth		Area Growth (ha)	
		5-Year	20-Year*	5-Year	20-Year*
Copperfield	SFIT0027	+ 0	+ 387	+ 0.0	+ 26.8
Buckstone	SCO0012 SFIT0046 6-119	+ 439	+ 439	+ 28.1	+ 28.1
South Courtenay	6-201	+ 0	+ 313	+ 0.0	+ 15.3
North Sandwick	FUT-SMH-032	+ 0	+ 54	+ 0.0	+ 46.8
Crown Isle Greenwood	7-179	+ 500	+ 1,200	+ 20.1	+ 48.3
Crown Isle South of Ryan	FUT-SMH-001	+ 0	+ 500	+ 0.0	+ 42.1
Lannan Property	4-1098	+ 500	+ 500	+ 16.3	+ 16.3
North Island College	5-319	+ 600	+ 600	+ 0.0	+ 0.0
3200 Majestic Dr	4-510	+ 200	+ 200	+ 6.8	+ 6.8
1900 Ryan Rd	5-250	+ 0	+ 200	+ 0.0	+ 0.0
2600 Mission Rd	5-411	+ 100	+ 100	+ 0.0	+ 0.0
2700 Mission Rd	5-401	+ 0	+ 100	+ 0.0	+ 0.0
3000 Mission Rd	5-433D	+ 0	+ 40	+ 0.0	+ 0.0
3300 Mission Rd	5-432	+ 85	+ 85	+ 0.0	+ 0.0
3301 Mission Rd	5-432	+ 0	+ 75	+ 0.0	+ 0.0
595 Silverdale Cres	7-178	+ 300	+ 300	+ 0.0	+ 0.0
	Total	**+ 2,724**	**+ 5,093**	**+ 71.3**	**+ 230.6**

***The 20-Year population growth is inclusive of the 5-Year population growth.**

4.1.3. Other Non-Specific Development Areas

Finally, the City also provided additional anticipated growth at specific points in the sanitary sewer collection system that are not yet associated with a specific development. This population growth is summarized in **Table 4.4**.

Table 4.4: Population Growth – Other Non-Specific Development Areas

Manhole ID	Population Growth	
	5-Year	20-Year*
2-571	+ 300	+ 300
3-686A	+ 100	+ 100
3-274	+ 150	+ 150
3-130	+ 150	+ 150
3-007	+ 200	+ 200
5-710B	+ 150	+ 150
5-440	+ 150	+ 150
4-459	+ 500	+ 500
Total	**+ 1,700**	**+ 1,700**

***The 20-Year population growth is inclusive of the 5-Year population growth.**

Table 4.5 summarizes the total population growth projected over the next 5 and 20 years.

Table 4.5: Total Projected Population Growth

Scenario	Population Growth
5-Year Outlook	+ 7,004
20-Year Outlook*	+ 9,623

***The 20-Year population growth is inclusive of the 5-Year population growth.**

The unit load rates summarized in **Table 4.6** were used to determine loads associated with future growth. The rates are based on the City of Courtenay Subdivision and Development Servicing Bylaw No. 2919.

Table 4.6: City of Courtenay Design Load Rates

Parameter	Unit Load Rate
BSF	360 L/cap/day
I&I	0.12 L/s/ha (10,368 L/ha/day)

Generally, existing loads and their spatial allocation were carried forward through all future scenarios; however, where specific redevelopment growth was projected, the existing loads were overwritten.

Table 4.7 shows the existing and future load data.

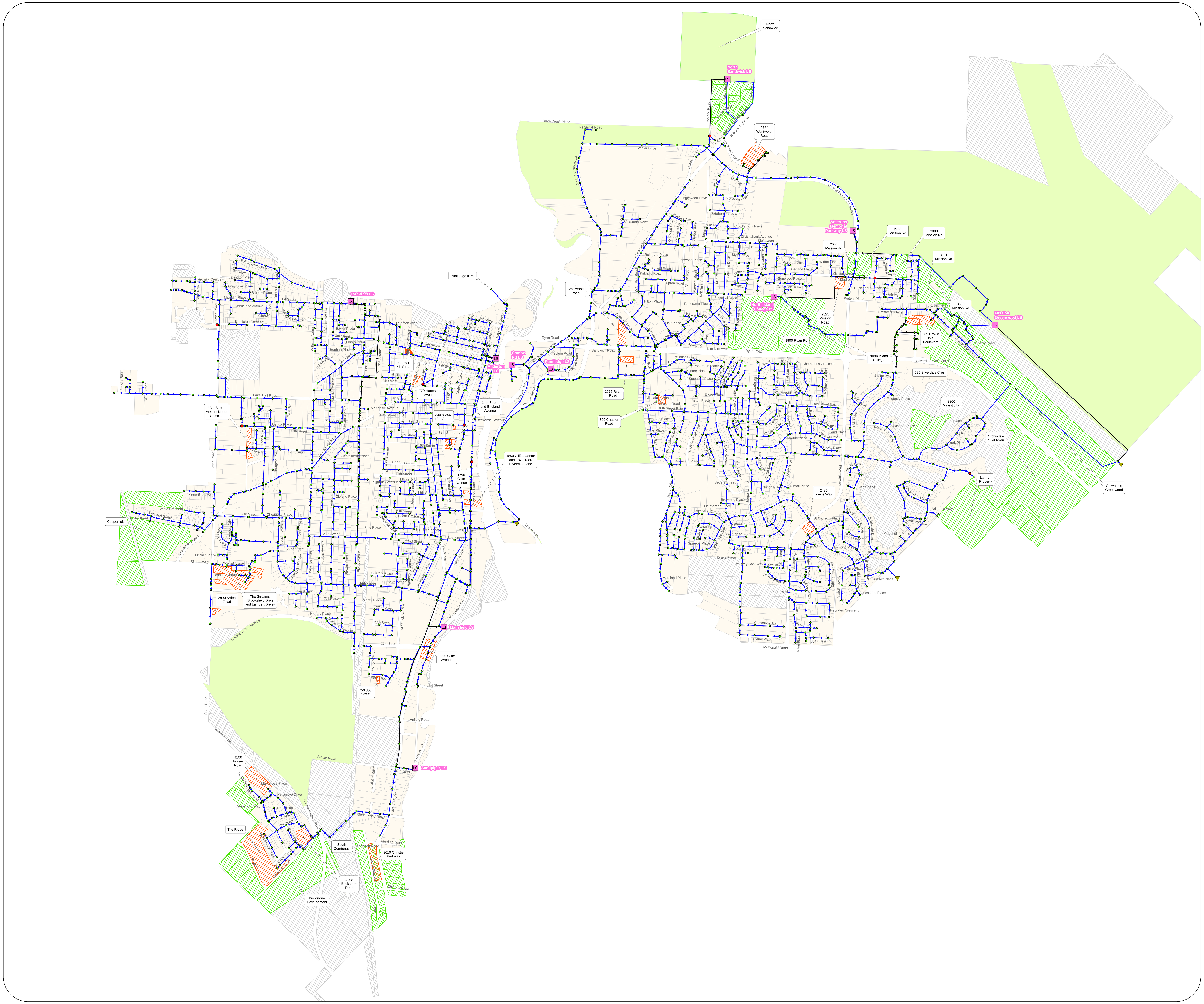
Table 4.7: Existing and Future Load Summary

Scenario	Existing Load	Growth Load	
		5-Year	20-Year*
BSF	68 L/s	+ 34 L/s	+ 51 L/s
5-yr 24-hr I&I	347 L/s	+ 10 L/s	+ 30 L/s
5-yr 24-hr AWWF	**415 L/s**	**+ 44 L/s**	**+ 81 L/s**

***20-year loads include 5-year loads.**

The growth population data and allocation are shown in **Figure 4.1**.

In modeling the wet weather flow scenarios, the BSF loads were factored with temporal patterns while the I&I loads remained constant throughout the simulations. Patterns were used to characterize the BSF loads over time and include multipliers or peaking factors (e.g. 24 multipliers) that are applied to the BSF load to estimate the actual load for a given time period (e.g. 1 hour). A 24-hour extended period simulation (EPS) was set up for evaluating the hydraulic capacity of the City sewer system over time.



GeoAdvice Engineering Inc.

Legend

- Not Sewer Serviced
- Sewer Serviced
- Outfall
- Lift Station
- Manhole
- Gravity Main
- Forcemain
- Agricultural Land Reserve
- Development Application
- Specific Development Area
- Non-Specific Development Area

Future Growth Allocation

COURTENAY 1915 2015

Project: **Sewer Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **April 2020**
Created by: **Ad'A**
Reviewed by: **WdS**

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0 0.5 1 2
Kilometers

Figure 4.1

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4.2 Future System Operation

The City has significant changes to the future operation of the sewer network planned for the 5-year and 20-year horizons. The planned changes include several new trunk mains and lift stations, as well as the decommissioning of existing lift stations. The system changes determined in consultation with the City are shown in and summarized below.

- 5-Year Horizon
  - Mission-Greenwood Lift Station and Greenwood Trunk Main
    - Decommission the existing Klanawa and Mission Road lift Stations
  - Sandpiper (Cliffe Avenue) Forcemain Extension, Mansfield Discharge Re-routing and Cliffe Trunk Mains
    - Decommission the existing Mansfield forcemain
  - 1st Street Lift Station and Forcemain Upgrades
  - Comox Road Improvements
    - Abandon River Crossing at Lewis Park
    - Construct Comox Road Lift Station
    - Block Flow Diversion at Old Island Highway and Puntledge Road
- 20-Year Horizon
  - All 5-Year horizon system changes
  - Arden North and Arden Central Trunk Mains
  - Fitzgerald Trunk Main
  - North Courtenay Area Servicing
  - South Courtenay Area Servicing
  - Veterans Memorial Parkway and North Island College Lift Stations
    - Decommission the existing Cascara Lift Station
  - Decommission the existing Majestic Lift Station

The above future system operational considerations are all part of the base 5-year and 20-year growth scenarios, which were used to analyze the capacity of the City sanitary sewer collection system.

5.0 System Capacity Analysis

This section summarizes the City sanitary sewer collection system capacity analysis under the existing and future conditions.

5.1 Gravity Main Likelihood of Failure Criteria

The criteria outlined in **Table 5.1** and **Table 5.2** were used to assess the capacity of all gravity mains within the City's system and to assign a likelihood of failure (LoF) rating. The LoF methodology below is based on q/Q results (max flow/full pipe flow) rather than d/D results (depth/Diameter). The q/Q methodology provides a better picture of the hydraulic condition of each gravity main and how the LoF is impacted by downstream conditions.

Table 5.1: Likelihood of Failure Criteria Scoring (Gravity Main)

Criteria	Score
Hydraulic Capacity (q/Q*)	
q/Q < 0.7	A
0.7 ≤ q/Q < 1.0	B
q/Q ≥ 1.0	C
Hydraulic Grade Line (HGL)	
HGL < Crown	A
Crown ≤ HGL < Rim Elevation	B
HGL > Ground Elevation	C
Velocity (v)	
v < 0.6 m/s	Fail
v >= 0.6 m/s	Pass

***q/Q = peak flow / full pipe flow.**

Table 5.2: Likelihood of Failure Ratings (Gravity Main)

<table>
<tr><th>LoF Rating</th><th>Capacity</th><th>HGL</th><th>Velocity</th><th>Description</th></tr>
<tr><td>1</td><td>A</td><td>A</td><td>Pass</td><td>Gravity main performing as designed</td></tr>
<tr><td>2</td><td>A</td><td>A</td><td>Fail</td><td>Adequate capacity, low velocity indicates potential sedimentation</td></tr>
<tr><td rowspan="3">3</td><td>A</td><td>B or C</td><td>Pass or Fail*</td><td>Adequate capacity, backwater caused by downstream conditions</td></tr>
<tr><td>B</td><td>A, B or C</td><td>Pass or Fail*</td><td rowspan="2">Marginal capacity</td></tr>
<tr><td>C</td><td>A</td><td>Pass or Fail*</td></tr>
<tr><td>4</td><td>C</td><td>B</td><td>Pass or Fail*</td><td>Capacity exceeded and surcharging likely</td></tr>
<tr><td>5</td><td>C</td><td>C</td><td>Pass or Fail*</td><td>Capacity exceeded and flooding likely</td></tr>
</table>

***LoF ratings from 3-5 are independent of velocity criteria.**

In general, ratings of ‘1’, ‘2’, and ‘3’ will not trigger an upgrade as there is capacity available in the gravity main to convey flows.

Only gravity mains receiving an LoF rating of ‘4’ and ‘5’ are considered deficient and should be investigated for upgrade recommendations. A gravity main receiving a ‘4’ rating requires an upgrade as the hydraulic capacity has been exceeded and is likely causing surcharging to occur. A gravity main receiving a ‘5’ rating indicates that surcharging to the manhole rim is likely, increasing the priority of the upgrade.

5.2 Lift Station Likelihood of Failure Criteria

The criteria outlined in **Table 5.3** and **Table 5.4** were used to assess the capacity of all lift stations within the City’s system and to assign a likelihood of failure (LoF) rating. A lift station is comprised of three (3) components: pump(s), wet well and downstream forcemain. Each component was assessed to determine the overall lift station LoF rating.

Table 5.3: Likelihood of Failure Criteria Scoring (Lift Station)

Criteria	Score
Pump Capacity	
PWWF ≤ Firm Capacity*	Pass
PWWF > Firm Capacity*	Fail
Wet Well Capacity	
Max. Operating Level < Inlet Pipe Invert	A
Max. Operating Level ≥ Inlet Pipe Invert	B
Max. Operating Level >= Max. Physical Depth	C
Forcemain Velocity	
v < 0.9 m/s	Fail
0.9 m/s ≤ v ≤ 3.5 m/s	Pass
v > 3.5 m/s	Fail

***q/Q = peak flow / full pipe flow.**

Table 5.4: Likelihood of Failure Ratings (Lift Station)

LoF Rating	Pump Capacity	Wet Well Capacity	Forcemain Velocity	Description
1	Pass	A	Pass	Lift station performing as designed
2	Pass	A	Fail	Forcemain velocity outside of design range
3	Pass	B	Pass or Fail	Inlet pipe invert within pump operating range and backup likely (submerged inlet)
4	Fail	A	Pass or Fail	Pump capacity exceeded
	Fail	B	Pass or Fail	
5	Fail	C	Pass or Fail	Pump capacity and wet well capacity exceed and overflow likely

In general, ratings of ‘1’ and ‘2’ will not trigger an upgrade as there is pump capacity available.

A lift station receiving a LoF rating of ‘3’ indicates that the lead pump “ON” level may be higher than the inlet pipe invert (submerged inlet), causing backup to occur in the upstream pipes. The City should assess these lift stations and adjust the operating conditions as required.

Lift stations receiving LoF ratings of ‘4’ or ‘5’ should be considered for upgrade as the pump capacity is exceed.

5.3 Gravity Main Likelihood of Failure Results

Table 5.5 summarizes the existing and future gravity main LoF results under each scenario.

Table 5.5: Gravity Main LoF Results (Number of Pipes)

LoF Rating	2019 Peak Wet Weather Flow 5-yr 24-hr I&I	2024 Peak Wet Weather Flow 5-yr 24-hr I&I	2039 Peak Wet Weather Flow 5-yr 24-hr I&I
1	668	692	725
2	1,366	1,389	1,416
3	153	125	90
4	20	13	17
5	13	11	4

The table above shows that there are a significant number of deficiencies under the existing 2019 scenario; however, a number of these deficiencies are addressed by the planned system operation changes in the future 2024 and 2039 scenarios. With the planned system operation changes, there are still twenty-three (23) deficient gravity mains that require upgrades.

Figure 5.1, **Figure 5.2**, and **Figure 5.3** show the gravity main LoF results. Detailed modeling results for the gravity mains receiving LoF ratings of '4' or '5' can be found in **Appendix D.**

5.4 Lift Station Likelihood of Failure Results

Table 5.6, **Table 5.7**, and **Table 5.8** summarize the existing and future lift station LoF results.

Table 5.6: 2019 Peak Wet Weather Flow 5-yr 24-hr I&I Lift Station LoF Results

Lift Station Name	Firm Capacity (L/s)	Peak Inflow (L/s)	Excess Capacity (L/s)	Forcemain Velocity (m/s)	LoF Rating
1st Street	16.4	24.6	**- 8.2**	0.9	**4**
Anderton	21.6	31.5	**- 9.9**	1.2	**4**
Cascara	1.0	0.5	+ 0.5	**0.2**	2
Klanawa	7.8	3.9	+ 3.9	1.0	1
Majestic	10.9	0.8	+ 10.1	2.5	1
Mansfield	22.7	42.8	**- 20.1**	1.3	**4**
Mission Road	12.4	5.5	+ 6.9	1.6	1
Puntledge	23.8	2.4	+ 21.4	3.0	1
Sandpiper	24.8	15.9	+ 8.9	1.4	1

Table 5.7: 2024 Peak Wet Weather Flow 5-yr 24-hr I&I Lift Station LoF Results

Lift Station Name	Firm Capacity (L/s)	Peak Inflow (L/s)	Excess Capacity (L/s)	Forcemain Velocity (m/s)*	LoF Rating
1st Street**	21.0	25.3	**- 4.3**	1.2	**4**
Anderton	21.6	11.2	+ 10.4	1.2	1
Cascara	1.0	0.5	+ 0.5	0.2	2
Klanawa	Decommissioned				
Majestic	10.9	0.8	+ 10.1	2.5	1
Mansfield	22.7	14.5	+ 8.2	1.3	1
Mission Road	Decommissioned				
Puntledge	23.8	2.4	+ 21.4	3.0	1
Sandpiper	24.8	25.5	**- 0.7**	1.4	**4**
Mission Greenwood**	N/A	21.7	N/A	**0.4**	2
Comox Road**	N/A	1.9	N/A	**0.2**	2

***For existing lift stations, forcemain velocity calculated based on firm capacity and forcemain diameter. For planned future lift stations, forcemain velocity calculated based on peak inflow and forcemain diameter.**
****Planned upgrade or future lift station.**

Table 5.8: 2039 Peak Wet Weather Flow 5-yr 24-hr I&I Lift Station LoF Results

Lift Station Name	Firm Capacity (L/s)	Peak Inflow (L/s)	Excess Capacity (L/s)	Forcemain Velocity (m/s)*	LoF Rating
1st Street**	21.0	18.8	+ 0.0	1.2	1
Anderton	21.6	17.5	+ 4.1	1.2	1
Cascara	Decommissioned				
Klanawa	Decommissioned				
Majestic	Decommissioned				
Mansfield	22.7	14.5	+ 8.2	1.3	1
Mission Road	Decommissioned				
Puntledge	23.8	2.4	+ 21.4	3.0	1
Sandpiper	24.8	37.1	**- 12.3**	1.4	**4**
Mission Greenwood**	N/A	67.3	N/A	1.3	1
Comox Road**	N/A	1.9	N/A	**0.2**	2
North Sandwick**	N/A	8.0	N/A	1.0	1
North Island College**	N/A	16.9	N/A	1.0	1
Veterans Memorial Parkway**	N/A	18.6	N/A	1.1	1

***For existing lift stations, forcemain velocity calculated based on firm capacity and forcemain diameter. For planned future lift stations, forcemain velocity calculated based on peak inflow and forcemain diameter.**
****Planned upgrade or future lift station.**

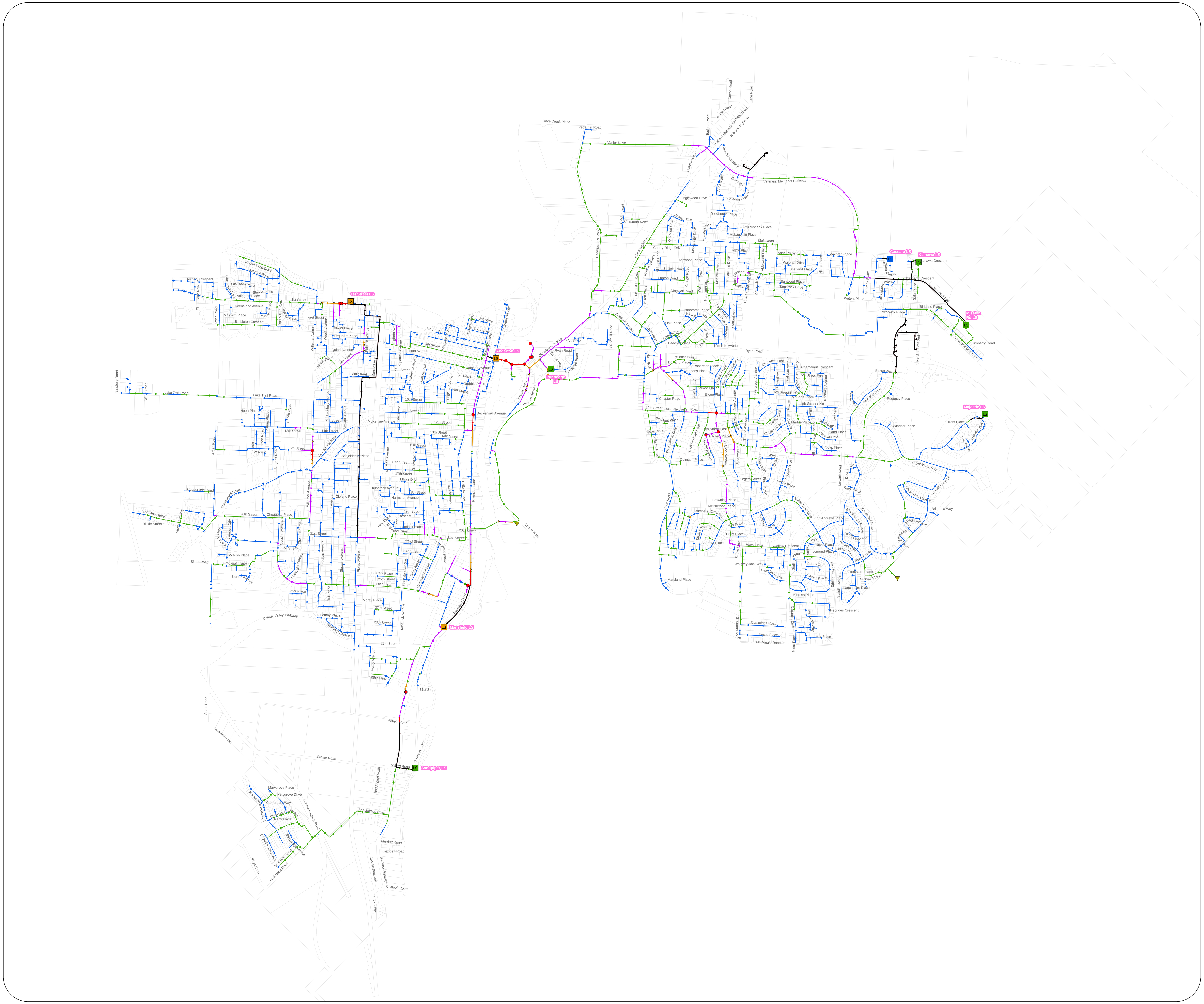
As shown in the above tables, the 1st Street lift station is predicted to be deficient under the existing scenario. Planned 5-year upgrades to this lift station will increase the capacity to 21.0 L/s. The 1st Street lift station will be deficient under the future 2024 scenario; however, the upgraded capacity will be sufficient under the future 2039 scenario, once the Arden North trunk is completed.

The Mansfield lift station is predicted to be deficient under the existing 2019 scenario; however, when the Sandpiper lift station forcemain extension is installed, the Mansfield lift station is predicted to have sufficient capacity.

The Anderton lift station is predicted to be deficient under the existing 2019 scenario; however, when the Comox Road improvements are completed and the river crossing main abandoned in the future 2024 scenario, the Anderton lift station is predicted to have sufficient capacity.

The Sandpiper lift station is predicted to become deficient under the future 2024 and 2039 scenarios.

Note that upgrades to the deficient lift stations may trigger more downstream gravity main deficiencies due to the higher pumped flow.



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Legend

Parcel

Outfall

Forcemain

Surcharged Above Pipe Crown

Flooding Manhole

Gravity Main LoF Rating

1 *Gravity main performing as designed*

2 *Adequate capacity, low velocity indicates potential sedimentation*

3 *Adequate capacity, downstream condition causing backwater OR Marginal Capacity*

4 *Capacity exceeded and surcharging likely*

5 *Capacity exceeded and overflow likely*

Lift Station LoF Rating

LS 1 *Lift station performing as designed*

LS 2 *Forcemain velocity outside of design range*

LS 3 *Inlet pipe invert within pump operating range and backup likely (submerged inlet)*

LS 4 *Pump capacity exceeded*

LS 5 *Pump capacity and wet well capacity exceeded and overflow likely*

Existing WWF 5-Year 24-Hour I&I Likelihood of Failure Results

Project: **Sewer Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **April 2020**
Created by: **Ad'A**
Reviewed by: **WdS**

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0 0.5 1 2
Kilometers

Figure 5.1

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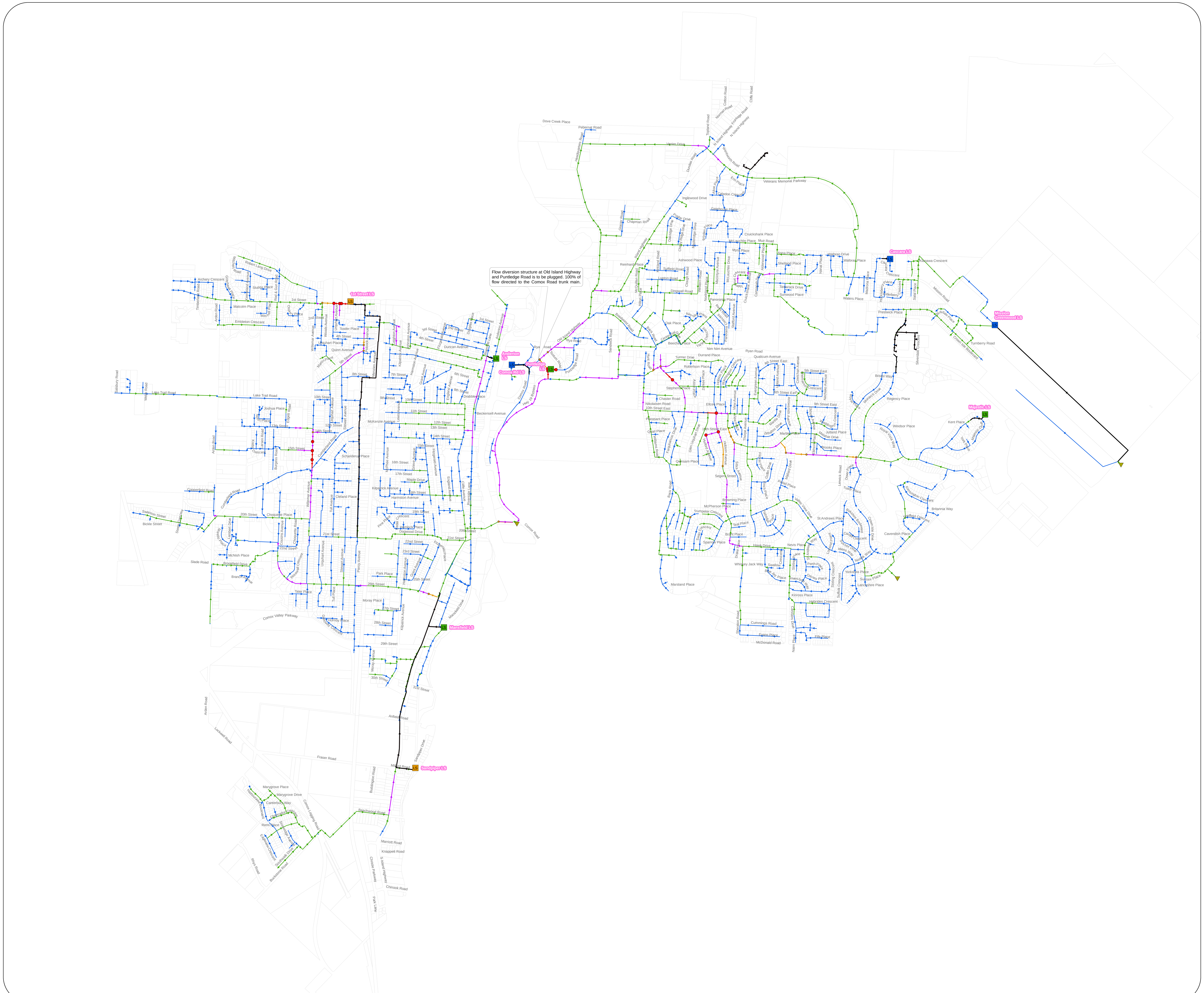

GeoAdvice Engineering Inc.

Legend

Parcel

Outfall

Forcemain

Surcharged Above Pipe Crown

Flooding Manhole

Gravity Main LoF Rating

1 *Gravity main performing as designed*

2 *Adequate capacity, low velocity indicates potential sedimentation*

3 *Adequate capacity, downstream condition causing backwater OR Marginal Capacity*

4 *Capacity exceeded and surcharging likely*

5 *Capacity exceeded and overflow likely*

Lift Station LoF Rating

1 *Lift station performing as designed*

2 *Forcemain velocity outside of design range*

3 *Inlet pipe invert within pump operating range and backup likely (submerged inlet)*

4 *Pump capacity exceeded*

5 *Pump capacity and wet well capacity exceeded and overflow likely*

2024 WWF 5-Year 24-Hour I&I Likelihood of Failure Results

COURTENAY 1915 2015

Project: **Sewer Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
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0 0.5 1 2
Kilometers

Figure 5.2

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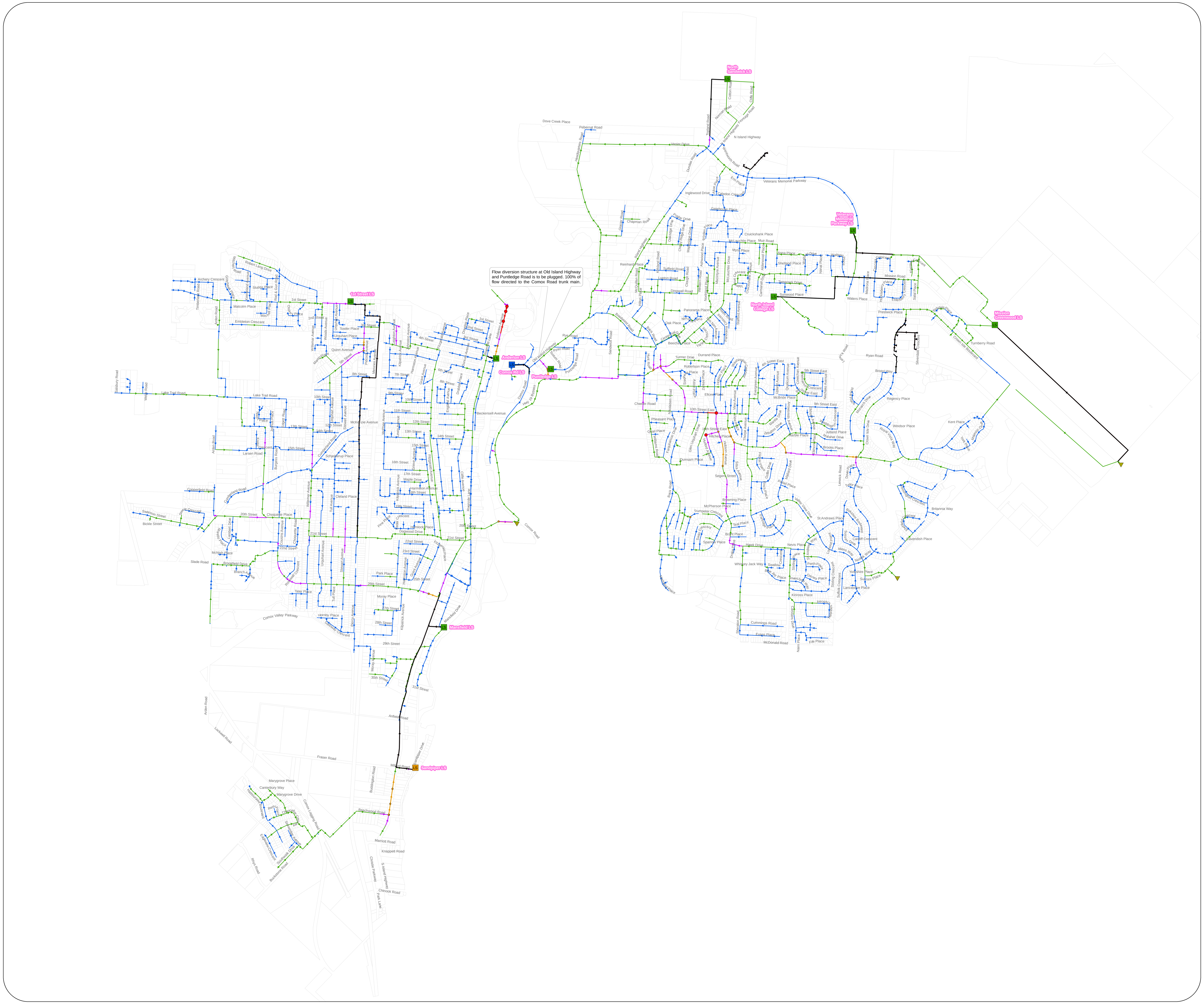

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Legend

Parcel

Outfall

Forcemain

Surcharged Above Pipe Crown

Flooding Manhole

Gravity Main LoF Rating

1 *Gravity main performing as designed*

2 *Adequate capacity, low velocity indicates potential sedimentation*

3 *Adequate capacity, downstream condition causing backwater OR Marginal Capacity*

4 *Capacity exceeded and surcharging likely*

5 *Capacity exceeded and overflow likely*

Lift Station LoF Rating

LS 1 *Lift station performing as designed*

LS 2 *Forcemain velocity outside of design range*

LS 3 *Inlet pipe invert within pump operating range and backup likely (submerged inlet)*

LS 4 *Pump capacity exceeded*

LS 5 *Pump capacity and wet well capacity exceeded and overflow likely*

2039 WWF 5-Year 24-Hour I&I Likelihood of Failure Results

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Client: **City of Courtenay**
Date: **April 2020**
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0 0.5 1 2
Kilometers

Figure 5.3

Document Path: W:\2019-051-COU\02\Mapping\2019-051-COU_F53_2039_WWF_5YRII_Results.mxd

5.5 Comox Valley Regional District Discharge Flows

The Courtenay sanitary sewer collection system discharges to the Comox Valley Regional District (CVRD) at two (2) existing locations and one (1) future location. **Table 5.9** summarizes the discharge flows under each model scenario.

Table 5.9: CVRD Discharge Flows

CVRD Discharge Location	2019 Peak Wet Weather Flow 5-yr 24-hr I&I	2024 Peak Wet Weather Flow 5-yr 24-hr I&I	2039 Peak Wet Weather Flow 5-yr 24-hr I&I
Courtenay Pump Station	465 L/s	474 L/s	457 L/s
Hudson Trunk	11 L/s	16 L/s	16 L/s
Greenwood Trunk	-	22 L/s	76 L/s

6.0 System Improvement Recommendations

This section summarizes the required infrastructure improvements to alleviate the identified hydraulic capacity deficiencies.

- Gravity mains with a LoF rating of either '4' or '5' were considered "deficient" and proposed upgrades were considered to eliminate these deficiencies.
- Lift stations with a LoF rating of either '4' or '5' were considered "deficient" and proposed pump, wet well and forcemain upgrades were considered to eliminate these deficiencies.

Based on Master Municipal Construction Documents (MMCD) guidelines and the City's Subdivision and Development Servicing Bylaw 2919 (May 7, 2018), the design criteria shown in **Table 6.1** were used size new infrastructure.

Table 6.1: Design and Sizing Criteria

Facility	Criterion	Parameter Value
Gravity Main	Design Flow/Sizing Scenario	2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change
	Max. depth/Diameter ratio	d/D < 0.5 (Diameter ≤ 200 mm) d/D < 0.7 (Diameter = 250 mm) d/D < 0.8 (Diameter ≥ 300 mm)
	Min. Velocity	v ≥ 0.6 m/s
	Min. Diameter	D = 200 mm
	Manning Roughness Coefficient	n = 0.013
Forcemain	Min. Velocity	v ≥ 0.9 m/s
	Max. Velocity	v ≤ 3.5 m/s
	Hazen-Williams Roughness	C = 120
Pump	Design Flow	2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change
	Maximum Pump Flow	PWWF = Firm Capacity

***d= flow depth, D = Diameter, n = Manning coefficient, v = velocity**

The criteria in **Table 6.1** were also used to size the planned infrastructure changes in the 5-year and 20-year horizons.

System improvements were grouped into three (3) categories:

- 5-Year Horizon Planned Improvements (see **Section 4.2**)
- 20-Year Horizon Planned Improvements (see **Section 4.2**)
- Proposed Upgrades (to address the deficiencies identifies in **Section 5**)

The system improvements are summarized in **Table 6.2** and shown in **Figure 6.1**. System improvement details can be found in **Appendix E**.

Table 6.2: Proposed System Improvements Summary

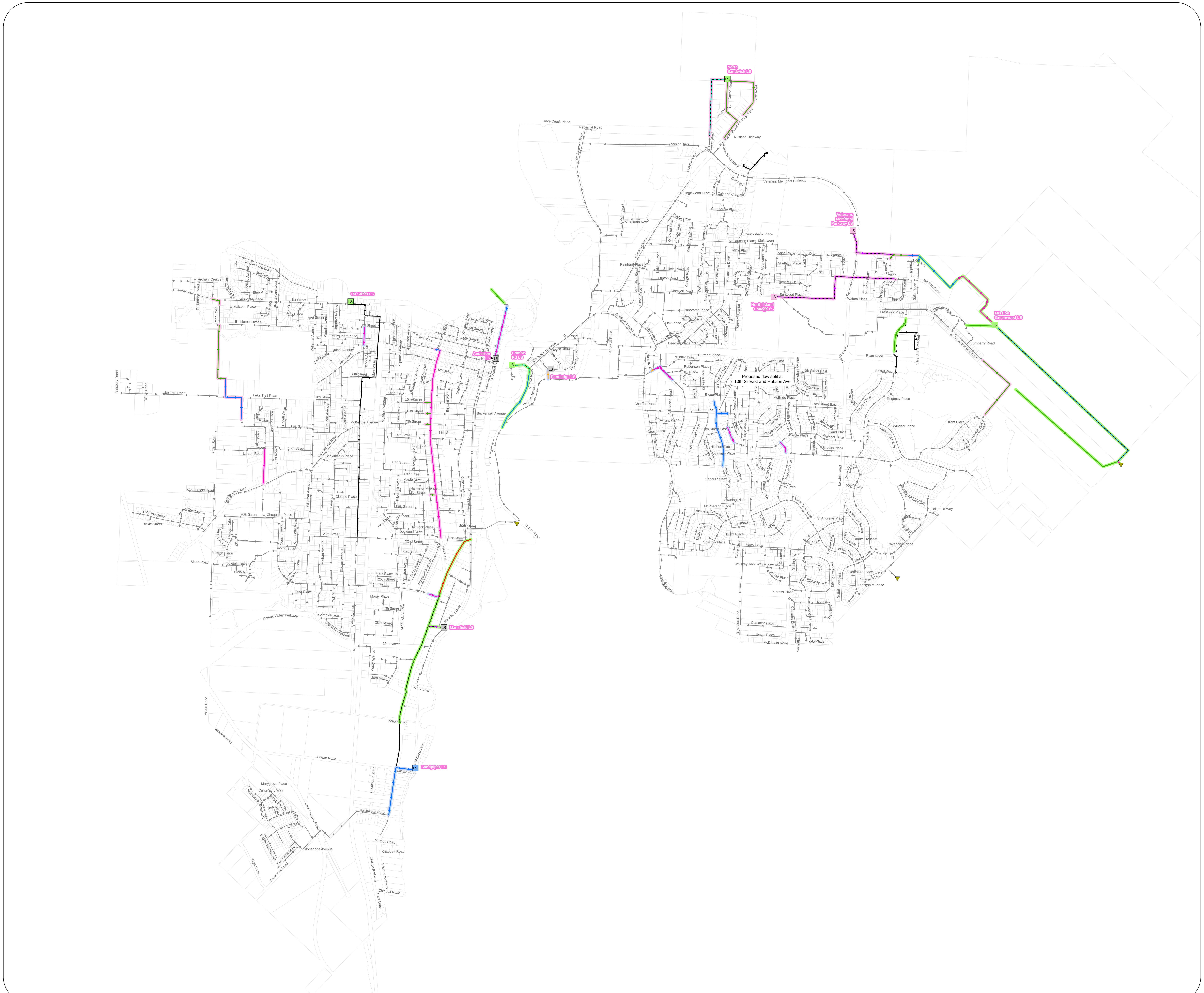
Improvement Category	Improvement Type	Quantity
5-Year Horizon Planned Improvements	New Gravity Mains	4,120 m
	Lift Station Upgrades	1
	New Lift Stations	2
	New Forcemains	3,470 m
20-Year Horizon Planned Improvements	New Gravity Mains	5,239 m
	New Lift Stations	3
	New Forcemains	2,336 m
Proposed Upgrades	New Gravity Mains	132 m
	Gravity Main Upgrades	2,372 m
	Lift Station Upgrades	1
	New Flow Split	1

With the proposed system improvements, there are two (2) remaining gravity main LoF '4' deficiencies. The remaining deficiencies and explanations for why they were not addressed are summarized in **Table 6.3**.

Table 6.3: Remaining Gravity Main Deficiencies

Pipe ID	Explanation
SMAIN-4-0185	A single deficient main (i.e. not connected to any other deficiencies). The model predicts approximately 15 cm of surcharging and there is more than 4.5 m remaining depth to the rim elevation. Determined to be a non-critical deficiency.
SMAIN-4-0762	This is a CVRD main. Part of a twin main on 20th Street that conveys flow to the Regional lift station. Although flagged as a LoF '4' deficiency, the twin mains appear to be operating as designed.

GeoAdvice Engineering Inc.



Legend

- Parcel
- Outfall
- Existing Lift Station
- Existing Forcemain
- Existing Gravity Main
- 5- Year Planned Lift Station
- 20- Year Planned Lift Station
- Proposed Lift Station Upgrade
- Planned 5-Year Improvement
- Planned 20-Year Improvement
- Proposed Upgrade

Forcemain Improvement

- 100 mm
- 150 mm
- 200 mm
- 250 mm

Gravity Main Improvement

- 200 mm
- 250 mm
- 300 mm
- 375 mm
- 450 mm

System Improvement Recommendations

COURTENAY 1915 2015

Project: **Sewer Model Development, Calibration, and Capacity Analysis**
Client: **City of Courtenay**
Date: **April 2020**
Created by: **Ad'A**
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 0.5 1 2
Kilometers

Figure 6.1

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7.0 Conclusions

The City of Courtenay, BC retained GeoAdvice Engineering Inc. to develop and calibrate a new hydraulic model of the City sanitary sewer collection system and use the model to analyze the capacity of the system.

Model Inputs

- The City InfoSWMM model was developed based on the City's most up-to-date GIS data.
- The existing water demands were calculated and allocated on a per parcel basis using estimated parcel population, 2018 water meter records, and 2018 bulk water consumption data. The water demands were then converted to sewer loads using conversion factors determine through model calibration. The City's existing base sanitary flow (BSF) in the model is 68 L/s.
- The model was calibrated against two (2) permanent flow monitoring sites provided by the City. Validation was performed to ten (10) temporary flow monitors installed in August 2019. Overall, the model shows a good agreement with the observed field data.
- I&I was determined using the "Envelope Method" at the two (2) permanent flow monitoring sites. At the Comox Road Flodar (east Courtenay), the 5-year 24-hour I&I is estimated to be 17,900 L/ha/day, and the 25-year 1-hour I&I is estimated to be 24,700 L/ha/day. At the 20th Street Flodar (west Courtenay), the 5-year 24-hour I&I is estimated to be 20,800 L/ha/day, and the 25-year 1-hour I&I is estimated to be 32,400 L/ha/day.
    - Additionally, an I&I scenario was created representing the impacts of climate change. Climate change was modeled by increasing the RDI&I portion of the I&I by 17%. At the Comox Road Flodar, the 5-year 24-hour I&I rate with climate change is estimated to be 20,700 L/ha/day. At the 20th Street Flodar, the 5-year 24-hour I&I rate with climate change is estimated to be 24,100 L/ha/day. The climate change I&I was not used as part of the analysis in this study, but is recommended to be used for the upgrade sizing scenario.
- Future sewer loads were estimated based on projected population growth provided by the City. For the 5-year growth outlook, 7,004 people were added to the existing population, and for the 20-year growth outlook, 9,623 people were added to the existing population.
- The base future scenarios included planned infrastructure and system operational changes, including infrastructure upgrade projects.

System Performance

- The gravity main capacity analysis predicts the following results:
    - Thirty-three (33) gravity main deficiencies under the existing 2019 scenario.
    - Twenty-four (24) gravity main deficiencies under the future 2024 scenario.
    - Twenty-one (21) gravity main deficiencies under the future 2039 scenario.

- The lift station capacity analysis predicts the following results:
  - The 1st Street lift station is predicted to be deficient under the existing scenario. Planned 5-year upgrades to this lift station will increase the capacity to 21.0 L/s. The 1st Street lift station will be deficient under the future 2024 scenario; however, the upgraded capacity will be sufficient under the future 2039 scenario, once the Arden North trunk is completed.
  - The Mansfield lift station is predicted to be deficient under the existing scenario; however, when the Sandpiper lift station forcemain extension is installed, the Mansfield lift station is predicted to have sufficient capacity.
  - The Anderton lift station is predicted to be deficient under the existing 2019 scenario; however, when the Comox Road lift station is installed and the river crossing main abandoned in the future 2024 scenario, the Anderton lift station is predicted to have sufficient capacity.
  - The Sandpiper lift station is predicted to become deficient under the future 2024 and 2039 scenarios.

System Improvement Recommendations

- System improvements were recommended to address the deficiencies identified in the capacity analysis. The system improvements were grouped into three (3) categories:
  - 5-Year Horizon Planned Improvements
    - 4.1 km of new gravity mains
    - 1 lift station upgrade
    - 2 new lift stations
    - 3.5 km of new forcemains
  - 20-Year Horizon Planned Improvements
    - 5.2 km of new gravity mains
    - 3 new lift stations
    - 2.3 km of new forcemains
  - Proposed Upgrades
    - 0.1 km of new gravity mains
    - 2.4 km of gravity main upgrades
    - 1 lift station upgrade
    - 1 new flow split

Recommendations

Upgrade Timing Analysis

Timing analysis should be performed for the system improvement recommendations identified in this report.

Field Verification of Sanitary Sewer Collection System Information

The City should undertake verification of the existing diameter and invert information for the gravity main deficiencies identified in **Appendix D**.

Additional Flow Monitoring

The City should undertake additional flow monitoring to continuously monitor the inflow & infiltration determined in this study. Prior to detailed design for any improvement projects, flow monitoring should be performed to verify the results presented in this report.

Conduct RDI&I – RTK (Variable I&I) Impact Study (Sensitivity Analysis)

The City's existing model assumes constant I&I point loads at each manhole based on the results of the "Envelope Method" analysis. While this is sufficient for conservative capacity analysis, it often over-estimates total flow volume and may misrepresent peak wet weather flow values. The RTK methodology would allow the model to represent realistic peak RDI&I timing and RDI&I volume based on real or design storm events and terrain characteristics. "RTK" refers to the three parameters used to describe the sewers systems response to a rainfall event:

- R: Fraction of excess rainfall volume
- T: Time to peak
- K: Recession constant

Development of Modeling Standards, Conventions and Guidelines

Modeling rules should be established for the City to observe when updating and running the model.

Maintenance of Sewer System Model

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

Submission

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Reviewed and Approved by:

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April 22 2020

Werner de Schaetzen, Ph.D., P.Eng.
Project Manager

Appendix A Modeled Diurnal Patterns

Table A.1: Single Family Residential Diurnal Pattern

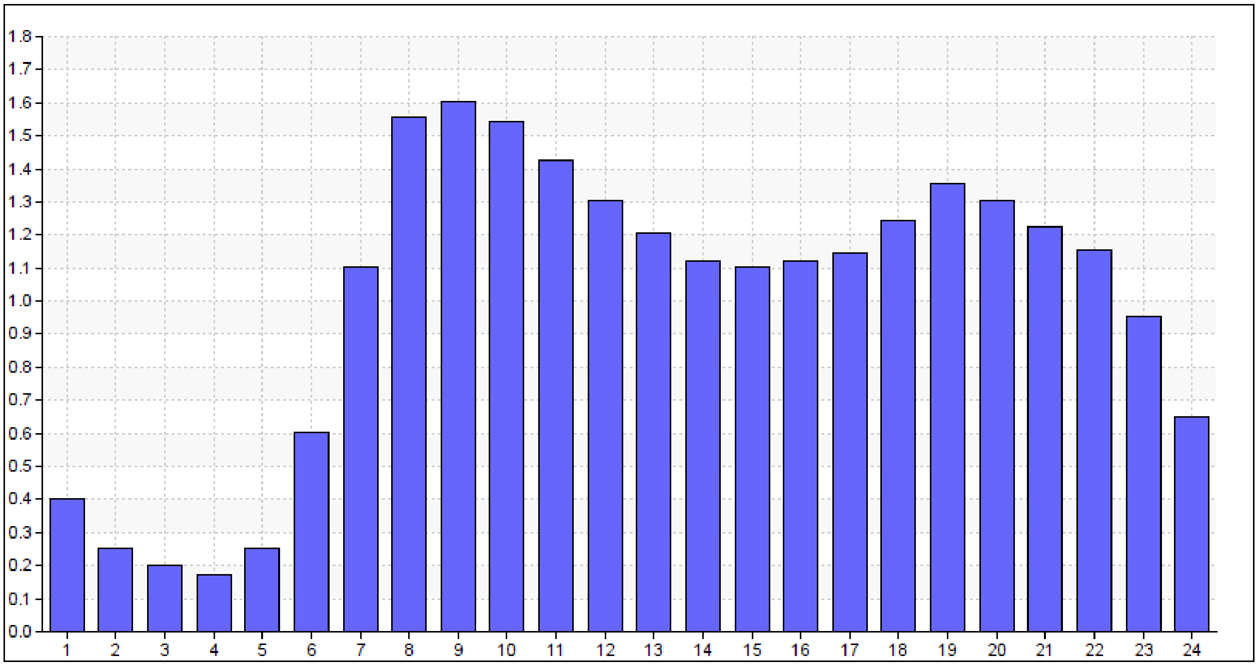


Table A.2: Multi-Family Residential Diurnal Pattern

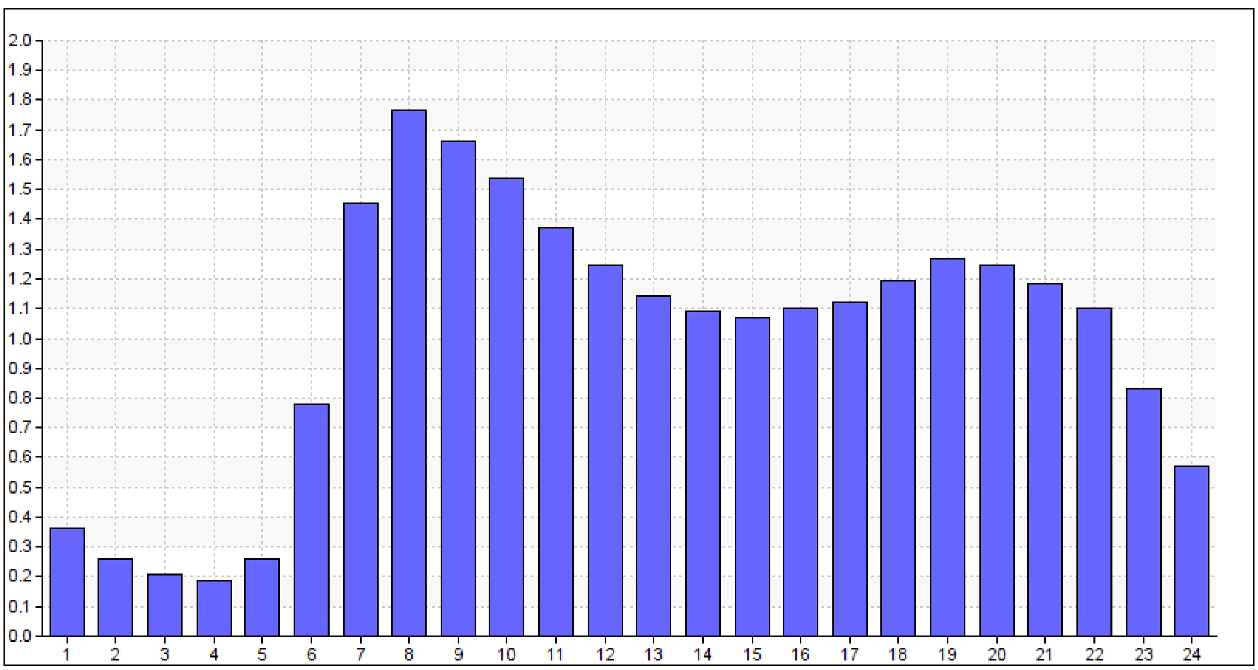


Table A.3: Commercial Diurnal Pattern

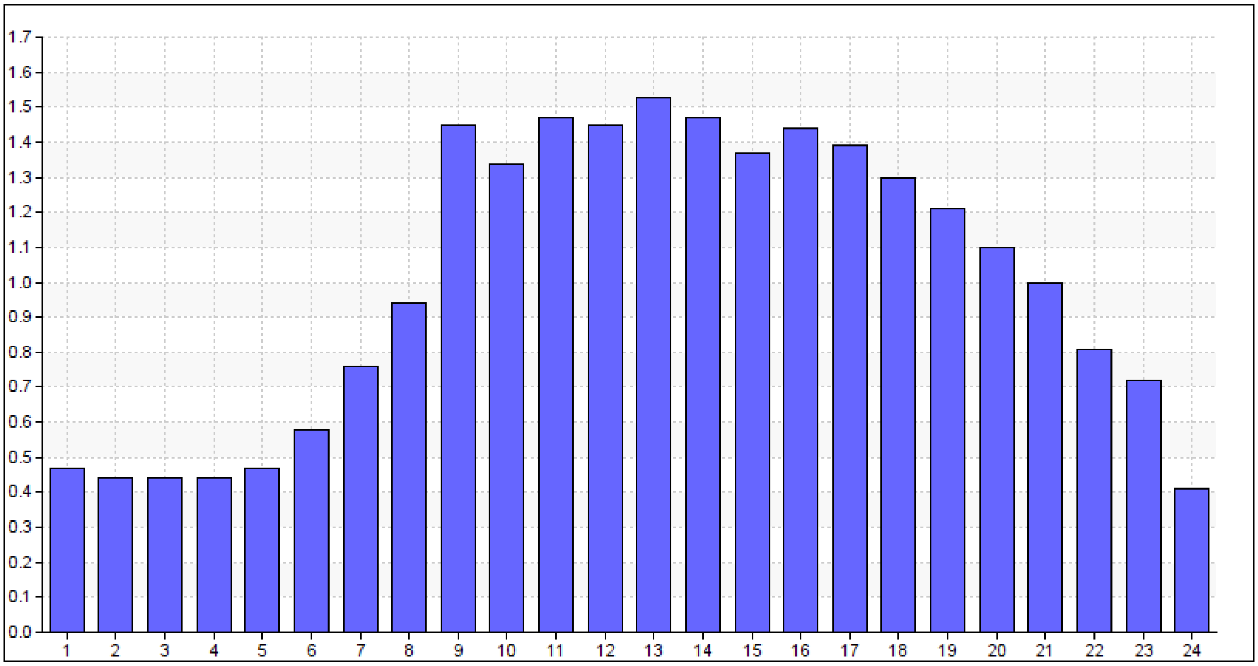


Table A.4: Industrial Diurnal Pattern

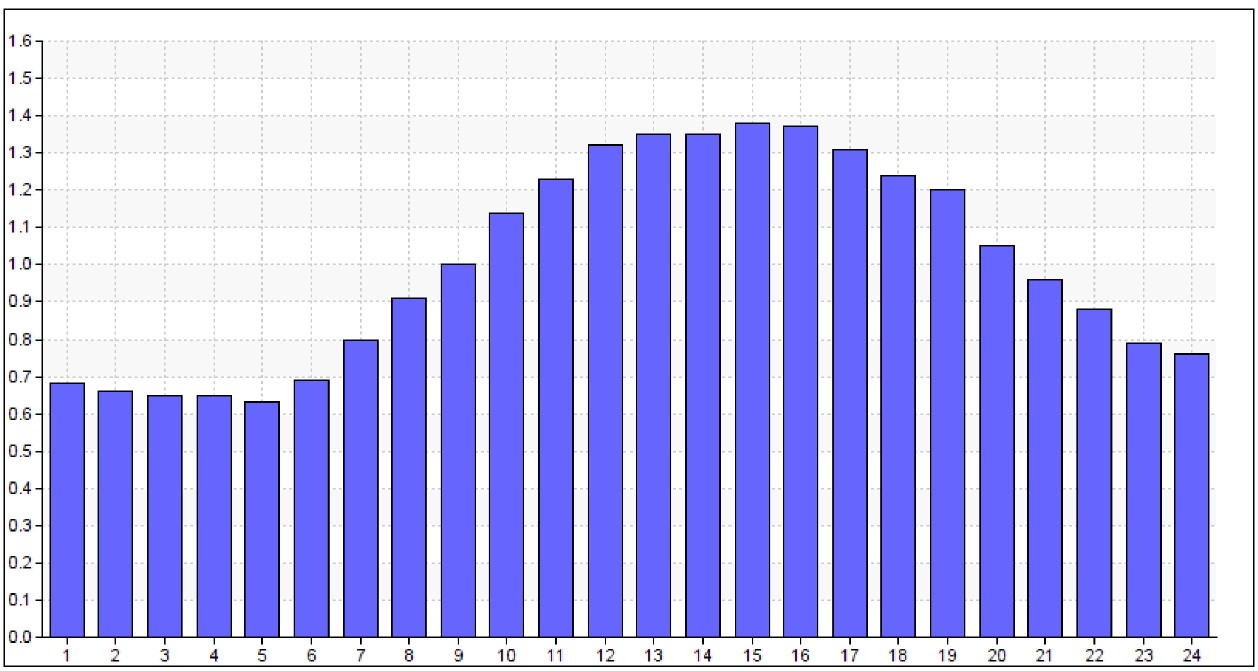


Table A.5: Institutional Diurnal Pattern

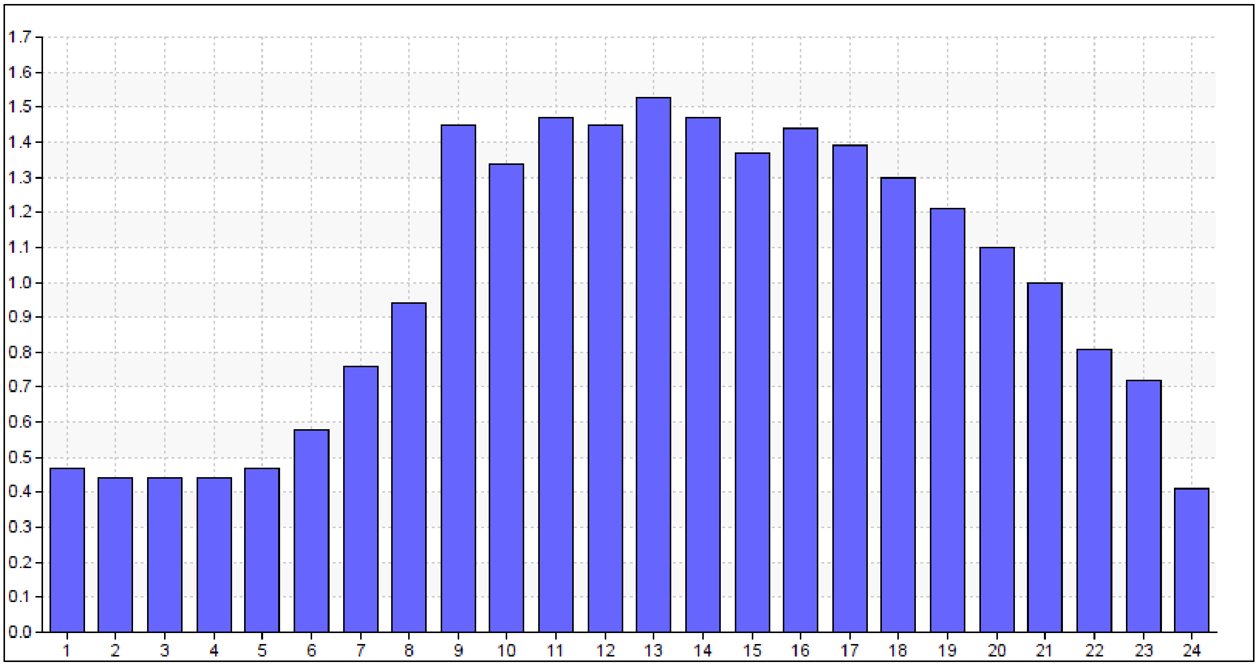


Table A.6: Agricultural Diurnal Pattern

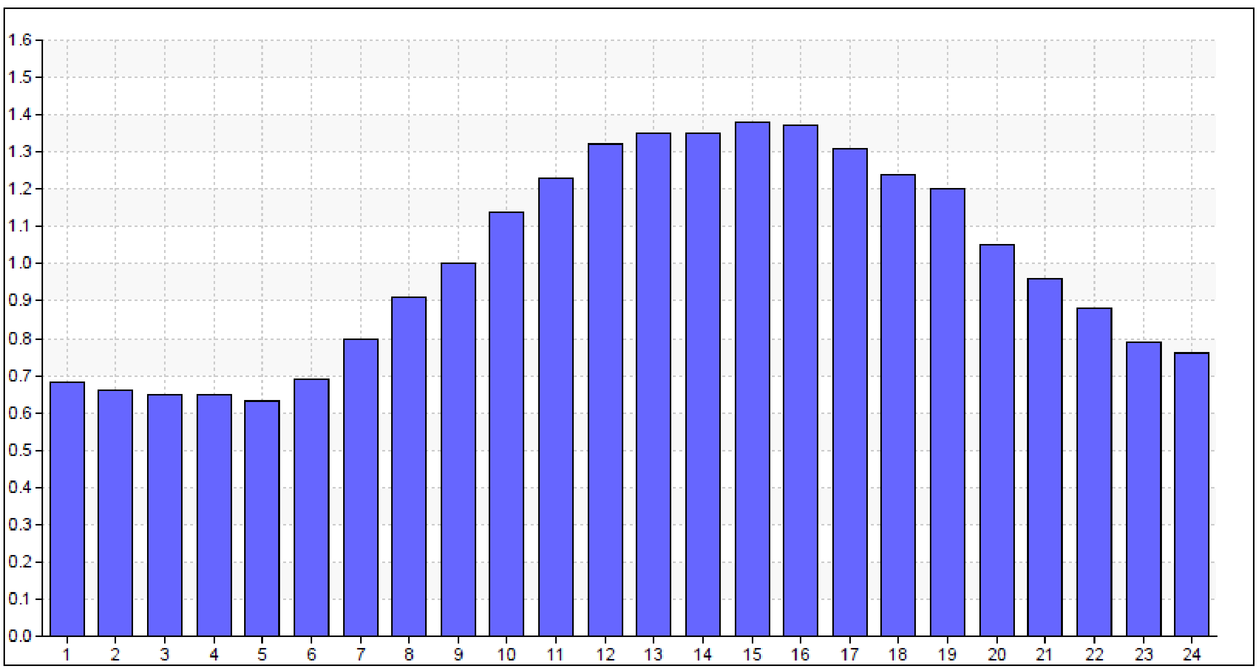
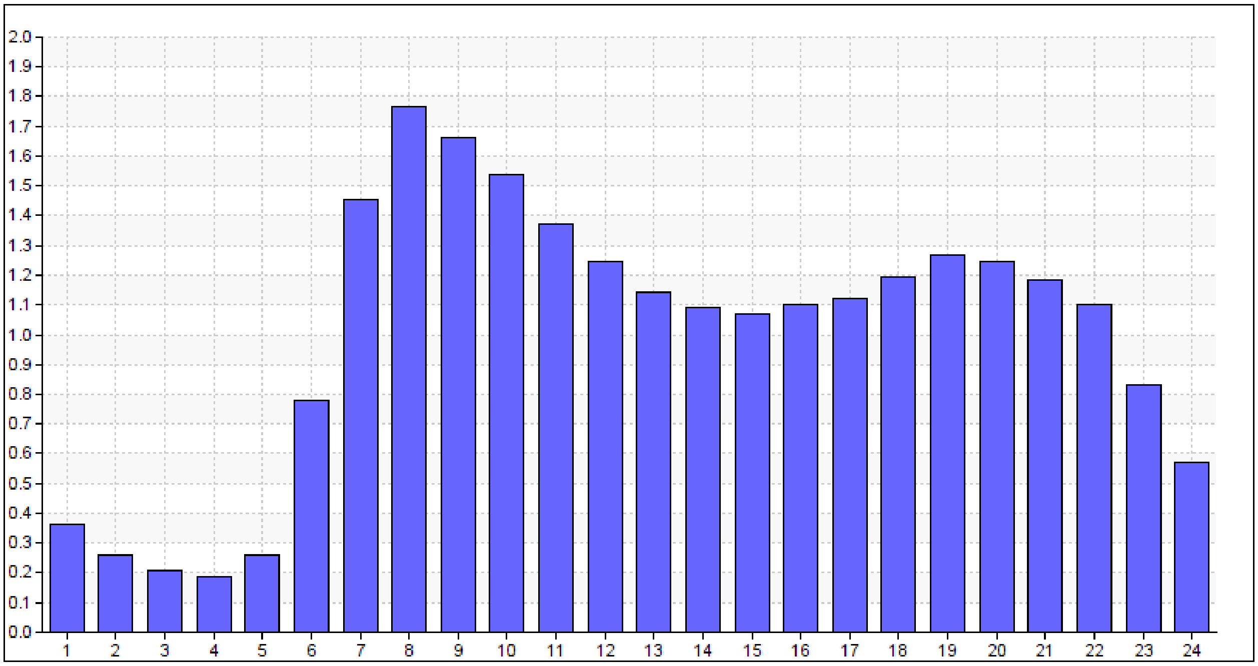


Table A.7: Future Growth Diurnal Pattern



Appendix B Dry Weather Flow Validation Graphs

Table B.1: Site A (SMH 5-712) Dry Weather Flow Validation Hydrograph

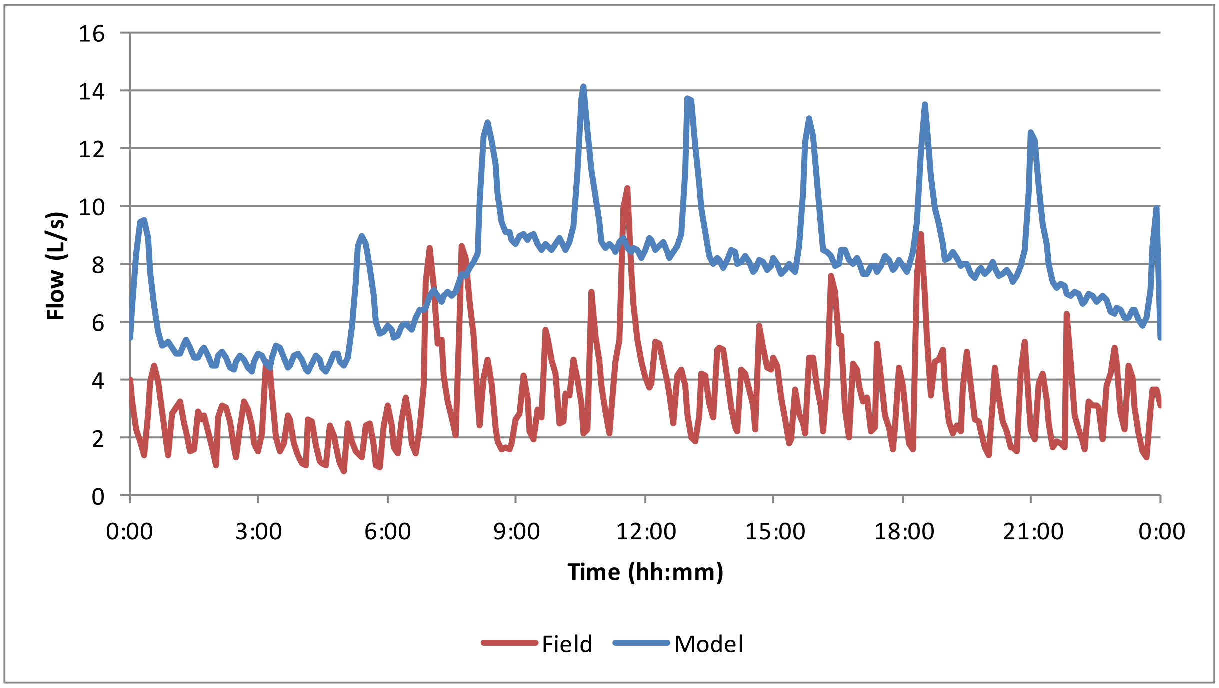


Table B.2: Site B (SMH 3-027) Dry Weather Flow Validation Hydrograph

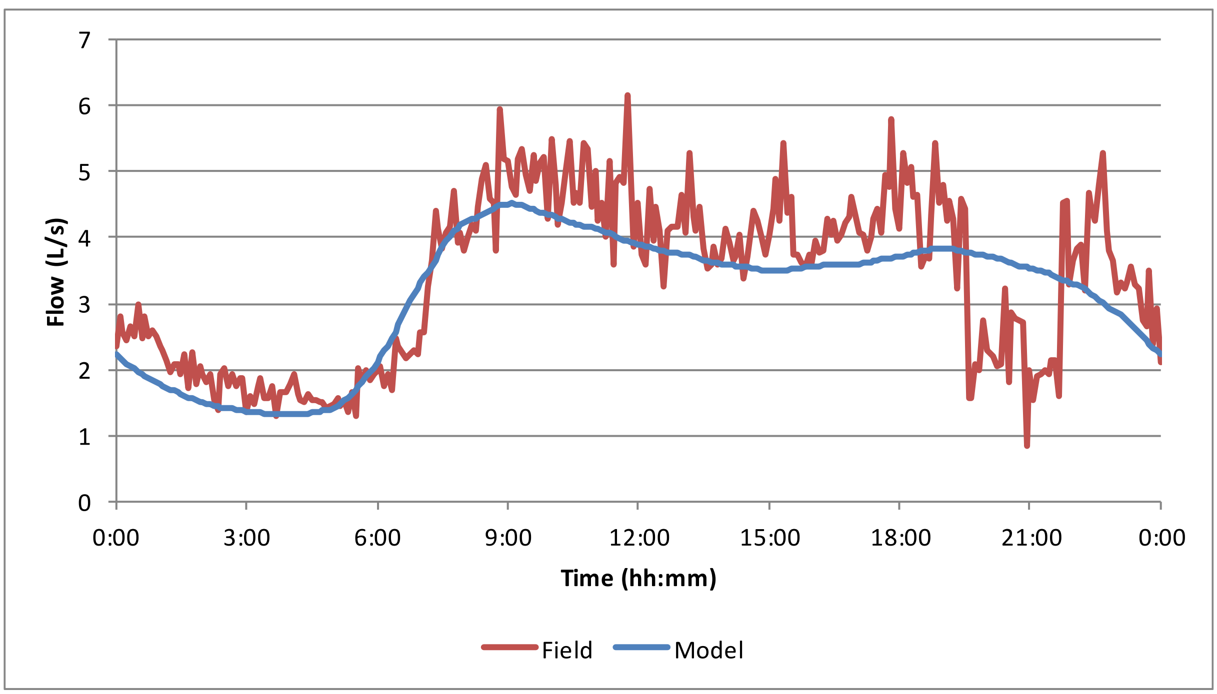


Table B.3: Site C (SMH 2-025) Dry Weather Flow Validation Hydrograph

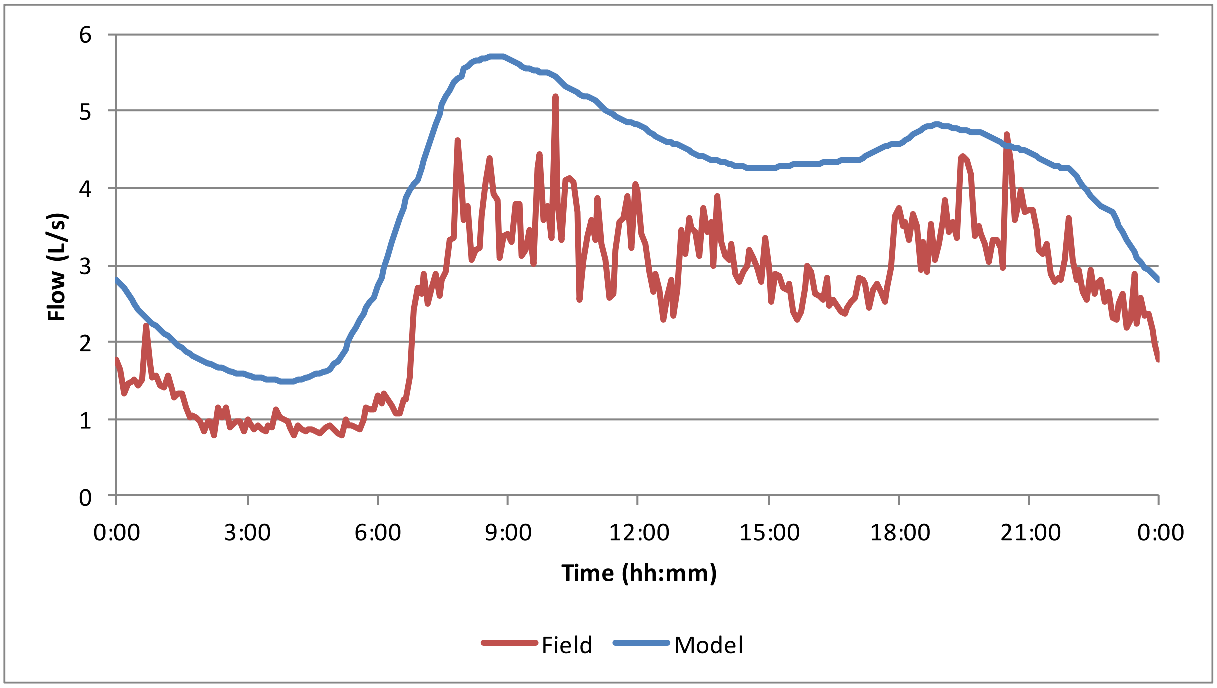


Table B.4: Site D (SMH 1-407) Dry Weather Flow Validation Hydrograph

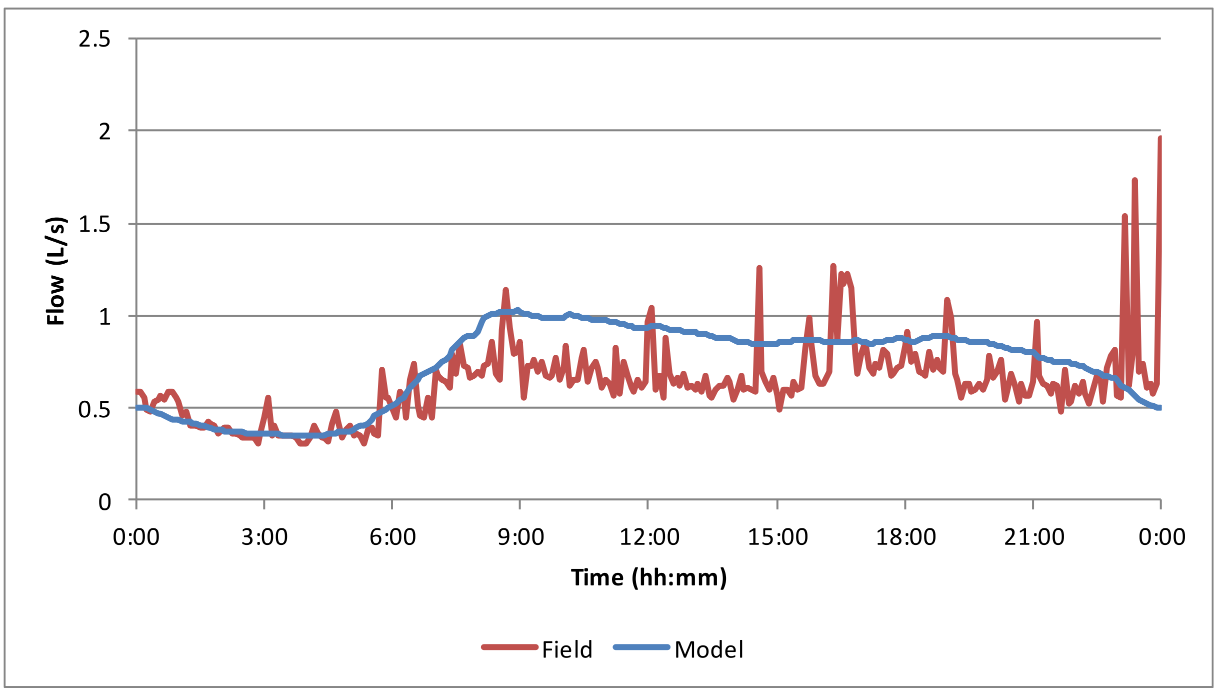


Table B.5: Site E (SMH 1-430) Dry Weather Flow Validation Hydrograph

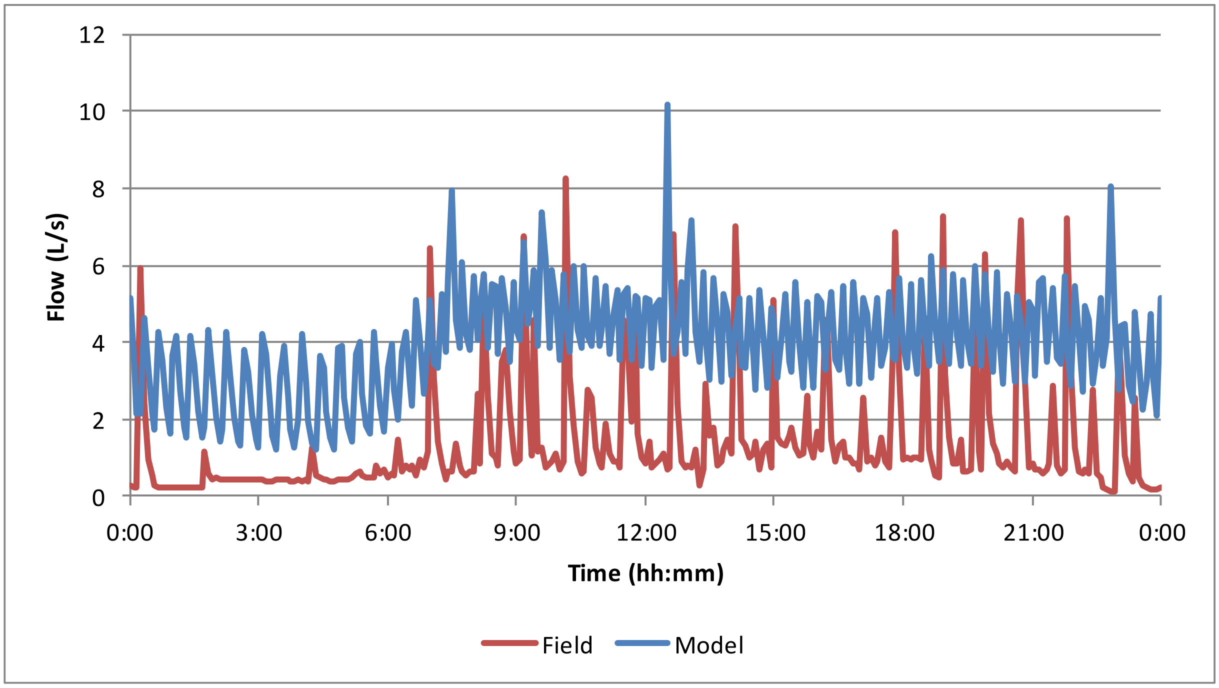


Table B.6: Site F (SMH 4-025) Dry Weather Flow Validation Hydrograph

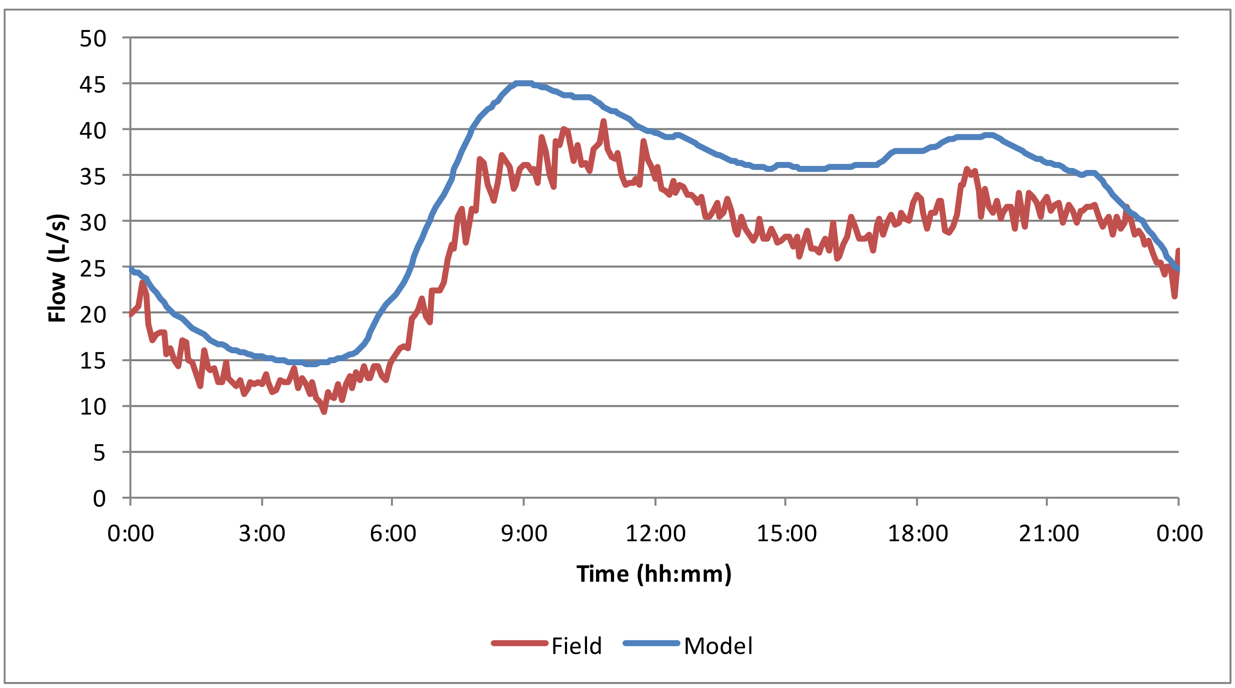


Table B.7: Site G (SMH 1-017) Dry Weather Flow Validation Hydrograph

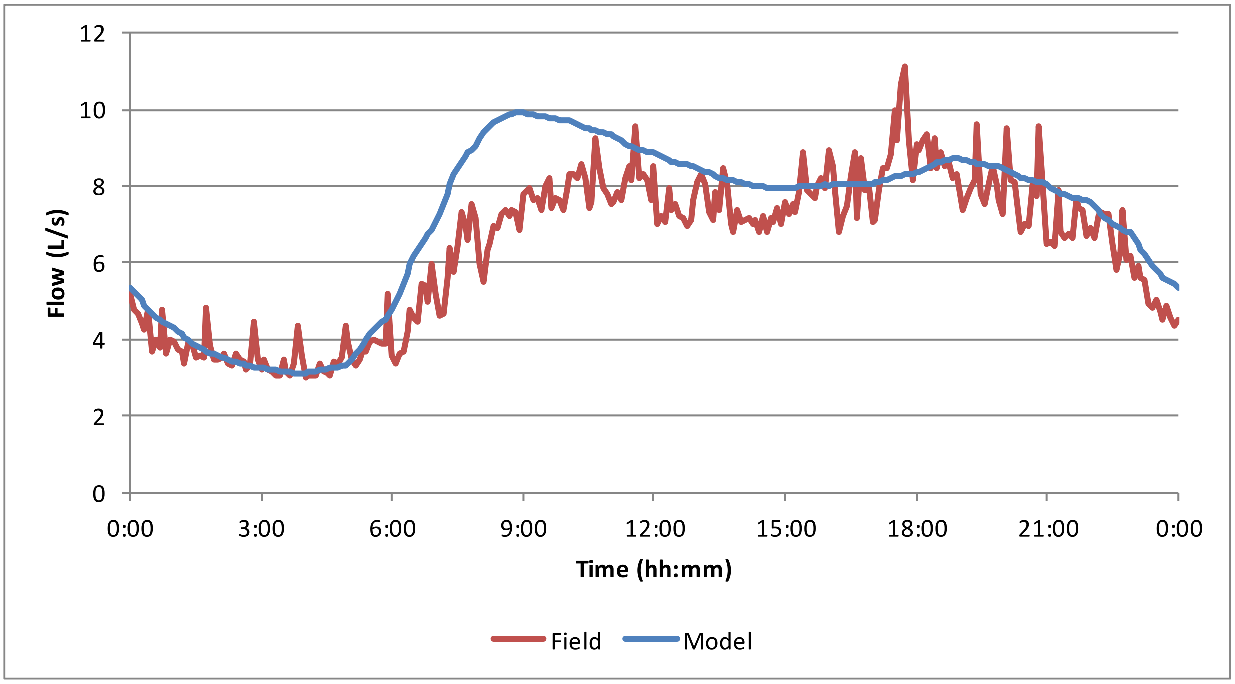


Table B.8: Site H (SMH 3-502) Dry Weather Flow Validation Hydrograph

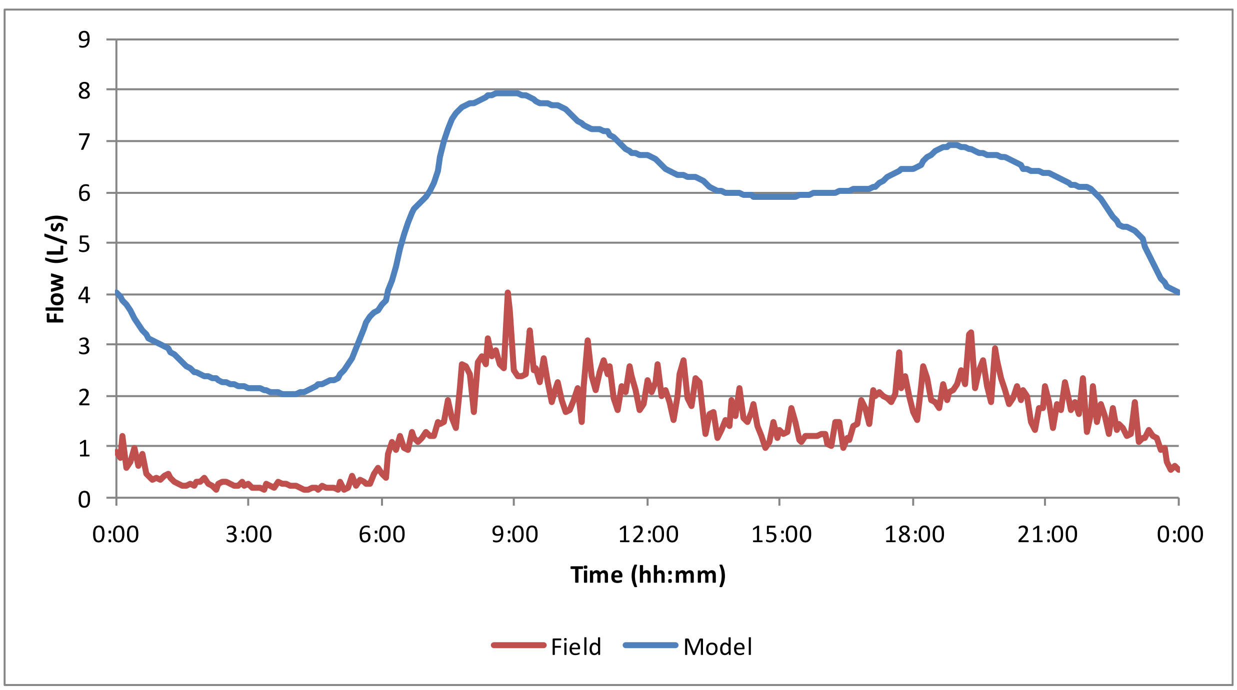


Table B.9: Site I (SMH 1-490A) Dry Weather Flow Validation Hydrograph

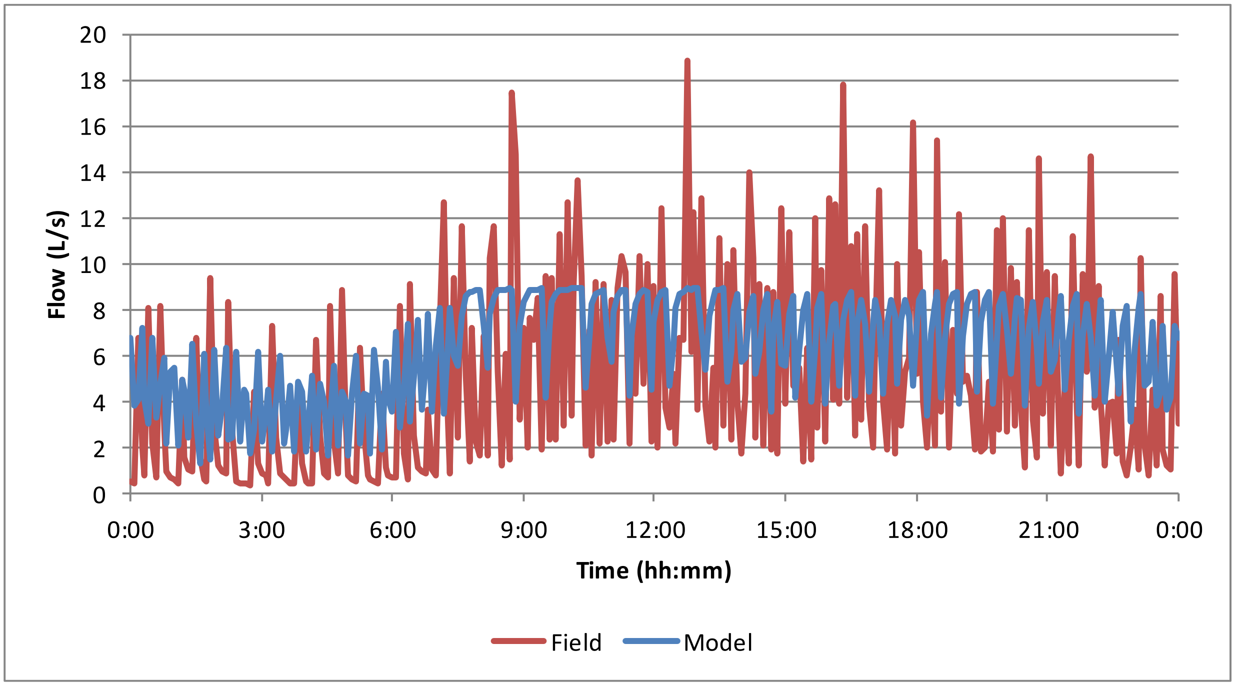
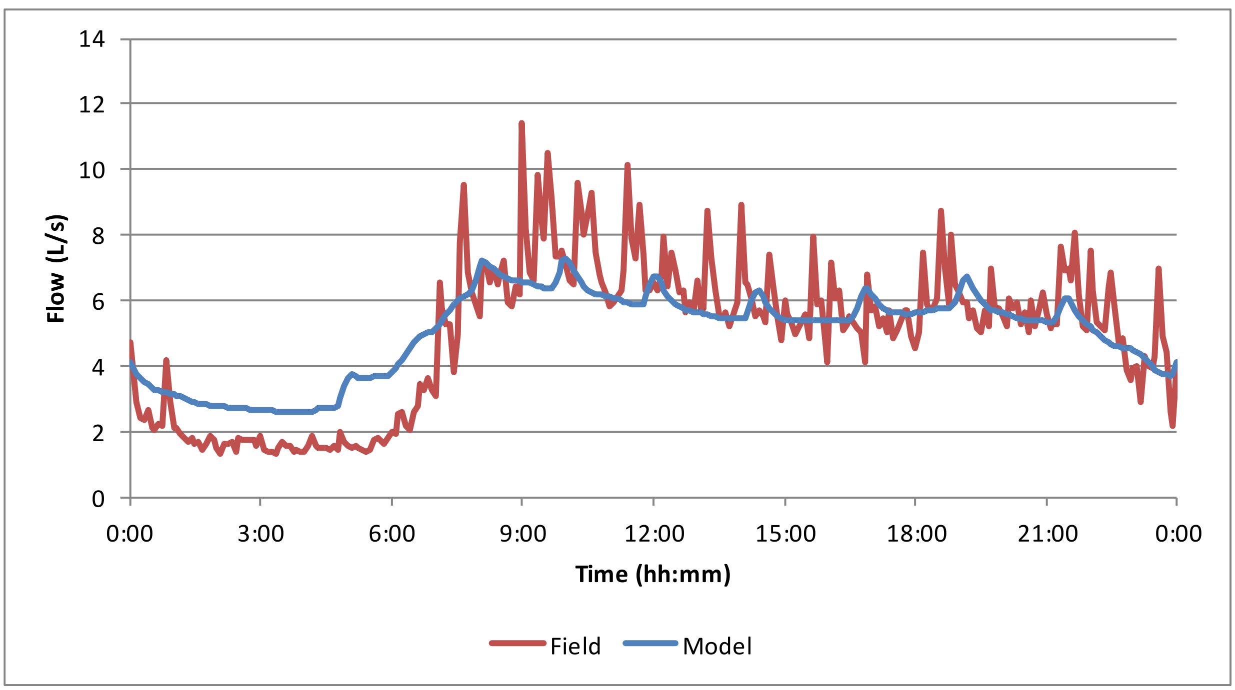


Table B.10: Site J (SMH 4-448) Dry Weather Flow Validation Hydrograph



Appendix C Development Applications

Table C.1: Development Application Growth

Development Location	Junction ID	Population Growth	
		5-Year	20-Year*
3610 Christie Parkway	6-201	+ 65	+ 65
2784 Wentworth Road	SVLV-0029	+ 14	+ 14
770 Harmston Avenue	3-275	+ 383	+ 383
4100 Fraser Road**	SCO0012	+ 63	+ 63
750 30th Street	1-443	+ 14	+ 14
2525 Mission Road	5-431	+ 183	+ 183
344 & 356 12th Street	3-131	+ 18	+ 18
4098 Buckstone Road	6-020	+ 92	+ 92
The Ridge	SFIT0046	+ 153	+ 153
632-680 5th Street	3-259	+ 48	+ 48
2485 Idiens Way	SFIT0171	+ 53	+ 53
Puntledge IR#2	FUT-SMH-037	+ 250***	+ 500***
605 Crown Isle Boulevard	SFIT0004	+ 195	+ 195
1790 Cliffe Avenue	3-005	+ 14	+ 14
1850 Cliffe Avenue and 1878/1880 Riverside Lane	3-043 3-004	+ 215	+ 215
14th Street and England Avenue	3-120	+ 174	+ 174
The Streams (Brooksfield Drive and Lambert Drive)	1-511 1-516 SFIT0111	+ 166	+ 166
13th Street, west of Krebs Crescent	2-496	+ 26	+ 26
925 Braidwood Road	SFIT0080	+ 208	+ 208
2800 Arden Road	2-707	+ 22	+ 22
2900 Cliffe Avenue	1-405	+ 26	+ 26
1025 Ryan Road	5-127	+ 193	+ 193
800 Chaster Road	4-111	+ 5	+ 5

***The 20-Year population growth is inclusive of the 5-Year population growth.**
****4100 Fraser Road increases serviced are by + 2.4 ha under the 5-Year and 20-Year growth.**
*****Pumped flow from development. Phases 1-2 included in 2024 at 6.26 L/s and Phases 1-3 included in 2039 at 12.52 L/s.**

Appendix D Gravity Main Deficiencies (LoF = 4 or 5)

Table D.1: 2019 Wet Weather Flow 5-yr 24-hr I&I Gravity Main Deficiencies (LoF = 4 or 5)

ID	Length (m)	Slope	Diameter (mm)	Flow (L/s)	q/Q	d/D	LoF
SMAIN-1-0008	79.3	0.004	250	39.7	1.12	0.97	4
SMAIN-1-0062	135.7	0.003	250	86.1	2.85	1.00	5
SMAIN-1-0063	20.5	0.002	250	240.9	8.20	1.00	5
SMAIN-1-0074	25.9	0.004	200	32.2	1.51	1.00	5
SMAIN-1-0104	121.6	0.002	375	85.8	1.22	0.92	4
SMAIN-1-0192	58.3	0.004	200	32.5	1.61	0.81	4
SMAIN-1-0193	41.9	0.009	200	184.8	5.99	1.00	5
SMAIN-1-0209	11.1	0.002	250	42.3	1.68	1.00	4
SMAIN-2-0122	72.2	0.002	200	19.7	1.26	0.80	4
SMAIN-2-0123	78.2	0.001	200	19.4	1.74	1.00	5
SMAIN-3-0034	127.1	0.001	350	72.0	1.32	0.73	4
SMAIN-3-0098	133.7	0.002	300	62.1	1.29	1.00	5
SMAIN-3-0173	54.9	0.000	200	13.9	3.13	0.87	4
SMAIN-3-0208	75.0	0.003	200	28.5	1.57	0.87	5
SMAIN-3-0221	98.2	0.004	200	22.2	1.08	1.00	4
SMAIN-3-0336	84.3	0.003	200	27.6	1.62	0.87	5
SMAIN-3-0337	59.3	0.004	200	27.4	1.30	1.00	5
SMAIN-3-0339	54.1	0.002	200	27.8	1.88	1.00	4
SMAIN-3-0347	0.7	0.000	150	20.5	6.60	1.00	4
SMAIN-3-0349	106.8	0.002	200	24.6	1.68	1.00	5
SMAIN-3-0369	12.2	0.002	150	16.5	2.42	1.00	5
SMAIN-3-0396	49.3	0.005	200	23.8	1.02	1.00	4
SMAIN-3-0400	14.9	0.004	200	27.2	1.31	1.00	5
SMAIN-3-0437	111.2	0.004	200	20.5	1.05	0.81	4
SMAIN-4-0194	83.8	0.014	200	45.2	1.18	0.95	4
SMAIN-4-0195	58.7	0.011	200	45.0	1.29	1.00	4
SMAIN-4-0214	206.1	0.004	200	24.3	1.14	0.71	4
SMAIN-4-0358	156.6	0.022	200	69.3	1.44	0.85	5
SMAIN-4-0418	84.5	0.012	250	74.9	1.16	0.90	4
SMAIN-4-0666	69.1	0.003	300	89.6	1.62	0.89	4
SMAIN-4-0739	18.8	0.001	250	79.1	4.08	0.74	4
SMAIN-4-0762	120.5	0.001	350	76.1	1.59	0.79	4
SMAIN-5-0191	16.3	0.005	300	72.5	1.03	1.00	4

Table D.2: 2024 Wet Weather Flow 5-yr 24-hr I&I Gravity Main Deficiencies (LoF = 4 or 5)

ID	Length (m)	Slope	Diameter (mm)	Flow (L/s)	q/Q	d/D	LoF
SMAIN-1-0008	79.3	0.004	250	41.1	1.16	0.76	4
SMAIN-2-0122	72.2	0.002	200	26.1	1.66	0.85	5
SMAIN-2-0123	78.2	0.001	200	22.2	2.00	1.00	5
SMAIN-3-0173	54.9	0.000	200	13.9	3.13	0.87	4
SMAIN-3-0208	75.0	0.003	200	34.5	1.90	0.90	5
SMAIN-3-0221	98.2	0.004	200	25.2	1.22	1.00	4
SMAIN-3-0396	49.3	0.005	200	28.5	1.22	1.00	5
SMAIN-3-0400	14.9	0.004	200	37.2	1.79	1.00	5
SMAIN-3-0431	2.3	0.000	450	203.7	3.46	1.00	4
SMAIN-4-0178	103.8	0.004	200	26.0	1.20	0.86	4
SMAIN-4-0180	98.5	0.006	200	25.5	1.01	0.78	4
SMAIN-4-0185	65.7	0.004	200	22.4	1.11	0.78	4
SMAIN-4-0194	83.8	0.014	200	48.8	1.27	0.96	4
SMAIN-4-0195	58.7	0.011	200	48.6	1.39	1.00	4
SMAIN-4-0214	206.1	0.004	200	24.5	1.15	0.71	4
SMAIN-4-0358	156.6	0.022	200	69.3	1.44	0.85	5
SMAIN-4-0418	84.5	0.012	250	74.9	1.16	0.90	5
SMAIN-4-0666	69.1	0.003	300	128.7	2.33	0.95	5
SMAIN-4-0739	18.8	0.001	250	78.2	4.03	0.74	4
SMAIN-4-0762	120.5	0.001	350	70.4	1.47	0.78	4
SMAIN-5-0191	16.3	0.005	300	87.7	1.24	1.00	5
SMAIN-5-0212	27.1	0.043	200	265.8	3.91	1.00	5
SMAIN-5-0437	44.6	0.003	200	132.1	8.00	0.83	5
SMAIN-5-0448	101.2	0.005	300	83.5	1.20	1.00	4

Table D.3: 2039 Wet Weather Flow 5-yr 24-hr I&I Gravity Main Deficiencies (LoF = 4 or 5)

ID	Length (m)	Slope	Diameter (mm)	Flow (L/s)	q/Q	d/D	LoF
SMAIN-1-0008	79.3	0.004	250	41.0	1.16	0.76	4
SMAIN-3-0173	54.9	0.000	200	13.9	3.13	0.87	4
SMAIN-3-0328	107.4	0.002	200	16.3	1.10	0.77	4
SMAIN-3-0330	106.0	0.001	200	16.5	1.69	0.85	5
SMAIN-3-0332	85.8	0.001	200	15.9	1.63	1.00	5
SMAIN-3-0333	43.3	0.002	200	17.4	1.16	1.00	5
SMAIN-4-0178	103.8	0.004	200	25.0	1.16	0.85	4
SMAIN-4-0185	65.7	0.004	200	21.4	1.06	0.77	4
SMAIN-4-0194	83.8	0.014	200	48.0	1.25	0.95	4
SMAIN-4-0195	58.7	0.011	200	47.8	1.37	1.00	4
SMAIN-4-0214	206.1	0.004	200	24.5	1.15	0.71	4
SMAIN-4-0358	156.6	0.022	200	69.3	1.44	0.85	5
SMAIN-4-0418	84.5	0.012	250	74.9	1.16	0.90	4
SMAIN-4-0666	69.1	0.003	300	89.1	1.61	0.89	4
SMAIN-4-0739	18.8	0.001	250	78.2	4.03	0.74	4
SMAIN-4-0762	120.5	0.001	350	71.8	1.50	0.79	4
SMAIN-5-0191	16.3	0.005	300	74.0	1.05	1.00	4
SMAIN-6-0026	124.7	0.005	200	26.5	1.14	0.85	4
SMAIN-6-0027	128.2	0.005	200	25.4	1.10	1.00	4
SMAIN-6-0028	93.5	0.005	200	25.3	1.11	1.00	4
SMAIN-6-0041	4.7	0.011	200	37.2	1.10	1.00	4

Appendix E Detailed System Improvements

Table E.1: 5-Year Horizon Planned Improvements – New Gravity Mains

ID	Length (m)	Slope	Proposed Diameter (mm)	Design Flow (L/s)*	Design d/D*
FUT-SMAIN-001	53.0	0.028	250	24.4	0.46
FUT-SMAIN-002	375.1	0.019	250	45.3	0.46
FUT-SMAIN-003	89.0	0.099	250	45.3	0.35
FUT-SMAIN-004	60.3	0.050	300	45.3	0.44
FUT-SMAIN-005	149.9	0.006	300	45.3	0.58
FUT-SMAIN-006	141.4	0.006	300	45.3	0.58
FUT-SMAIN-007	51.1	0.006	300	45.3	0.58
FUT-SMAIN-008	70.7	0.006	300	45.3	0.58
FUT-SMAIN-009	172.9	0.006	300	45.3	0.57
FUT-SMAIN-012	1,117.9	0.026	200	9.6	0.40
FUT-SMAIN-018	157.6	0.004	200	12.5	0.50
FUT-SMAIN-028	183.3	0.002	450	101.7	0.63
FUT-SMAIN-029	357.3	0.002	450	95.8	0.58
FUT-SMAIN-043	247.7	0.050	200	30.4	0.45
FUT-SMAIN-044	29.3	0.034	300	84.2	0.49
FUT-SMAIN-045	1.0	0.482	200	2.1	0.07
FUT-SMAIN-053	41.6	0.012	300	46.0	0.70
FUT-SMAIN-055	515.5	0.001	250	3.3	0.29
SMAIN-4-0677	77.8	0.005	200	4.8	0.30
SMAIN-4-0678	45.6	0.007	200	5.8	0.30
SMAIN-4-0686	121.2	0.005	200	6.1	0.35
SMAIN-4-0765	60.7	0.007	200	5.1	0.29

***Design flow and design d/D based on 2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change.**

Table E.2: 5-Year Horizon Planned Improvements – Lift Station Upgrades

Lift Station Name	Design Flow (L/s)*	Design TDH (m)
1st Street	21.0	28.2

***Design flow based on 2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change.**

Table E.3: 5-Year Horizon Planned Improvements – New Lift Stations

Lift Station Name	Design Flow (L/s)*	Design TDH (m)
Mission Greenwood	74.8	34.4
Comox Road	2.1	36.1

***Design flow based on 2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change.**

Table E.4: 5-Year Horizon Planned Improvements – New Forcemains

ID	Length (m)	Proposed Diameter (mm)	Design Flow (L/s)*	Design Velocity (m/s)*
FUT-SFMAIN-001	286.8	200	32.8	1.04
FUT-SFMAIN-002	1,160.6	200	55.5	1.77
FUT-SFMAIN-004	1,675.6	250	74.8	1.52
FUT-SFMAIN-006	208.2	100	2.1	0.27**
FUT-SFMAIN-008	138.7	150	22.7	1.28

***Design flow and design velocity based on upstream lift station design flow.**
****Velocity at design flow and minimum forcemain diameter as per MMCD.**

Table E.5: 20-Year Horizon Planned Improvements – New Gravity Mains

ID	Length (m)	Slope	Proposed Diameter (mm)	Design Flow (L/s)*	Design d/D*
FUT-SMAIN-010	330.6	0.021	200	0.9	0.11
FUT-SMAIN-011	352.1	0.009	200	0.9	0.12
FUT-SMAIN-013	25.9	0.120	200	20.9	0.29
FUT-SMAIN-014	98.7	0.147	200	20.9	0.27
FUT-SMAIN-015	100.5	0.118	250	20.9	0.40
FUT-SMAIN-016	580.7	0.035	200	1.6	0.11
FUT-SMAIN-017	539.2	0.029	200	7.6	0.25
FUT-SMAIN-019	118.6	0.006	200	7.1	0.40
FUT-SMAIN-020	189.7	0.004	200	7.1	0.37
FUT-SMAIN-021	142.0	0.012	200	7.1	0.30
FUT-SMAIN-022	66.4	0.012	200	7.1	0.42
FUT-SMAIN-023	157.3	0.001	250	7.1	0.44
FUT-SMAIN-024	47.1	0.001	250	7.1	0.38

ID	Length (m)	Slope	Proposed Diameter (mm)	Design Flow (L/s)*	Design d/D*
FUT-SMAIN-025	93.9	0.009	250	11.0	0.40
FUT-SMAIN-026	184.5	0.002	250	11.0	0.38
FUT-SMAIN-027	226.3	0.005	300	18.7	0.43
FUT-SMAIN-031	94.4	0.003	300	21.8	0.56
FUT-SMAIN-032	156.7	0.002	300	24.8	0.55
FUT-SMAIN-033	200.6	0.006	300	29.1	0.47
FUT-SMAIN-034	92.3	0.006	300	31.8	0.48
FUT-SMAIN-035	91.7	0.006	300	33.1	0.48
FUT-SMAIN-036	120.3	0.005	300	34.5	0.50
FUT-SMAIN-037	226.5	0.005	300	34.5	0.50
FUT-SMAIN-038	96.9	0.005	300	34.5	0.51
FUT-SMAIN-039	156.2	0.005	300	34.5	0.48
FUT-SMAIN-040	132.3	0.011	300	42.6	0.46
FUT-SMAIN-041	119.0	0.011	300	42.6	0.46
FUT-SMAIN-042	111.4	0.011	300	42.6	0.46
FUT-SMAIN-046	1.0	0.770	200	18.6	0.24
FUT-SMAIN-047	0.8	1.844	200	20.4	0.19
FUT-SMAIN-048	45.7	0.013	250	21.8	0.47
FUT-SMAIN-049	58.2	0.017	200	2.7	0.47
FUT-SMAIN-050	44.0	0.017	200	1.2	0.40
FUT-SMAIN-051	44.4	0.026	200	1.4	0.44
FUT-SMAIN-052	52.2	0.011	200	8.2	0.51
FUT-SMAIN-054	41.1	0.043	200	0.5	0.18
FUT-SMAIN-056	99.5	0.014	200	3.9	0.24

***Design flow and design d/D based on 2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change.**

Table E.6: 20-Year Horizon Planned Improvements – New Lift Stations

Lift Station Name	Design Flow (L/s)*	Design TDH (m)
North Island College	18.6	30.4
North Sandwick	9.3	3.5
Veterans Memorial Parkway	20.4	14.8

***Design flow based on 2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change.**

Table E.7: 20-Year Horizon Planned Improvements – New Forcemains

ID	Length (m)	Proposed Diameter (mm)	Design Flow (L/s)*	Design Velocity (m/s)*
FUT-SFMAIN-003	505.7	150	20.4	1.15
FUT-SFMAIN-005	1,213.2	150	18.6	1.05
FUT-SFMAIN-007	616.8	100	9.3	1.18

***Design flow and design velocity based on upstream lift station design flow.**

Table E.8: Proposed Upgrades – New Gravity Mains

ID	Length (m)	Slope	Proposed Diameter (mm)	Design Flow (L/s)*	Design d/D*
FUT-SMAIN-057	103.7	0.024	250	53.4	0.54
FUT-SMAIN-058	28.3	0.041	375	98.0	0.36

***Design flow and design d/D based on 2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change.**

Table E.9: Proposed Upgrades – Gravity Main Upgrades

ID	Length (m)	Slope	Existing Diameter (mm)	Proposed Diameter (mm)	Design Flow (L/s)*	Design d/D*
SMAIN-1-0008	79.3	0.004	250	300	46.0	0.60
SMAIN-3-0170	97.1	0.003	200	300	16.2	0.36
SMAIN-3-0173	54.9	0.000	200	300	15.6	0.50
SMAIN-3-0326	12.2	0.151	200	300	18.0	0.15
SMAIN-3-0328	107.4	0.002	200	300	16.7	0.40
SMAIN-3-0329	107.1	0.004	200	300	15.8	0.34
SMAIN-3-0330	106.0	0.001	200	300	15.7	0.47
SMAIN-3-0332	85.8	0.001	200	300	15.2	0.55
SMAIN-3-0333	43.3	0.002	200	250	14.0	0.57
SMAIN-4-0178	103.8	0.004	200	300	27.3	0.50
SMAIN-4-0194	83.8	0.014	200	300	52.8	0.48
SMAIN-4-0195	58.7	0.011	200	300	52.6	0.50
SMAIN-4-0202	23.0	0.052	200	250	58.9	0.45
SMAIN-4-0203	76.5	0.085	200	250	59.3	0.48
SMAIN-4-0204	161.8	0.019	250	250	29.0	0.48
SMAIN-4-0212	90.1	0.029	250	250	27.7	0.38
SMAIN-4-0214	206.1	0.004	200	250	27.3	0.53
SMAIN-4-0416	20.4	0.023	250	300	95.3	0.63
SMAIN-4-0417	50.9	0.018	250	300	95.3	0.62

ID	Length (m)	Slope	Existing Diameter (mm)	Proposed Diameter (mm)	Design Flow (L/s)*	Design d/D*
SMAIN-4-0418	84.5	0.012	250	300	94.6	0.72
SMAIN-4-0666	69.1	0.003	300	375	89.8	0.71
SMAIN-4-0740	66.9	0.022	250	300	97.6	0.57
SMAIN-6-0022	19.2	0.011	200	250	32.4	0.51
SMAIN-6-0023	86.0	0.012	200	250	32.1	0.50
SMAIN-6-0024	69.0	0.058	200	250	30.3	0.31
SMAIN-6-0025	58.6	0.025	200	250	30.3	0.39
SMAIN-6-0026	124.7	0.005	200	250	29.0	0.59
SMAIN-6-0027	128.2	0.005	200	250	27.7	0.58
SMAIN-6-0028	93.5	0.005	200	250	26.7	0.57
SMAIN-6-0041	4.7	0.011	200	250	32.7	0.52

***Design flow and design d/D based on 2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change.**

Table E.10: Proposed Upgrades – Lift Station Upgrades

Lift Station Name	Design Flow (L/s)*	Design TDH (m)
Sandpiper	32.8	27.9

***Design flow based on 2039 Peak Wet Weather Flow 5-yr 24-hr I&I w/ Climate Change.**

Table E.11: Proposed Upgrades – Flow Split

Manhole ID	Location
4-041	10th St East and Hobson Ave

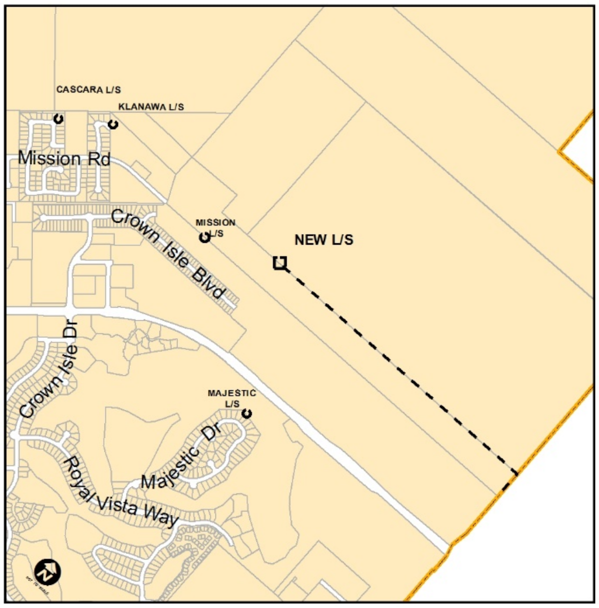
B

CAPITAL PROJECT LIST

Project ID: SEW 001

GREENWOOD - TRUNK SEWER EXTENSION

Greenwood Trunk



Term: Short-term

Category: Primary Core

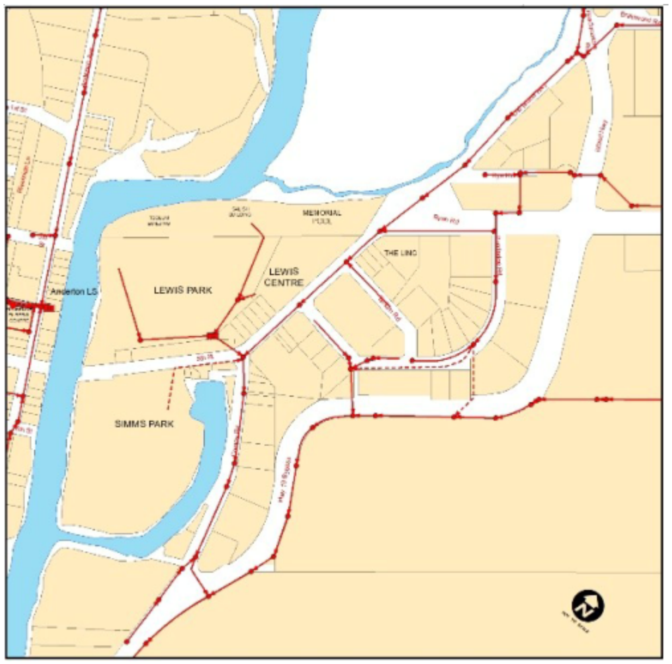
Project Description:

The Greenwood Trunk was identified as a growth driven project in the draft version of this plan and has since been under construction and is planned for completion in 2021. As growth continues in East Courtenay, the flows going to the Courtenay Regional Sewer Pump Station on Comox Rd continue to increase as well. This regional pump station receives all flows from West Courtenay and the majority of flows from East Courtenay. With the completion of the Greenwood Trunk Sewer a connection now exists to route flows from portions of East Courtenay to the CVRD Greenwood connection on Anderton Rd creating capacity for the Courtenay Regional Sewer Pump Station.

Estimated Project Budget	**$7,950,000**

Project ID: SEW 002

PUNTLEDGE CATCHMENT REDIRECTION



Timing: Short-term

Category: Primary Core

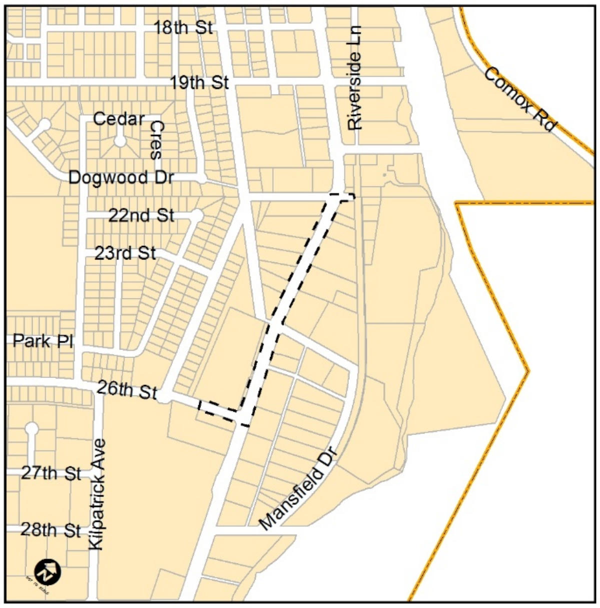
Project Description:

The existing sewer crossing under the Puntledge River to the Anderton Lift Station is no longer feasible due to the age and condition of the pipe. In addition, the nearby Puntledge Lift Station is under capacity and operates under the flood plain. By re-grading the pipe along Puntledge Rd and rerouting flows along Comox Rd toward the East Courtenay Trunk Main it would be possible to remove a sewer lift station and create capacity in the in the Anderton Lift Station.

Estimated Project Budget	**$1,700,000**

Project ID: SEW 003

CLIFFE AVE – TRUNK SEWER (26th St. to 21st St.)



Timing: Short-term

Category: Primary Core

Project Description:

All South Courtenay sewer flows are currently routed via the Sandpiper Lift Station to the Mansfield Lift Station and then onto the 20 St CVRD connection via the Riverway Trunk. The Mansfield Lift Station and forcemain along with the Riverway Trunk main currently operate near capacity. In addition, a significant portion of West Courtenay flows (south of 21 St) are routed via 26 St to the Riverway Trunk. By creating a Cliffe Ave trunk main receiving flows at 26 St and routing to the 21 St Trunk Main will allow capacity in the Riverway Trunk and create a receiving point for an extended forcemain from South Courtenay.

Estimated Project Budget **$2,300,000**

Project ID: SEW 004

CLIFFE AVE – SEWER FORCEMAIN (S. Courtenay to 26th St.)

Timing: Short-term

Category: Primary Core

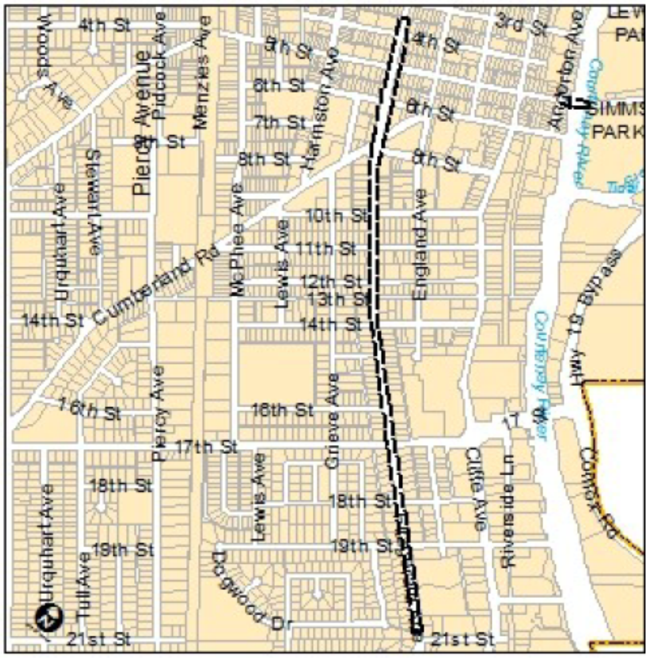
Project Description:

All South Courtenay flows from Sandpiper Lift Station all route into the Mansfield Lift Station and Riverway Trunk, both of which at near capacity. A forcemain extension to the proposed Cliffe Ave Trunk Main at 26 St, would allow capacity at Mansfield Lift Station and the Riverway Trunk Main.

Estimated Project Budget **$2,000,000**

Project ID: SEW 005

FITZGERALD AVE – TRUNK SEWER (4th St. to 21st St.)

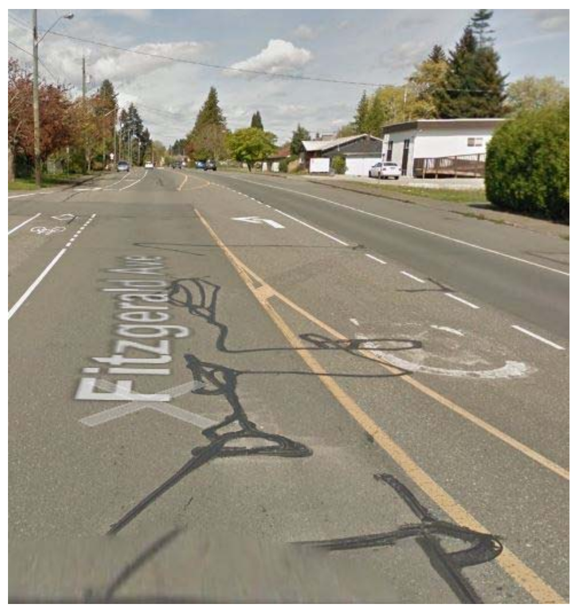


Timing: Short-term

Category: Primary Core

Project Description:

Flows in West Courtenay below the rail corridor and north of 21 St are routed at several points into the Riverway Trunk Sewer which currently operates near capacity. Infill growth in this area continues to add sewer flows to the Riverway Trunk. Adding capacity to the Riverway trunk main involves construction challenges and archaeological work. A trunk main along Fitzgerald would allow capacity in the Riverway Trunk and growth potentially in the area serviced in West Courtenay.



Estimated Project Budget **$3,900,000**

Project ID: SEW 006

ARDEN CENTRAL – TRUNK SEWER (Lake Trail Rd. to Cumberland Rd.)

Timing: Short-term

Category: Secondary

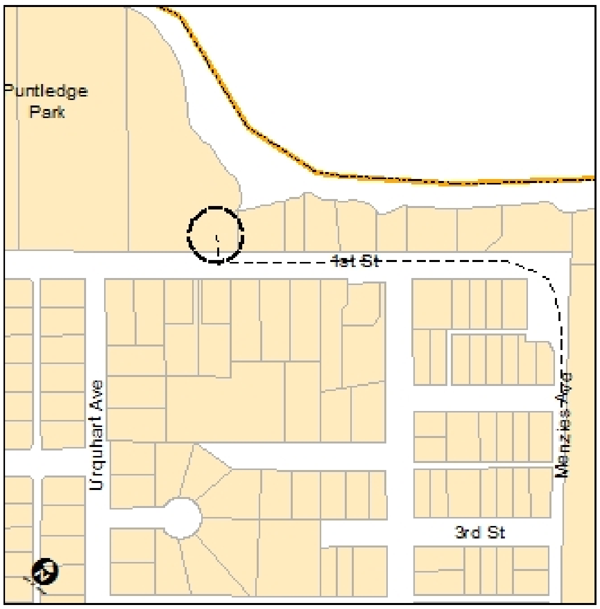
Project Description:

Due to flat pipe grade in the Willemar Ave sewer pipe that receives flows from 15 St, 13 St and Lake Trail Rd, the pipe regularly flows at capacity near the roundabout at Cumberland Rd. Routing flows from these areas through an Arden Central Trunk would allow capacity in the Willemar Ave sewer and future growth in the upper area of this catchment.

Estimated Project Budget	**$800,000**

Project ID: SEW 007

1st STREET LIFT STATION & FORCEMAIN UPGRADES

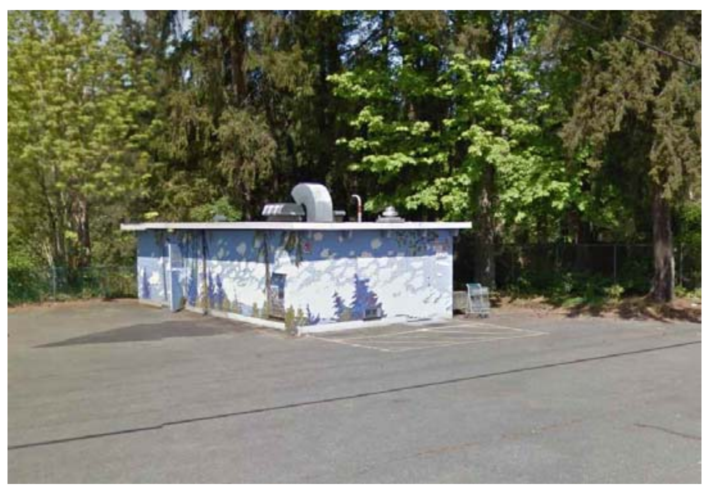


Timing: Short-term

Category: Secondary

Project Description:

The 1st St Lift Station and forcemain were built in 1961 and have been in service since that time with no significant upgrades. Replacing and upgrading the aging 1St Street Lift Station and Forcemain will improve capacity in the 1st Street catchment and meet asset management renewal requirements.



Estimated Project Budget **$2,500,000**

Project ID: SEW 008

EAST COURTENAY LIFT STATION & FORCEMAIN

Timing: Medium-term

Category: Secondary

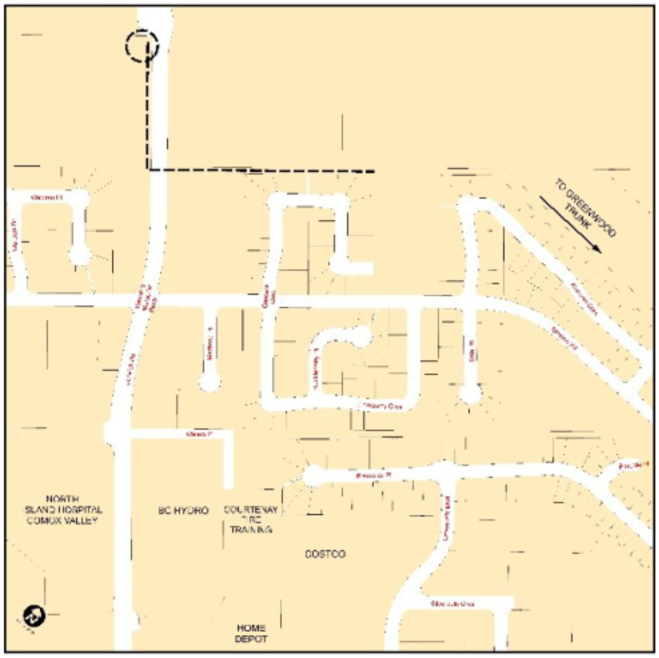
Project Description:

Flows from Costco, the shopping centre including Home Depot and North Island College (NIC) currently flow into the Muir Rd – Carmanah Dr residential collection system. Any future growth in this upstream portion of the catchment would see the downstream sewer increase over-capacity. A Lift Station at the bottom of the NIC collection system would reroute flows to the Greenwood Trunk system and allow capacity in the residential sewer below.

Estimated Project Budget	**$2,100,000**

Project ID: SEW 009

VETERANS MEMORIAL PKWY LIFT STATION AND FORCEMAIN

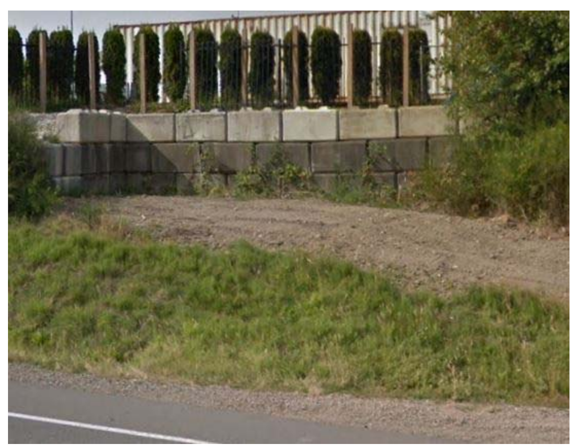


Timing: Medium-term

Category: Secondary

Project Description:

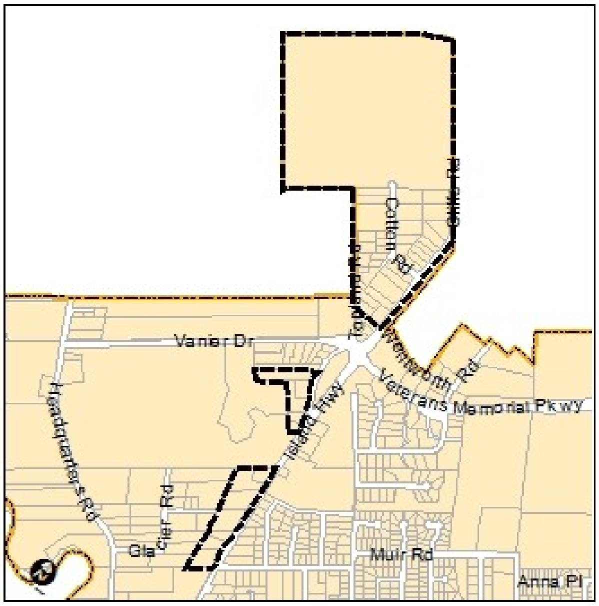
Current flows from the Comox Valley Hospital on Lerwick Rd, along with future multi-family developments to be completed in the 5-year time frame are routed down Veterans Memorial Parkway and then via the East Courtenay Trunk Main to the Courtenay Regional Sewer Pump Station. Installing a lift station at the top of Veterans Memorial Parkway would redirect flows to the Greenwood Trunk and create capacity in the East Courtenay system. A pipe crossing Veterans Memorial Parkway was installed prior to paving in 2020 for the potential forcemain from the lift station.



Estimated Project Budget **$1,600,000**

Project ID: SEW 010

NORTH COURTENAY AREA SERVICING



Timing: Medium-term

Category: Secondary

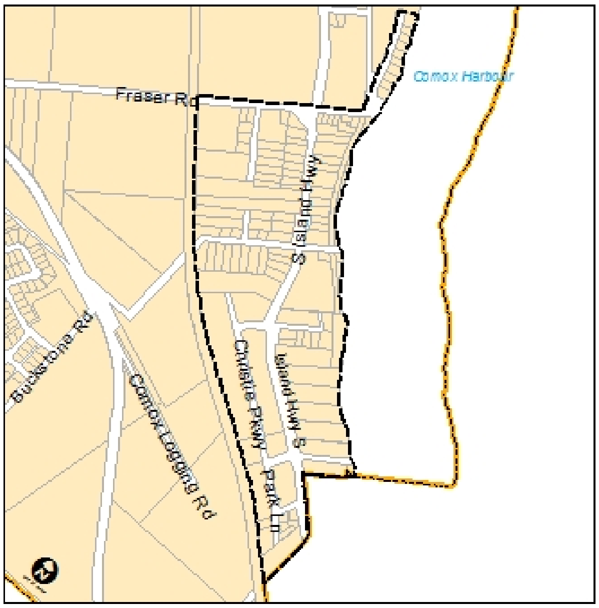
Project Description:

The North Courtenay area is one of the remaining developed areas in the City not serviced by sewer. Developing a legislative and engineering approach to service the North Courtenay area will meet the City's goal of expanding the level of service in the area.

Estimated Project Budget	**$TBD**

Project ID: SEW 011

SOUTH COURTENAY AREA SERVICING



Timing: Medium-term

Category: Secondary

Project Description:

The South Courtenay area was annexed into the City and aside from 'The Ridge' development has not seen sewer servicing. Developing a legislative and engineering approach to service the South Courtenay area will meet the City's goal of expanding the level of service in the area.

Estimated Project Budget **$3,500,000 TBD**

Project ID: SEW 012

ARDEN NORTH – TRUNK SEWER (ARDEN RD. - 1ST ST. TO LAKE TRAIL RD.)

Timing: Medium-term

Category: Secondary

Project Description:

Sewer flows from strata developments at the upstream end of the 1st St Lift Station Catchment could be rerouted to Lake Trail Rd and into the Arden Central Trunk allowing capacity in the downstream catchment and lift station. Should the 1st St Lift Station and forcemain be upgraded, the Arden North Trunk could be redundant, however the pipe could receive flows from areas outside the City should ever the need arise.

Estimated Project Budget **$2,000,000**

URBAN

SYSTEMS